SEISMIC MARGIN STUDY
J. Kane needs to review the portions of Attachment 2 relative to geotechnical engineering

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

NOTE FOR: George Lear, Chief SGEB

THRU: P. T. Kuo, Section Leader, Section B, SGEB

FROM: Frank Rinaldi, Structural Engineer, Section B, SGEB

SUBJECT: MEETING SUMMARY - TERA's IDCVP

On April 17, 1984, I attended a meeting in Chicago, IL, at the request of I&E. The meeting was requested by TERA to discuss SMA's Seismic Margins Evaluation (SME) of Midland and its potential applicability to the disposition of outstanding civil/structural issues. The meeting notice is enclosed as Attachment 1 and a list of participants is enclosed as Attachment 2.

TERA was interested in SMA's SME because it related to their review of Bechtel's seismic analysis and design, with special emphasis on modeling assumptions and the various discrepancies noted in their IDCVP.

SMA presented an overview of their work and detailed discussions in the areas of soil structure interaction, floor flexibility, equipment qualification, parameter variations, sampling criteria, and differences between the SME and FSAR seismic evaluations. Attachment 3 (approximately 90 pages) provides a copy of the viewgraphs used by SMA.

It was my impression that SMA provided TERA all of the necessary clarifications required by TERA for their work related to the IDCVP on Midland NPP. Also, during side discussions with H. Wang of I&E, I learned that his office was planning to write an SER evaluation on TERA's IDCVP with the help of a sole source contractor not yet named.

Frank Rinaldi

Frank Rinaldi, Structural Engineer
Structural Engineering Section B
Structural and Geotechnical
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Enclosures: As stated

cc: J. Knight w/o enclosures
T. Sullivan w/o enclosures
D. Hood w/o enclosures
L. Heller w/o enclosures
[redacted] w/o enclosures
G. Lear w/enclosures
P. Kuo w/enclosures
F. Rinaldi w/enclosures

8408020195 840718
PDR FOIA
RICE84-96 PDR

Rec'd in mail on 4/30/84

TERA

April 18, 1984

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Re: Docket Nos. 50-329 OM, OL and 50-330 OM, OL
Midland Nuclear Plant - Units 1 and 2
Independent Design and Construction Verification (IDCV) Program
Meeting Summary

Gentlemen:

A meeting was held in Chicago, Illinois on April 17, 1984 to discuss details of the SMA Seismic Margins Evaluation (SME) of the Midland plant and its potential applicability to the disposition of outstanding items in the IDCVP civil/structural review area. Attachment 1 identifies participants which included representatives of TERA, CPC, and NRC. Attachment 2 includes viewgraphs presented by SMA at the meeting.

TERA indicated that elements of the SME were being reviewed to assist in the independent design verification of Bechtel's seismic analysis and design with emphasis on modeling assumptions and inputs used in the design evaluations as well as the significance of various discrepancies noted by the IDCVP.

SMA presented an overview of their work and a detailed discussion in areas of particular interest to TERA. Concentration was given to the areas such as soil-structure interaction, floor flexibility, equipment qualification, parameter variation, sampling criteria, and differences between the SME and FSAR seismic

~~8404200219 840418~~
~~PDR ADOCK 05000329~~
~~A PDR~~

91pp.

D021

1/1

TERA CORPORATION
7101 WISCONSIN AVENUE BETHESDA, MARYLAND 20814 301-654-8960

evaluations. SMA provided TERA with necessary clarification to understand information presented in their series of SME reports as well as the level of detail and parametric evaluation actually applied during the course of their study.

Sincerely,

Howard A. Levin
Project Manager
Midland IDCV Program

Enclosure

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IDCV Program Service List

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ATTACHMENT I

PARTICIPANTS

MIDLAND INDEPENDENT DESIGN AND
CONSTRUCTION VERIFICATION PROGRAM MEETING

CHICAGO, ILLINOIS

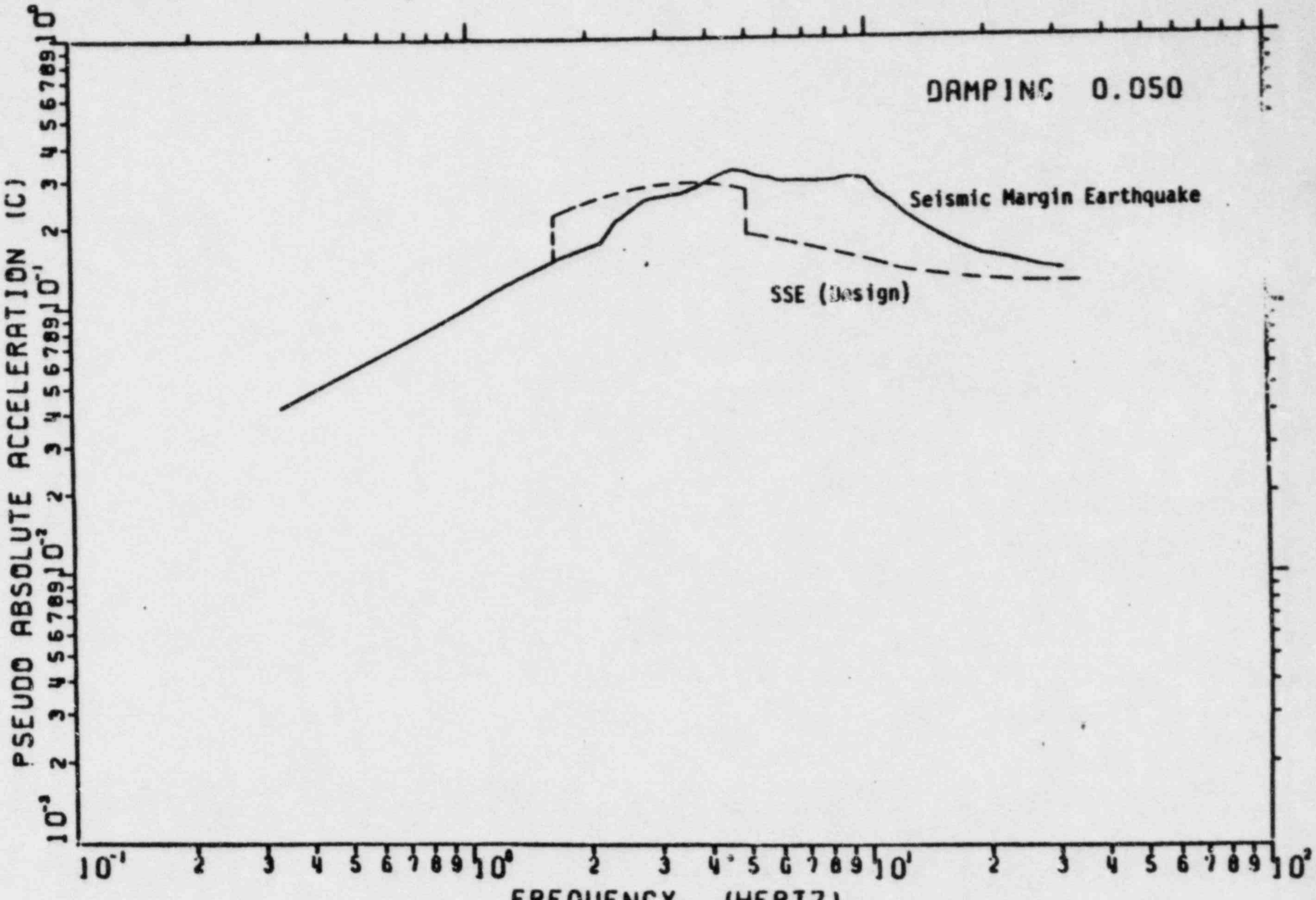
APRIL 17, 1984

Name	Affiliation
H. Levin	TERA
J. Martore	TERA
C. Mortgat	TERA
W. Hall	TERA Consultant, Univ. of Illinois
D. Wesley	SMA
R. Campbell	SMA
L. Gibson	CPC
T. Thiruvengadam	CPC
H. Wang	NRC
F. Rinaldi	NRC

ATTACHMENT 2

SEISMIC MARGIN EARTHQUAKE (SME)

- BASED ON SITE SPECIFIC EARTHQUAKE
- INCLUDES STRUCTURES AND EQUIPMENT
- SCREENING PROCESS USED TO IDENTIFY CRITICAL ELEMENTS AND COMPONENTS FOR REVIEW FOR SEISMIC ADEQUACY
- ALLOWS FOR DEVIATIONS FROM STANDARD REVIEW PLAN FOR FAILURE CAPACITY EVALUATION



MIDLAND - ORIGINAL GROUND SURFACE ENVELOPE RESPONSE SPECTRA

DIFFERENCES BETWEEN SME REVIEW AND FSAR DESIGN

- SEISMIC INPUT
- WIDER RANGE OF SOIL PARAMETERS
- PARAMETRIC VARIATION OF RELATIVE SOIL STIFFNESS UNDER AUXILIARY PENETRATION WINGS
- DAMPING

STRUCTURES EVALUATION

- USE BECHTEL STRUCTURES MODELS FOR:
  - CONTROL/AUXILIARY BUILDING*
  - SERVICE WATER PUMP STRUCTURE*
  - REACTOR BUILDINGS
  - DIESEL GENERATOR BUILDINGS

- DEVELOP NEW MODEL FOR BORATED WATER STORAGE TANK*

- DEVELOP NEW SOIL COMPLIANCE FUNCTIONS FOR A WIDER RANGE OF SOIL PROPERTIES THAN CONSIDERED IN DESIGN

- GENERATE NEW STRUCTURE LOADS AND IN-STRUCTURE RESPONSE SPECTRA

- CALCULATE SEISMIC MARGIN AGAINST CODE STRENGTH FOR SELECTED ELEMENTS

- CALCULATE SEISMIC MARGIN AGAINST FAILURE (IF REQUIRED)

* INCLUDES SOILS REMEDIAL DESIGN EFFECTS

DAMPING

- REG. GUIDE 1.61 SSE DAMPING USED FOR THE CODE MARGIN EVALUATION FOR BOTH STRUCTURES AND EQUIPMENT

- INCREASED DAMPING FOR FAILURE MARGIN EVALUATION FOR EQUIPMENT TO REFLECT HIGH STRESSES AT FAILURE

- GEOMETRIC (RADIATION) DAMPING FOR SOIL-STRUCTURE INTERACTION LIMITED TO EITHER 75% OF THEORETICAL ELASTIC HALF SPACE VALUES OR 100% OF ANALYTICALLY DETERMINED VALUES FOR LAYERED SOIL PROFILES WHICH-EVER IS LOWER

SOIL PROPERTIES

- WIDE PARAMETRIC RANGE OF SOIL PROFILES WERE DEVELOPED TO ACCOUNT FOR UNCERTAINTIES IN SITE CONDITIONS

THREE PROFILES DEVELOPED:

- SOIL LAYERING PROFILE REPRESENTATIVE OF SOFT SITE CONDITIONS
- SOIL LAYERING PROFILE REPRESENTATIVE OF STIFF SITE CONDITIONS
- INTERMEDIATE SOIL PROFILE

Elevation

634 ——— Top of Grade

603 ——— Original Ground Sur

Glacial Till

W_s = 135 pcf — G_{max} = $7 \cdot 10^6$ psf

ν = 0.47 — G_{SME} = $2 \cdot 10^6$ psf

V_s = 1290 fps

550 ———

Glacial Till

W_s = 135 pcf — G_{max} = $12 \cdot 10^6$ psf

ν = 0.47 — G_{SME} = $4.2 \cdot 10^6$ psf

V_s = 1690 fps

410 ———

Dense Cohesionless Material

W_s = 135 pcf — V_s = 2540 fps — G_{max} = $27 \cdot 10^6$ psf; G_{SME} = $17.8 \cdot 10^6$ psf } Elevat 410

ν = 0.34

V_s = 2970 fps — G_{max} = $37 \cdot 10^6$ psf; G_{SME} = $25.2 \cdot 10^6$ psf } Elevati 260

260 ———

Bedrock

W_s = 150 pcf — V_s = 5000 fps

ν = 0.33

Soft Site Soil Profile

Elevation

634 — Top of Grade

603 — Original Ground Sur

Glacial Till

W_s = 120 pcf
ν = 0.49
V_s = 1400 fps
G_{max} = $7.3 \cdot 10^6$ psf
G_{SME} = $3.65 \cdot 10^6$ psf

Aux. Bldg.- 570
Reactor Bldg.- 568

Glacial Till

W_s = 135 pcf
ν = 0.42
V_s = 2300 fps
G_{max} = $22.2 \cdot 10^6$ psf
G_{SME} = $13.3 \cdot 10^6$ psf

463

Glacial Till

W_s = 135 pcf
ν = 0.42
V_s = 3000 fps
G_{max} = $37.8 \cdot 10^6$ psf
G_{SME} = $25.0 \cdot 10^6$ psf

363

Dense Cohesionless Material

W_s = 135 pcf
ν = 0.34
V_s = 3000 fps
G_{max} = $37.8 \cdot 10^6$ psf
G_{SME} = $31.0 \cdot 10^6$ psf

263

Bedrock

W_s = 150 pcf
ν = 0.33
V_s = 5000 fps

Stiff Site Soil Profile

Elevation

634 — Top of Grade

603 — Original Ground Sur

Glacial Till

W_s = 110 pcf — G_{max} = $7.7 \cdot 10^6$ psf

ν = 0.49 — G_{SME} = $4.08 \cdot 10^6$ psf

V_s = 1500 fps

553

Glacial Till

W_s = 135 pcf — G_{max} = $15 \cdot 10^6$ psf

ν = 0.42 — G_{SME} = $7.95 \cdot 10^6$ psf

V_s = 1890 fps

463

Dense Cohesionless Material

W_s = 135 pcf — G_{max} = $25.6 \cdot 10^6$ psf

ν = 0.34 — G_{SME} = $13.6 \cdot 10^6$ psf

V_s = 2468 fps

263

Bedrock

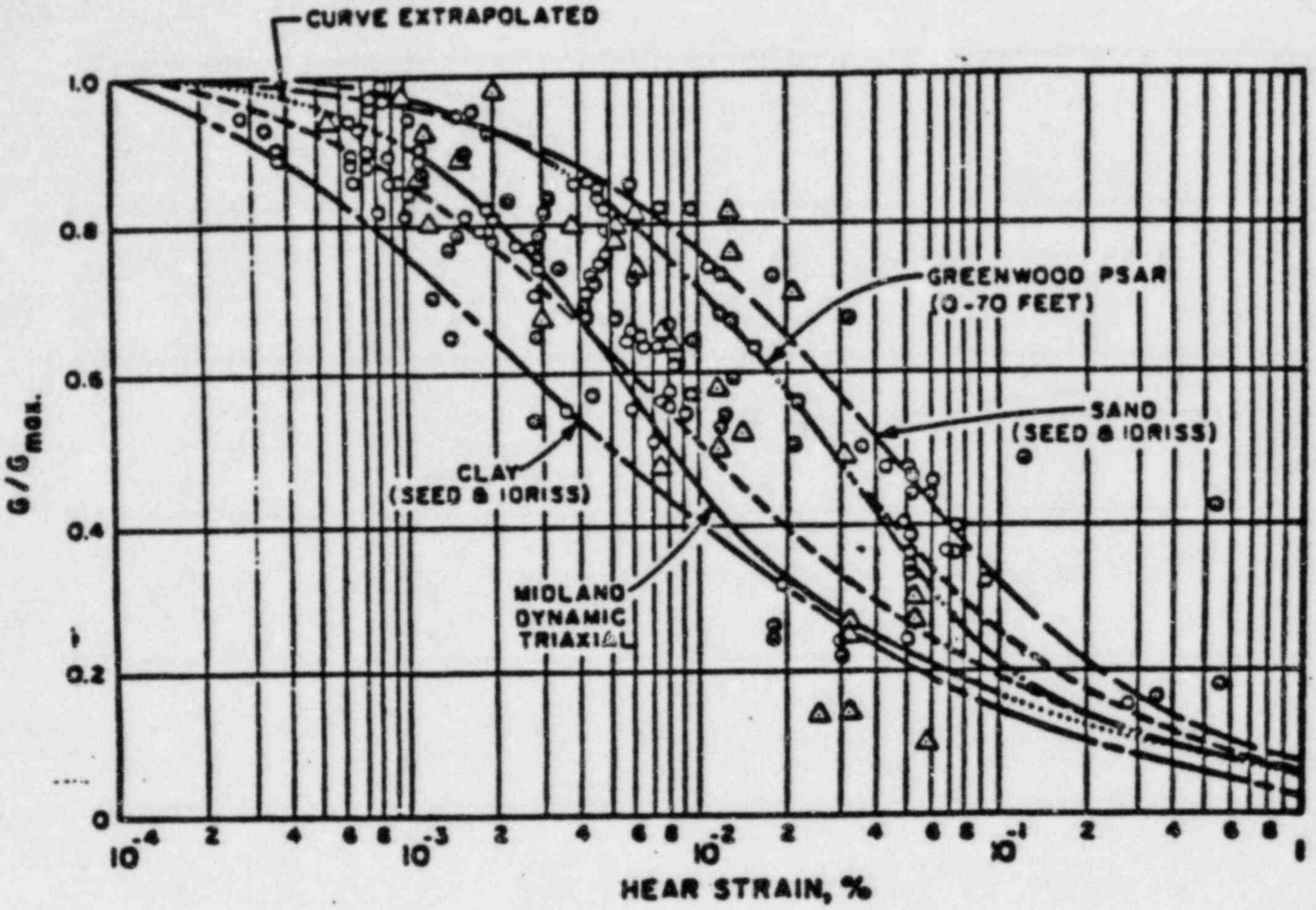
W_s = 145 pcf — V_s = 5000 fps

ν = 0.33

INTERMEDIATE SOIL PROFILE

STRAIN DEGRADATION EFFECTS

- SOIL PROFILES BASED ON LOW STRAIN SHEAR MODULI, G_{MAX}
- EQUIVALENT LINEAR HIGH STRAIN SOIL SHEAR MODULI, G_{SME}, ACCOUNT FOR EFFECT OF EARTHQUAKE INDUCED SHEAR STRAINS ON SOIL MATERIAL PROPERTIES
- STRAIN DEGRADATION RELATIONSHIPS APPROPRIATE FOR SME GROUND MOTION LEVELS WERE DEVELOPED BY DAMES & MOORE



EXPLANATION

- ○ LOW PLASTICITY SILTS AND CLAYS (ARANGO et al)
- △ HIGH PLASTICITY SILTS AND CLAYS (ARANGO et al)
- ☐ RECOMMENDED BAND

STRAIN DEGRADATION RELATIONSHIPS

LAYERED SITE SOIL IMPEDANCE

SOIL IMPEDANCE DEVELOPMENT:

- PROGRAM CLASSI USED
- FIVE PERCENT SOIL MATERIAL DAMPING

REASONS FOR CLASSI APPROACH:

- LAYERED SOIL PROFILES MAY ENTRAP ENERGY NORMALLY DISSIPATED BY GEOMETRIC DAMPING
- PROCEDURE WITH THEORETICAL BASIS FOR EVALUATING EFFECTIVE STIFFNESS OF LAYERED SOIL PROFILE

EFFECTIVE SOIL SHEAR MODULUS

- AN EFFECTIVE SOIL SHEAR MODULUS, G_{EFF}, WAS DEVELOPED BASED ON CLASSI RESULTS

ADVANTAGES OF THIS APPROACH:

1. CHECK ON CLASSI RESULTS
   - COMPARE G_{EFF} TO LAYERED SOIL PROFILE CHARACTERISTICS
2. ALLOWS FOR MODIFICATION OF SOIL SPRINGS AND DASHPOTS TO ACCOUNT FOR:
   - NON-STANDARD FOUNDATION SHAPES
   - EMBEDMENT EFFECTS

UNCERTAINTY RANGE ON SHEAR MODULUS

CONSIDERATIONS:

- UNCERTAINTY IN LOW STRAIN SHEAR MODULUS, G_{MAX}
- UNCERTAINTY IN STRAIN DEGRADATION EFFECTS
- UNCERTAINTY IN LAYERING EFFECTS
- UNCERTAINTY IN MODELING USED TO OBTAIN SOIL COMPLIANCES

PARAMETRIC RANGES USED:

- LOWER BOUND SOIL CASE
  - 0.6 G_{EFF} (SOFT SITE PROFILE)
- UPPER BOUND SOIL CASE
  - 1.3 G_{EFF} (STIFF SITE PROFILE)
- INTERMEDIATE SOIL CASE
  - REMAINS THE SAME

ENERGY ENTRAPMENT DUE TO LAYERING

TWO TYPES OF DAMPING:

1. HYSTERETIC (MATERIAL) DAMPING
   - ESTIMATED AS 5 PERCENT OF CRITICAL DAMPING
   - NOT STRONGLY AFFECTED BY LAYERING

2. GEOMETRIC (RADIATION) DAMPING
   - WAVE PROPOGATION OF ENERGY THROUGH THE SOIL
   - LAYERED SOIL PROFILE MAY ENTRAP ENERGY EFFECTIVELY REDUCING GEOMETRIC DAMPING
   - EFFECT IS EVALUATED BY A KNOCKDOWN FACTOR

$$F_{LAYER} = \frac{C(\text{CLASSI LAYERED SITE ANALYSIS})}{C(\text{THEORETICAL ELASTIC HALF-SPACE})}$$

   - LIMITED TO EITHER 75 PERCENT OF THEORETICAL ELASTIC HALF-SPACE VALUES OR 100 PERCENT OF ANALYTICALLY DETERMINED VALUES FOR SOIL PROFILE WHICH EVER IS <u>LOWER</u>

DEVELOPMENT OF IN-STRUCTURE RESPONSE SPECTRA

CONSIDERATIONS:

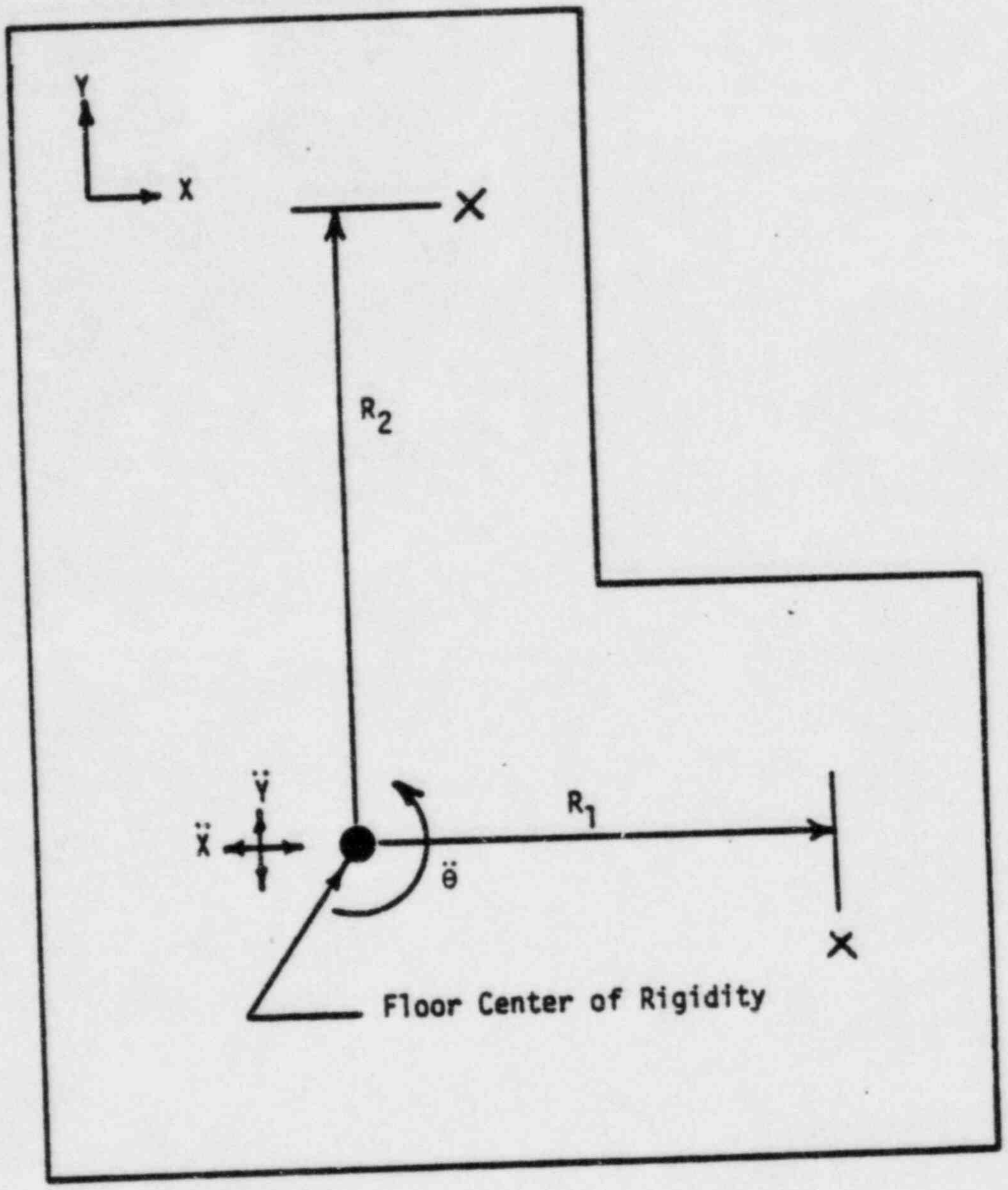
- THREE SOIL CASES (LOWER, INTERMEDIATE, UPPER)
- EFFECTS OF MULTIDIRECTIONAL EXCITATION
- TORSIONAL RESPONSE
- BROADENING AND ENVELOPING TECHNIQUES
- FLOOR SLAB VERTICAL AMPLIFICATION

DETERMINATION OF SME IN-STRUCTURE RESPONSE SPECTRA

- TRANSLATIONAL AND ROTATIONAL SPECTRA AT THE FLOOR CENTER OF RIGIDITY FOR EACH RESPONSE DIRECTION WERE DETERMINED BY TAKING THE SQUARE-ROOT-SUM-OF THE-SQUARES OF CONTRIBUTIONS TO THE SPECTRAL ORDINATES FROM THE VERTICAL AND THE TWO HORIZONTAL GROUND MOTIONS

- TORSIONAL RESPONSE CONTRIBUTION TO TRANSLATIONAL RESPONSE WAS INCLUDED:
  - IMPORTANT FOR EQUIPMENT NOT AT THE CENTER OF RIGIDITY
  - TRANSLATIONAL COMPONENT DUE TO TORSION WAS CONSERVATIVELY INCLUDED BY ADDING IN THE ABSOLUTE SUM OF A MOMENT ARM R_1 TIMES THE ROTATIONAL SPECTRA AT THE FLOOR CENTER OF RIGIDITY TO THE APPROPRIATE TRANSLATIONAL COMPONENT

× - Critical Equipment Locations on Floor

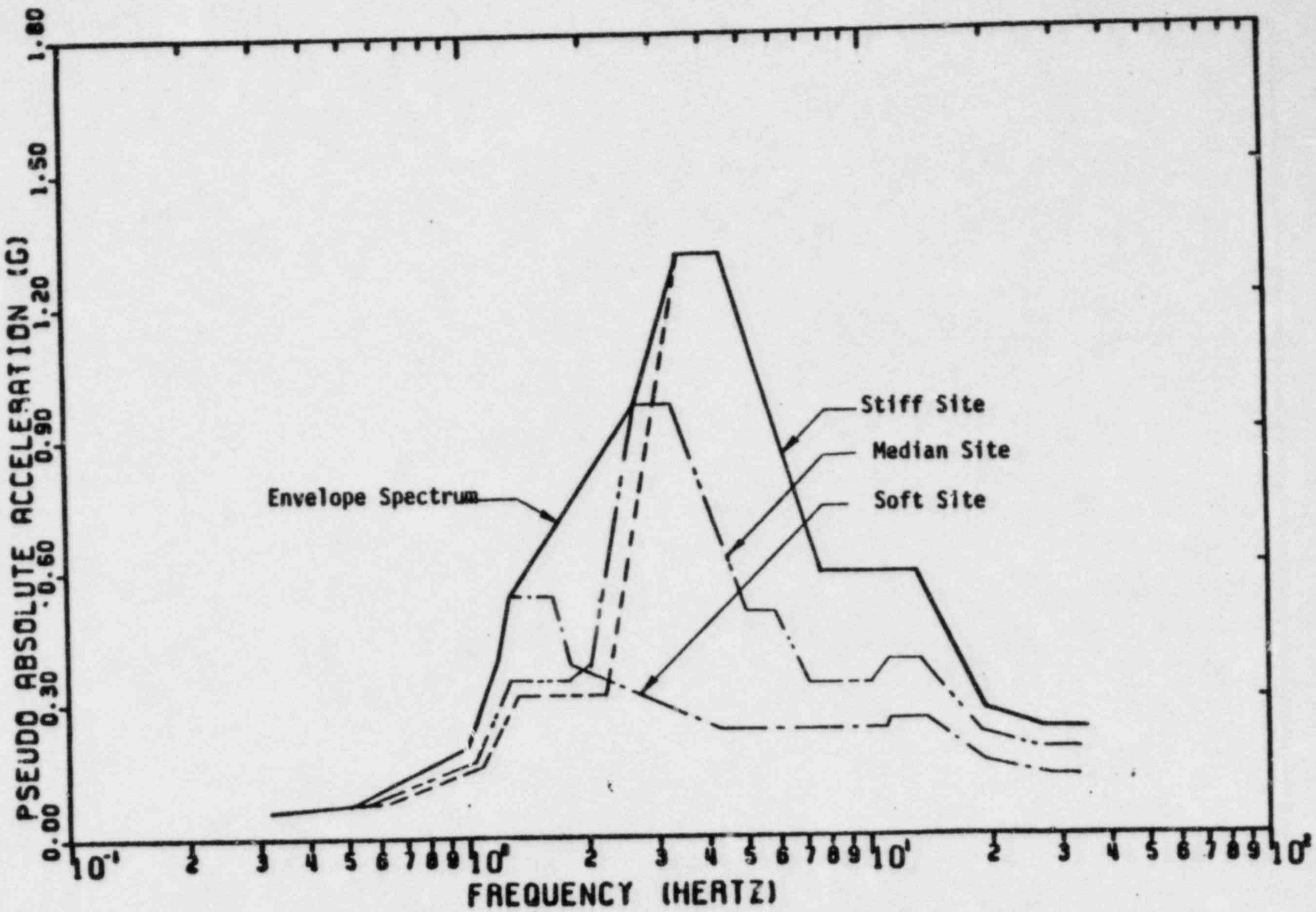


SCHEMATIC REPRESENTATION OF TYPICAL FLOOR SHOWING CRITICAL EQUIPMENT LOCATIONS RELATIVE TO THE FLOOR CENTER OF RIGIDITY

IN-STRUCTURE RESPONSE SPECTRA SMOOTHING AND BROADENING

- PEAKS OF THE SPECTRA WERE BROADENED AN ADDITIONAL ± 10%
- ACCOUNTS FOR VARIABILITIES IN-STRUCTURE FREQUENCIES DUE TO UNCERTAINTIES IN:
  - A) MATERIAL PROPERTIES
  - B) STRUCTURAL MODELING ASSUMPTIONS
- UNCERTAINTY IN SITE SOIL CHARACTERISTICS IS COVERED BY BROAD RANGE OF SOIL SHEAR MODULI USED IN SME

- FINAL SME IN-STRUCTURE RESPONSE SPECTRA WERE DEVELOPED AS AN ENVELOPE OF THE BROADENED SPECTRA FOR THE THREE SOIL CASES
  - CONSIDERED POSSIBLE SHIFTING OF STRUCTURE FREQUENCIES
  - SPECTRA WERE SMOOTHED TO REMOVE MINOR VOLLEYS



DEVELOPMENT OF ENVELOPE IN-STRUCTURE RESPONSE SPECTRA

FLOOR SLAB VERTICAL AMPLIFICATION

- SEISMIC DESIGN MODELS DEVELOPED TO COMPUTE OVERALL BUILDING RESPONSE AND DID NOT INCLUDE FLOOR FLEXIBILITY.

