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SCHWENCER,A. Licensing Branch 2

SUBJECT: Forward info to close out open issues of NRC structural audit.Info also closes SER Open Items 27,30,31.SER Item 34 re load verification should be changed to confirmatory.

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NIAGARA MOHAWK

NIAGARA MOHAWK POWER CORPORATION/300 ERIE BOULEVARD WEST, SYRACUSE, N.Y. 13202/TELEPHONE (315) 474-1511

July 6, 1984
(NMP2L 0103)

Mr. A. Schwencer, Chief
Licensing Branch No. 2
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Schwencer:

Re: Nine Mile Point Unit 2
Docket No. 50-410

Enclosed for your review are eight copies of information to close out certain open issues of the Nuclear Regulatory Commission Structural Audit. During the Structural Audit of December 12 through 16, 1983, we committed to provide this information.

We believe that this information also closes the NRC staff Safety Evaluation Report Open Items numbered 27, 30, 31. Also Safety Evaluation Report Item 34 should be changed to confirmatory, since we have committed to provide the results of the load verification in September 1985 (see Structural Audit Item 1 attached).

Sincerely,

NIAGARA MOHAWK POWER CORPORATION

C. V. Mangan
C. V. Mangan
Vice President
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NINE MILE POINT NUCLEAR STATION - UNIT 2

NRC REQUEST NO. 1

Verify and confirm the design of all structures affected by SRV and hydrodynamic loading.

RESPONSE

The design of the reactor pedestal has been verified to account for the SRV and hydrodynamic loadings described in Tables GA.5-1 through GA.5-8. Although these loads are higher than those used in the original design, adequate design margin was provided in the original design so that stresses remain within acceptable limits.

The load verification for the other structures will be completed by September 1985. The NRC will be notified of the results of the verification upon completion.

NRC REQUEST NO. 2

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
Chapter 1, General Requirement		a) Requires copies of structural drawings, typical details, and specification be signed by licensed engineer		a) NMP2 Project drawings and specifications are prepared under the supervision of licensed engineers, who also sign the documents.
		b) Requires inspection by owner	b) Recommends inspectors be experienced and familiar with ACI and ASTM standards	b) Inspections are performed by the owner's Quality Control representatives who are familiar with the standards.
Chapter 2, Definitions		a) OBE, SSE defined in accordance with 10CFR100, Appendix A		a) NMP2 Project seismic design is based on NRC Regulatory Guide 1.60, which meets the requirements of Appendix A to 10CFR100.
	b) Massive concrete not specifically mentioned	b) Requires areas to be treated as massive concrete to be identified on drawings or specifications		b) NMP2 Project concrete specification defines the massive concrete and the special requirements for massive concrete placement.
Chapter 3, Materials	a) No certified mill test reports (CMTRs) required for cement	a) CMTRs required on each cement shipment. No cement can be used prior to receipt of 7-day mill test strength		a) NMP2 Project specifications require mill test reports for each cement shipment. Cement conforms to ASTM C150, Type II, low alkali.
		b) Excludes use of lightweight aggregate concrete		b) NMP2 Project specifications refer to ASTM C33 for aggregates, which exclude lightweight aggregates.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
	c)Allows use of rail-steel and axle steel bars. Also allows Grade 90 bars	c)Requires use of Billet steel reinforcing bars of Grade 60 or less only		c)NMP2 Project specification requires that the material for rebars comply with ASTM A615 Grade 40 through Grade 60.
		d)Acceptance testing of the materials for concrete (e.g., cement, aggregates, etc) is required		d)NMP2 Project specifications require acceptance testing of the concrete materials as required by ANSI N45.2.5, which meets or exceeds the ACI 349 requirements.
Chapter 4, Concrete Quality	a)Frequency of compressive strength tests: i not less than once a day ii not less than once for 150 cy of concrete	a)Same as for ACI 318 with a provision to decrease frequency of testing by 50 cy for each 100 psi lower standard deviation	a)Requires testing frequency in accordance with ANSI N45.2.5 once every 100 cy of concrete or once a day	a)NMP2 Project complies with ANSI N45.2.5, frequency of testing.
Chapter 5, Mixing and Placing Concrete		b)Requires that construction specifications include: i. method of curing ii. method of controling temperature for hot weather concreting		b)NMP2 Project concrete specifications describe the method of controlling temperature for hot weather concreting.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
Chapter 6, Formwork, Embedded Pipes, and Construction Joints		a)Refer to ACI 347 for formwork design		a)NMP2 Project complies with ACI 347.
	a)Limits pressure and temperature of embedded piping to 200 psi and 150°F, respectively	a)Limits pressure to 200 psi. However, allows 200°F for localized areas, 350°F for accident or short-term periods, and 650°F for the local areas affected by fluid jet during pipe rupture.		a)NMP2 Project complies with ACI 349.
		b)All construction joints shall be indicated on the drawings or approved by the engineers		b) NMP2 Project drawings indicate the construction joints on the drawings. Any revision to the drawings is subject to prior approval of the engineers.
	c) Vertical construction joints to be coated with neat cement grout	c) Vertical construction joints to be saturated with water prior to placing new concrete		c) NMP2 Project complies with ACI 318 and ACI 349.
Chapter 7, Details of Reinforcement		a) Rebar placement tolerances are same as those stated in ACI 301		a) NMP2 Project complies with the tolerances stated in ACI 301 and therefore complies with ACI 349.
		b) Requires tests on full welded splices and full positive connections		b) NMP2 Project follows the requirements of ANSI N45.2.5 for positive connections.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
		c) Requires welded splices or positive connections for splicing load-carrying rebar located in a region with membrane tension normal to splice		c) NMP2 Project uses cadweld splices to splice N14 and N18 rebars in accordance with NRC Regulatory Guide 1.10 and ANSI N45.2.5. Welded splices are used when cadwelding is possible.
Chapter 8, Analysis and Design	a) Provides procedures for alternate design method using service loads and permissible service load stresses	a) Does not address such method		a) NMP2 Project uses strength design methods of ACI 318.
	b) Allows use of fillers in concrete joist construction	b) Prohibits use of fillers in concrete joist construction		b) Concrete joints are not used at NMP2 Project, therefore not applicable.
Chapter 9, Strength and Serviceability Requirements		c) Requires consideration of dynamic response of concrete structure, its foundation, and surrounding soil		c) NMP2 Project considers the dynamic loading in the design of structures.
				d) (Refer to Table 3.8-11 of FSAR)
	d) Loading Combinations			NMP2 Project Combinations
	1. U = 1.4D + 1.7L	d) 1. U = 1.4D + 1.7L + 1.7Ro		1. U = 1.4D + 1.7L + 1.3 (To + Ro)
	2. U = 0.75 (1.4D + 1.7L + 1.7W)	2. U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7Eo + 1.7Ro	2. U = 1.4D + 1.4F + 1.7L + 1.7H + 1.9Eo + 1.7Ro	2. U = 1.4D + 1.7L + 1.9Eo + 1.3 (To + Ro)

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
	3. U = 0.9D + 1.3W	3. U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7W + 1.7Ro	6. U = D + F + L + H + Ta + Ra + 1.5Pa	3. U = 1.4D + 1.7L + 1.7W + 1.3 (To + Ro)
	4. U = 0.75 (1.4D + 1.7L + 1.9Eo)	4. U = D + F + L + H + To + Ro + Ess	7. U = D + F + L + H + Ta + Ra + 1.25Pa + 1.0 (Yr + Yj + Ym) + 1.25Eo	4. U = D + L + To + Ro + Ess 5. U = D + L + To + Ro + Wt
	5. U = 1.4D + 1.7L + 1.7H	5. U = D + F + L + H + To + Ro + Wt	9. U = 1.05D + 1.3L + 1.3To + 1.3Ro	5a. U = D + L + F + To + Ro
	6. U = 0.9D + 1.7H	6. U = D + F + L + H + Ta + Ra + 1.25Pa	10. U = 1.05 (D + F) + 1.3 (L + H) + 1.7Eo + 1.3 (To + Ro)	6. U = D + L + Ta + Ra + 1.5Pa
	7. U = 1.4D + 1.7L + 1.4F	7. U = D + F + L + H + Ta + Ra + 1.5Pa + 1.0 (Yr + Yj + Ym) + 1.15Eo	11. U = 1.05 (D + F) + 1.3 (L + H) + 1.3W + 1.3 (To + Ro)	7. U = D + L + Ta + Ra + 1.25Pa + 1.25Eo + 1.0 (Yr + Yj + Ym)
	8. U = 0.75 (1.4D + 1.4T + 1.7L)	8. U = D + F + L + H + Ta + Ra + Pa + Yr + Yj + Ym + Ess		8. U = D + L + Ta + Ra + Pa + Yr + Yj + Ym + Ess
	9. U = 1.4 (D + T)	9. U = 0.75 (1.4D + 1.7L + 1.4To + 1.7 Ro)		
		10. U = 0.75 (1.4D + 1.4F + 1.7L + 1.7H + 1.7Eo + 1.4To + 1.7Ro)		