- FLOOR SLAB AMPLIFICATION MAY BE SIGNIFICANT FOR SLABS WITH RELATIVELY LOW FREQUENCIES.

- SLABS WITH LOWEST EXPECTED FREQUENCIES WERE SELECTED FOR ANALYSIS FROM:

    - AUXILIARY BUILDING
    - DIESEL GENERATOR BUILDING (DGB)
    - SERVICE WATER PUMP STRUCTURE (SWPS)

- SLAB FLEXIBILITY INCLUDED IN THE REACTOR BUILDING EQUIPMENT QUALIFICATION ANALYSIS.

BUILDING FLOOR SLABS EVALUATED

- AUXILIARY BUILDING FLOORS SELECTED FROM:

  MAIN AUXILIARY BUILDING
  CONTROL TOWER
  ELECTRICAL PENETRATION AREA (EPA)

  EL. 584'-0" MAIN AUX. BLDG. (LOW, HEAVILY LOADED SLAB)
  EL. 614'-0" MAIN AUX. BLDG. (HIGH, FLEXIBLE SLAB)
  EL. 646'-0" CONTROL TOWER (LOW, FLEXIBLE SLAB)
  EL. 685'-0" CONTROL TOWER (HIGH, MOST FLEXIBLE SLAB)
  EL. 642'-7" EPA (MOST FLEXIBLE, HIGH MASS)

- DGB FLOOR

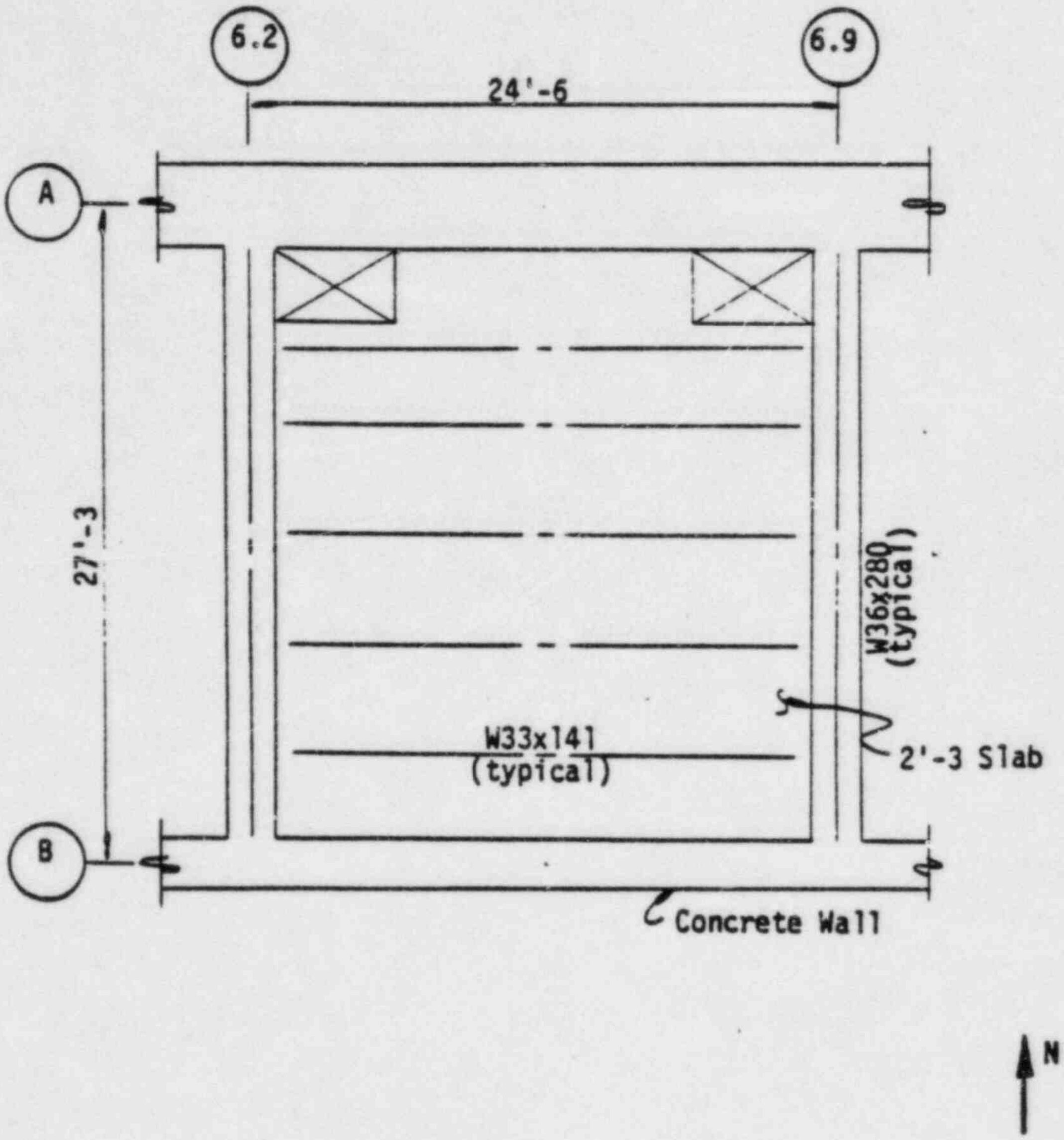
  EL. 664'-0" (INCLUDES SOME CAT.I EQUIPMENT)

- SWPS FLOOR

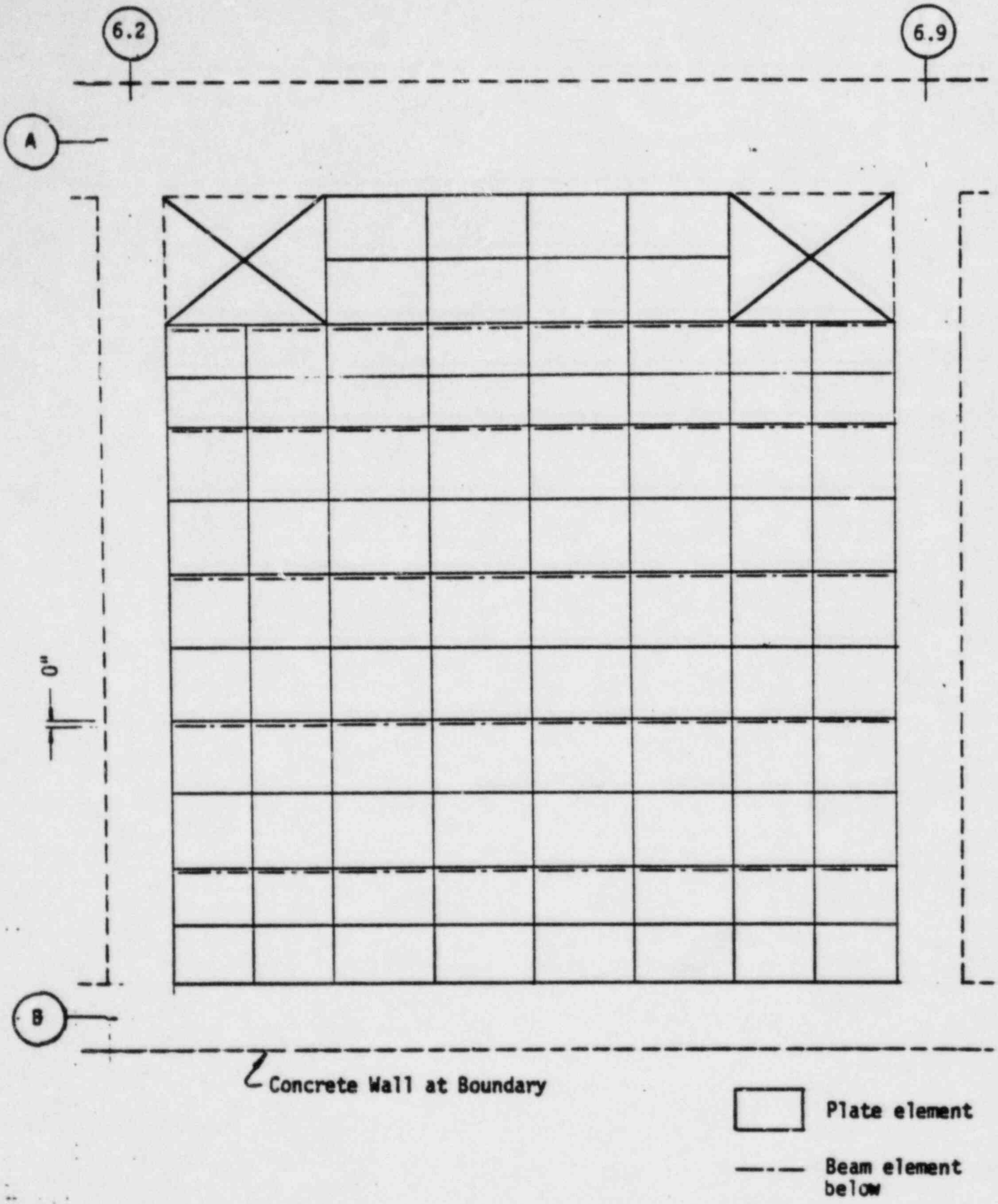
  EL. 634'-6" (INCLUDES MOST CAT. I EQUIPMENT)

FLOOR SLAB ANALYSIS

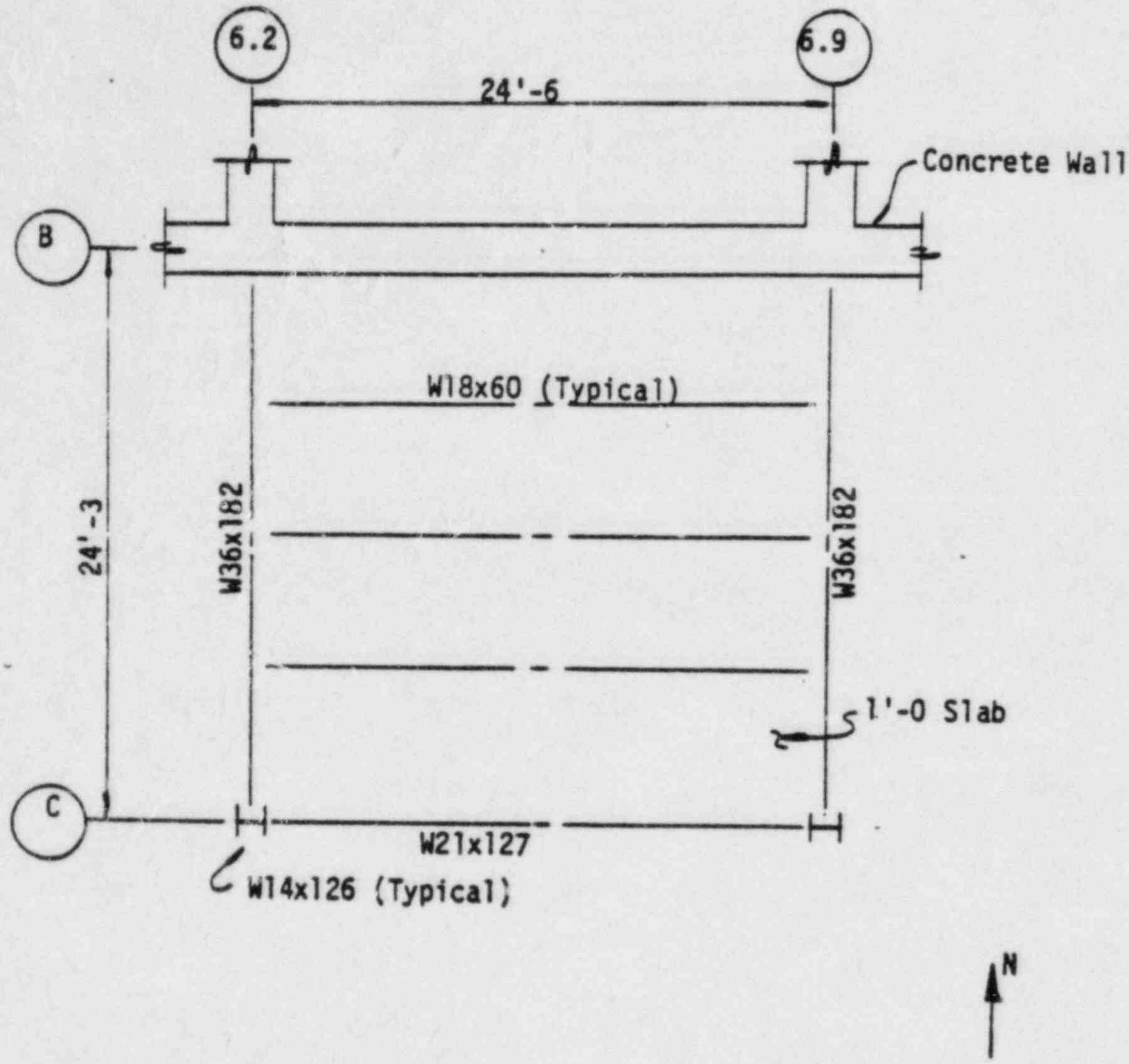
- FLOORS SELECTED ARE SINGLE BAYS BOUNDED BY VERTICAL SUPPORTS.
- FINITE ELEMENT MODELS DEVELOPED TO CONSERVATIVELY REFLECT APPROPRIATE GEOMETRY AND BOUNDARY CONDITIONS.
- MODELS CONSIST OF PLATE AND BEAM ELEMENTS.
- MASS REPRESENTING STRUCTURAL ELEMENTS AND NON-LOAD BEARING WALLS AND EQUIPMENT INCLUDED.
- FLOOR STRESSES SUBSEQUENTLY CHECKED TO ESTIMATE DAMPING.



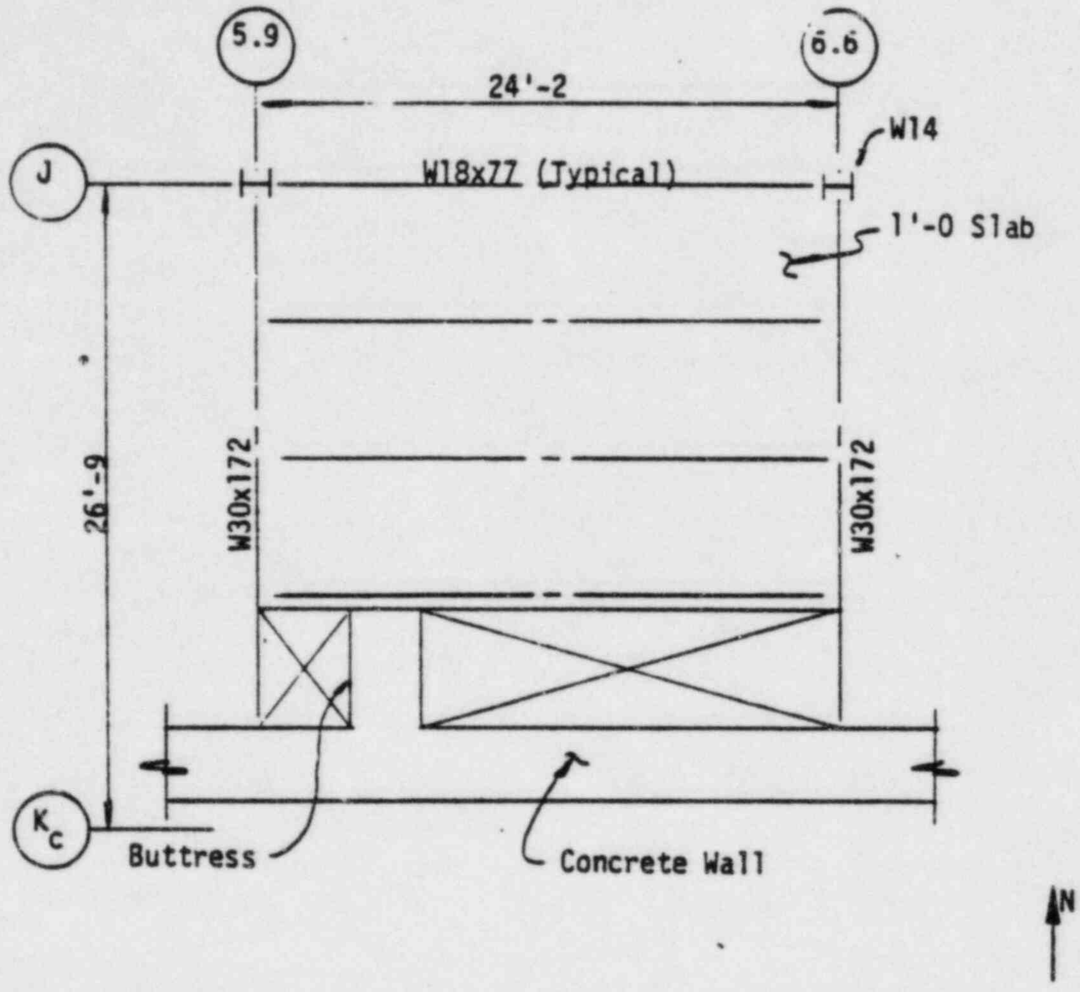
AUXILIARY BUILDING FLOOR AT ELEVATION 584'-0



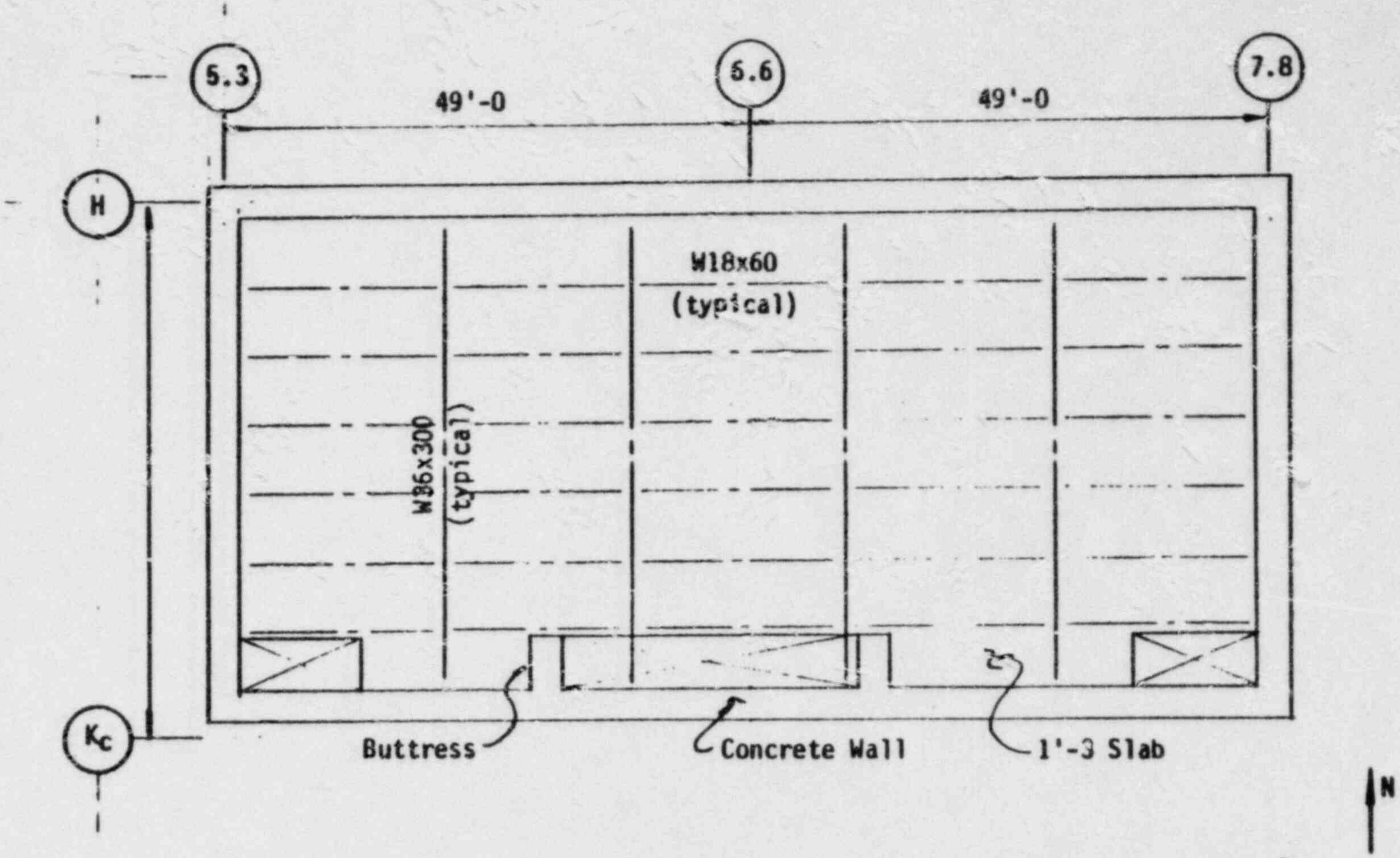
FINITE ELEMENT MESH OF AUXILIARY BUILDING FLOOR AT ELEVATION 584'-0"



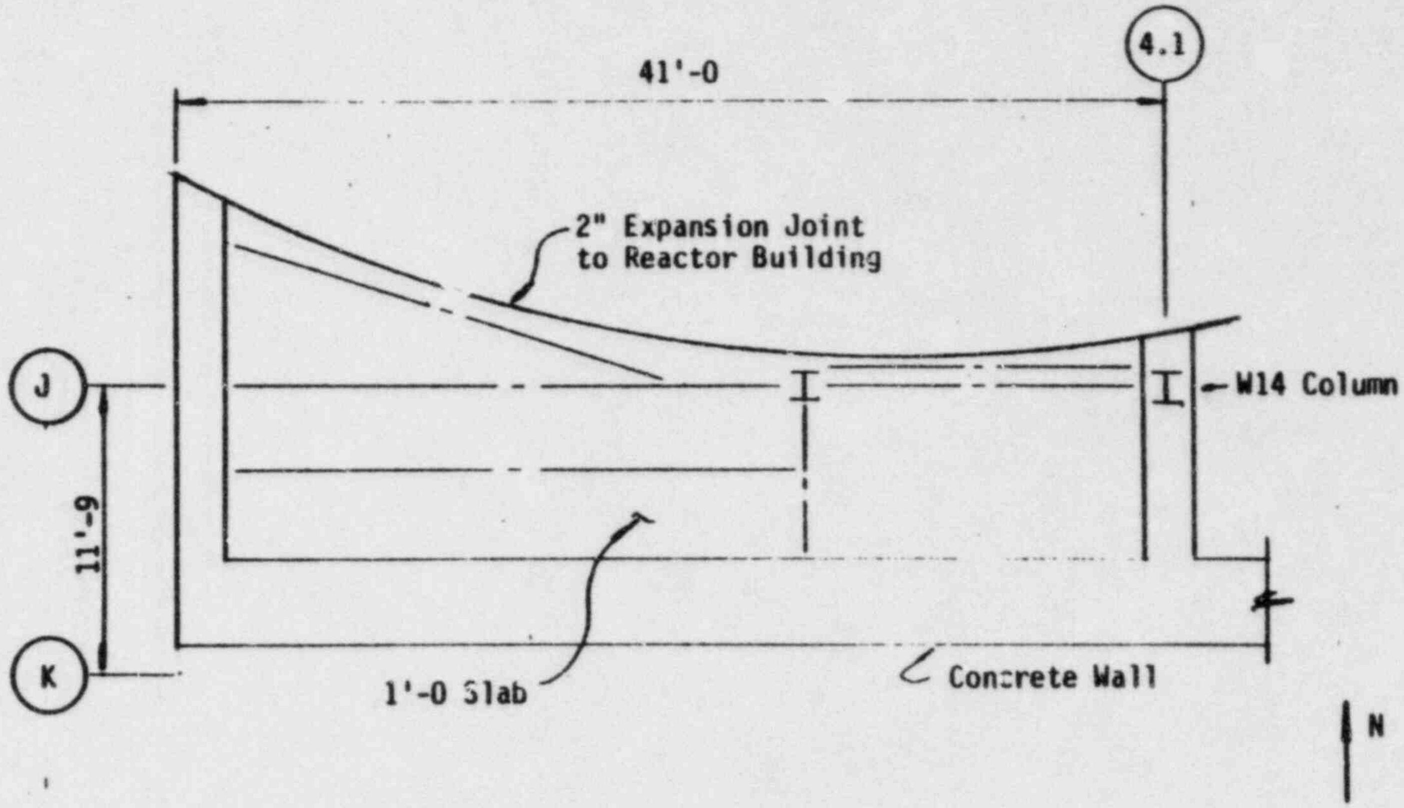
AUXILIARY BUILDING FLOOR AT ELEVATION 614'-0



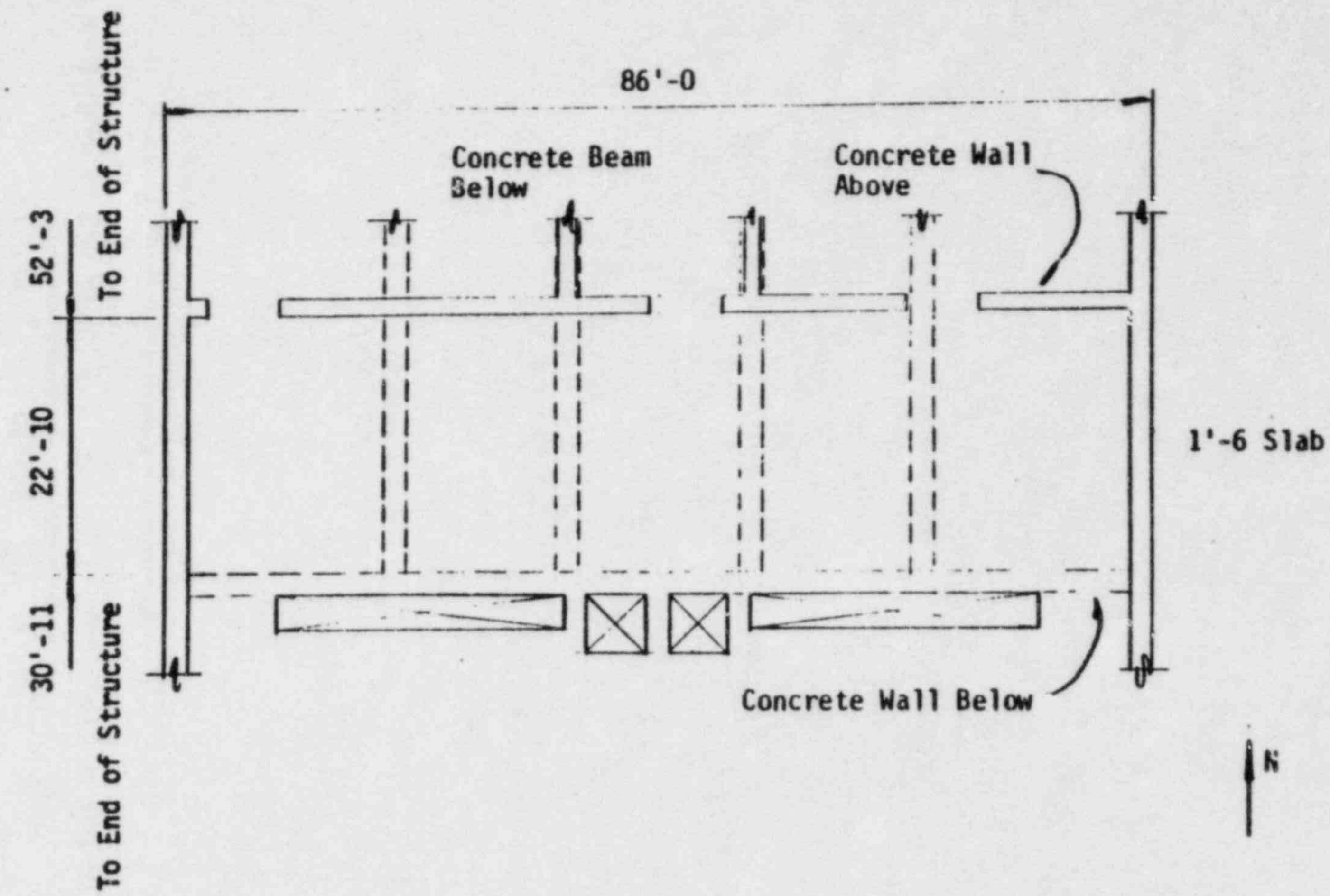
AUXILIARY BUILDING FLOOR AT ELEVATION 646'-0"



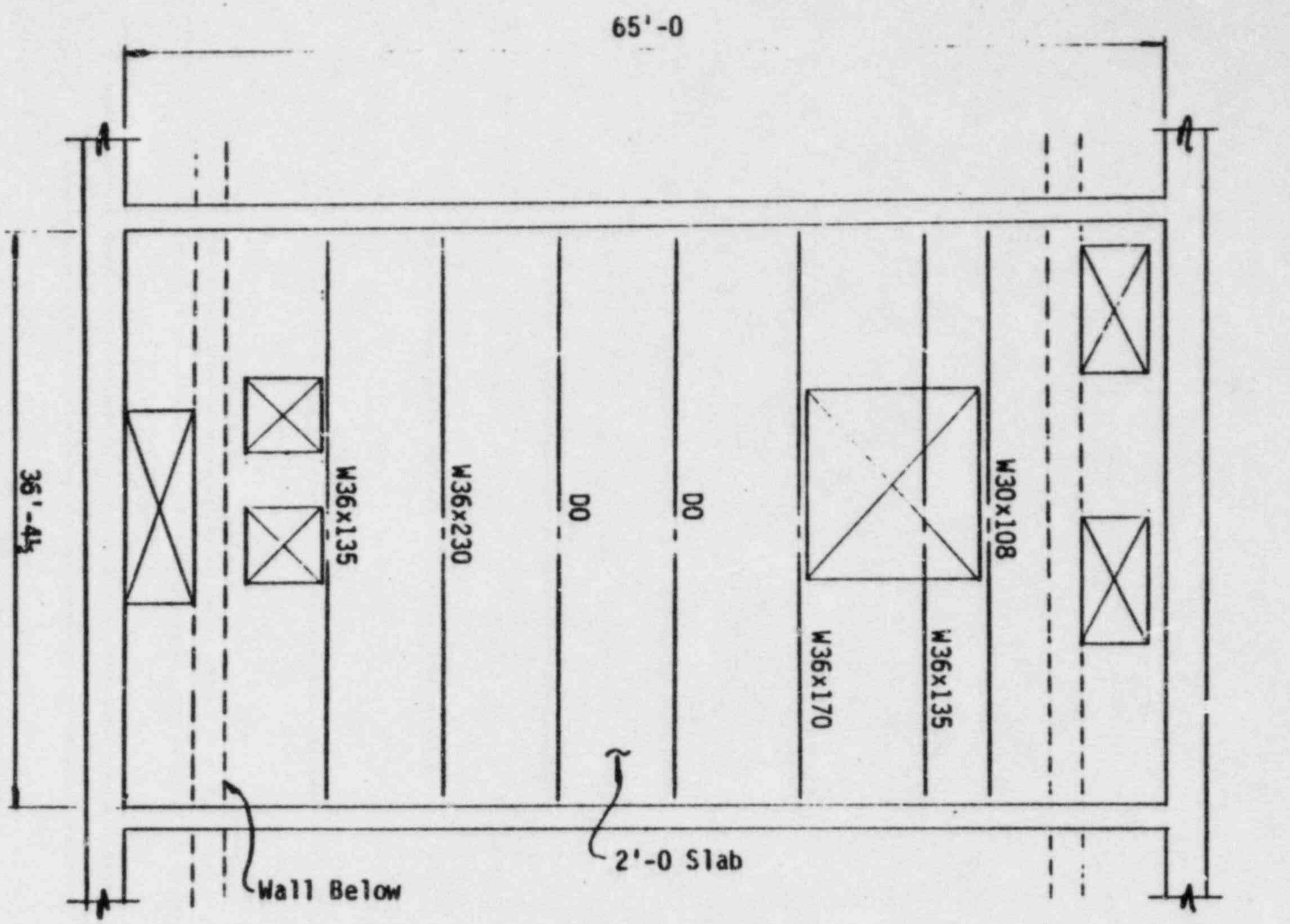
AUXILIARY BUILDING FLOOR AT ELEVATION 685'-0



AUXILIARY BUILDING FLOOR AT ELEVATION 642'-7
(WEST ELECTRICAL PENETRATION WING)



SERVICE WATER PUMP STRUCTURE FLOOR
AT ELEVATION 634'-6



Note: Some walls and framing not shown for clarity.