e) Discussion on Loading Combinations

The loading combinations given in ACI 349-76 as augmented by NRC Reg. Guide 1.142, Rev. 1, are essentially followed on NMP2 project as shown below:

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
		11. U = 0.75 (1.4D + 1.4F + 1.7L + 1.7H + 1.7W + 1.4To + 1.7Ro)		i. The terms F and H of ACI 349 Equations 2 through 11 are included in D and L respectively on NMP2 Project. ii. Loading combinations 4 through 8 as required by ACI 349 and Reg. Guide 1.142 are identical to the combinations 4 through 8 on NMP2 Project. iii. Loading combinations 9, 10, and 11 of ACI 349 and Reg. Guide are more critical than the combinations 1, 2, and 3. The combinations 1, 2, and 3 used on NMP2 Project are more conservative than the combinations 9, 10, and 11 of ACI 349 and Reg. Guide 1.142, Rev. 1. Conclusion: The loading combinations used on NMP2 project meets or exceeds the requirements of ACI 349-76 and Reg. Guide 1.142, Rev. 1.
		f) If extreme flood is specified for the plant, add a loading combination to consider its effect		f) See loading combination 5a above.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
		g) In load combinations 6, 7, and 8, the maximum values of Pa, Ta, Ra, Yj, Yr, and Ym including an appropriate dynamic load factor, should be used unless an appropriate time-history analysis is performed to justify otherwise		g) NMP2 Project complies with this requirement.
		h) For load combinations 7 and 8, local section strengths may be exceeded provided there is no loss of function of any safety-related component		h) NMP2 Project complies with this requirement.
Chapter 10, Flexure and Axial Loads		a) Specifies minimum temperature and shrinkage reinforcing for massive concrete		a) NMP2 Project complies with this requirement.
Chapter 11, Shear and Torsion, Through Chapter 17		No significant changes		
Chapter 18, Prestressed Concrete				Not applicable to NMP2 Project.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
Chapter 19, Shells	a) Applies to thin shell concrete structures (and folded plates only)	a) Applies to the design of shell concrete structures having thickness equal to or greater than 12 in.		a) The primary containment and secondary containment walls are considered thin shells with thickness greater than 12 in. The NMP2 Project meets the design criteria for shells given in both ACI 318 and ACI 349.
Appendix A (318), Special Provisions for Seismic Design (ACI 318)	a) This appendix provides criteria for ductile moment-resisting space frames for seismic loading	a) Not included in ACI-349	a) To ensure the ductility of concrete frames requirements of ACI 318 is acceptable	a) NMP2 Project complies with Appendix A of ACI 318-77.
Appendix B (318), Alternate Design Method (ACI 318)	a) Service load and stresses are used in designing the structures	a) Not included in ACI-349		a) NMP2 Project uses strength design methods and therefore this section is not applicable.

NRC REQUEST NO. 2

Provide an assessment of the significant differences between the requirements of ACI 349, as augmented by the NRC Regulatory Guide 1.142 and the requirements of ACI 318-77. (Reference NRC Q Nos. 220.31 and 220.33).