DIESEL GENERATOR BUILDING FLOOR AT ELEVATION 664'-0

VERTICAL INPUT TO EQUIPMENT

- IN-STRUCTURE RESPONSE SPECTRA DEVELOPED FROM SINGLE DEGREE OF FREEDOM MODELS WITH FREQUENCIES EQUAL TO FEM FUNDAMENTALS.
- DAMPING FOR UNCRACKED CONCRETE (4% OF CRITICAL) USED FOR ALL SLABS.
- FOR AUXILIARY BUILDING: VERTICAL TIME HISTORIES FROM BUILDING STRUCTURAL MODEL USED TO DEVELOP IN-STRUCTURE RESPONSE SPECTRA.
- FOR DGB AND SWPS: SDOF MODELS ADDED TO OVERALL BUILDING MODELS.
- VERTICAL IN-STRUCTURE RESPONSE SPECTRA WITHOUT FLOOR FLEXIBILITY INCREASED BY VERTICAL AMPLIFICATION FACTOR (VAF) IN AUXILIARY BUILDING.

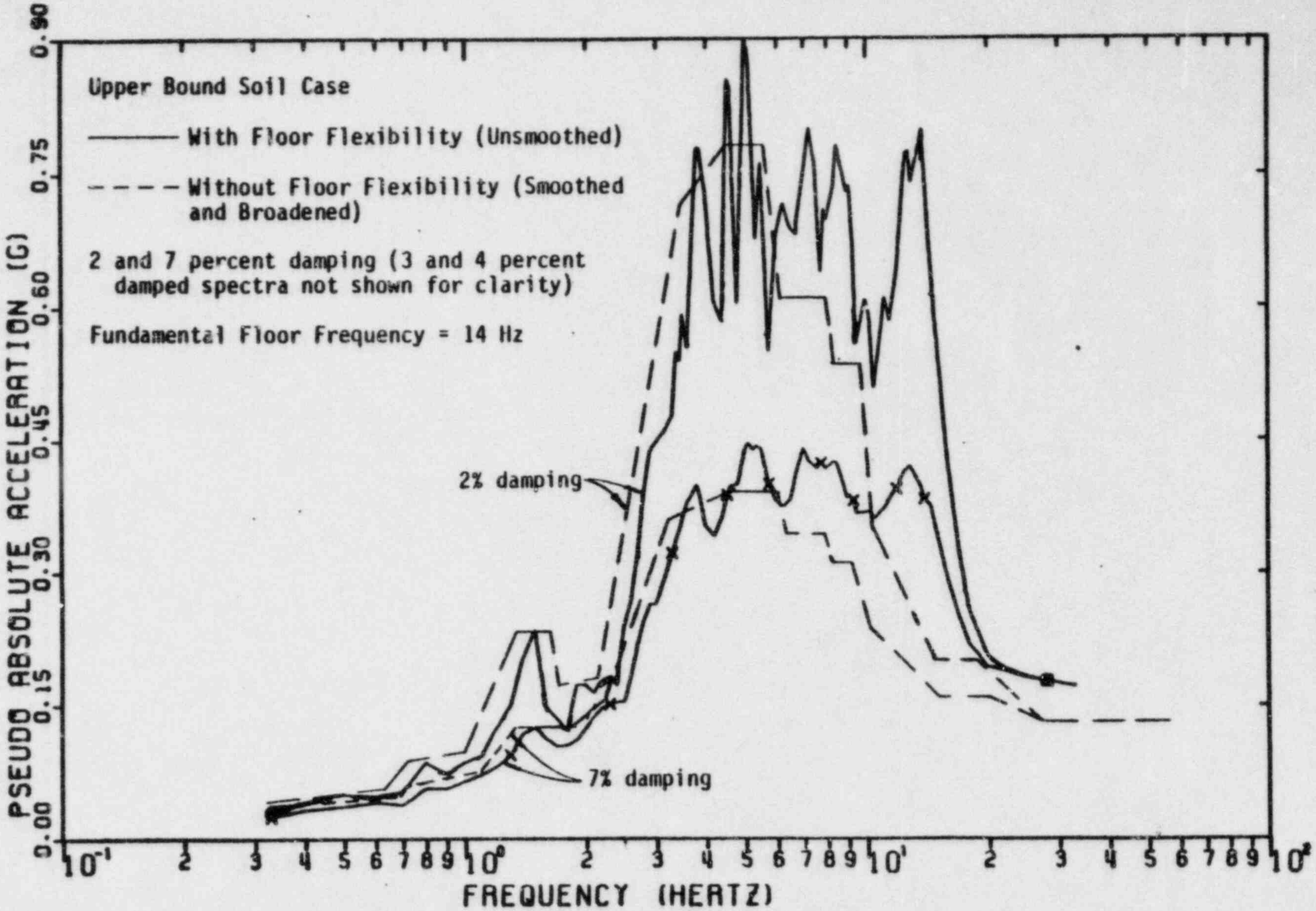
VERTICAL AMPLIFICATION FACTOR (VAF)

- VAF = (UNBROADENED SPECTRAL ACCELERATION AT FREQUENCY F INCLUDING FLOOR FLEXIBILITY / (BROADENED SPECTRAL ACCELERATION AT FREQUENCY F NOT INCLUDING FLOOR FLEXIBILITY

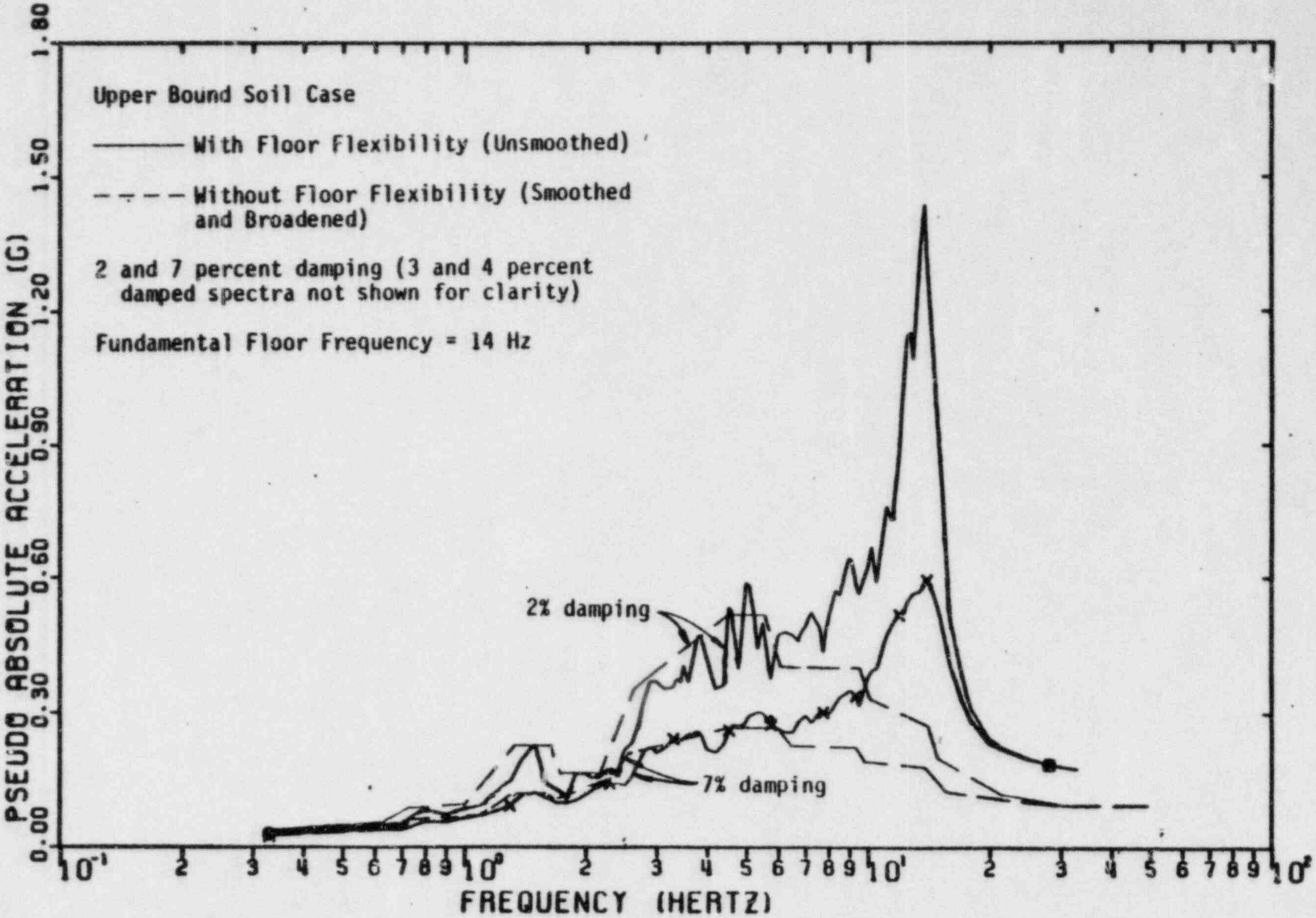
- OVERALL VAF DEVELOPED FROM ENVELOPE OF ALL FLOORS AS A FUNCTION OF EQUIPMENT FREQUENCY AND DAMPING.

- VAF BROADENED ± 10%.

- VAF FOR EQUIPMENT LOCATED AWAY FROM SLAB CENTER ASSUMED FOLLOW SINE WAVE.



COMPARISON OF VERTICAL SPECTRA
WITH AND WITHOUT FLOOR FLEXIBILITY AT
ELEVATION 646'-0", CONTROL TOWER

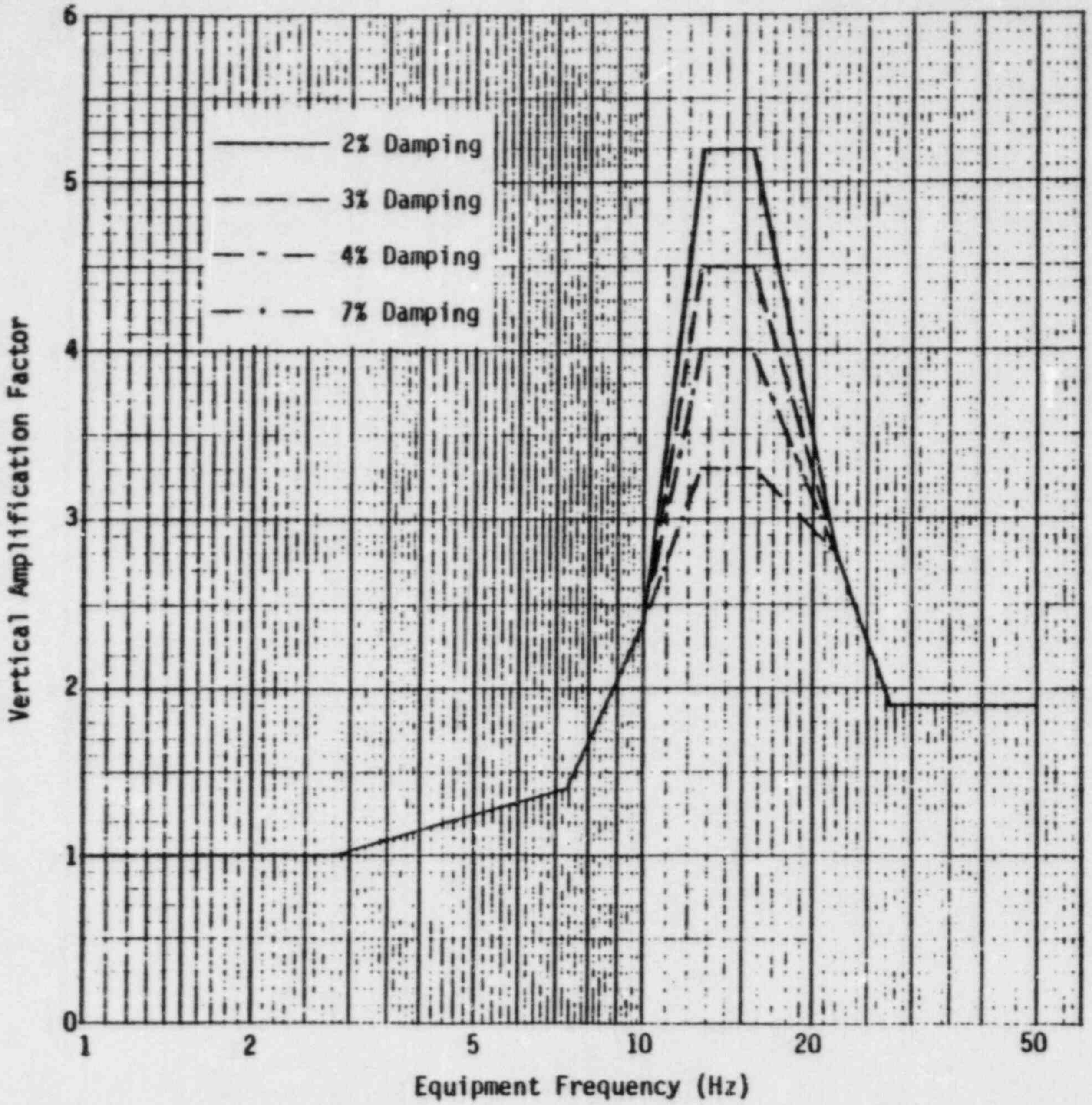


COMPARISON OF VERTICAL SPECTRA
WITH AND WITHOUT FLOOR FLEXIBILITY AT
ELEVATION 614'-0", MAIN AUXILIARY BUILDING

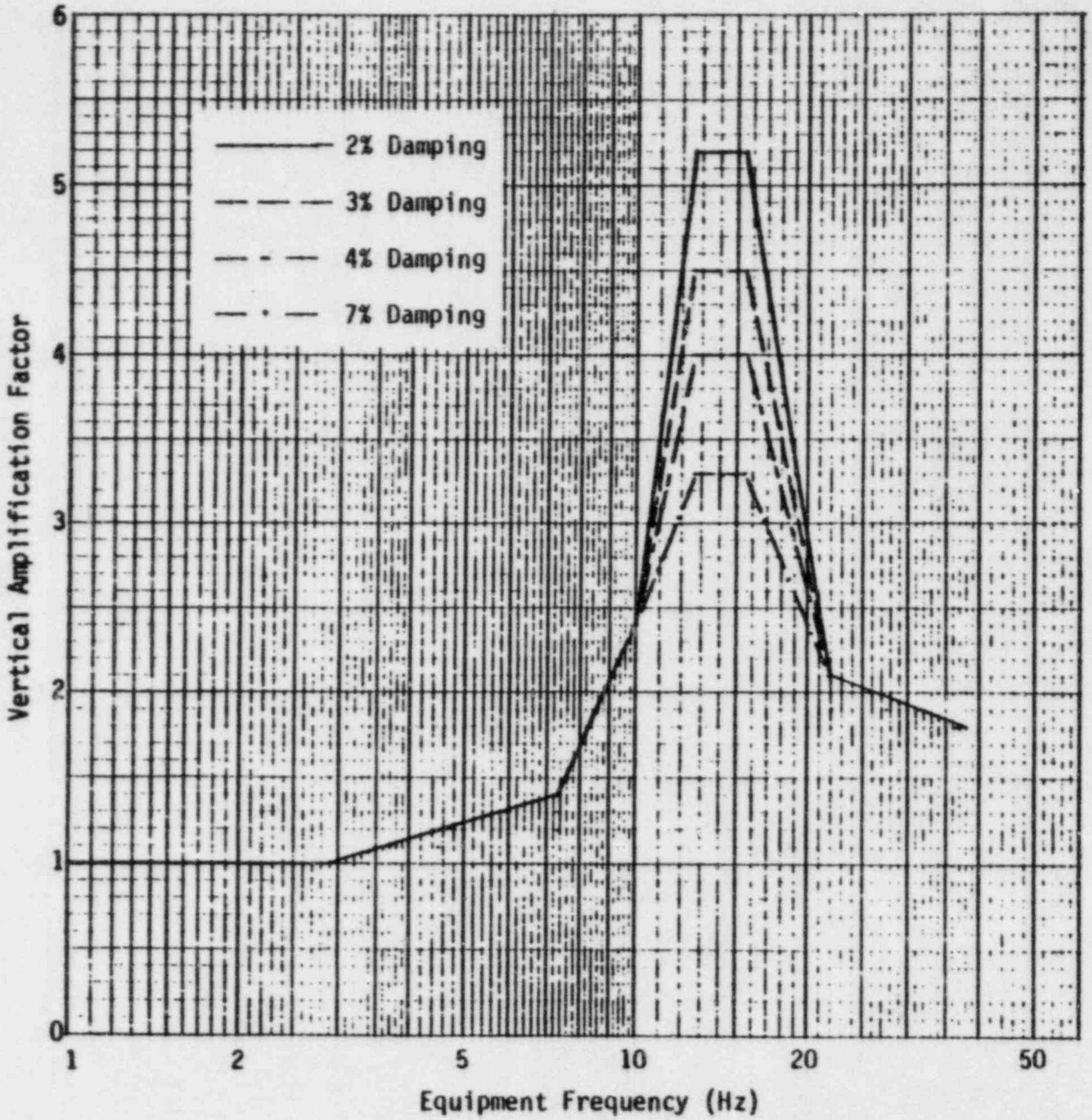
AUXILIARY BUILDING VERTICAL AMPLIFICATION FACTORS

2% Equipment Damping

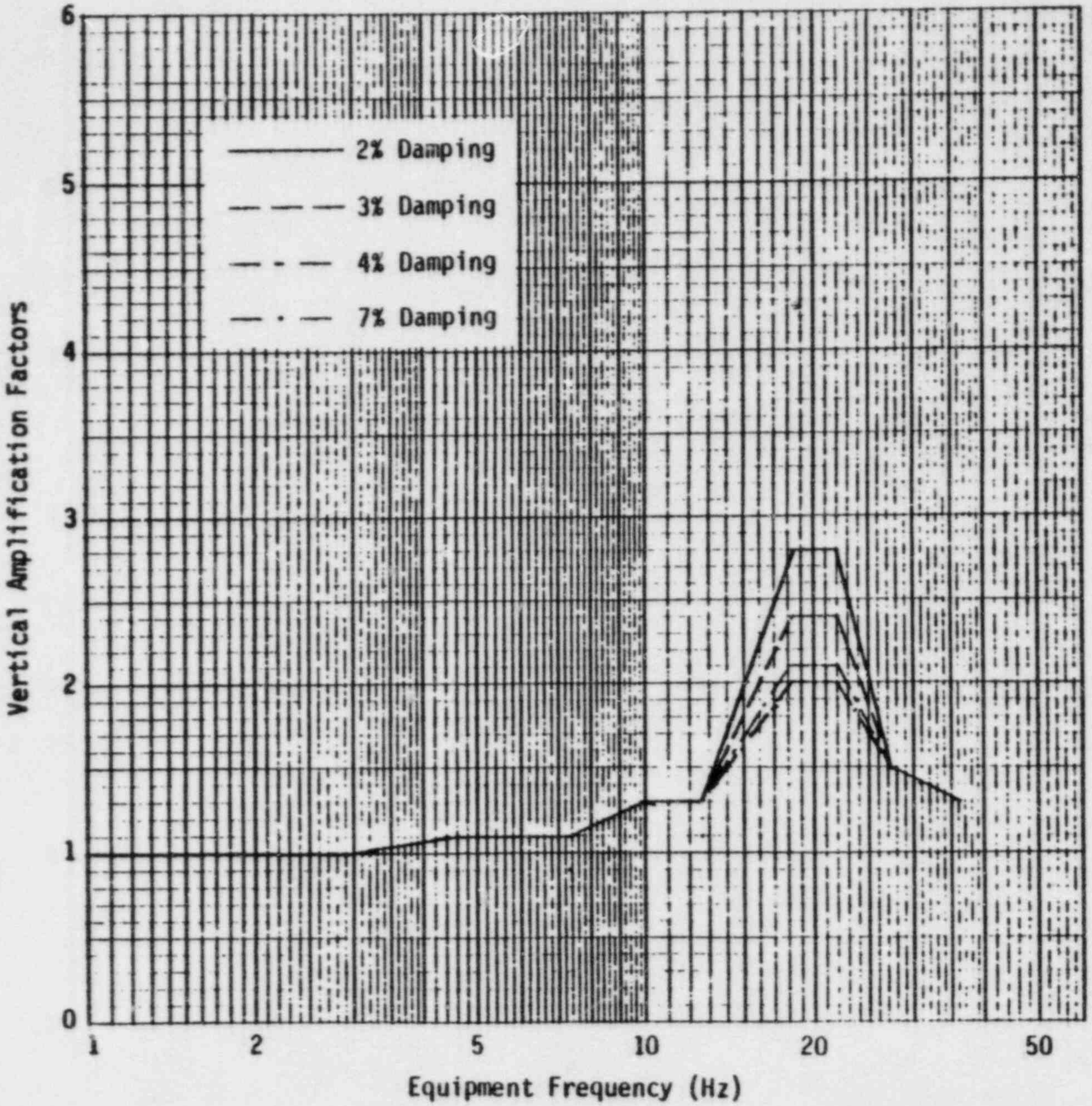
Location	Floor Frequency (Hz)	Equipment Frequency 5 Hz	8 Hz	11 Hz	14 Hz	20 Hz	25 Hz	29 Hz	33 Hz
El. 584'-0", Main Auxiliary Bldg.	35	1.0	0.89	0.96	0.79	0.95	1.1	1.3	1.6
El. 614'-0", Main Auxiliary Bldg.	14	1.1	1.3	2.3	5.2	1.9	1.8	1.9	1.9
El. 646'-0", Control Tower	14	1.2	1.1	1.8	3.4	1.1	1.3	1.4	1.4
El. 685'-0", Control Tower	11	1.3	1.7	5.0	2.1	1.6	2.0	2.0	2.0
El. 642'-7", West Penetration Wing	29	1.0	0.96	0.87	1.1	0.98	1.1	1.3	1.1



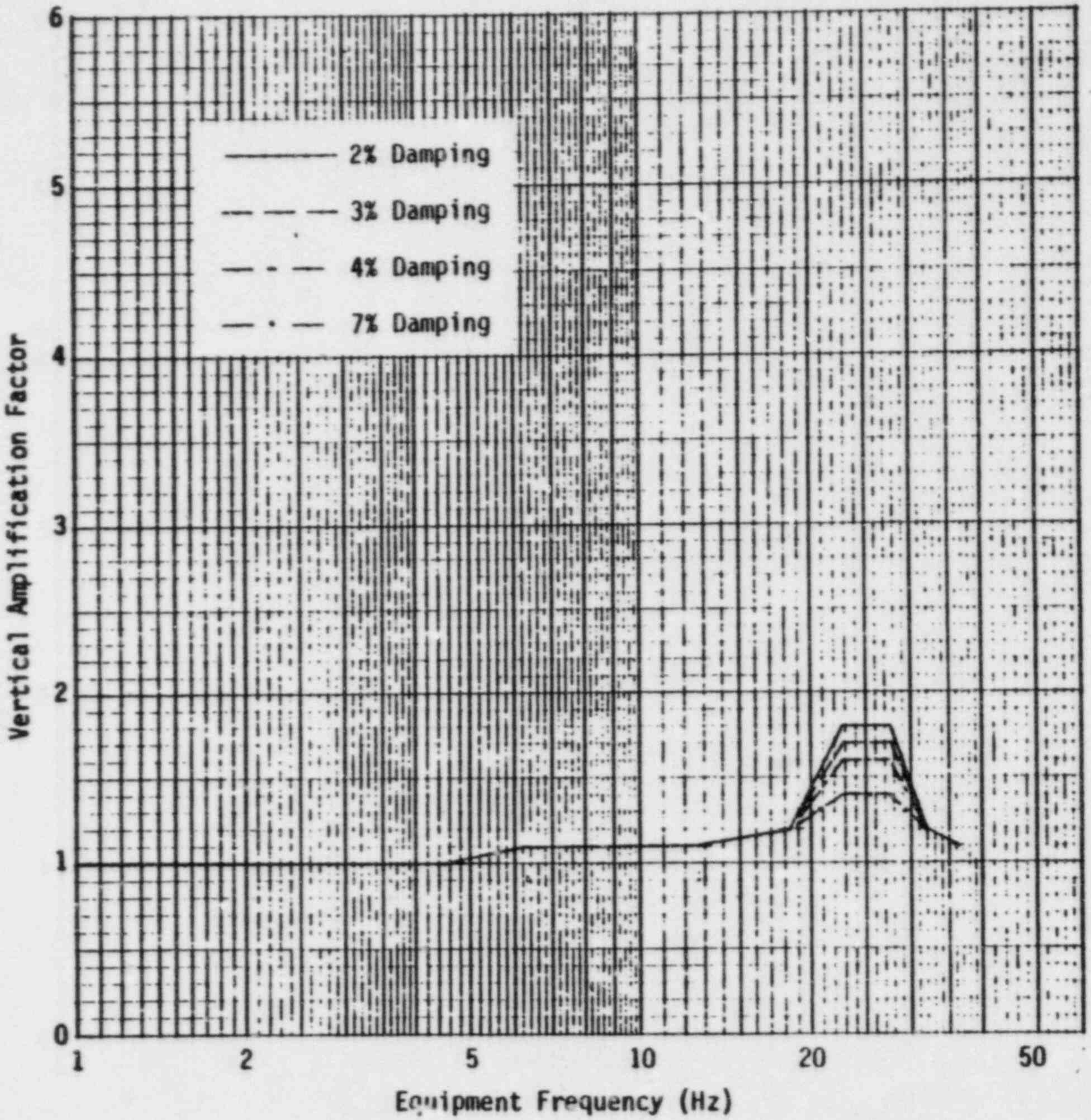
ENVELOPE VERTICAL AMPLIFICATION FACTORS
FOR AUXILIARY BUILDING



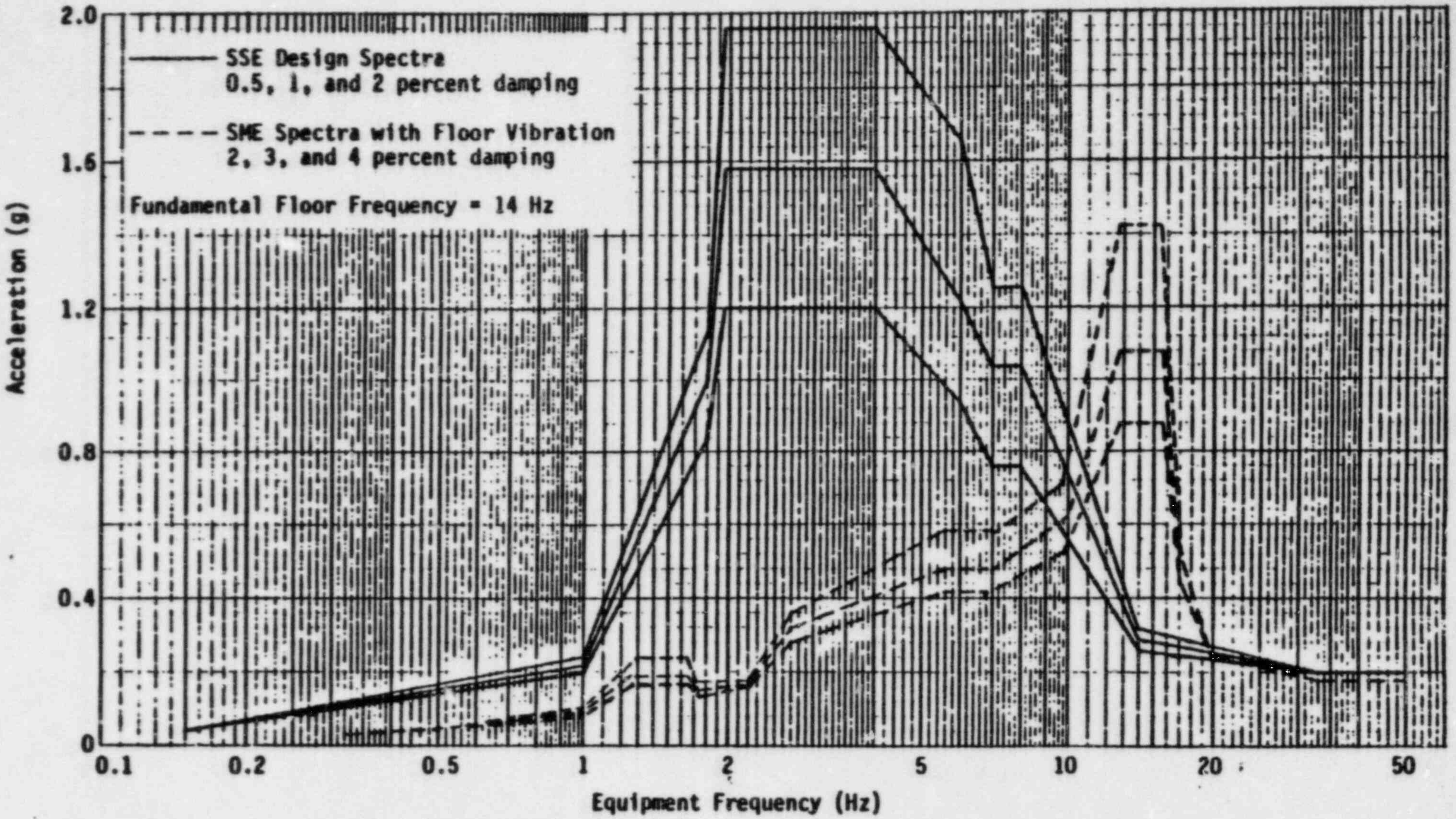
VERTICAL AMPLIFICATION FACTOR FUNCTIONS
FOR 14 Hz FUNDAMENTAL FREQUENCY FLOORS
FOR AUXILIARY BUILDING



VERTICAL AMPLIFICATION FACTOR FUNCTIONS
FOR 20 Hz FUNDAMENTAL FREQUENCY FLOORS
FOR AUXILIARY BUILDING



VERTICAL AMPLIFICATION FACTOR FUNCTIONS
FOR 25 Hz FUNDAMENTAL FREQUENCY FLOORS
FOR AUXILIARY BUILDING



COMPARISON OF SSE DESIGN AND SME VERTICAL SPECTRA
AT ELEVATION 614'-0", MAIN AUXILIARY BUILDING

SEISMIC MARGINS

FOR

MECHANICAL, ELECTRICAL, CONTROL AND INSTRUMENTATION EQUIPMENT

PRESENTATION TO

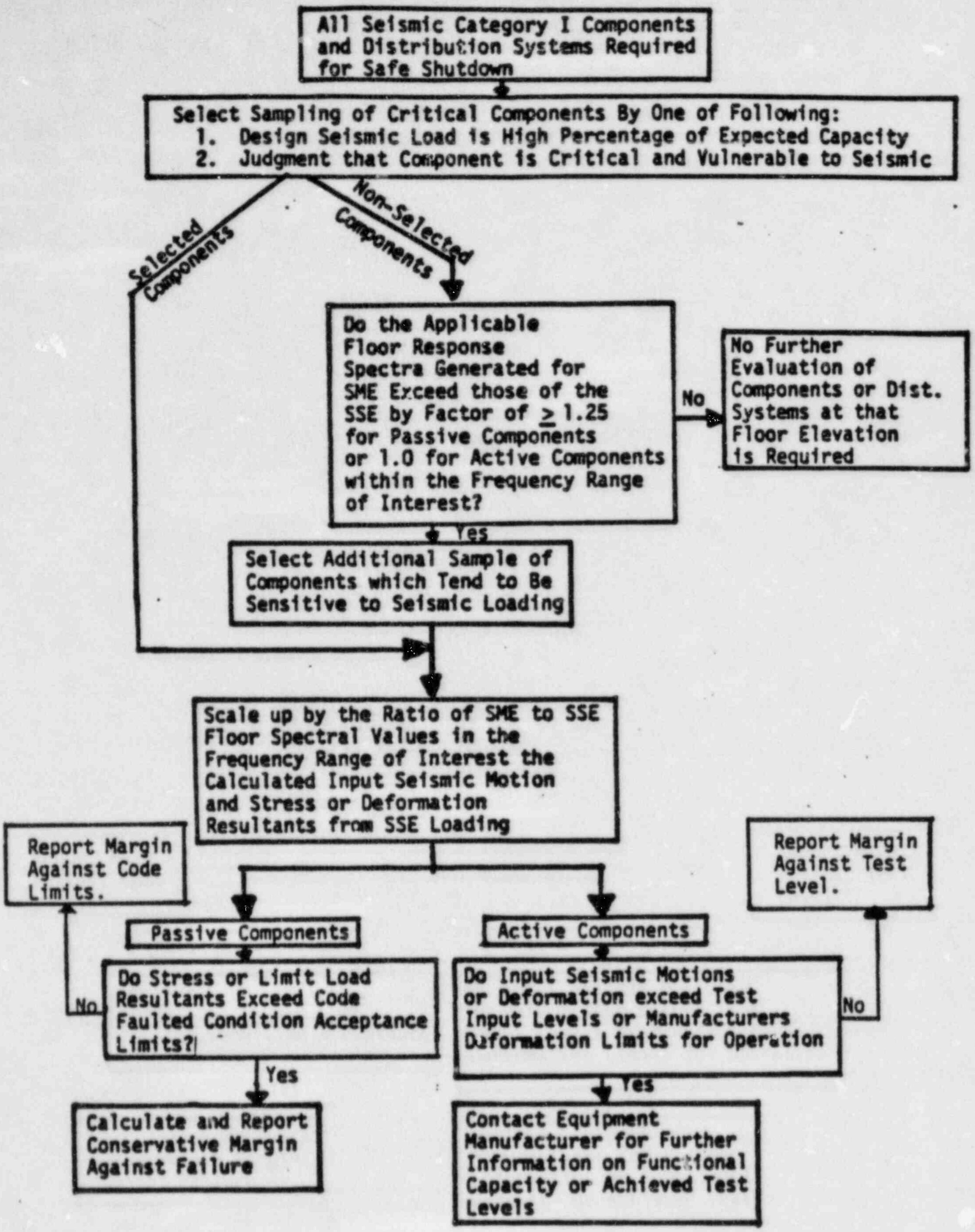
USNRC/CONSUMERS POWER CO.

APRIL 1984

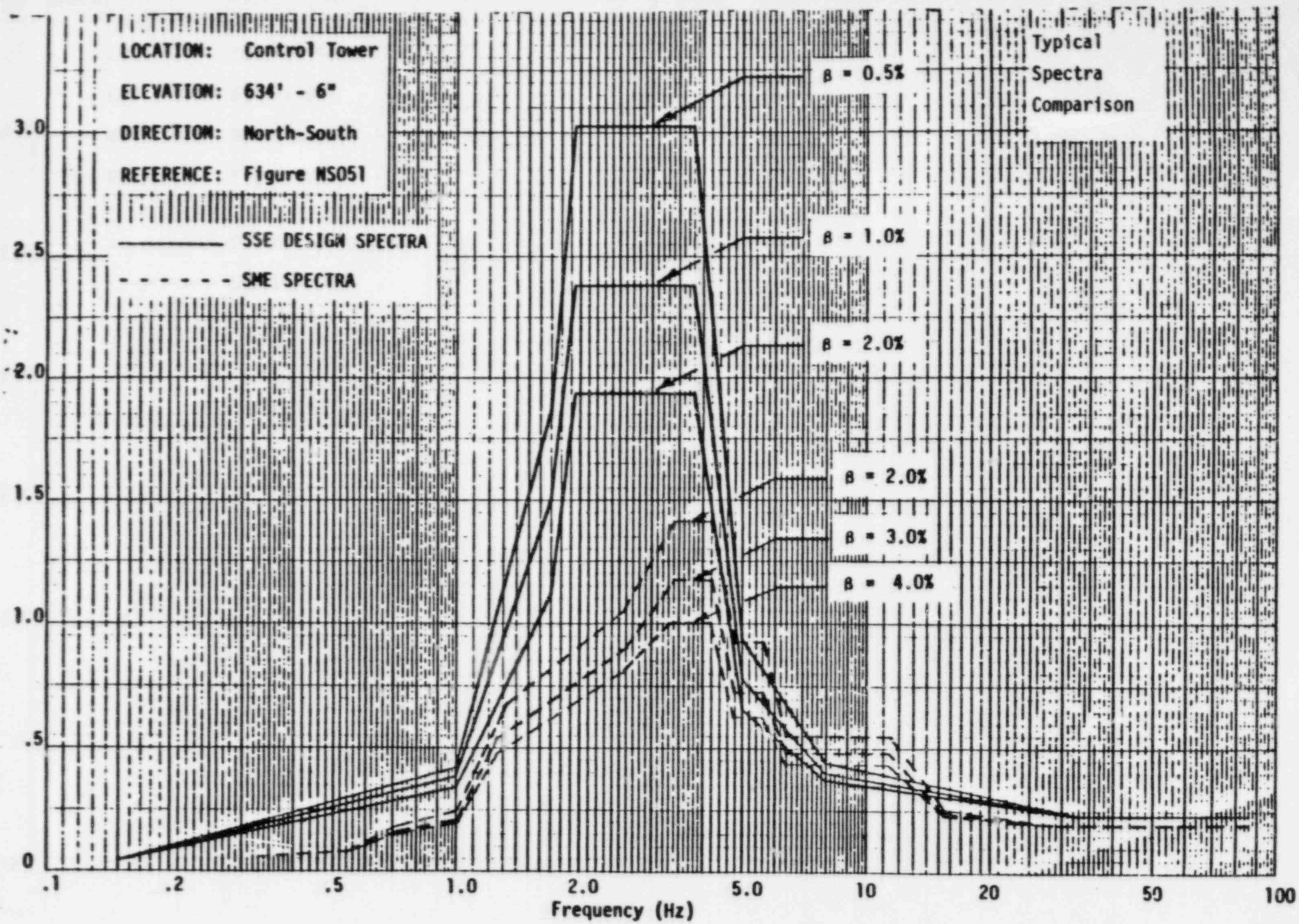
SCOPE OF STUDY

- CONSIDER ALL EQUIPMEMT AND SUPPORTING SYSTEMS REQUIRED FOR SAFE SHUTDOWN
- SELECT REPRESENTATIVE SAMPLES FROM TOTAL INVENTORY
- EVALUATE SAMPLES FOR SEISMIC MARGIN EARTHQUAKE PLUS NORMAL OPERATING LOADS
- DETERMINE MARGIN AGAINST:

  CODE ALLOWABLE OR
  FUNCTIONAL ALLOWABLE OR
  FAILURE



PROCESS TO SELECT COMPONENTS AND DISTRIBUTION SYSTEMS
FOR SEISMIC SAFETY MARGIN EVALUATION AND DEVELOP MARGINS



Comparison of SSE Design and Enveloped SME Spectra
Control Tower, Elevation 634'-6"
North-South Direction

SYSTEMS REQUIRED FOR SAFE SHUTDOWN

- REACTOR COOLANT & PRESSURE CONTROL
- MAKEUP & PURIFICATION
- DECAY HEAT REMOVAL (COLD SHUTDOWN ONLY)
- COMPONENT COOLING WATER
- SERVICE WATER
- SAFEGUARDS CHILLED WATER
- EMERGENCY DIESEL GENERATOR FUEL OIL STORAGE AND TRANSFER
- HVAC
- MAIN STEAM
- CONDENSATE AND FEEDWATER (AUX. F.W.)
- EMERGENCY DIESEL POWER GENERATION
- STATION BATTERIES
- ELECTRICAL POWER DISTRIBUTION, CONTROL AND INSTRUMENTATION SYSTEMS

NSSS SUBSYSTEMS AND COMPONENTS

- o REACTOR VESSEL AND SUPPORTS
- o REACTOR VESSEL INTERNALS
- o CONTROL ROD DRIVES AND HOUSINGS
- o STEAM GENERATORS AND SUPPORTS
- o REACTOR COOLANT PUMPS AND SUPPORTS
- o PRESSURIZER AND SUPPORTS
- o REACTOR COOLANT LOOP PIPING
- o PRESSURIZER SURGE LINE

AE DESIGNED SUBSYSTEMS

- o BOP PIPING
- o HVAC DUCTING AND SUPPORTS
- o CABLE TRAYS AND SUPPORTS
- o ELECTRICAL CONDUIT AND SUPPORTS

VENDOR SUPPLIED BOP EQUIPMENT PURCHED BY A/E AND NSSS SUPPLIER

ELECTRICAL POWER DISTRIBUTION

SWITCHGEAR, MCC'S, TRANSFORMERS, BUSSES

ELECTRICAL POWER SUPPLY

AC - DIESEL GENERATOR UNITS
DC - 125 V STATION BATTERIES

INSTRUMENTATION AND CONTROL

CONTROL PANELS, CABINETS,
INSTRUMENTATION PANELS, CABINETS

MECHANICAL EQUIPMENT

ACTIVE - PUMPS, FANS, COMPRESSORS
PASSIVE - TANKS, HEAT EXCHANGERS, FILTERS

VALVES

ACTIVE MOV, AOV

SAMPLING CRITERIA

- MAJOR COMPONENTS AND SUBSYSTEMS ESSENTIAL FOR SAFE SHUTDOWN

- COMPONENTS AND SUBSYSTEMS DEEMED MUST SENSITIVE TO SEISMIC LOADING (EXPERIENCE FROM PRA)

- COMPONENTS AND SUBSYSTEMS LOCATED IN AREAS OF GREATEST SEISMIC RESPONSE

- REPRESENTATION OF EQUIPMENT IN ALL CATEGORY 1 BUILDINGS (RB, AUX. BLDG, DGB, SWPS)

SELECTIONS BASED UPON CRITICALITY

- ALL PUMPS AND HEAT EXCHANGERS IN SERVICE WATER, COMPONENT COOLING WATER, AUXILIARY FEED WATER, MAKEUP AND DECAY HEAT REMOVAL SYSTEMS.

- ALL AC AND DC EMERGENCY POWER SUPPLIES, SWITCHGEAR AND MOTOR CONTROL CENTERS.

- ALL OF NSSS SYSTEM.

SENSITIVITY TO SEISMIC RESPONSE

o CONTROL AND INSTRUMENTATION CABINETS IN CONTROL STRUCTURE AND ELECTRICAL PENETRATION AREAS.

HIGH SEISMIC RESPONSE AREAS

- CONTROL ROOM HVAC HIGH IN CONTROL BUILDING.

- DUCTING FOR CONTROL ROOM HVAC

- CABLE TRAYS IN SPREADING ROOM AND ELECTRICAL PENETRATION AREAS.

REPRESENTATION IN ALL STRUCTURES

o PIPING, PIPE SUPPORTS AND VALVES

o CABLE TRAYS AND SUPPORTS

o CONDUIT AND SUPPORTS

o MISCELLANEOUS ELECTRICAL AND MECHANICAL EQUIPMENT AND SUPPORTS.

FRACTION OF COMPONENTS SELECTED

BOTH UNITS AND REDUNDANT COMPONENTS INCLUDED IN QUANTITY STATED.

ELECTRICAL POWER DISTRIBUTION	34 OF 93
ELECTRIC POWER SUPPLY	
AC - DIESEL GEN. & GRD. REST.	8 OF 8
DC - STA. BATTERIES & CHGS.	4 OF 12
INSTRUMENTATION & CONTROL CABINENTS	23 OF 77
MECHANICAL EQUIPMENT	
ACTIVE COMPONENTS	27 OF 61
PASSIVE COMPONENTS	61 OF 69
VALVES	
ACTIVE VALVES INCLUDED IN PIPING SYSTEMS INDEPENDENTLY EVALUATED	19 OF 290

SAMPLE SIZE FOR BOP EQUIPMENT

157 OF 320 COMPONENTS = 49%

19 OF 290 ACTIVE VALVES = 7%

NOTE: ALL VALVES WERE INCLUDED IN GENERIC PROBABILISTIC STUDY TO DEMONSTRATE EXTREMCY HIGH NON-EXCEEDENCE PROBABILITY OF EXCEEDING 3 G DESIGN CRITERIA.

METHODOLOGY

QUALIFICATION BY ANALYSIS

VENDOR COMPUTED RESPONSE FOR SSE IS SCALED BY RATIO OF SME/SSE AT EQUIPMENT NATURAL FREQUENCY

CASE 1 - SEISMIC & NORMAL STRESSES ARE SEPARATED

$$F_{SME} = \frac{\sigma_A - \sigma_N}{\sigma_{SME}}$$

CASE 2 - SEISMIC & NORMAL STRESSES NOT SEPARATED
SME EXCEEDS SSE

$$F_{SME} > \frac{\sigma_A}{\sigma_T}$$

$$\text{WHERE} \quad \sigma_T = \frac{S_{a_{SME}}}{S_{a_{SSE}}} (\sigma_{SSE} + \sigma_N)$$

CASE 3 - SEISMIC & NORMAL STRESSES NOT SEPARATED
SSE EXCEEDS SME

$$F_{SME} > \frac{\sigma_A}{\sigma_D}$$

$$\text{WHERE} \quad \sigma_D = (\sigma_{SSE} + \sigma_N)$$

FOR FUNCTIONAL FAILURE MODES, ABOVE EQUATIONS APPLY SUBSTITUTING δ FOR σ

METHODOLOGY (CONT)

QUALIFICATION BY TEST

$$F_{SME} = \left(\frac{TRS}{RRS}\right)_{MIN}$$

- COMPARISON OF TRS AND RRS MADE AT EQUIPMENT FUNDAMENTAL FREQUENCY FOR EACH DIRECTION
- MIN. MARGIN REPORTED FOR GOVERNING DIRECTION
- IF TESTS ARE SINGLE AXIS OR SINGLE FREQUENCY, APPROPRIATE ADJUSTMENTS ARE MADE TO TRS TO EQUATE TO MULTIAXIS RANDOM MOTION INPUT

NSSS

- B & W CONDUCTED ANALYSIS OF NSSS USING SME BASEMAT INPUT FROM SMA.

- B & W PROVIDED TO SMA:

  SME RESPONSES
  SSE RESPONSES
  FAULTED CONDITION DESIGN LOADS
  SELECTED STRESS ANALYSIS RESULTS

- SMA DEVELOPED SEISMIC MARGINS BY COMPARING LOAD RATIOS AND SCALING STRESSES.

- RESULTS - ALL NSSS PIPING, VESSELS, SUPPORTS & INTERNALS MEET ACCEPTANCE CRITERIA

CLASS 1, 2 & 3
BOP PIPING AND SUPPORTS

- PIPING SYSTEMS SELECTED FOR INDEPENDENT ANALYSIS ON BASIS OF STRESS RESPONSE COMPUTED FOR SSE PLUS NORMAL LOADING. ONLY THE HIGHEST STRESSED LINES WITH THE MAJOR LOADING CONTRIBUTION COMING FROM SEISMIC WERE SELECTED.

- ALL RESULTS ARE POSITIVE. CODE ALLOWABLES ARE MET.

CLASS 1, 2 & 3 BOP EQUIPMENT AND SUPPORTS

- VENDOR REPORTS REVIEWED.
- SSE RESPONSE SCALED BY RATIO OF SPECTRAL ACCELERATION OF SME/SSE AT EQUIPMENT FUNDAMENTAL FREQUENCY.
- FOR COMPONENTS QUALIFIED BY TEST, TRS WAS SHOWN TO EXCEED RRS FOR SME AT FUNDAMENTAL FREQUENCY OF EQUIPMENT.

LOADING COMBINATION AND STRESS LIMITS
FOR CLASS 1 VESSELS, PUMPS AND VALVES

Loading Combination	Stress Limit[1,2,3,4]	
$P_N + D + OML + SME$	$P_m \leq 2.4\ S_m$, $0.7\ S_u$ $P_L + P_b \leq 3.6\ S_m$, $1.05\ S_u$	For Materials in Table I-1.2
	$P_m \leq 0.7\ S_u$ $P_L + P_b \leq 1.05\ S_u$	For Materials in Table I-1.1
	$P_L + P_b \leq S_y$ (5)	

Where:

P_N = Normal operating pressure

D = Deadweight

OML = Operating mechanical loads from connecting piping including earthquake anchor motion and restraint of free end thermal displacement

SME = Seismic Margin Earthquake Inertial Loading

S_m = Allowable stress value from ASME Code, 1974 edition with Addenda through Winter 1976, Table I-1

P_m = General membrane stress intensity produced by pressure and other mechanical loads

P_L = Local membrane stress intensity produced by pressure and other mechanical loads

P_b = Primary bending stress intensity produced by pressure and other mechanical loads

S_y = Specified Yield Strength

Notes:

1. Stress limits apply to extended support structures for valves.

   For active valves, the extended operator support structure primary stress is limited to S_y.
2. Faulted condition stress criteria per 1974 ASME Code, Section III, with Winter 76 Addenda.
3. Use lesser of limits specified.
4. Valve operator acceleration is limited to 3g in any direction.
5. Functional limit for active components.

LOADING COMBINATIONS AND STRESS LIMITS FOR

ASME CLASS 1 COMPONENT SUPPORTS

Loading Combination	Linear Type Support Limits[1,2,3,7]	Component Standard Linear Supports Designed by Load Rating	Plate and Shell[3] Support Limit
D + OML + SME	Within Lesser of: $\frac{1.2\ S_y}{F_t}$ or $\frac{0.7\ S_u}{F_t}$ Times Normal Operating Stress Limit, F_{all}.	$0.8\ L_t$	$P_m \le \left\{\begin{array}{l} 1.5\ S_m \\ 1.2\ S_y \end{array}\right\}^{4,5}$ $P_m + P_b \le \left\{\begin{array}{l} 2.25\ S_m \\ 1.8\ S_y \end{array}\right\}^{4,6}$

where:

- D = Deadweight
- OML = Operating Mechanical Loads
- SME = Seismic Margin Earthquake Loading
- S_y = Material yield strength at temperature
- S_u = Material ultimate strength at temperature
- F_t = Allowable tensile stress per ASME Section III, Appendix XVII at temperature
- F_{all} = Allowable stress value from ASME Code, Appendix XVII, XVII-1100
- L_t = Ultimate Collapse Load as defined in ASME Code, Appendix F, F1370(d)
- P_m = Primary membrane stress intensity produced by mechanical loads
- P_b = Primary bending stress intensity produced by mechanical loads
- S_m = Allowable stress intensity from ASME Code, Appendix I

Notes:

1. Compressive axial member loads should be kept to less than 0.67 times the critical buckling load.
2. Includes Component Standard Supports designed by analysis.
3. Component support analyses and material allowables per ASME Code, Section III, 1974 edition with Winter 1976 Addenda.
4. Use greater of values specified.
5. Not to exceed $0.7\ S_u$.
6. Not to exceed $1.05\ S_u$.

LOADING COMBINATION AND STRESS LIMITS FOR NSSS COMPONENT SUPPORTS DESIGNED TO THE AISC CODE

Loading Combination	Stress Limit[1]
D + OML + SME	1.6 f_s

where:

D = Dead Load

OML = Operating Mechanical Loads

SME = Seismic Margin Earthquake Loading

f_s = Allowable stress from Part 1 of the AISC Specification for Design, Fabrication and Erection of Structural Steel for Buildings, 7th Edition

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Notes:

1. Shear Stress is limited to 0.5 Fy where Fy is the specified yield strength of the material

LOADING COMBINATIONS AND STRESS LIMITS FOR CLASS 1 PIPING

Loading Combinations for Faulted Conditions:

Operating Pressure + Deadweight + Seismic Margin Earthquake Loads (SME)

Code Stress Acceptance Criteria

$$B_1 \frac{P D_o}{2t} + B_2 \frac{D_o}{2I} M_i \leq 3.0 S_m \quad (1)$$

Where:

B_1, B_2 = primary stress indices for the specific product under investigation (NB-3680)

P = Design Pressure, psi

D_o = outside diameter of pipe, in (NB-3683)

t = nominal wall thickness of product, in. (NB-3683)

I = moment of inertia, $in.^4$ (NB-3683)

M_i = resultant moment due to a combination of Design Mechanical Loads (Dead Wt.+SME)

S_m = allowable design stress intensity value, psi (Tables I-1.0)

Notes:

1. Faulted condition criteria per 1974 ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, with no addenda.

LOADING COMBINATIONS AND STRESS LIMITS FOR CLASS 2 AND 3 COMPONENT SUPPORTS

Loading Combination	Linear Type Support Limits[1,2,3]	Component Standard Linear Supports Designed by Load Rating	Plate and Shell[3] Support Limit
D + OML + SME	Within Lesser of: $\frac{1.2\ S_y}{F_t}$ or $\frac{0.7\ S_u}{F_t}$ Times Normal Operating Stress Limit, F_{all}.	$0.8\ L_t$	$\sigma_1 \leq 1.5\ S$[4] $\sigma_1 + \sigma_2 \leq 2.25\ S$[5] $\sigma_3 \leq 0.5\ S$

where:

D	=	Deadweight
OML	=	Operating Mechanical Loads
SME	=	Seismic Margin Earthquake Loading
S_y	=	Material yield strength at temperature
S_u	=	Material ultimate strength at temperature
F_t	=	Allowable tensile stress per ASME Section III, Appendix XVII at temperature
F_{all}	=	Allowable stress value from ASME Code, Appendix XVII, XVII-1100
L_t	=	Ultimate Collapse Load as defined in ASME Code, Appendix F, F1370(d)
σ_1	=	Average membrane stress produced by mechanical loads
σ_2	=	Primary bending stress produced by mechanical loads
σ_3	=	Maximum tensile stress at contact surface of welds in through thickness direction of plates and rolled sections
S	=	Allowable stress from ASME Code, Appendix I

Notes:

1. Compressive axial member loads should be kept to less than 0.67 times the critical buckling load.
2. Includes Component Standard Support designed by analysis.
3. Component support analyses and material allowables per ASME Code, Section III, 1974 edition with Winter 1976 Addenda.
4. Not to exceed $0.4\ S_u$.
5. Not to exceed $0.6\ S_u$.

LOADING COMBINATIONS AND STRESS LIMITS FOR CLASS 2 & 3 PIPING

Loading Combination for
Faulted Conditions:

Operating Pressure + Deadweight + Seismic
Margin Earthquake Loads (SME)

Stress Acceptance Criteria

$$\frac{P_{max} D_o}{4t_n} + 0.75i \left(\frac{M_A + M_B}{Z} \right) \leq 2.4\ S_h \qquad (1)$$

Where:

P_{max} = peak pressure, psi

D_o = outside diameter of pipe, in.

t_n = nominal wall thickness, in.

M_A = resultant moment loading on cross section due to weight and other sustained loads, in.lb.

M_B = resultant moment loading on cross section due to earthquake inertial loads.

Z = section modulus of pipe, in.^{3}(NC-3652.4)

i = stress intensification factor [NC-3673.2(b)]. The product of 0.75i shall never be taken as less than 1.0.

S_h = basic material allowable stress at operating temperture, psi

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Note:

1. Faulted condition stress criteria per 1974 ASME Code, Section III, with Winter 1976 Addenda.

LOADING COMBINATIONS AND STRESS LIMITS FOR CLASS 2 & 3 VESSELS, PUMPS AND VALVES

Loading Combination	Stress Limit[1,2]
$P_N + D + OML + SME$	$\sigma_m \leq 2.0\ S$
	$\sigma_L + \sigma_b \leq 2.4\ S$
	$\sigma_L + \sigma_b \leq S_y$ (4)

Where:

P_N = Normal operating pressure

D = Deadweight

OML = Operating mechanical loads including earthquake anchor motion and restraint of free-end thermal displacement loading from connecting pi

SME = Seismic Margin Earthquake Inertial Loading

S = Allowable stress value from ASME Code, 1974 edition with Addenda through Winter 1976, Tables I-7 or I-8

σ_m = General membrane stress produced by pressure and and other mechanical loads

σ_L = Local membrane stress produced by pressure and other mechanical loads

σ_b = Primary bending stress produced by pressure and other mechanical loads

S_y = Specified Yield Stress

Notes:

1. Stress limits apply to extended support structures for valves.

   For active valves, the extended operator support structure primary stress is limited to S_y.

2. Faulted condition stress criteria per 1974 ASME Code, Section III, with Winter 76 Addenda.

3. Valve operator acceleration is limited to 3.0g in any direction.

4. Stress limit for function of active components.

HVAC DUCTING AND SUPPORTS

- CRITICAL DUCTING SYSTEMS SELECTED AS REPRESENTATIVE OF MIDLAND DUCTING.
- INDEPENDENT ANALYSES CONDUCTED.
- RESULTS ARE ALL POSITIVE FOR DUCTING AND SUPPORTS.

LOADING COMBINATION AND STRESS LIMITS FOR HVAC DUCTING

Loading Combination	Stress Limit
P + D + SME	$0.5\ \sigma_{cr}$

where:

P = Design pressure acting externally on duct

D = Dead Weight

SME = Seismic Margin Earthquake

σ_{cr} = Critical buckling stress computed for thin sheet simply supported on all edges and subjected to biaxial compressive stresses resulting from P, D and SME

CABLE TRAYS AND SUPPORTS

- TYPICAL RUNS OF CABLE TRAYS WERE SELECTED IN REGIONS OF HIGH SEISMIC RESPONSE.
- INDEPENDENT ANALYSES WERE CONDUCTED.
- RESULTS ARE ALL POSITIVE FOR TRAYS AND SUPPORTS.

LOADING COMBINATION AND ACCEPTANCE CRITERIA FOR CABLE TRAYS

Load Combination

D + SME

Acceptance Criteria[1,2]

$$\frac{M_D}{M_{UV}} + \left[\left(\frac{M_V}{M_{UV}}\right)^2 + \left(\frac{M_T}{M_{UT}}\right)^2 + \left(\frac{E_L}{Y_L}\right)^2\right]^{1/2} \leq 1$$

where:

D	= Dead Weight of Tray and Contents
SME	= Seismic Margin Earthquake Inertial Loading
M_D	= Bending Moment due to Dead Weight
M_V	= Bending Moment in the Vertical Plane from the SME
M_T	= Bending Moment in the Transverse Plane from the SME
M_{UV}	= Allowable Moment in the Vertical Plane
M_{UT}	= Allowable Moment in the Transverse Plane
E_L	= Axial Load in Tray from the SME
Y_L	= Allowable Axial Load in Tray

Note:

1. M_{UV} and M_{UT} are derived from ultimate load tests and are based on the lessor of 2/3 the maximum collapse moment or the moment at a displacement equal to 1/2 the ultimate load displacement.

2. Y_L is 2/3 of the ultimate load capacity.

LOADING COMBINATION AND ACCEPTANCE CRITERIA FOR HVAC AND CABLE TRAY SUPPORTS

Load Combination	Allowable Stress*
D + L + To + SME	1.6 S or Y

Where:

- D = Dead Load
- L = Live Load
- To = Loading from Restraint of Free-End Thermal Displacement
- SME = Loading from Seismic Margin Earthquake Including Inertial Effects and Differential Anchor Motion
- S = Working Stress Allowable from AISC Code, 8th Edition, 1980
- Y = Section Strength Required to Resist Design Loads and Based on Plastic Design Methods Described in Part 2 of the AISC Code

*Allowable Stress Based upon AISC Code, 8th Edition, Part 2, Plastic Design and NUREG-0800

LOADING COMBINATIONS AND STRESS LIMITS FOR COMPONENT SUPPORT ANCHORAGE[1,2]

Loading Combination (1)	Embedded Anchors (2,3,4)	Grouted Anchors	Expansion Anchors
D+L+To+Ro+SME	Lesser of U or 1.6S	Allowable loads per Bechtel Specification 7220-C-306Q	Allowable loads per Bechtel Specification 7220-C-305Q

where:

D = Dead loads from attached equipment or piping

L = Live loads from attached equipment or piping

To= Restraint of free-end thermal displacement of attached equipment or piping

Ro= Pipe and equipment reactions during normal operating or shutdown conditions not already included in D+L+To (i.e., piping reactions on vessel which are transmitted to vessel anchors)

SME= Load effects of Seismic Margin Earthquake including effects of differential anchor movement.

U= Ultimate pullout strength per ACI 349-80, Appendix B

S= Allowable working stress per AISC Code, 8th edition, 1980.

NOTES:

1. Load combinations are consistent with NUREG-0800 Standard Review Plan, Section 3.8.4; ACI 349-1980, Section 9.2, and Regulatory Guide 1.142
2. Strength criteria are consistent with NUREG-0800, Standard Review Plan, Section 3.8.4; ACI 349-1980, Appendix B and AISC Part 2, eighth edition, 1980.
3. The faulted stress limit for the reactor vessel anchor studs is 75 ksi (See Reference 43)
4. The faulted stress limits for LAQT bolts will be provided later.

ELECTRICAL CONDUIT

- GENERIC EVALUATION OF CONDUIT AND SUPPORT DESIGN CRITERIA WAS CONDUCTED FOR THE SEISMIC MARGIN EARTHQUAKE.

- SPAN SPACING AND SUPPORT CRITERIA USED IN DESIGN WERE DEMONSTRATED TO BE ACCEPTABLE FOR THE SME.

ACCEPTANCE CRITERIA FOR ELECTRICAL CONDUIT AND SUPPORTS

- o CLASS 3 THREADED PIPING CRITERIA USED FOR CONDUIT.
- o CONDUIT CLAMP STRENGTH DETERMINED BY TEST.
- o INTERACTION EQUATION FOR CLAMPS.

$$\left[\left(\frac{Q_P}{P}\right)^2 + \left(\frac{Q_S}{S}\right)^2 + \left(\frac{Q_L}{L}\right)^2\right]^{1/2} + \frac{|Q_{PST}|}{P} + \frac{|Q_{SST}|}{S} + \frac{|Q_{LST}|}{L} \lessapprox 1.0$$

Q_P = Clamp or strap force in the pull direction due to earthquake in the vertical, East-West or North-South direction

Q_S = Clamp or strap force in the slip direction due to earthquake in the vertical, East-West or North-South direction

Q_L = Clamp or strap force in the longitudinal direction due to earthquake in the vertical East-West or North-South direction

$Q_{PST}, Q_{SST}, Q_{LST}$ = Clamp or strap force in the pull, slip, and longitudinal directions due to the weight of the conduits and cables, i.e., 1g

P, S, L = Clamp or strap allowable loads in the pull, slip, and longitudinal directions, respectively

RESULTS

- ALL COMPONENTS COMPLETED MEET CODE OR FUNTIONAL LIMIT

- COMPUTATION OF MARGINS AGAINST FAILURE NOT REQUIRED

SUMMARY OF SEISMIC MARGINS FOR SELECTED NSSS PIPING AND EQUIPMENT SUPPORTS

Description		Minimum Margin F_{SME}
1. RPV Support Skirt/Base Interface	(Vessel Skirt)	>8.10
	(RPV Anchor Studs)	31.0
2. RPV Upper Support		3.54*
3. OTSG Support Skirt/Base Mat Interface	(Skirt)	6.43
	(OTSG Anchor Studs)	>4.65
4. OTSG Upper Support		>4.75
5. Pressurizer Lug/Support Structure Interface		8.26
6. Pressurizer Upper Support		>3.82
7. RPV 36" Hot Leg Outlet Nozzle		9.98
8. RPV 28" Cold Leg Inlet Nozzle		5.83
9. OTSG 36" Hot Leg Inlet Nozzle		12.99
10. OTSG 28" Cold Leg Outlet Nozzle		9.87
11. RCP 28" Cold Leg Inlet Nozzle		>4.51
12. RCP 28" Cold Leg Outlet Nozzle		>6.65
13. CRD Housing/RPV Interface		8.94
14. RCP Snubbers (P1A1 Upper Horizontal Support)		>2.34

* Margin Against Gap Closure

SUMMARY OF SEISMIC MARGINS FOR SELECTED REACTOR VESSEL INTERNALS

Description	Minimum Margin F_{SME}
1. Plenum Cover	26.2
2. Upper Grid Assembly - Rib Section	25.0
3. Upper Grid Pad Joint	14.4
4. Core Support Shield - Lower End	37.7
5. Core Support Shield - Upper Flange	22.7
6. Thermal Shield - Upper End	107.3
7. Thermal Shield/Lower Grid Shell Bolted Joint	63.1
8. Thermal Shield Upper Restraint Flange	67.9
9. Core Barrel Assembly - Upper End	31.5
10. Core Barrel/Former Bolted Joint	21.7
11. Lower Grid Assembly - Top Rib Section	73.9
12. Lower Grid Assembly - Top Rib Section/Shell Forging Bolted Joint	101.8
13. Lower Grid Assembly - Support Post/Support Forging Welded Joint	145.5
14. Control Rod Guide Tubes - Slotted Region	203.5
15. Plenum Cylinder - Upper End	80.8

SUMMARY OF SEISMIC MARGINS FOR BOP EQUIPMENT

Equipment	Qualification (1) Method	Governing Critical Area (2)	Minimum F_{SME} Margin (3)	Notes
Main Switchgear 1A05, 2A05	Test,(Random Input)	N/A	6.10	
Main Switchgear 1A06, 2A06	Test,(Random Input)	N/A	6.10	
Motor Control Centers 1B23, 2B23	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B24, 2B24	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B43, 2B43	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B44, 2B44	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 0B45, 0B46	Test,(Sine Beat)	N/A	6.3	
Motor Control Centers 1B53, 2B53	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B54, 2B54	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B55, 2B55	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B56, 2B56	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B63, 2B63	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B64, 2B64	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 0B65, 0B66	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 0B68, 0B69	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B79, 2B79	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B80, 2B80	Test,(Random Input)	N/A	>3.25	
Motor Control Centers 1B89, 2B89	Test,(Random Input)	N/A	>3.25	(7)
Motor Control Centers 1B90, 2B90	Test,(Random Input)	N/A	>3.25	(7)
125V DC Batteries and Racks 1D1, 2D1, 1D2, 2D2	Anal. & Test (Random Input)	Battery Rack Structures	2.24	

SUMMARY OF SEISMIC MARGINS FOR BOP EQUIPMENT (cont.)