RESPONSE

See Table 2-1, attached.

TABLE 2-1

NRC REQUEST NO. 2

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
Chapter 1, General Requirement		a) Requires copies of structural drawings, typical details, and specification be signed by licensed engineer		a) NMP2 Project drawings and specifications are prepar under the supervision of licensed engineers, who also sign the documents.
		b) Requires inspection by owner	b) Recommends inspectors be experienced and familiar with ACI and ASTM standards	b) Inspections are performed by the owner's Quality Control representatives who are familiar with the standards.
Chapter 2, Definitions		a) OBE, SSE defined in accordance with 10CFR100, Appendix A		a) NMP2 Project seismic desi is based on NRC Regulator Guide 1.60, which meets t requirements of Appendix to 10CFR100.
	b) Massive concrete not specifically mentioned	b) Requires areas to be treated as massive concrete to be identified on drawings or specifications		b) NMP2 Project concrete specification defines the massive concrete and the special requirements for massive concrete placemen
Chapter 3, Materials	a) No certified mill test reports (CMTRs) required for cement	a) CMTRs required on each cement shipment. No cement can be used prior to receipt of 7-day mill test strength		a) NMP2 Project specifications require mill test reports for each cement shipment. Cement conform to ASTM C150, Type II, low alkali.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
		b) Excludes use of lightweight aggregate concrete		b) NMP2 Project specifications refer to ASTM C33 for aggregates, which excludes lightweight aggregates.
	c) Allows use of rail-steel and axle steel bars. Also allows Grade 90 bars	c) Requires use of Billet steel reinforcing bars of Grade 60 or less only		c) NMP2 Project specificatio requires that the materia for rebars comply with ASTM A615 Grade 40 throug Grade 60.
		d) Acceptance testing of the materials for concrete (e.g., cement, aggregates, etc) is required		d) NMP2 Project specificatio require acceptance testin of the concrete materials as required by ANSI N45.2.5, which meets or exceeds the ACI 349 requirements.
Chapter 4, Concrete Quality	a) Frequency of compressive strength tests: i) not less than once a day ii) not less than once for 150 cy of concrete	a) Same as for ACI 318 with a provision to decrease frequency of testing by 50 cy for each 100 psi lower standard deviation	a) Requires testing frequency in accordance with ANSI N45.2.5 once every 100 cy of concrete or once a day	a) NMP2 Project complies with ANSI N45.2.5, frequency of testing.
Chapter 5, Mixing and Placing Concrete		a) Requires that construction specifications include: i) method of curing ii) method of controling temperature for hot weather concreting		a) NMP2 Project concrete spe ifications describe the method of curing and method of controlling tem perature for hot weather concreting.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
Chapter 6, Formwork, Embedded Pipes, and Construction Joints		a) Refer to ACI 347 for formwork design		a) NMP2 Project complies wit ACI 347.
	b) Limits pressure and temperature of embedded piping to 200 psi and 150°F, respectively	b) Limits pressure to 200 psi. However, allows 200°F for localized areas, 350°F for accident or short-term periods, and 650°F for the local areas affected by fluid jet during pipe rupture.		b) NMP2 Project complies wit ACI 349.
		c) All construction joints shall be indicated on the drawings or approved by the engineers		c) NMP2 Project drawings indicate the construction joints on the drawings. A revision to the drawings subject to prior approval of the engineers.
	d) Vertical construction joints to be coated with neat cement grout	d) Vertical construction joints to be saturated with water prior to placing new concrete		d) NMP2 Project complies wit ACI 318 and ACI 349.
Chapter 7, Details of Reinforcement		a) Rebar placement tolerances are same as those stated in ACI 301		a) NMP2 Project complies wit the tolerances stated in ACI 301 and therefore com plies with ACI 349.
		b) Requires tests on full welded splices and full positive connections		b) NMP2 Project follows the requirements of ANSI N45. for positive connections.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
		c) Requires welded splices or positive connections for splicing load-carrying rebar located in a region with membrane tension normal to splice		c) NMP2 Project uses cadweld splices to splice N14 and N18 rebars in accordance with NRC Regulatory Guide 1.10 and ANSI N45.2.5. Welded splices are used when cadwelding is not possible.
Chapter 8, Analysis and Design	a) Provides procedures for alternate design method using service loads and permissible service load stresses	a) Does not address such method		a) NMP2 Project uses strengt design methods of A[illegible]318
	b) Allows use of fillers in concrete joist construction	b) Prohibits use of fillers in concrete joist construction		b) Concrete joints are not used at NMP2 Project, therfore not applicable.
Chapter 9, Strength and Serviceability Requirements		a) Requires consideration of dynamic response of concrete structure, its foundation, and surrounding soil		a) NMP2 Project considers th dynamic loading in the de- sign of structures.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
	b) Loading Combinations	b) Loading Combinations		b) NMP2 Project Combinations (Refer to Table 3.8-11 of FS
	1. U = 1.4D + 1.7L	1. U = 1.4D + 1.7L + 1.7Ro		1. U = 1.4D + 1.7L + 1.3 (To + Ro)
	2. U = 0.75 (1.4D + 1.7L + 1.9Eo)	2. U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7Eo + 1.7Ro	2. U = 1.4D + 1.4F + 1.7L + 1.7H + 1.9Eo + 1.7Ro	2. U = 1.4D + 1.7L + 1.9Eo + 1.3 (To + Ro)
	3. U = 0.9D + 1.4Eo	3. U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7W + 1.7Ro		3. U = 1.4D + 1.7L + 1.7W + 1.3 (To + Ro)
	4. U = 0.75 (1.4D + 1.7L + 1.7W)	4. U = D + F + L + H + To + Ro + Ess		4. U = D + L + To + Ro + Ess
	5. U = 1.9D + 1.3W	5. U = D + F + L + H + To + Ro + Wt		5. U = D + L + To + Ro + Wt 5a. U = D + L + F + To + Ro
	6. U = 1.4D + 1.7L + 1.7H	6. U = D + F + L + H + Ta + Ra + 1.25Pa	6. U = D + F + L + H + 1.3 (L + H) +	6. U = D + L + Ta + Ra + 1.5 Ta + Ra + 1.5Pa
	7. U = 1.4D + 1.7L + 1.4F	7. U = D + F + L + H + Ta + Ra + 1.15Pa + 1.0 (Yr + Yj + Ym) + 1.15Eo	7. U = D + F + L + H + Ta + Ra + 1.25Pa + 1.0 (Yr + Yj + Ym) + 1.25Eo	7. U = D + L + Ta + Ra + 1.25Pa + 1.25Eo 1.0 (Yr + Yj + Ym)
	8. U = 0.75 (1.4D + 1.4T + 1.7L)	8. U = D + F + L + H + Ta + Ra + Pa + Yr + Yj + Ym + Ess		8. U = D + L + Ta + Ra + Pa + Yr + Yj + Ym + Ess