Equipment	Qualification Method (1)	Governing Critical Area(2)	Minimum SME Margin (3)	Notes
Diesel Generator, Engine and Appendages	Anal. & Test (Random Input)	Engine Appendages	>3.49	
Diesel Generator, Neutral Grounding Cabinet 1G-11X, 2G-11X, 1G-12X, 2G-12X	Test,(Random Input)	N/A	3.83	
Diesel Generator, Generator Control Panel 1C-231, 2C-231, 1C-232, 2C-232	Test,(Random Input)	N/A	3.55	
Diesel Generator, Engine Control Panel 1C-111, 2C-111, 1C-112, 2C-112	Test,(Random Input)	N/A	1.5	
Diesel Generator, Generator Unit 1G-11, 2G-11, 1G-12, 2G-12	Analysis	Stator, beam adjacent to foot pad	1.70	
Diesel Generator, Exhaust Air Silencer 1M-101 A&B, 2M-101 A&B	Analysis	Shell	>1.24	(5)
Diesel Generator Intake Air Filter 1F-19 A-D, 2F-19 A-D	Analysis	Shell	>1.86	(5)
Diesel Generator Jacket Water Standpipe	Analysis	Anchor Bolting to pedestal	>2.06	(6)
Diesel Generator Skid and Building Mounted Auxiliaries Qualified by Testing	Testing (Random Input)	N/A	>5.0	
Other Diesel Generator Building Mounted Equipment	Analysis	Misc.	>2.06	(8)
Auxiliary Shutdown Panel 1C-114, 2C-114	Analysis	Support Angle (Struct.) Devices	1.52 Incomplete	(4)(10)
HVAC Control Cabinet 1C-175A-B, 2C-175A-B	Analysis & Test (Random Input)	Angle Frame (Struct.) Devices	25.2 Incomplete	(4)(10)

SUMMARY OF SEISMIC MARGINS FOR BOP EQUIPMENT (cont.)

Equipment	Qualification Method (1)	Governing Critical Area (2)	Minimum SME Margin(3)	Notes
HVAC Control Panel OC-151	Analysis & Test (Random Input)	Roof Bar (Structural Devices	1.48 Incomplete	(4,10)
ESFAS 1C-44, 2C-44	Test, (Random Input)	N/A	1.33	
Balance of Plant Logic Cabinet 1C-166, 2C-166	Test, (Sine Beat)	N/A	1.49	
Safeguards Chiller, IVM-59A&B,2VM-59A&B	Analysis & Testing	Compressor Wobble Foot Bolts	>1.07	(4,6)
Control Room HVAC, OVM-01 A&B	Analysis & Test (Sine Sweep)	Finned Coils	1.42	
Component Cooling Water Surge Tank 1T-173 A&B, 2P-73 A&B	Analysis	Tank Legs	1.31	
Service Water Pumps OP-75 A-E	Analysis	Nozzle	1.43	(9)
Component Cooling Water Pumps 1P-73 A&B, 2P-73 A&B	Analysis	Suction Nozzle Flange	1.0	(9)
Component Cooling Water Heat Exchanger 1E-73 A&B, 2E-73 A&B	Analysis	Anchor Bolts	1.20	
Auxiliary Feed Pump (Electric) 1P-05A, 2P-05A	Analysis	Discharge Flange	2.10	(9)
Auxiliary Feed Pump (Turbine) 1P-05B, 2P-05B	Analysis	Discharge Flange	>2.10	(9)
Air Filtration Unit OVM-79 A&B	Analysis	Door Frame	>1.50	(6,7)
Decay Heat Removal Pump 1P-60 A&B, 2P-60 A&B	Analysis	Discharge Flange	1.76	(9)

SUMMARY OF SEISMIC MARGINS FOR BOP EQUIPMENT (cont.)

Equipment	Qualification Method (1)	Governing Critical Area (2)	Minimum SME Margin (3)	Notes
Decay Heat Exchanger 1E-60 A&B, 2E-60 A&B	Analysis	Shell at Support	1.23	
Makeup Pump 1P-58 A,B&C, 2P-58 A,B,&C	Analysis	Suction Flange	4.2	(9)
Service Water Strainer 0F75-A-E	Analysis	Base Plate Gusset Weld	>1.62	

Notes:

1. For designs governed by allowable stresses, the margin against code allowable is (code allowable/applied SME stress). For equipment qualified by test, the margin is defined as (test response/required response).
2. Qualification test method is described in Section 5 through 8 and in Appendix A.
3. Critical area is local region or component within a subsystem with the governing minimum margin.
4. Structural portion qualified by analysis. Devices qualified by test.
5. Margin calculation was very conservative. Stresses in vendor report were scaled upward by the maximum ratio of the SME to the SSE in effect at the time of equipment qualification.
6. Margin based upon original design load since seismic and normal portion of design load could not be separated out from information in design report. Safe shutdown earthquake load exceeded SME load.
7. These units are not required for safe shutdown to cold condition.
8. Detailed margins not computed. Equipment less critically stressed than other items evaluated for SME.
9. Minimum margin quoted is for function. Structural margins are greater.
10. Completion of SSE qualification of all devices is pending.

MINIMUM SEISMIC MARGINS FOR BOP PIPING

Piping System	Critical Element	Node	Maximum Stress (psi)	Allowable Stress (psi)	Code Margin (CM)	Seismic Factor (F_{SME})
1. DHR and Core Flooding	Reducing Tee	495	19,895	49,800	2.50	5.25
2. DHR Suction	Taper Transition	480	12,046	39,600	3.29	7.20
3. DHR Suction and Reactor Building Spray	Tee	240	4,173	41,856	10.03	49.2
4. Makeup and Purification Discharge	Taper Transition	631	21,761	45,120	2.07	2.67
5. High Pressure Injection (Part 1)	Branch	190	20,570	49,800	2.42	4.52
6. High Pressure Injection (Part 2)	Pipe (Anchor)	250	18,457	45,120	2.44	2.52
7. Reactor Coolant and Pressure Control	Socket Weld	400	17,637	40,080	3.07	3.82
8. SWS - Reactor Building Return Header	Elbow	459	5,892	36,000	6.11	8.51
9. SWS - Pump Structure Header	Tee	60	26,724	42,000	1.57	2.66

MINIMUM SEISMIC MARGINS BASED UPON PIPE SUPPORT CAPACITY

Piping System	Support No.	Restraint Type and Direction	Node	Calculated Code Margin (CM)	Calculated Seismic Factor (F_{SME}) [1]	Minimum Seismic Factor (F_{SME}) [2]
1. DHR and Core Flooding	FSK-2CCA-66H3	Restraint (x)	514	22.0	34.9	≥2.24
2. DHR Suction	1-610-3-4	Strut (z)	139	1.14	1.26	≥1.03
3. DHR Suction and Reactor Building Spray	1-610-3-37	Anchor	185	1.35	1.60	≥1.33
4. Makeup and Purification Discharge	2-604-9-33	Strut (x)	667	1.81	1.90	≥1.22
5. High Pressure Injection (Part 1)	2-604-1-101	Restraint (z)	620	*	*	≥2.91
6. High Pressure Injection (Part 2)	2-604-1-1	Strut (x)	142	*	*	≥1.66
7. Reactor Coolant and Pressure Control	2-602-2-32	Restraint (z)	500	*	*	≥3.06
8. SWS - Reactor Building Return Header	2-619-2-511	Strut (x)	720	4.66	8.78	≥1.07
9. SWS - Pump Structure Header	0-618-1-17	Snubber (z)	428	1.15	1.40	1.17

* Support design load always exceeds seismic margin load

1 Based upon a detailed stress analysis of supports where SMR load exceed design load

2 Based upon a ratio of design load to SMR load when SMR load is less than the design load assuming the design load stresses the support to the Code allowable limit

MINIMUM SEISMIC MARGINS BASED UPON VALVE ACCELERATIONS

Piping System	Valve Type	Node	Maximum Combined Acceleration (g)	Qualification Margin	Seismic Factor (F_{SME})
1. DHR and Core Flooding	3/4" Angle Relief	460	1.516	1.98	2.88
2. DHR Suction	2-1/2" HO Globe	480	1.407	2.13	3.94
3. DHR Suction and Reactor Building Spray	12" Butterfly	518	1.235	2.43	6.48
4. Makeup and Purification Discharge	2-1/2" MO Globe	660	1.700	1.76	2.20
5. High Pressure Injection (Part 1)	1" Globe	646	1.448	2.07	4.04
6. High Pressure Injection (Part 2)	1" Globe	221	1.481	2.03	2.76
7. Reactor Coolant and Pressure Control	1/2" Globe	445	1.610	1.86	2.40
8. SWS - Reactor Building Return Header	6" MO Butterfly	625	1.824	1.64	2.30
9. SWS - Pump Structure Header	6" MO Gate	570	2.228	1.35	1.56

SUMMARY OF SEISMIC MARGINS - HVAC SYSTEMS

HVAC System	System Element	Maximum Stress Ratio	Minimum Code Margin CM	Minimum Seismic Factor F_{SME}
Aux. Building	Duct	0.25 < 1.0	4.0	15.8
	Support Angle	0.054 < 1.0	18.5	19.5
Diesel Gen. Bldg.	Duct	0.28 < 1.0	3.6	17.2
	Support Anchor Bolts	0.39 < 1.0	2.6	8.6

SUMMARY OF SEISMIC MARGINS - CABLE TRAYS

Cable Tray System	Critical Area	Maximum Combined Stress Ratio	Minimum Seismic Factor, F_{SME}
Upper Cable Spreading Room:			
36" Cable Tray	Element #38	0.63	2.14
Cable Tray Support	3/4" Expansion Anchor Bolt Element #64	0.89	1.21
Auxiliary Building East-West Wing:			
24" Cable Tray	Element #98	0.331	5.34
12" Cable Tray	Element #210	0.168	10.14
Cable Tray Support	Elements #53,54	0.714	1.73
Containment Building Internal Structure:			
24" Cable Tray	Element #27	0.17	9.66
Cable Tray Support	3/16" Fillet Weld Element #16	0.46	2.62
Auxiliary Building East-West Wing:			
24" Cable Tray (2BJQ)	Element #4	0.33	3.50
Cable Tray Support	1/2" ϕ Expansion Anchor Bolt Element #6	0.59	2.29
Service Water Pump Structure:			
18" Cable Tray	8' Maximum Span	0.498	2.68
Cable Tray Support	1/2" ϕ Expansion Anchor Bolt Element #9	0.71	1.42

MINIMUM SEISMIC MARGIN FOR ELECTRICAL CONDUIT AND SUPPORTS

Element	Code Margin CM	Seismic Factor F_{SME}
Conduit	2.78	3.32
Conduit Strap	1.32	1.57
Conduit Clamp	1.10	1.13
Conduit Support	1.36	1.56

UNRESOLVED ITEMS

- AUXILIARY SHUTDOWN PANEL -DEVICES
- CONTROL ROOM HVAC CONTROL PANEL -DEVICES
- DIESEL GENERATOR HVAC CONTROL PANEL-DEVICES
- UNRESOLVED ISSUES STEM FROM INCOMPLETE VENDOR QUALIFICATION

5/8/84
1 of
J. Kane

Subject: Midland Plant - Seismic Margin Review Reports

Structure	Volume	Date Submitted	J. Kane has copy	Pages Applicable to GES
Methodology & Criteria	I			
Reactor Containment Bldg	II	Mar. 30, 1983	5/20/83	
Auxiliary Bldg	III		5/11/84	
SWPS	IV	Sept. 13, 1983	10/3/83	
DGB	V	Apr. 28, 1983	5/19/83	
BWST	VI	Feb. 16, 1983	5/20/83	
Electrical, Control Instrumentation & Mech Eqpt	VII		5/11/84	
NSSS Eqpt. & Piping	VIII		5/11/84	
Balance of Plant Class 1, 2 and 3 Piping, Pipe Supports & Valves	IX			
Miscellaneous Subsystems and Components	X	Mar. 1, 1984	4/ /84	

On 5/8/84 I wrote a note to D. Hood requesting that I be provided copies of

MIDLAND - SEISMIC MARGIN REVIEW
VOL. 1 Methodology & Criteria

Rec'd 5/27/83

May 26, 1983

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JSniezak, IE
JStone, IE

Docket Nos. 50-329 OM, OL
and 50-330

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

Dear Mr. Cook:

Subject: Request for Additional Information Regarding Seismic Margin Review - Volume I: Methodology and Criteria

Sections 1.8 and 3.7.2.2 of Supplement 2 to the SER identified seismic margin studies as a confirmatory issue for Midland Plant, Units 1 and 2. Your letter of February 4, 1983 forwarded Volume I of the Seismic Margin Review by Structural Mechanics Associates (SMA) for NRC review. The NRC staff has reviewed Volume I and finds that additional information identified by Enclosure 1 is needed to complete this review.

Should you have questions regarding Enclosure 1, contact our Licensing Project Manager. Your timely response to this request will provide for continued review of subsequent volumes which address specific structures and equipment.

The reporting and/or recordkeeping requirements contained in this letter affect fewer than ten respondents; therefore, OMB clearance is not required under P.L. 96-511.

Sincerely,

/S/

Elinor G. Adensam, Chief
Licensing Branch No. 4
Division of Licensing

8306020062 8pp.

Enclosure:
As stated

cc: See next page

8306020062 8pp.

*See Previous White

OFFICE	DL:LB#4	LA:DL:LB#4	DL:LB#4				
SURNAME	*DHood:eb	*MDuncan	EAdensam				
DATE	*5/13/83	*5/13/83	5/ /83				

ENCLOSURE 1

REQUEST FOR ADDITIONAL INFORMATION

130.0 STRUCTURAL ENGINEERING BRANCH

130.28 With respect to Volume I, Seismic Margin Review: Methodology and Criteria, forwarded by your letter of February 4, 1983, provide the following information:

130.28.1 State how the STUF computer code discussed in Section 2.4 meets the verification requirements identified in the Standard Review Plan (SRP) Section 3.8.4.III.4.

130.28.2 A statement is made in Section 2.4 that the synthetic time histories were baseline corrected. However, the displacement and velocity time histories (Fig. I-2-5) shows positive values for displacement and velocity at the end of the specified 10 seconds period, respectively. Explain the apparent inconsistency between the statement and the data provided in Fig. I-2-5. Also, address the limited changes between positive and negative sign for the displacement curve in Fig. I-2-5.

130.28.3 Explain why the value for Vs utilized in Section 3.2 for the intermediate soil profile (Fig. I-3-3) between elevations 553' - 603' is larger than the equivalent value used for a stiff soil profile (Fig. I-3-2).

130.28.4 State how the CLASSI computer code discussed in Section 4.1 meets the verification requirements identified in SRP 3.8.4.III.4.

130.28.5 State how the idealized layered horizontal soil boundaries utilized in your analyses in Section 4.2 reflect the actual field conditions.

130.28.6 Explain in more detail in Section 4.4 the different approaches utilized in devloping the impedance values for the auxiliary building and the service water pump structure for horizontal and torsional considerations vs. vertical and rocking.

130.28.7 Explain in Seciton 4.4 how you consider in your analyses the fact that when a complicated foundation shape is simplified into a rectangular shape the center of stiffness for the complicated shape may not coincide with the geometric center of the simplified rectangular shape. Also, address how you account for changes in the distribution of reactions, at the foundation level, between the actual and simplified models.

130.28.8 Explain in Section 4.4 why the impedance for rocking is not based upon the entire foundation area (R = 28.5') when the BWST is analyzed as full of water. It appears that in this condition most of the water load will be transmitted to the soil, therefore, requiring complete participation of the entire area (R = 28.5). Also, identify all terms used in Fig. I-4-5 and state if the relationships identified in this figure apply for rectangular foot-prints as well as for circular ones.

130.28.9 The electrical penetration wings act as horizontal cantilevers, thereby producing increased horizontal acceleration at locations away from the control tower. Discuss in Section 5.2 the magnitude of this effect and how it is incorporated into the response spectra results. If these details are to be provided in the proposed Vol. III, please state so.

130.28.10 In Section 5.2, state if you have analyzed the diesel generators and the respective foundations separate from the building, since they are physically separated. Also, provide details of these analyses in Vol. V of the proposed reports.

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130.28.15 Expand your justification in Sections 8.2 and 3.7.2.9 for using a broadening factor of ± 10% instead of the value of ± 15% recommended in R.G. 1.122.

130.28.16 Discuss and/or correct the following apparent typrographical errors:

(a) In Section 1.0, SSE peak ground acceleration should be 0.06g. (3rd line 1st para.).

(b) In Section 4.1, (+) should be replaced with (=) (Eq. 4-1).

(c) In Section 4.5, Vs should be Vw (3rd line p. I-4-12).

(d) In Section 7.1, K in the second equation should be replaced with k (p.I-7-1).

Response to Melanie Miller 6/2/83

1. GES needs to review SMS Vol. 1. Only recently printed copies.
2. Not necessary to participate in telecon but CPC written response to SES questions 130.28-3 & 130.28.5 will be of interest to GES

Telecon at 2 on enclosed questions

May 26, 1983

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ACRS (16)
JSniezak, IE
JStone, IE

Rinaldi, Gunner Harstead, CPCo -- possibly RIII are participating. Do you need to participate? Please let me know by 11 am. Melanie 24259

Docket Nos. 50-329 OM, OL
and 50-330

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

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Enclosure:
As stated

cc: See next page

*See Previous White

OFFICE	DL:LB#4	LA:DL:LB#4	DL:LB#4				
SURNAME	*DHood:eb	*MDuncan	EAdensam				

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J. Kane
Rec'd 10/17/83

James W Cook
Vice President - Projects, Engineering and Construction

General Offices: 1945 West Parnall Road, Jackson, MI 49201 • (517) 788-0453

September 28, 1983

Harold R Denton, Director
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND ENERGY CENTER
MIDLAND DOCKET NOS 50-329, 50-330
NRC REQUEST FOR ADDITIONAL INFORMATION ON THE
SEISMIC MARGIN REVIEW REPORT
FILE: B3.7.1 SERIAL: 25654

REFERENCE: (1) LETTER FROM J W COOK TO H R DENTON
DATED FEBRUARY 4, 1983, SERIAL 21010

(2) LETTER FROM E G ADENSAM (NRC) TO J W COOK
DATED MAY 26, 1983

In reference (1), Consumers Power Company submitted Volume I of the Seismic Margin Review Report titled, "Methodology and Criteria," for the Staff's review. Subsequently, in reference (2) the NRC requested additional information on Volume I in question number 130.28. As an attachment to this letter, CPCo is submitting the response to question 130.28 for Staff review.

It is expected that this information will enable the NRC Staff to complete its review of Volume I of the Seismic Margin Review Report

James W. Cook

JWC/MFC/bjw

CC RJCook, Midland Resident Inspector
JGKeppler, Administrator, NRC Region III
DSHood, US NRC
FRinaldi, US NRC
GHarstead, Harstead Engineering Company
GBagchi, US NRC
RBosnak, US NRC
MAMiller, US NRC Licensing Branch No 4 (2)

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oc0983-0625a100

CONSUMERS POWER COMPANY
Midland Units 1 and 2
Docket No 50-329, 50-330

Letter Serial 25654 Dated September 28, 1983

At the request of the Commission and pursuant to the Atomic Energy Act of 1954, and the Energy Reorganization Act of 1974, as amended and the Commission's Rules and Regulations thereunder, Consumers Power Company submits additional information on the Seismic Margin Review Report Volume I titled, "Methodology and Criteria."

CONSUMERS POWER COMPANY

By J W Cook
J W Cook, Vice President
Projects, Engineering and Construction

Sworn and subscribed before me this 4 day of October 1983

Barbara Blunsend
Notary Public
Jackson County, Michigan

My Commission Expires Sept 8, 1984

oc0983-0625a100

Question 130.28.1 State how the STUF computer code discussed in Section 2.4 meets the verification requirements identified in the Standard Review Plan (SRP) Section 3.8.4.III.4.

Response: STUF creates artificial earthquake time histories from given response spectra. The method is an iterative process tnat operates on the Fourier Series representation of the artificial earthquake. Once the time history has been generated by STUF, the response spectra developed from the time history record are compared with the given response spectra. The comparison of the response spectra with the given response spectra assures the computer program results produce spectra which essentially envelop the given response spectra and thus provides the verification of results. The computer manual for STUF together with associated check problems is maintained by Structural Mechanics Associates, Inc.

Question 130.28.2 A statement is made in Section 2.4 that the synthetic time histories were baseline corrected. However, the displacement and velocity time histories (Figure I-2-5) shows positive values for displacement and velocity at the end of the specified 10 seconds period, respectively. Explain the apparent inconsistency between the statement and the data provided in Figure I-2-5. Also, address the limited changes between positive and negative sign for the displacement curve in Figure I-2-5.

Response: A parabolic baseline correction was used for the synthetic earthquake time history records. This procedure typically results in the type of drift exhibited in the velocity and displacement records shown in Figure I-2-5. The acceleration time history record shown produces response spectra which essentially envelop the Seismic Margin Earthquake (SME) spectra. The evaluation of the Midland structures was based on seismic responses developed from response spectrum analyses. The in-structure response spectra developed using the synthetic earthquake time history are pseudo-absolute acceleration spectra which are essentially unaffected by velocity or displacement drift. Thus, the method of baseline correction used is immaterial to any results developed in the Seismic Margin Review, and the number of zero-crossings of the displacement trace or the existence of a small residual velocity or displacement does not influence any results for either structures or equipment.

Question 130.28.3 — Explain why the value for Vs utilized in Section 3.2 for the intermediate soil profile (Figure I-3-3) between Elevations 553' - 603' is larger than the equivalent value used for stiff soil profile (Figure I-3-2).

Response: Figures I-3-1 through I-3-3 present a soft site, a stiff site, and an intermediate representation of the soil profiles, respectively, beneath the auxiliary building, reactor building, and service water pump structures at the Midland site. These three profiles were selected to reasonably span the uncertainty range which exists for soil-structure interaction (SSI) impedance functions for the buildings. The soft site profile (Figure I-3-1) results in the lowest values for all SSI impedance function terms, the intermediate profile (Figure I-3-3) results in intermediate values, and the stiff profile (Figure I-3-2) results in the highest values. The labels "soft", "stiff", and "intermediate" were simply selected to indicate the relative values for the SSI impedance functions which result from the use of these profiles. These terms were not meant to imply that the soil properties for every layer in the intermediate profile lay midway between those for the corresponding layer of soft and stiff profiles. All three profiles were selected to represent possible and slightly bounding profiles which might exist under the Midland buildings.

The intermediate profile was established based upon the following considerations. First, both the soft site profile (Figure I-3-1) and the stiff site profile (Figure I-3-2) contain two major impedance mismatches above bedrock. It was decided to retain this feature of two major impedance mismatches for the intermediate profile.

Secondly, the impedance mismatch at Elevation 550 has the greatest influence on stiffness (K) and damping (C) SSI impedance function terms for the soft site profile while that at Elevation 463 has the greatest influence for the stiff site profile. Therefore, for the intermediate profile, it was decided to place the two impedance mismatches at Elevations 553 (approximately 550) and 463 so as to be consistent with the location of impedance mismatches of both the soft site and stiff site profiles which most influence radiation damping. Next, the ratio of G_{SME} above and below Elevation 553 for the intermediate profile was selected to be approximately equal to that for the soft site profile near this elevation. Similarly, the ratio of G_{SME} above and below Elevaton 463 for the intermediate profile was selected to be approximately equal to that for the stiff site profile at this elevation. In this way, the primary impedance mismatch influences of both the soft and stiff profiles on the reduction in radiation damping was incorporated into the intermediate profile.

For both the soft and stiff site profiles, SSI stiffness (K) impedance terms are primarily influenced by the soil properties between Elevations 410 and the foundation level. Therefore, in addition to the impedance mismatch ratios described above, it was decided that the intermediate profile should have G_{SME} values approximately midway between those for the soft and stiff site profiles between Elevations 410 and the building foundation levels (Elevations 562 to 587).

An intermediate profile should have SSI stiffness (K) impedance terms approximately midway between those for the soft and stiff site profiles while maintaining about the same radiation damping reduction factors due to layering as exhibited by both the soft and stiff profiles. In this way, the intermediate profile retains the most important characteristics of both the soft site and stiff site profiles while providing SSI impedance terms approximately midway between these two profiles.

It is recognized that the intermediate profile has a V_S value of 1500 fps as compared to 1400 fps for the stiff site profile at elevations above Elevation 568 to 585 (depending upon building being considered). This condition results from ignoring the rather unimportant impedance mismatch at Elevations 568 to 585 for the stiff site profile while retaining in the intermediate profile the more important impedance mismatch characteristics of the soft site profile at about Elevation 550. Similarly, the intermediate profile has a V_S value of 2468 fps at elevations between Bedrock and Elevation 410. This V_S is less than that for the soft site profile at these elevations. This also occurs because the intermediate profile ignores the less important impedance mismatch at Elevation 410 of the soft site profile while retaining the more important impedance mismatch characteristics of the stiff site profile at Elevation 463. The intermediate profile retains all the most important characteristics of both the soft and stiff profiles and these apparent deficiencies are considered to be of very minor importance for the buildings founded on glacial till.

It should be noted that the largest structural responses for all buildings founded on the glacial till occurred for the upper bound SSI impedances which were taken as 1.3 times those given for the stiff site profile (Figure I-3-2) and thus are not governed by the chosen intermediate profile.

Question 130.28.4 State how the CLASSI computer code discussed in Section 4.1 meets the verification requirements identified in SRP 3.8.4.III.4.

Response: Comparison of CLASSI calculated soil impedances to classical solutions have been presented in published technical literature (References 1 and 2). These comparisons demonstrate excellent agreement between soil impedances developed by classical methods for rigid foundations on an elastic half-space and the frequency dependent impedances determined by CLASSI. CLASSI is also available in the public domain.

In addition, soil impedances determined by CLASSI have been further verified for layered sites by studies conducted for the Zion nuclear power plant (Reference 3). In this study, the structural response of a Zion reactor building was developed based on a CLASSI representation of the layered soil site at Zion. Additional analyses of the reactor building were then conducted using a linear finite element representation of the site as modeled by computer program FLUSH (Reference 4). Comparisons of reactor building acceleration response demonstrated substantial agreement between the two methods with differences in peak values generally averaging about 5 percent.

Therefore, the results presented in References 1, 2, and 3 are considered to comply with the intent of Sections 3.8.1.II.4.e. (i), (ii) and (iii) of the Standard Review Plan. The computer manual and associated check problems for CLASSI are maintained by Structural Mechanics Associates, Inc.

References:

1. Wong, H. L., and J. E. Luco, "Dynamic Response of Rigid Foundations of Arbitrary Shape", Earthquake Engineering and Structural Dynamics, Vol. 4, pp 579-587, 1976.

2. Luco, J. E., "Vibrations of a Rigid Disc on a Layered Viscoelastic Medium", Nuclear Engineering and Design, Vol. 36, pp 325-340, 1976.

3. Maslenikov, O. R., Chen, J. C., and J. J. Johnson, "Uncertainty in Soil-Structure Interation Analysis of a Nuclear Power Plant - A Comparison of Two Analysis Procedures", Lawrence Livermore Laboratory, UCRL-85702 Preprint.

4. Lysmer, J., et al, "FLUSH - A Computer Program for Approximate 3-D Analysis of Soil-Structure Interaction Problems", Report No. EERC 75-30, Earthquake Engineering Research Center, University of California, Berkeley, California, November, 1975.

Question 130.28.5 State how the idealized layered horizontal soil boundaries utilized in your analyses in Section 4.2 reflect the actual field conditions.

Response: The layered site analyses were conducted to evaluate the effects of layering on the stiffness and geometric damping characteristics of the site. A wide range of properties was used in order to conservatively bound the expected actual field conditions. The layered site analyses conducted for Midland were based on geotechnical investigations conducted by Dames & Moore, Inc. and Weston Geophysical Corporation. The Dames & Moore results are considered representative of soft site conditions at Midland while the Weston Geophysical results are representative of stiff site conditions. These investigations established the layer descriptions shown in Figure I-3-1 and I-3-2 together with the low strain properties of these layers. An intermediate site condition was developed from a weighted average of the soft and stiff site properties in order to also compute approximately mid-range response for the Midland structures and equipment.

For the layered site characteristics used in the analysis described in Section 4.2, strain degradation effects appropriate for the SME soil strain levels were introduced for the various soil layers. CLASSI analyses were then conducted using these layered site profiles together with the appropriate foundation plan dimensions at the appropriate foundation depths for the various structures. Equivalent shear moduli were developed which resulted in the same elastic half-space foundation stiffnesses as the layered site analyses. These shear moduli were reduced for the soft site and increased for the stiff site to conservatively increase the range of soil properties considered. Where uncertainties exist, assumptions were introduced to further stiffen the stiff site compliance functions and soften the soft site compliance functions.

Question 130.28.6 Explain in more detail in Section 4.4 the different approaches utilized in developing the impedance values for the auxiliary building and the service water pump structure for horizontal and torsional considerations vs. vertical and rocking.

Response: The development of the soil impedance values for the auxiliary building and the service water pump structure are discussed in more detail in Volumes III and IV, respectively. In summary, for the horizontal translation and torsion degrees of freedom, the entrapped soil is considered to act integrally with the foundation base mat. For rocking and vertical translation, the assumed foundation shape was based on the foundation contact area only. For horizontal translation, an equivalent rectangle was developed for the foundation based on equivalence of area and moment of inertia considering the entire foundation plan dimensions including entrapped soil. For torsion, an equivalent circle with radius based on the polar moment of inertia was developed, again including the entrapped soil. For the vertical translation, an equivalent rectangle based on the contact area of the foundation was calculated. An equivalent rectangle based on both the contact area and moment of inertia was used for the rocking degrees-of-freedom.

The above approach is considered to most accurately simulate the foundation stiffness characteristics of structures with entrapped soil subject to seismic excitation. Since the entrapped soil is forced to move in-phase with the structure for horizontal motions, soil shear forces will be transmitted through the entrapped soil to the vertical structural walls enclosing the soil and a stiffness based on the foundation plan area including the

Question 130.28.6 (Continued)

soil is considered appropriate. However, for vertical motion (including rocking) separation of the soil and structure may occur due to the lack of ability to transmit tension across the soil-structure interface, and the entrapped soil does not necessarily all have to move in-phase with the structure. For these degrees-of-freedom, an equivalent foundation stiffness based on the foundation contact area only is considered appropriate.

Where any significant uncertainty exists on including the entrapped soil in the stiffness and mass properties of the structure, as for instance in the diesel generator building, a parametric study was conducted and the structural loads and in-structure response spectra were based on an envelope of the parametric results. Details of these calculations are discussed in the appropriate volumes for the individual structures.

<u>Question 130.28.7</u> Explain in Section 4.4 how you consider in your analyses the fact that when a complicated foundation shape is simplified into a rectangular shape the center of stiffness for the complicated shape may not coincide with the geometric center of the simplified rectangular shape. Also, address how you account for changes in the distribution of reactions, at the foundation level, between the actual and simplified models.

<u>Response:</u> As discussed in Volumes III and IV, different equivalent rectangular foundations were developed for structures with entrapped soil. When this is done, the centers of rigidity for the different degrees-of-freedom do not necessarily correspond. When these centers of rigidity are not coincident, the soil compliance functions were located at the rocking center of rigidity. As an example, for the auxiliary building, the center of rigidity of the equivalent rectangular foundation was calculated at approximately 123.6' north of Column Line K_C of the structure for the vertical and rocking degrees-of-freedom compared to approximately 117.0' for the horizontal translation and torsion degrees-of-freedom, or about a 5 percent shift. When the foundation center of rigidity does not corresoond with either the center of mass or the center or rigidity of the shear walls above the base slab, these locations were connected in the model by rigid links.

Distribution of reactions at the foundation level is of concern only for the calculation of bearing pressures in the soil. For this calculation, a rigid base mat was assumed together with a linear soil stress distribution based on the actual foundation geometry.

Question 130.28.8 Explain in Section 4.4 why the impedance for rocking is not based upon the entire foundation area (R = 28.5') when the BWST is analyzed as full of water. It appears that in this condition most of the water load will be transmitted to the soil, therefore, requiring complete participation of the entire area (R = 28.5). Also, identify all terms used in Figure I-4-5 and state if the relationships identified in this figure apply for rectangular foot-prints as well as for circular ones.

Response: For horizontal and vertical translation of tanks, seismic induced forces are transmitted to the underlying soil over the entire tank area. However for rocking, it was judged that seismic-induced forces are transmitted to the underlying soil primarily through the ring wall foundation. For translation, the water is forced to respond by seismic response of the tank as the walls and the base of the tank force the water into compatible deformations with the tank. In the rocking mode, the tank can respond somewhat independently of the contained water because the flexible tank bottom does not induce significant rocking response of the fluid.

In Figure I-4-5, α_i is the normalized embedment coefficient used in Equation 4-6, $a_o = \omega R/V_s$ is the dimensionless frequency, h is the embedment depth, and R is the radius of the embedment structure. The relationship can be used for rectangular footprints if an equivalent radius, R, is used based on equal stiffnesses for corresponding degrees-of-freedom.

Question 130.28.9 The electrical penetration wings act as horizontal cantilevers, thereby producing increased horizontal acceleration at locations away from the control tower. Discuss in Section 5.2 the magnitude of this effect and how it is incorporated into the response spectra results. If these details are to be provided in the proposed Volume III, please state so.

Response: The overall model as shown in Figure I-5-3 includes three-dimensional representations of the Electrical Penetration Areas (EPAs) as well as the main auxiliary and control tower portions of the structure. Thus, the amplification through the EPAs is predicted from the overall model, and the structural loads developed in the EPAs reflect this amplification. In-structure response spectra were developed at locations near the extremities of the EPAs for use in evaluating the EPA mounted equipment. In addition, a parametric evaluation was conducted to determine the effects of relative soil stiffness modeling assumptions for the EPAs, and the structural loads were based on the worst-case results of this parametric study. The results of the auxiliary building analysis are presented in Volume III of this report.

Question 130.28.10 In Section 5.2, state if you have analyzed the diesel generators and the respective foundations separate from the building, since they are physically seprated. Also, proide details of these analyses in Volume V of the proposed reports.

Response: The in-structure response spectra presented in Volume V for the diesel generator building were considered to be applicable for equipment mounted in the building. Additional in-structure response spectra were developed for the diesel generators which account for the small foundation size and independence of the diesel generator pedestals from the rest of the structure. Details of this anlaysis and the resulting spectra used to evaluate the diesel generators will be presented in Volume VII on electrical, control, instrumentation, and mechanical equipment.

Question 130.28.11 Explain how Equation 6-1 in Section 6.4 will ensure that sufficient modes will be obtained in the evaluation of the structures. This formulation differs from the requirements identified in the SRP Section 3.7.2.7.

Response: The criteria presented in Section 6.4 provide a conservative basis to establish the seismic response of the structures since Equation 6-1 is applied to any nodal location rather than to a total percentage of structure mass participating. All structures analyzed as part of the SMR had essentially 100 percent of the mass participating in the response spectrum analyses for all directions of response. Therefore, the use of additional modes would not alter the building responses as they are presented in their respective volumes. The actual total percentages of mass participating as well as a breakdown of the mass participating on a mode by mode basis is presented in the appropriate volumes for the individual structures.

Question 130.28.12 In Section 6.7, the walls are assumed to be rotationally fixed at floor levels (top and bottom) for the calculation of horizontal shear stiffness of each wall at each floor level. Explain how the overall building cantilever bending stiffness was evaluated.

Response: The overall building cantilever dynamic response models used for the SMR were the same models developed for design and reported in the FSAR. These models include both the shear and cantilever bending flexibility. The models are based on a linearly elastic system assuming plane sections remain plane, and consist of lumped masses connected by massless flexible elements. Plate finite elements were incorporated where additional detail was required. The overall dynamic building models are discussed in Section 5 of Volume I and in more detail in the appropriate volumes for the individual structures. In general, the contribution of bending stiffness to the overall response of the Midland structures is small.

In Section 6.7, the distribution of load from the overall dynamic models to the individual shear walls is discussed. For shear wall-type structures, these loads were proportioned to the shear walls based on their relative stiffnesses as determined based on the assumption the walls are rotationally fixed top and bottom. The capacity of the walls was also checked for overturning moment capacity where the incremental changes in overall building overturning moment are distributed to the individual walls in the same proportion as the distribution of the shears in the resisting system.

Question 130.28.13 Explain in detail how you determined in Section 8.1 that the translational response in the vertical direction, due to rotations about the two horizontal building axes, should not be considered in the development of the vertical in-structure response spectra.

Response: The small vertical component due to horizontal rocking of the structures is maximized for the lower bound soil condition. However, the vertical response of the structure, and hence the in-structure response spectra in the governing frequency range of the equipment, is controlled by the stiff site soil condition where the rocking is much less pronounced. Because of its height-to-diameter ratio, rocking is more pronounced for the reactor building than for the other structures. Therefore, increases in vertical response due to horizontal rocking are maximized for the reactor building. Rotational response about a horizontal axis was computed for this structure and the increase in the vertical input to equipment was found to be less than 20 percent at the maximum distance from the center of the structure. For equipment located away from the containment building wall or in other structures, the effect of rocking is less.

One reason for the relatively small increase in the vertical response compared to the effect of torsion on the horizontal response is that the contribution to the vertical from rocking is combined with the vertical translation by SRSS since the vertical and horizontal ground motions are expected to be out-of-phase. Since the torsional response occurs in-phase with the horizontal translational response, these effects must be combined on an absolute sum basis. Where significant vertical amplification is expected, as for instance, towards the centers of the more flexible floor slabs, it has been included in the analysis by accounting for dynamic amplification due to floor slab flexibility.

Question 130.28.14 State how the SOILST computer code discussed in Section 8.1 meets the verification requirements identified in SRP Section 3.8.4, Paragraph III.4.

Response: Computer program SOILST was verified by comparison of test problem results with computer program EASE (Reference 1) in accordance with SRP 3.8.1.II.4.e.(ii). EASE is available in the public domain. Direct integration time history analysis of the Service Water Pump Structure dynamic model were conducted using both EASE and SOILST computer codes. Peak accelerations were compared at typical locations in the structure. Results from the two analyses were shown to be virtually identical with the maximum difference in acceleration response being less than 3.5 percent. Similar comparisons of displacement response showed a maximum difference in peak displacements of about 4 percent. The minor differences in results are attributable to slightly different methods of modeling damping in the two codes. The computer manual and associated check problems for SOILST are maintained by Structural Mechanics Associates, Inc.

Reference:

1. EASE2 - "Finite Element Application for Performing Static/Dynamic Linear Elastic Analyses of 3-D Structural Systems", Engineering Analysis Corporation, Lomita, California.

Question 130.28.15 Expand your justification in Section 8.2 and 3.7.2.9 for using a broadening factor of ±10% instead of the value of ±15% recommended in R.G. 1.122.

Question: SRP Section 3.7.2.III.9 states that peak broadening should not be less than ± 10%. Regulatory Guide 1.122 also permits broadening of the response spectra peaks by ± 10% if a parameteric study is performed to justify this value. The response of the Midland structures is controlled to a large extent by the soil parameters at the site. As discussed in Section 8.2, a very wide range of soil properties was used in the SMR. The soil properties were further varied by multiplying the lower bound soil properties by 0.6 and the upper bound soil properties by 1.3. This wide range is reflected in very broad in-structure response spectra peaks since the in-structure spectra consist of an envelope of the spectra from the entire soil range. These spectra were further broadened to conservatively cover any additional uncertainty in the structural models as discussed in Section 3.7.2.III.9 of the SRP. Where additional uncertainty could be possible, as for instance in the soil-structure interaction of the diesel generator building, additional parametric studies were conducted, and the in-structure response spectra were generated from an envelope of the parametric results. Thus, the combination of a parametric study based on a very broad range of soil parameters in combination with an additional peak broadening is considered to conservatively meet the intent of R. G. 1.122.

Question 130.28.16 Discuss and/or correct the following apparent typographical errors:

(a) In Section 1.0, SSE peak ground acceleration should be 0.06g. (3rd line 1st paragraph).

(b) In Section 4.1, (+) should be replaced with (=) (Equation 4-1).

(c) In Section 4.5, Vs should be Vw (3rd line p. I-4-12).

(d) In Section 7.1, K in the second equation should be replaced with k (p. I-7-1).

Response:

(a) The 1st line of the 1st paragraph should read 0.06g peak horizontal ground acceleration for the Operating Basis Earthquake (OBE).

(b) In Section 4.1, (+) should be replaced with (=) in Equation 4-1 as indicated.

(c) In Section 4.5, the v_w in the denominator of Equation 4-7 should be replaced with v_s where v_s is the high strain shear wave velocity.

(d) In Section 7.1, the K in the second equation should be replaced with a k as noted.

Seismic Margin Study - MEB Review Comments Vol. VII Jo Nane

April 30, 1984

Docket Nos: 50-329 OM, OL
and 50-330 OM, OL

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JNGrace, I&E

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

Dear Mr. Cook:

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION ON SEISMIC MARGIN REVIEW REPORT VOL. VII

The NRC, with the technical assistance of its consultant from the Energy Technologies Engineering Center, has reviewed mechanical engineering aspects of Volume VII of your Seismic Margin Review Reports, entitled "Electrical, Control, Instrumentation and Mechanical Equipment-Margins" and submitted to the NRC under your February 4, 1983 cover letter. We find that additional information, identified by Enclosure 1, is needed to complete this review.

Please provide the information requested by Enclosure 1 by June 1, 1984. Contact our project manager, Darl Hood, if you have questions regarding this request or are unable to meet the requested response date. A copy of your responses should also be forwarded directly to our ETEC consultant.

The reporting and/or recordkeeping requirements contained in this letter affect fewer than ten respondents; therefore, OMB clearance is not required under P.L. 96-511.

Sincerely,

Elinor G. Adensam, Chief
Licensing Branch No. 4
Division of Licensing

Enclosure:
As stated

cc: w/enclosure
See next page

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DL:LB#4	DL:LB#4	DL:LB#4
MDuncan	DHood/po'b	EAdensam
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ETEC COMMENTS ON SEISMIC MARGIN REVIEW
MIDLAND ENERGY CENTER PROJECT, VOLUME VII

ETEC has reviewed Volume VII "Electrical, Control, Instrumentation and Mechanical Equipment Margins," which is part of the Seismic Margin Review for Midland.

The following additional information/clarification is needed to complete this review:

(1) Table VII-5-5 Diesel Engine Generator, Part VI. 8.8 shows "Max. Critical Deflection" N/A. Explain why this maximum critical deflection was not included, as part of the required assurance of operability.

(2) Page VII-7-5 states:

"The TRS do not completely envelope the SME spectra in the low frequency regions. See Appendix A, Figures VII-A-9-1 through VII-A-9-3. The unenveloped regions of the SME spectra have negligible effects on the total response of the cabinet because the cabinet fundamental frequencies are at least 1.5 times higher than the unenveloped frequencies of the SME spectra. In conclusion, the cabinet and instruments are considered qualified for the SME."

The test, for these cabinets, is described in Appendix A, Table VII-A-9 as multi-axis and multi-frequency. Figure VII-A-9-3 presents the seismic spectra for the side-side/vertical axes of excitation for SME and TRS spectra. This figure shows at the fundamental side-side frequency for the sensor cabinet (6.1 HZ) and the ECCAS cabinet (8.1 HZ), the SME is 1.88 and 2.38, respectively, greater than the TRS accelerations. Clarify the above statement to account for the multi-axis aspect of this test versus the single axis presentation.

(3) Table VII-A-12 (Control Room HVAC OVM-01A and 02A) shows that the unit was qualified by a combination of test and analysis. The natural frequencies for side-side, front-back and vertical by testing were all above 33 HZ (V.5), while the natural frequencies by dynamic analysis were 4.8 HZ (side-side), 5.0 HZ (front-back) and 7.0 HZ (vertical) (VI.2). Explain (1) this discrepancy, (2) why the frequency range for the dynamic analysis did not consider the higher modes up to 33 HZ and (3) why the maximum critical deflection for the motor was not addressed.

(4) Table VII-A-17 (Aux. Feedwater Pump - Motor Driven), Item VI, 8.8 shows "the maximum critical deflection = .003 inches (for the flexible coupling lateral deflection) and the maximum allowable deflection to assure functional operability = .003 inches" for SSE seismic loading. The report, in section 8.7, has only addressed the seismic margins for the high stress locations and not this critical operational deflection. Explain why this maximum deflection was not calculated for the SME spectra accelerations.

(5) Table-A-18 (Aux. Feedwater Pump - Turbine Driven), Item VI.8.B shows "the maximum critical deflection = .003 inches (for the flexible coupling lateral deflection) and the maximum allowable deflection to assure functional operability = .003 inches" for SSE seismic loading. The report, in section 8.8, has only addressed the seismic margins for the high stress locations and not this critical operational deflection. Explain why this maximum deflection was not calculated for the SME spectra accelerations.

(6) Page VII-8-9 for Section 8.7 (Aux. Feedwager Pump - Electric Motor Driven) states: "The SME ZPA's were greater than the design ZPA's in both horizontal directions but were less than the design ZPA in the vertical direction," and for section 8.8 (Aux. Feedwater Pump - Turbine Driven) states: "The design zero period accelerations in the horizontal directions were less than the corresponding SME accelerations, but the vertical design acceleration was greater than the vertical SME acceleration." Since both of these pumps are located in the Auxiliary Building at elevation 524'-0", explain why there is a difference in these two statements and present the appropriate horizontal and vertical seismic spectra.

Thane
Rec'd 10/3/83

Consumers Power Company

Frederick W Buckman
Executive Manager
Midland Project Office

General Offices: 1945 West Parnall Road, Jackson, MI 49201 • (517) 788-1933

September 21, 1983

Harold R Denton, Director
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND ENERGY CENTER
MIDLAND DOCKET NOS 50-329, 50-330
NRC REQUEST FOR ADDITIONAL INFORMATION ON THE
SEISMIC MARGIN REVIEW REPORT
FILE: B3.7.1 SERIAL: 25652

REFERENCE: (1) LETTER FROM J W COOK TO H R DENTON
DATED MARCH 30, 1983

(2) LETTER FROM E G ADENSAM (NRC) TO J W COOK
DATED AUGUST 11, 1983

In reference (1), Consumers Power Company submitted Volume II of the Seismic Margin Review Report titled, "Reactor Containment Building," for the Staff's review. Subsequently, in reference (2) the NRC requested additional information on Volume II in question number 130.30. As an attachment to this letter, CPCo is submitting the response to question 130.30 for Staff review.

It is expected that this information will enable the NRC Staff to complete its review of Volume II of the Seismic Margin Review Report.

FWBuckman

JWC/MFC/bjw

CC PJCook, Midland Resident Inspector
JGKeppler, Administrator, NRC Region III
DSHood, US NRC
FRinaldi, US NRC
GHarstead, Harstead Engineering Company
GBagchi, US NRC
RBosnak, US NRC
MAMiller, US NRC Licensing Branch No 4

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CONSUMERS POWER COMPANY
Midland Units 1 and 2
Docket No 50-329, 50-330

Letter Serial 25652 Dated September 21, 1983

At the request of the Commission and pursuant to the Atomic Energy Act of 1954, and the Energy Reorganization Act of 1974, as amended and the Commission's Rules and Regulations thereunder, Consumers Power Company submits additional information on the Seismic Margin Review Report Volume II titled, "Reactor Containment Building."

CONSUMERS POWER COMPANY

By F W Buckman
F W Buckman, Executive Manager
Midland Project Office

Sworn and subscribed before me this 21st day of Sept, 1983.

Pamela J. Griffin
Notary Public
Jackson County, Michigan

My Commission Expires Sept 8, 1984

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130.0 STRUCTURAL ENGINEERING BRANCH

130.30 With respect to Volume II, Seismic Margin Review: Reactor Containment Building, forwarded by your letter of March 30, 1983, provide the following information:

Question 130.30.1 The response spectra in Figures II-5-3 through 6, -10 through -22, -24, -27, -30, -33, -36 and -39 show the valleys. This does not seem consistent with the previously made statement that the peaks of three soil stiffnesses would be connected so as to eliminate valleys and, therefore, cover possible intermediate soil stiffnesses. Please discuss this inconsistency.

Response: The final Seismic Margin Earthquake (SME) in-structure response spectra were developed as an envelope of the broadened spectra for the different soil cases at each location as discussed in Section 8 of Volume I. This development of the enveloped spectra considered possible shifting of structure frequencies due to uncertainty in actual site soil conditions. The enveloped spectra were further smoothed to remove minor valleys.

The procedure used to develop the in-structure response spectra can be demonstrated by the example in the attached Figure Q&R 130.30.1-1. This figure forms the basis for Figure II-5-4 for 2 percent of critical damping and is similar to all the questioned response spectra curves. The three dashed lines in the figure correspond to the in-structure response spectra generated for the lower bound, intermediate, and upper bound soil cases. These spectra already include a peak broadening of $\pm 1.10f_j$ on structure mode j having frequency f_j. The solid line surrounding the dashed line spectra represents an envelope of the results for the three soil cases studied that accounts for possible variations in structure frequencies.

The first peak in the final enveloped spectrum accounts for the possible variation in the fundamental reactor building frequency. These frequencies are presented in Table II-3-2 of Volume II and range from a low of 1.13 Hz for the lower bound soil case to a high of 2.60 Hz for the upper bound soil case. The second peak in this spectrum accounts for possible variation in the second mode response of the structure. Frequencies for this mode range from 2.37 Hz for the lower bound soil case to 6.16 Hz for the upper bound soil case. The valley between the two peaks represents a region where amplified reactor building structural response does not occur from either the fundamental or second mode for the range of soil conditions considered. Enveloped spectra at all locations on the reactor building were developed in a similar fashion.

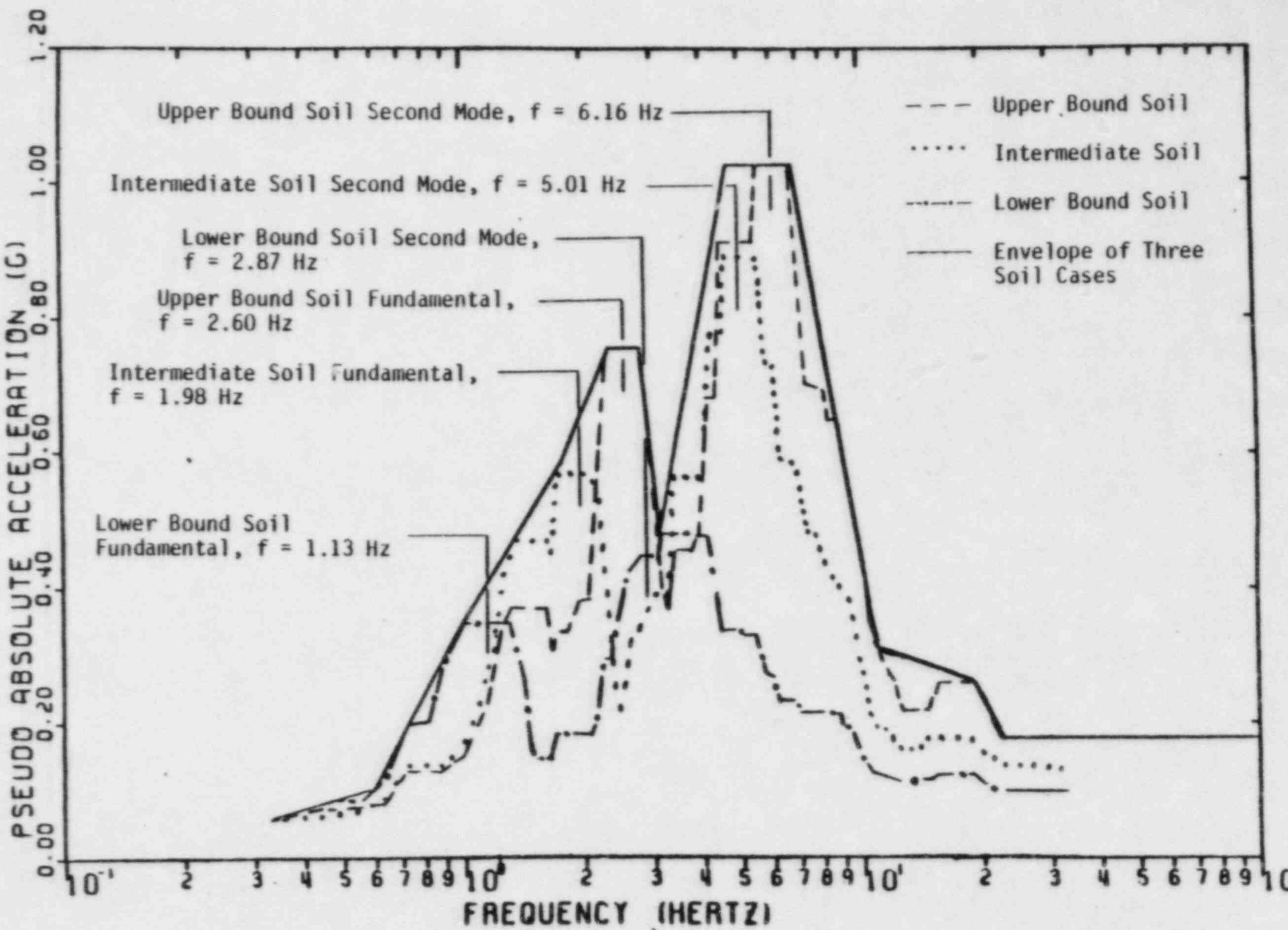

FIGURE Q&R 130.30.1-1 ENVELOPED SRSS COMBINED RESPONSE SPECTRA REACTOR BUILDING, INTERNAL STRUCTURE, ELEVATION 626'-0", NORTH-SOUTH DIRECTION, 2% CRITICAL DAMPING

Question 130.30.2 Section 5 of the report presents in-structure response spectra for internal structures. However, none are provided for the steam generators and the reactor vessel. Please provide these missing spectra or justify their omission.

Response: Volume II was written to describe the analysis of the reactor containment buildings and their internal structures. In addition, Volume II presents the in-structure response spectra for use in evaluating equipment attached to the structure. Seismic input at the Nuclear Steam Supply System (NSSS) interfaces in the reactor containment buildings was developed by Structural Mechanics Associates, Inc. (SMA) for the Seismic Margin Earthquake. This input was defined in terms of translational and rotational time histories and response spectra for each of the three soil cases studied. The requested seismic response spectra were generated by Babcock & Wilcox (B&W), the NSSS Vendor. Since the B&W generated seismic response spectra are only an intermediate step in the Balance-of-Plant piping analysis, they were not included in Volume VIII. Figures Q&R 130.30.2-1 through Q&R 130.30.2-7 present the schematic of the reactor vessel model used by B&W and the seismic response spectra for 4 percent of critical damping. Similarly, Figures Q&R 130.30.2-8 through Q&R 130.30.2-17 are presented for the steam generators.

Question 130.30.3 Table II-3-4 of the report provides comparison between the accelerations from the direct integration and modal superposition. Please provide a comparison of these values with the values of the peak modal accelerations calculated from the response spectrum method.

Response: Table Q&R 130.30.3-1 presents a comparison of the reactor building in-structure zero period accelerations determined by direct integration, modal superposition, and response spectrum techniques for the upper bound soil case.

TABLE Q&R 130.30.3-1

COMPARISON OF IN-STRUCTURE ZERO PERIOD ACCELERATIONS DETERMINED BY DIRECT INTEGRATION, MODAL SUPERPOSITION, AND RESPONSE SPECTRUM TECHNIQUES

UPPER BOUND SOIL CASE

Location	North-South Response Due to North-South Excitation			East-West Response Due to East-West Excitation			Vertical Response Due to Vertical Excitation		
	Direct Integration	Modal Superposition	Response Spectrum	Direct Integration	Modal Superposition	Response Spectrum	Direct Integration	Modal Superposition	Response Spectrum
Containment - Elev. 786'-0"	0.385	0.386	0.360	0.389	0.392	0.362	0.114	0.114	0.108
Containment - Elev. 664'-0"	0.170	0.167	0.164	0.177	0.181	0.166	0.106	0.109	0.096
Containment - Elev. 591'-6"	0.139	0.159	0.116	0.138	0.154	0.118	0.099	0.105	0.081
Reactor Internals - Elev. 685'-0"	0.270	0.284	0.263	0.277	0.292	0.287	0.099	0.107	0.087
Reactor Internals - Elev. 640'-0"	0.188	0.205	0.175	0.184	0.199	0.186	0.098	0.106	0.086

Question 130.30.4 For Equation 3-3 you have determined the capacity utilizing the load factors as unity. It may be reasonable to utilize a load factor greater than unity for the pressure and the equivalent operating basis earthquake. We would consider a factor of 1.25 for these two terms in Equation 3-3. Please provide the results of this study and a comparison with current results from Equation 3-3.

Response: Code margins for the containment were determined using the load combination expressed in Equation 3-3. This load combination, which utilizes load factors of unity for the Seismic Margin Earthquake (SME) and the design basis accident internal pressure and thermal gradient, is consistent with the Seismic Margin Review (SMR) criteria described in Volume I of this report. The scope of the Seismic Margin Review (SMR) was first presented to the staff in a meeting in Bethesda on June 30, 1981. After a follow-on telephone conference on July 17, 1981, the staff agreed to the applicants SMR. In addition, the scope of the SMR has been presented to ACRS subcommittee and full committee meeting and has been accepted.

Question 130.30.5 Fie'd reports have indicated cracks in the outside surfaces of the containment structures. These cracks have been described as thru-cracks at buttresses locations. Please address the following concerns:

(a) State if your evaluation has considered these cracks in the determination of the seismic margins and provide a discussion on the subject.

(b) If these cracks have not been considered in your evaluation, provide a discussion addressing the reasons for the omission of this condition or provide your proposed method of evaluating the effects of these reported cracks in the determination of the seismic margins to current code allowables, and if necessary, the seismic margins to failure.

Response: The structure response was conservatively based on uncracked structure stiffness properties. Utilization of uncracked stiffness properties leads to an increase in the structure-soil system frequencies. This, in turn, produces greater seismic loads compared with those resulting from the use of the cracked stiffness properties. Because the structure seismic loads were developed from the uncracked properties, reported structure seismic loads and code margins are conservative.

The cracks identified at the outer surfaces of the containment structures were not considered in the Seismic Margin Review (SMR). These cracks, located near the intersections of the buttresses and the base slabs, are small in width with random orientations. The cracks have been concluded to be due to volume change effects caused primarily by local restraint against concrete shrinkage strain (Reference 2). References 1, 2, and 3 have noted that this type of cracking is expected for containment structures and have also concluded that these cracks do not affect the containment integrity. Based on the information available, it can be concluded that the cracks at the buttresses are not significant and should not be considered in the SMR.

References:

1. Affidavit of Dr. Palanichamy Shunmagavel, before the Atomic Safety and Licensing Board, Nuclear Regulatory Commission, in the Matter of Consumers Power Company, Midland Plant, Units 1 and 2, Docket Nos. 50-329-OM, 50-330-OM, 50-329-OL, 50-330-OL, July 15, 1983.

2. Affidavit of Dr. W. G. Corley, before the Atomic Safety and Licensing Board, Nuclear Regulatory Commission, in the Matter of Consumers Power Company, Midland Plant, Units 1 and 2, Docket Nos. 50-329-OM, 50-330-OM, 50-329-OL, 50-330-OL, July 15, 1983.

3. Atomic Safety and Licensing Board Memorandum and Order, dated August 17, 1983, in the Matter of Consumers Power Company, ASLBP 78-389-03OL and 80-429-02SP.