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
	9. U = 1.4 (D + T)	9. U = 0.75 (1.4D + 1.7L + 1.4To + 1.7 Ro)	9. U = 1.05D + 1.3L + 1.3To + 1.3Ro	**Discussion on Loading Combinations** The loading combinations given in ACI 349-76 as augmented by NRC Reg. Guide 1.142, Rev. 1, are essentially followed on NMP2 project as shown below:
		10. U = 0.75 (1.4D + 1.4F + 1.7L + 1.7H + 1.7Eo + 1.4To + 1.7Ro)	10. U = 1.05 (D + F) + 1.7Eo + 1.3 (To + Ro)	
		11. U = 0.75 (1.4D + 1.4F + 1.7L + 1.7H + 1.7W + 1.4To + 1.7Ro)	11. U = 1.05 (D + F) + 1.3 (L + H) + 1.3W + 1.3 (To + Ro)	
				i) The terms F and H of ACI 349 Equations 2 through 11 are included in D and L respectively on NMP2 Project. ii) Loading combinations 4 through 8 as required by ACI 349 and as augmented Reg. Guide 1.142 are identical to the combinations 4 through 8 on NMP2 Project. iii) Loading combinations 9, 10, and 11 of ACI 349 and Reg. Guide are more critical than the combination 1, 2, and 3 of ACI 349. The combinations 1, 2, an 3 used on NMP2 Project ar more conservative than th combinations 9, 10, and 11 of ACI 349 and Reg. Guide 1.142, Rev. 1.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
				Conclusion The loading combination used on NMP2 project meets or exceeds the requirements of ACI 349-7 and Reg. Guide 1.142, Rev. 1.
		c) If extreme flood is specified for the plant, add a loading combination to consider its effect		c) See loading combination 5 above.
		d) In load combinations 6, 7, and 8, the maximum values of Pa, Ta, Ra, Yj, Yr, and Ym including an appropriate dynamic load factor, should be used unless an appropriate time-history analysis is performed to justify otherwise		d) NMP2 Project complies wit this requirement.
		e) For load combinations 7 and 8, local section strengths may be exceeded provided there is no loss of function of any safety-related component		e) NMP2 Project complies wit this requirement.