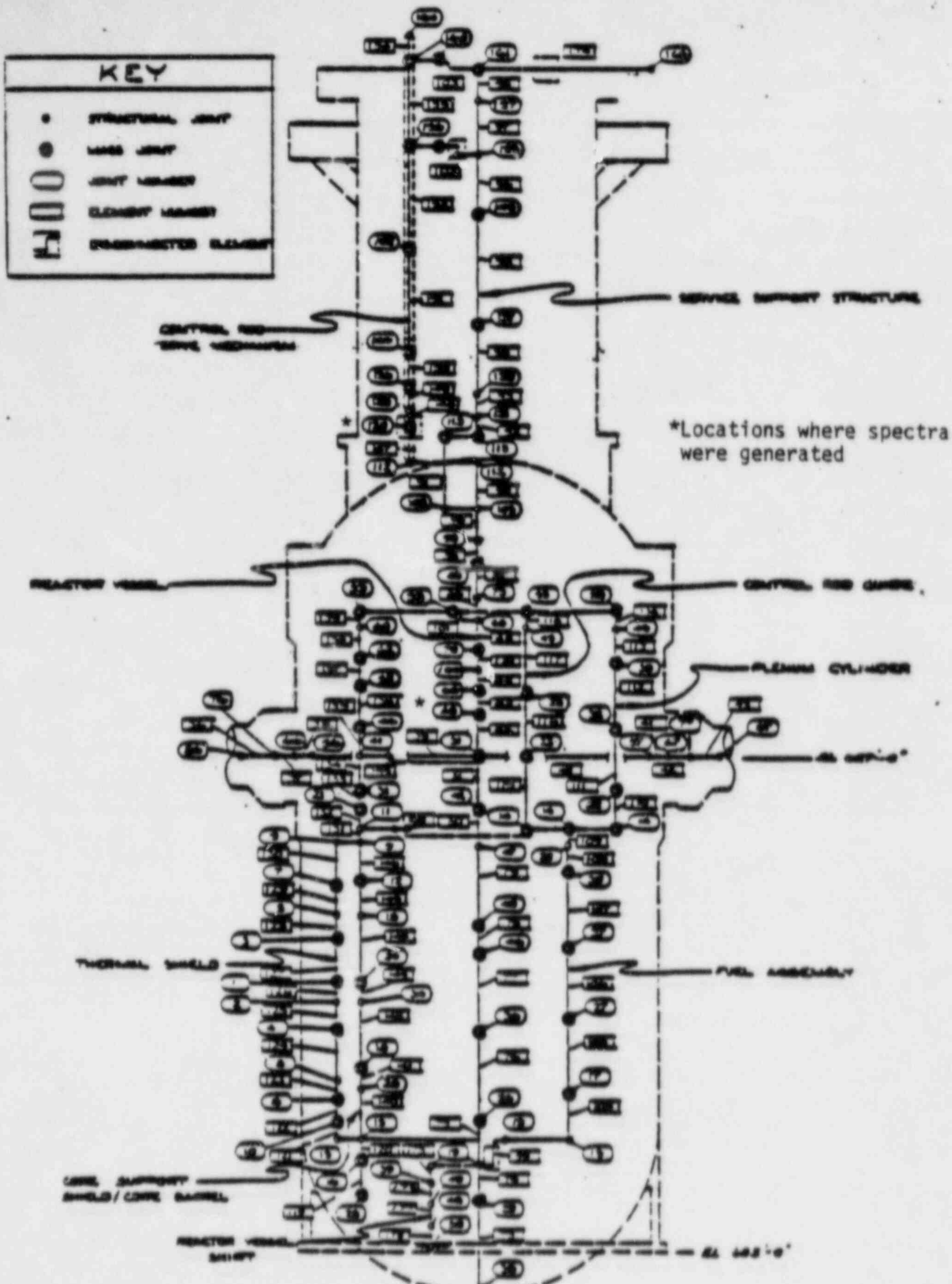

FIGURE Q&R 130.30.2-1. Reactor Vessel Isolated Model

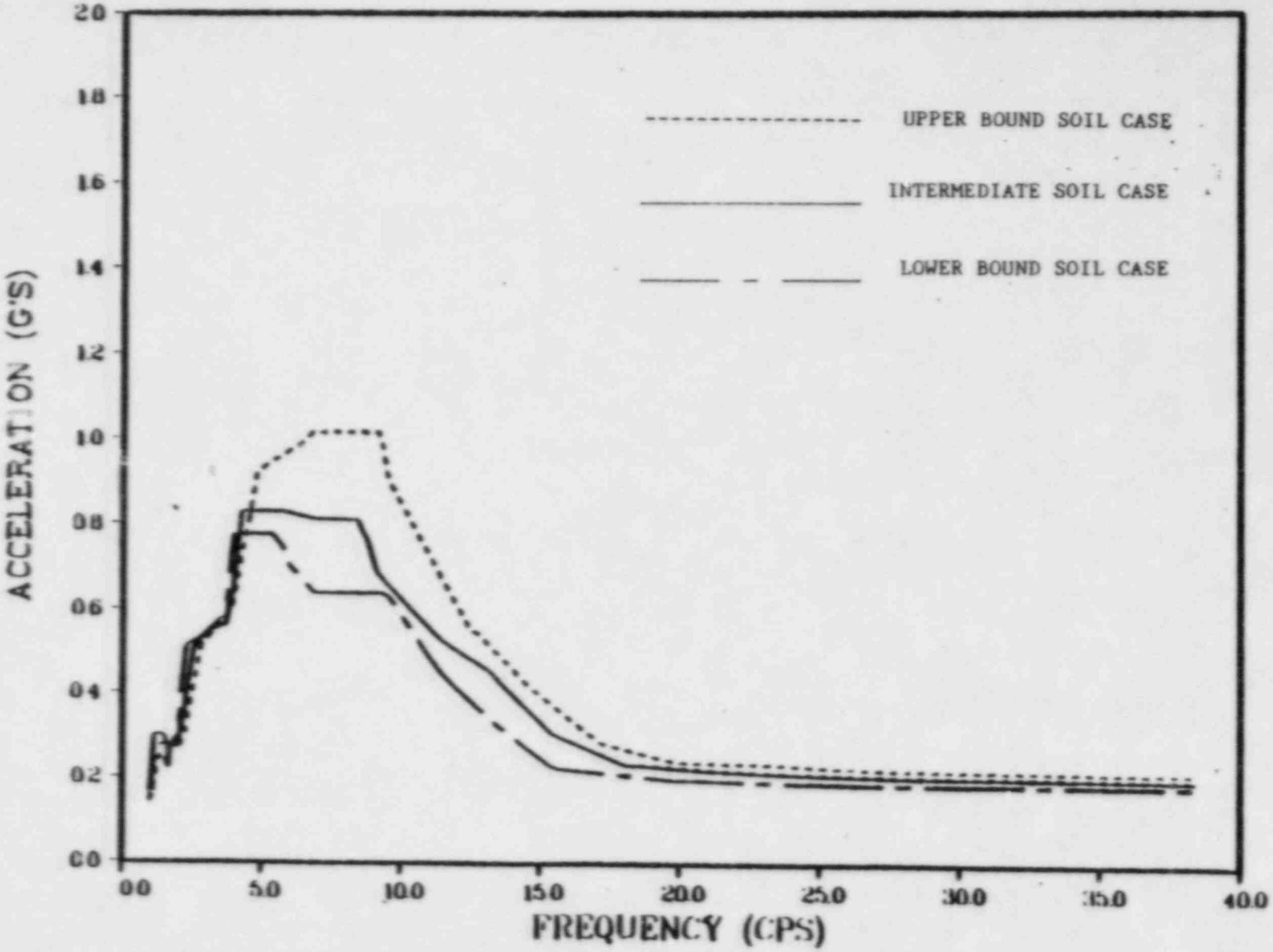

FIGURE Q&R 130.30.2-2. RVIS Point 58 X-DIR 4% Damping

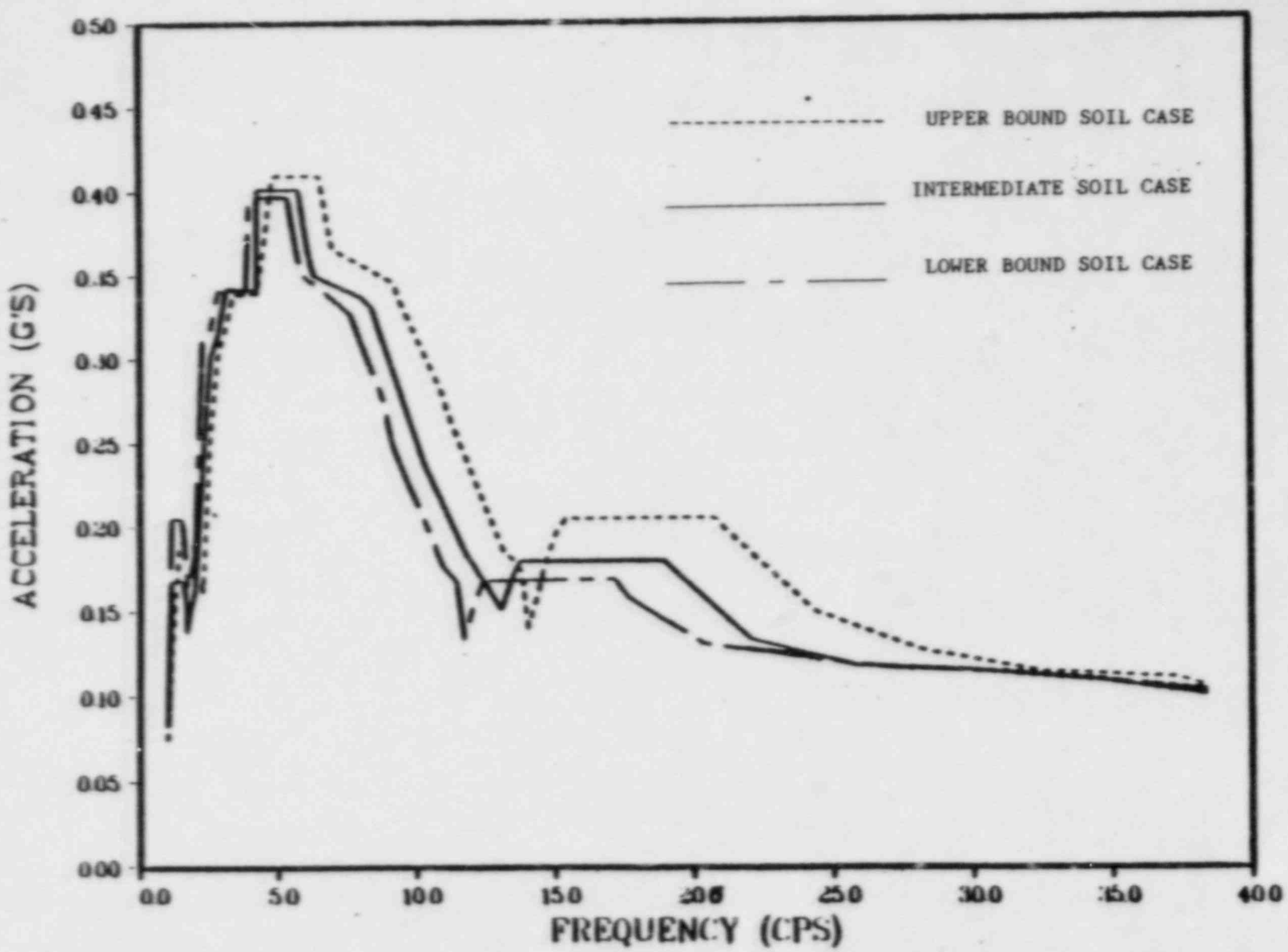

FIGURE Q&R 130.30.2-3. RVIS Point 58 Y-DIR 4% Damping

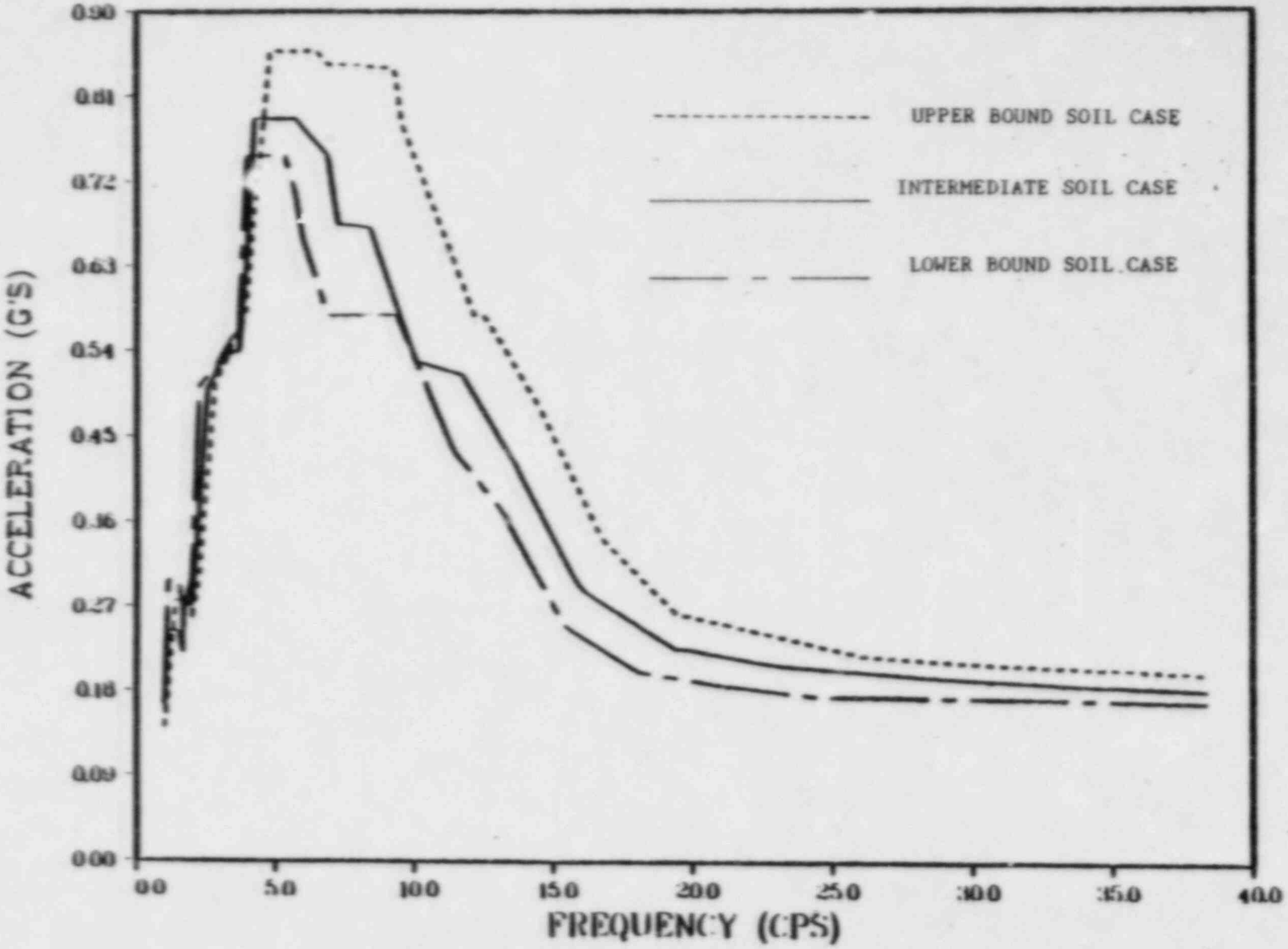

FIGURE Q&R 130.30.2-4. RVIS Point 58 Z-DIR 4% Damping

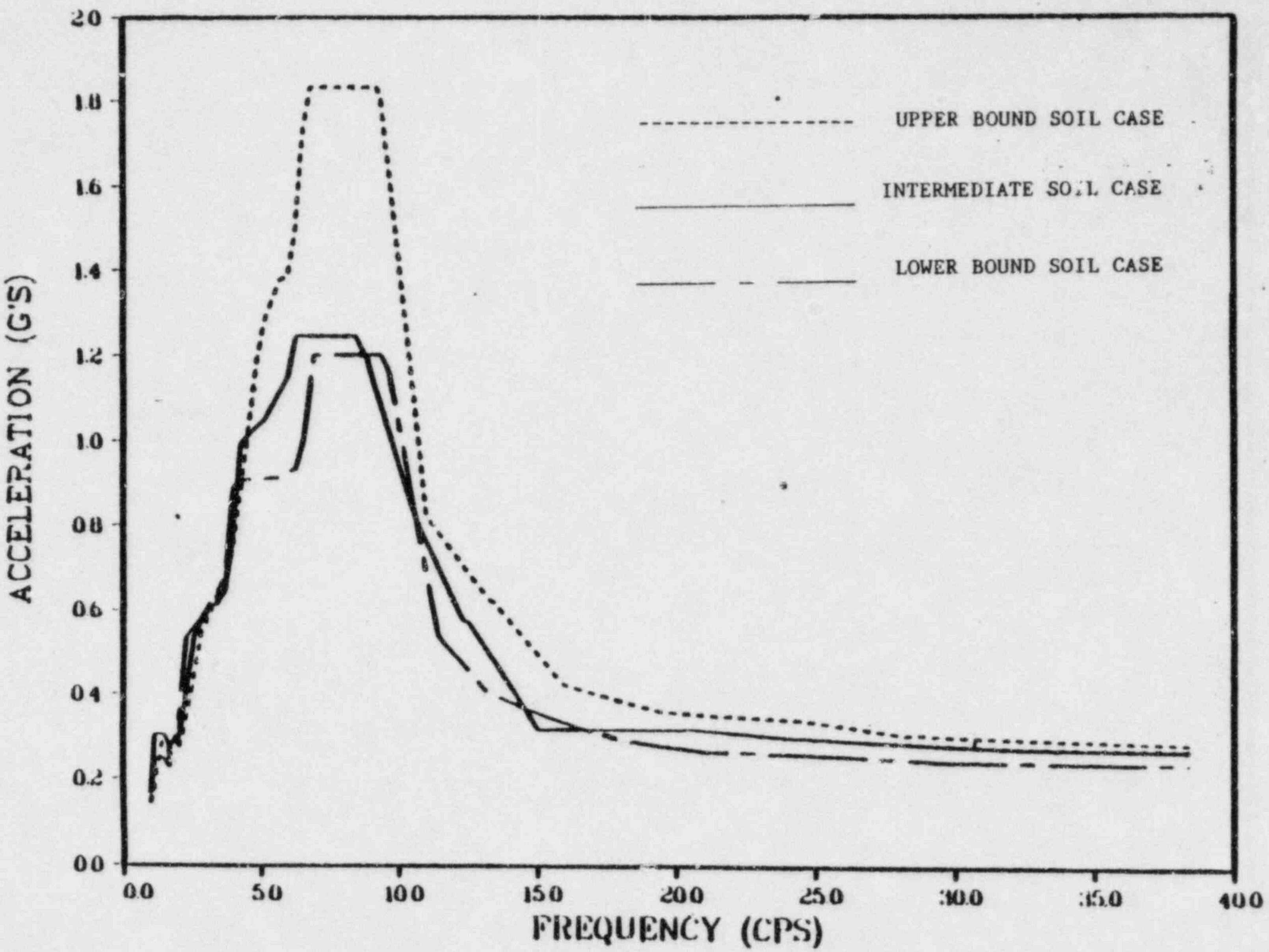

FIGURE Q&R 130.30.2-5. RVIS Point 120 X-DIR 4% Damping

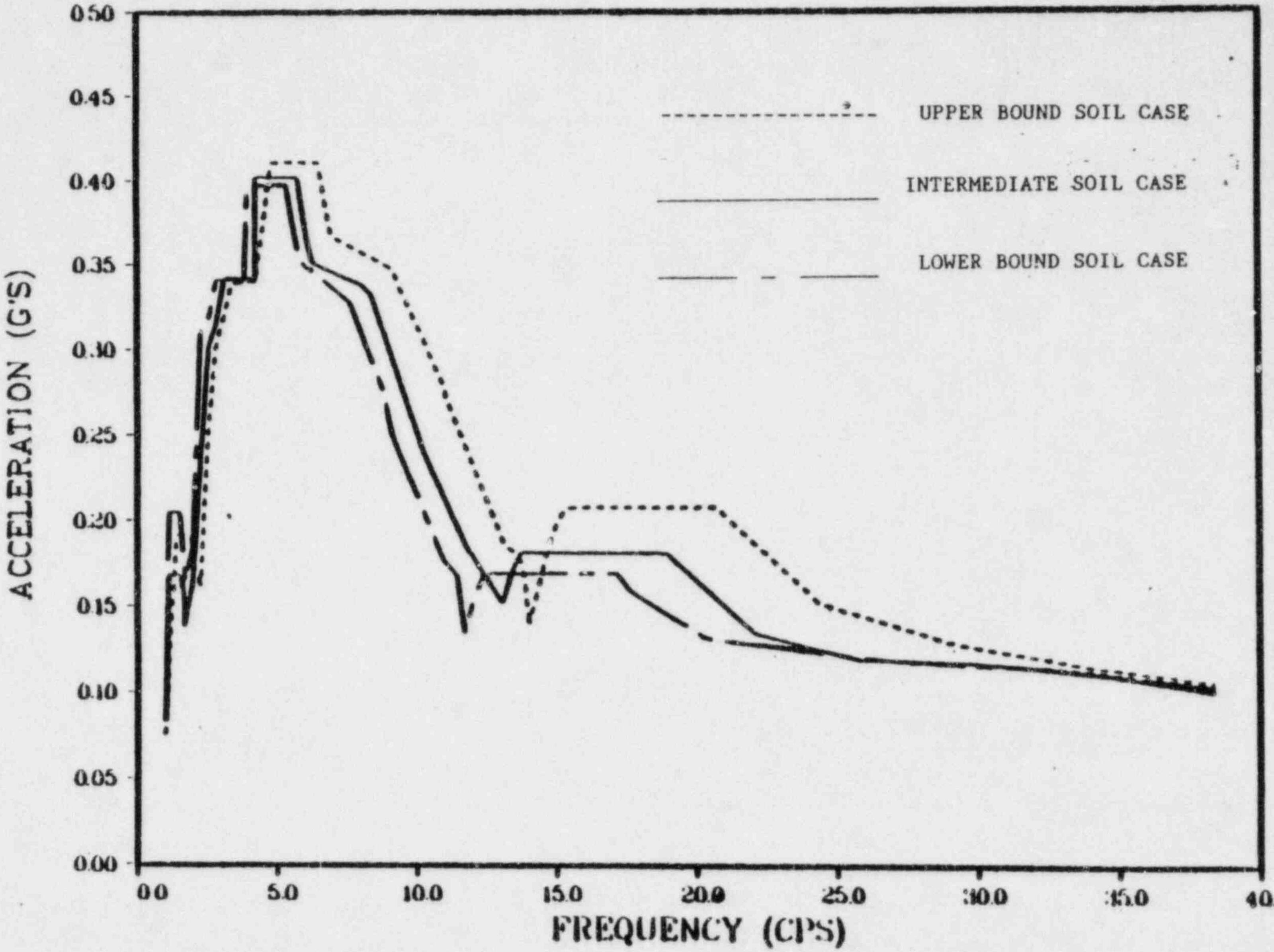

FIGURE Q&R 130.30-2.6. RVIS Point 120 Y-DIR 4% Damping

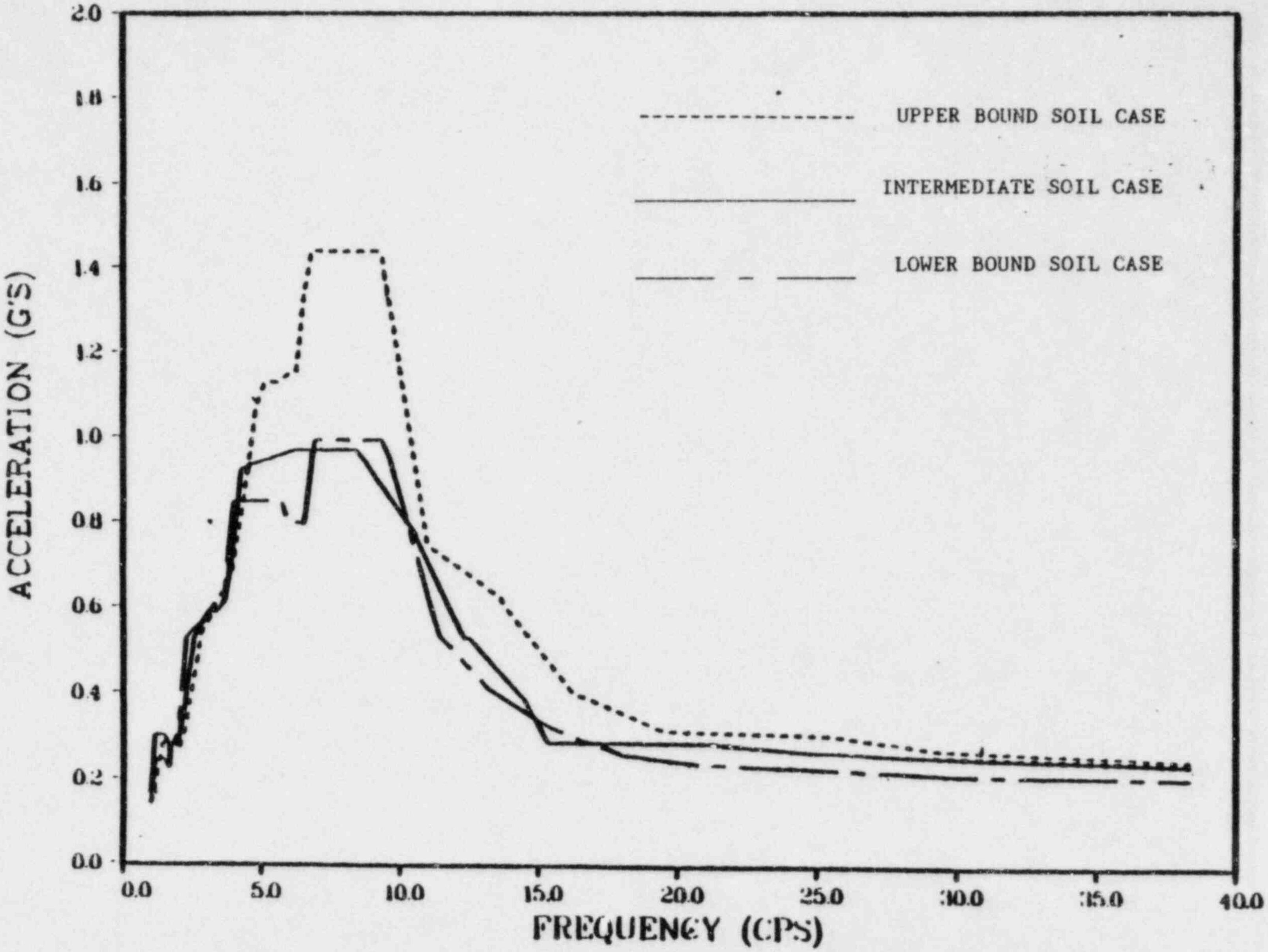

FIGURE Q&R 130.30.2-7. RVIS Point 120 Z-DIR 4% Damping

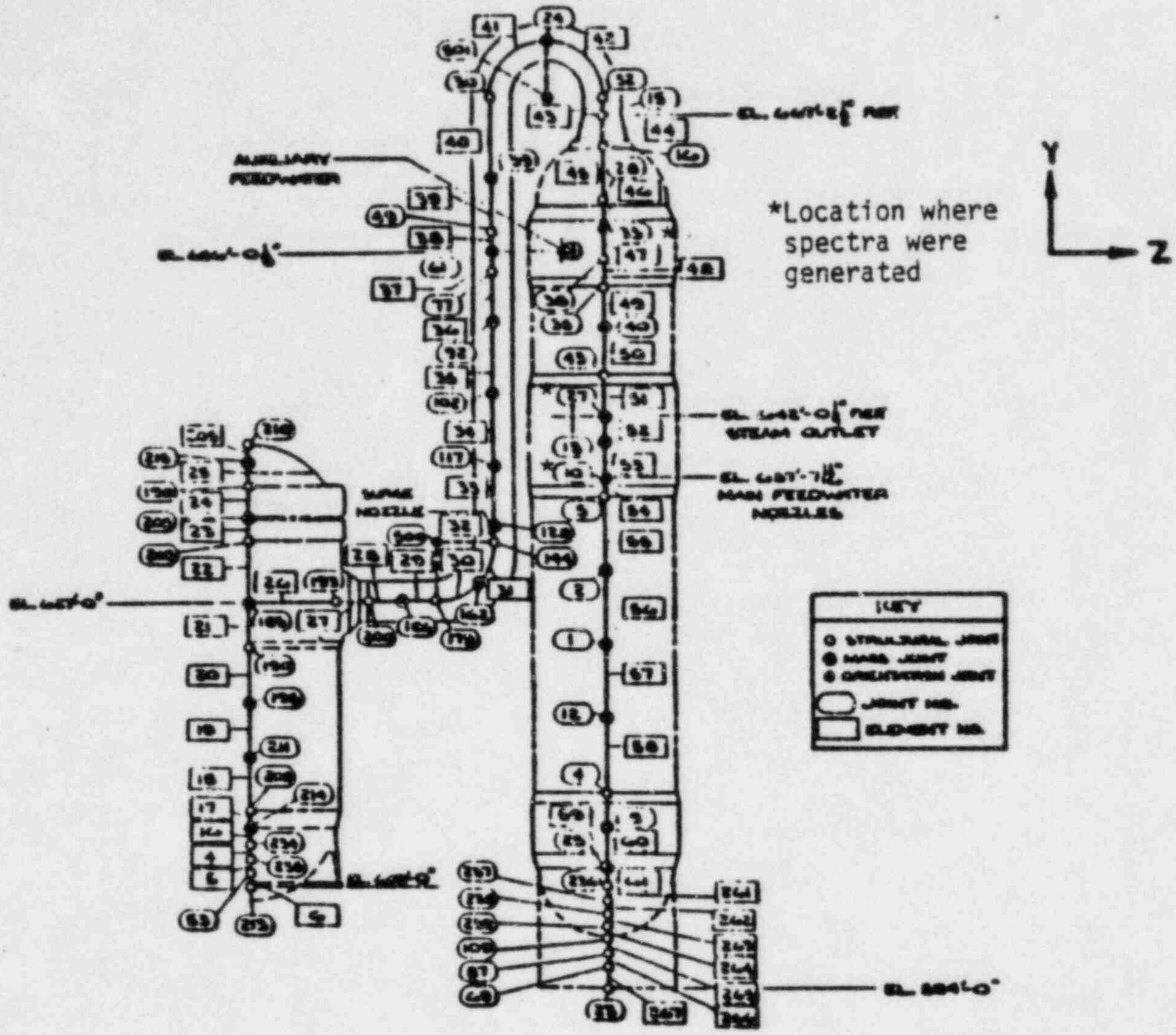

FIGURE Q&R 130.30.2-8. NSSS Loop Model

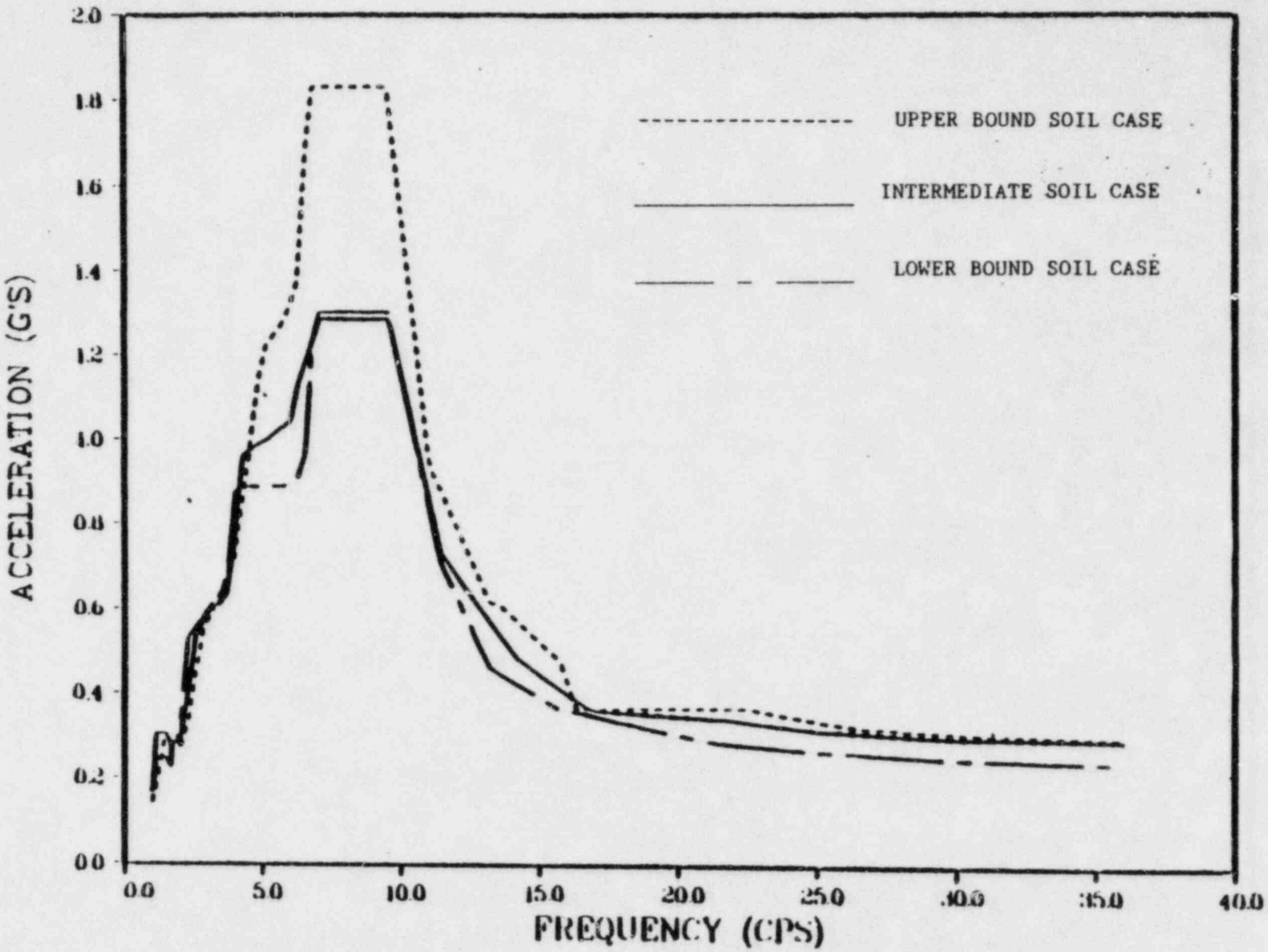

FIGURE Q&R 130.30.2-9. OTSG Point 10 X-DIR 4% Damping

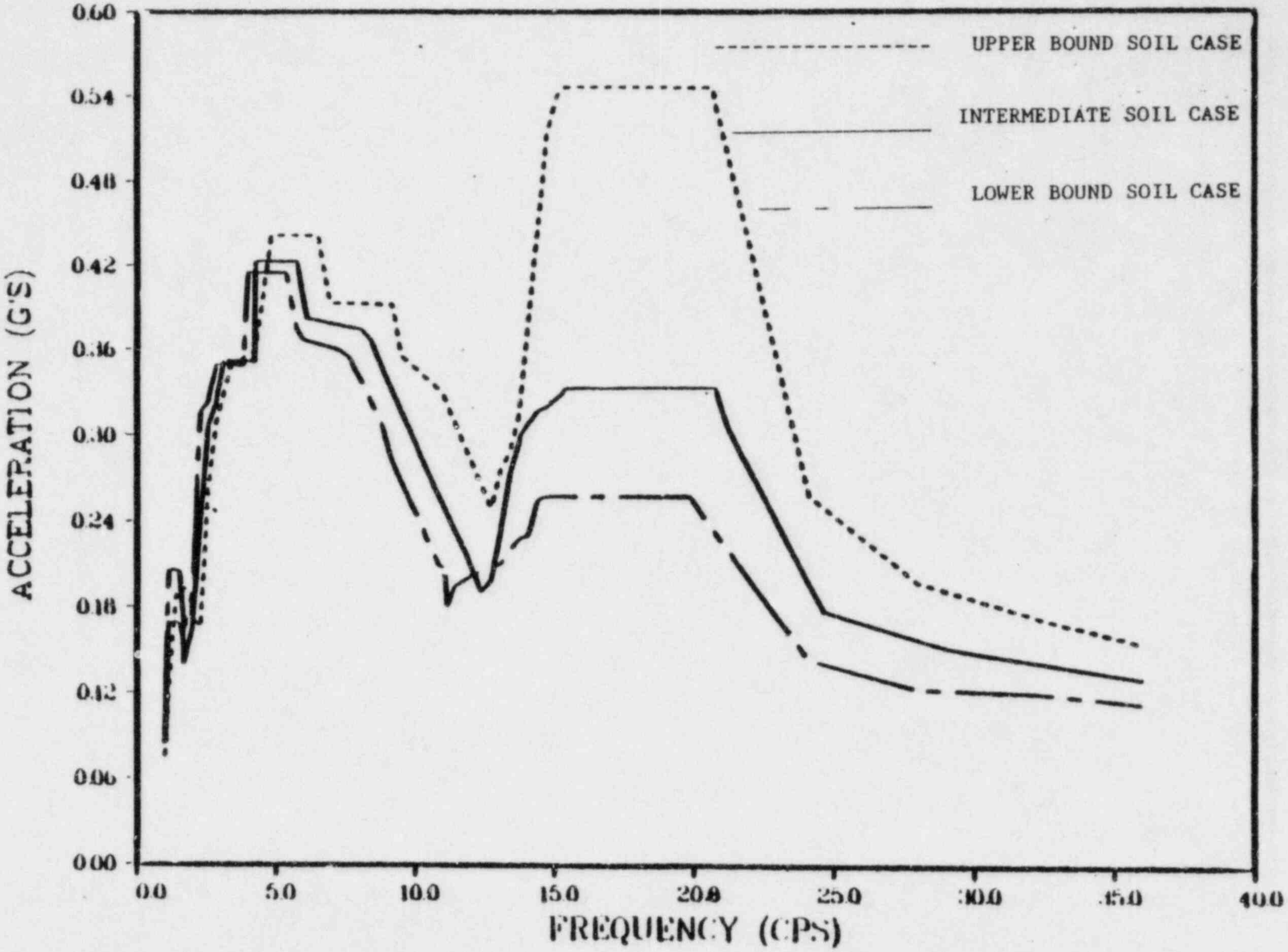

FIGURE Q&R 130.30.2-10. OTSG Point 10 Y-DIR 4% Damping

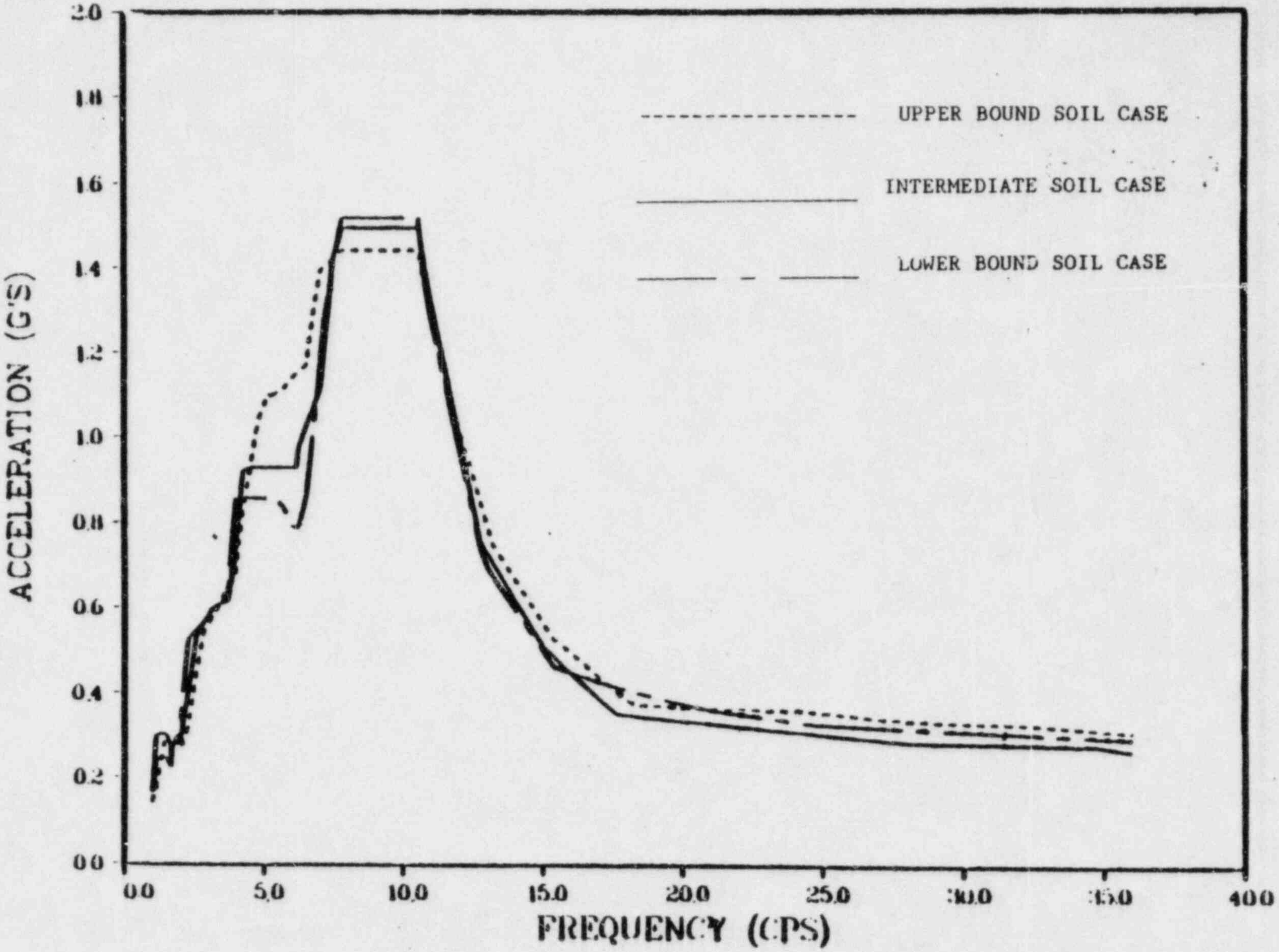

FIGURE Q&R 130.30.2-11. OTSG Point 10 Z-DIR 4% Damping

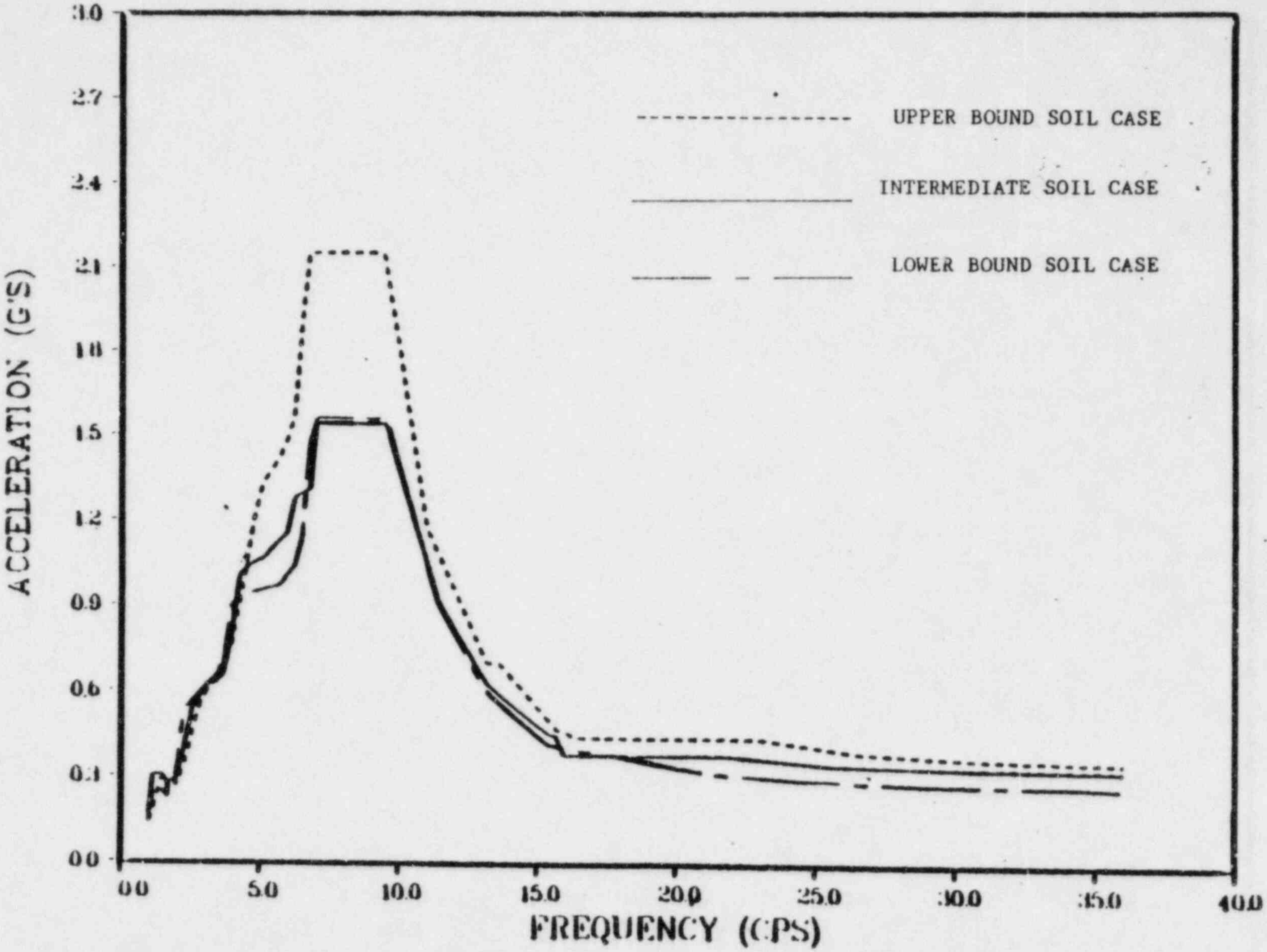

FIGURE Q&R 130.30.2-12. OTSG Point 33 X-DIR 4% Damping

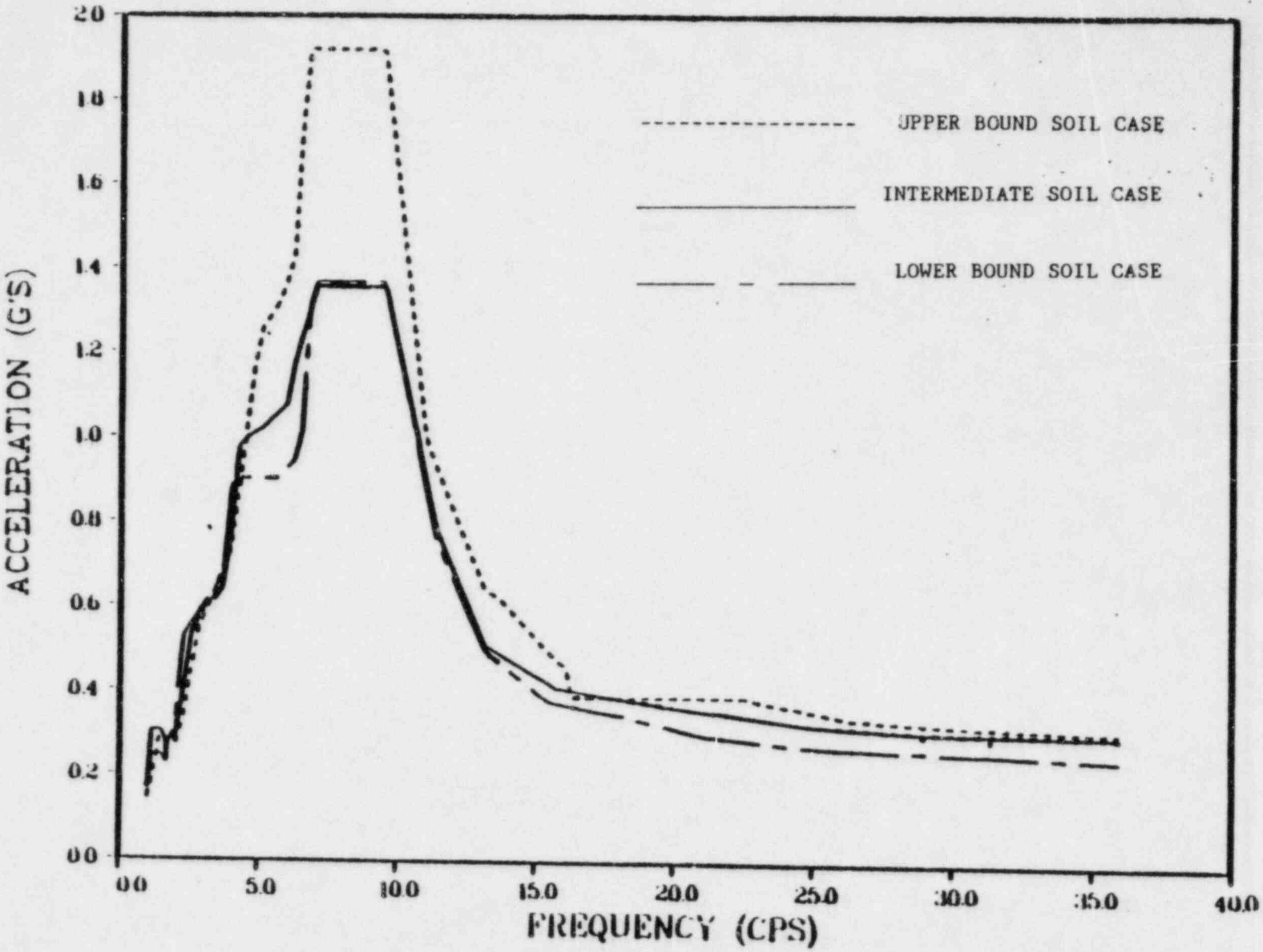

FIGURE Q&R 130.30.2-13. OTSG Point 27 X-DIR 4% Damping

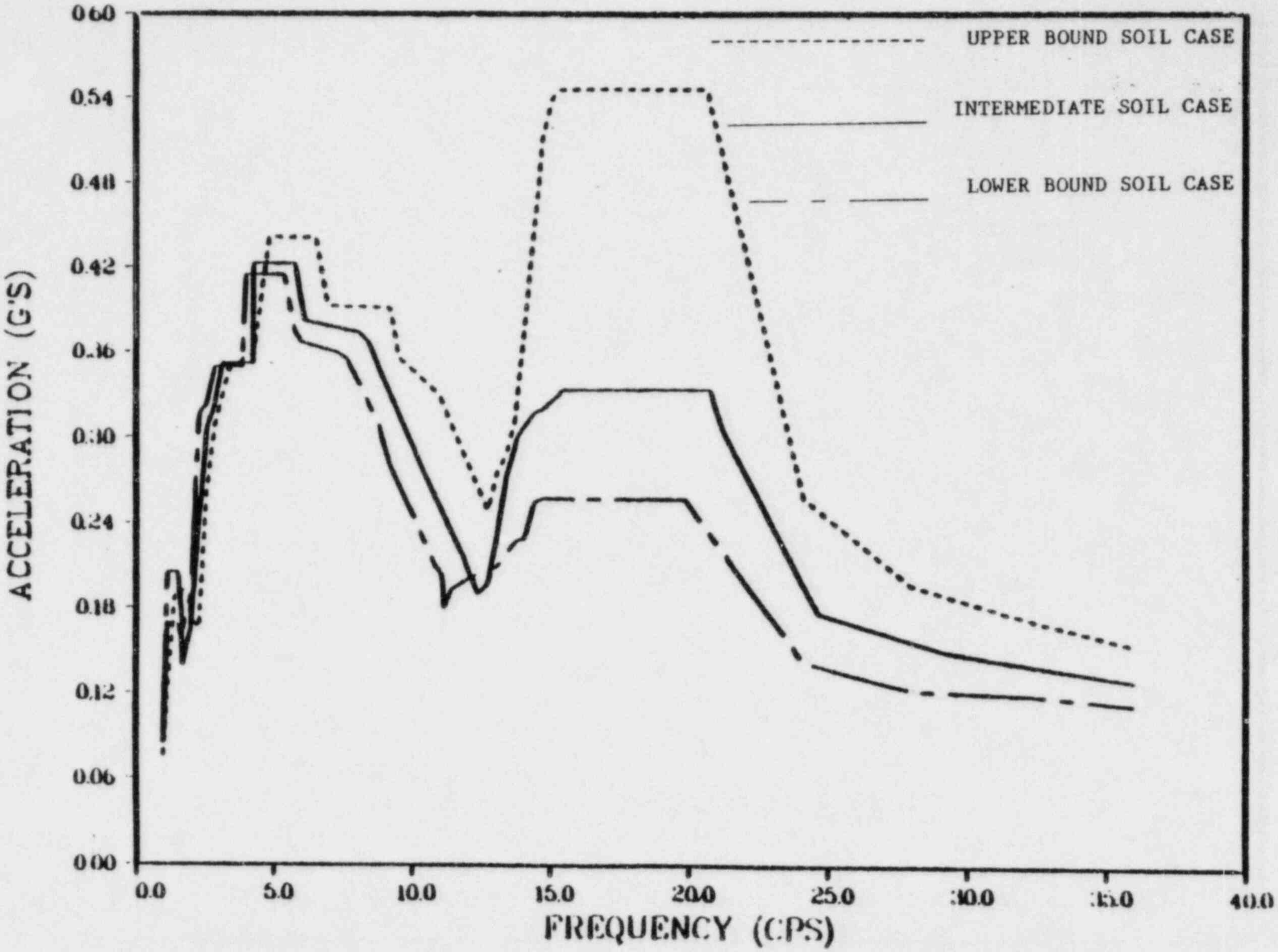

FIGURE Q&R 130.30.2-14. OTSG Point 27 Y-DIR 4% Damping

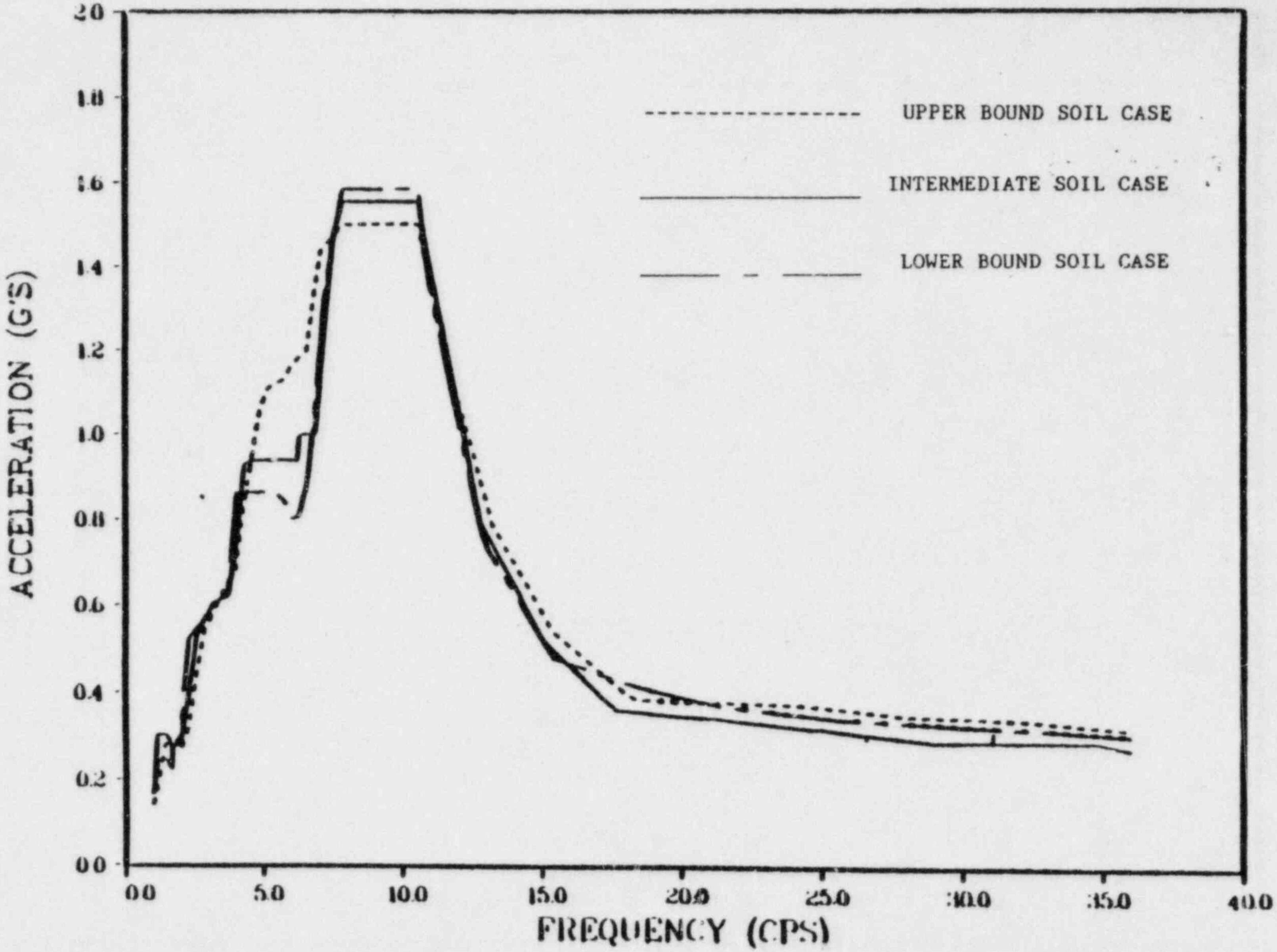

FIGURE Q&R 130.30.2-15. OTSG Point 27 Z-DIR 4% Damping

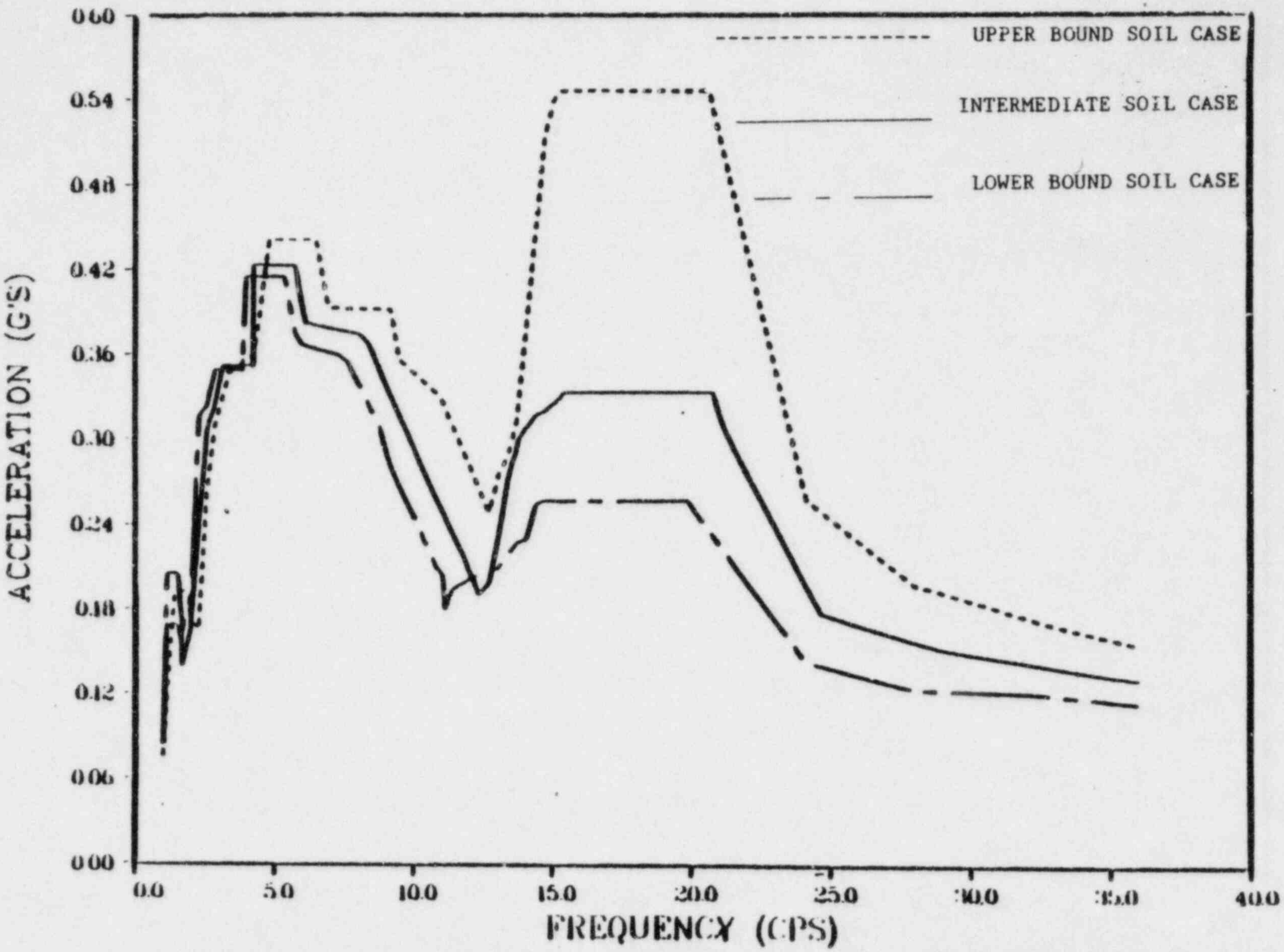

FIGURE Q&R 130.30.2-16. OTSG Point 33 Y-DIR 4% Damping

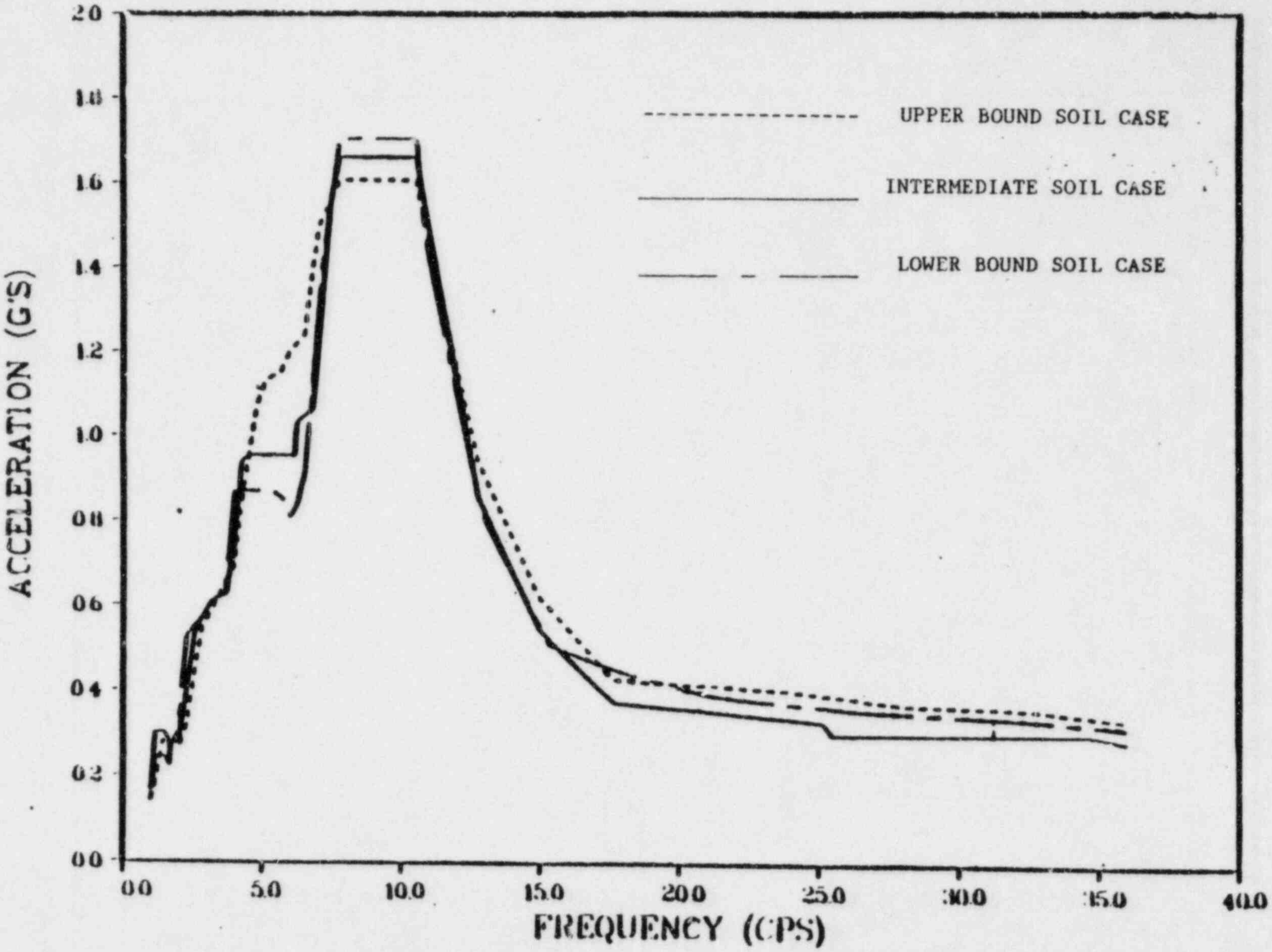

FIGURE Q&R 130.30.2-17. OTSG Point 33 Z-DIR 4% Damping