Code Section	ACI 318-77	ACI 349-76	NRC Regulatory Guide 1.142 Revision 1, October 1981	Justification
Chapter 10, Flexure and Axial Loads		a) Specifies minimum temperature and shrinkage reinforcing for massive concrete		a) NMP2 Project complies wit this requirement.
Chapter 11, Shear and Torsion, Through Chapter 17		No significant changes		
Chapter 18, Prestressed Concrete				Not applicable to NMP2 Project.
Chapter 19, Shells	a) Applies to thin shell concrete structures (and folded plates) only	a) Applies to the design of shell concrete structures having thickness equal to or greater than 12 in.		a) The primary containment a secondary containment wal are considered thin shell with thickness greater th 12 in. The NMP2 Project meets the design criteria for shells given in both ACI 318 and ACI 349.
Appendix A (318), Special Provisions for Seismic Design (ACI 318)	a) This appendix provides criteria for ductile moment-resisting space frames for seismic loading	a) Not included in ACI-349	a) To ensure the ductility of concrete frames requirements of ACI 318 is acceptable	a) NMP2 Project complies wit Appendix A of ACI 318-77.
Appendix B (318), Alternate Design Method (ACI 318)	a) Service load and stresses are used in designing the structures	a) Not included in ACI-349		a) NMP2 Project uses strengt design methods and therefore this section is not applicable.

NINE MILE POINT NUCLEAR STATION - UNIT 2

NRC Request No. 3

Review the effect of vertical floor flexibility in the analysis of equipment and floor designs.

Response

The modeling technique used on NMP2 to determine responses of structures, systems, and equipment during a seismic event, provides conservative results and adequate assurance for analyses and design. This modeling technique accounts for possible variations in amplified response spectra (ARS) at different locations during a seismic event. ARS were generated at the centers of masses in a lumped mass model to represent the responses for equipment and floor designs.

ARS for the NMP2 Project are derived from a time history analysis of structures. Structural response is based on a lumped-mass model in which floors are represented by rigid masses with six assigned degrees of freedom. These lumped masses are constrained by stiffness matrices which account for eccentricities between centers of mass and stiffness in each horizontal and vertical direction.

These dynamic models provide the structural response for the purpose of qualifying supported systems and equipment. All such structural dynamic models are condensations of the entire structure. The NMP2 model contains sufficient degrees of freedom to produce representative responses for seismic events and provides an input to the piping, conduit, cable tray, HVAC duct systems and equipment analyses that is consistent with the physical arrangement of these systems.

Such systems with multiple supports at different locations, in both plan and elevation, must be analyzed using a single ARS at all support points. The seismic motion exciting such multifrequency systems is best characterized by the broad frequency spectrum input to the dynamic models. A model of a floor, made more detailed to precisely determine the response at a location, may predict the results which would vary at some locations and frequencies, and may not be conservative depending on the system frequencies. Thus, neither the results from a lumped-mass model or a more detailed model are exact results. Each is an approximation of building motion. The lumped mass spectra, representative of the building as a whole, is an equally appropriate input to qualify a broad range of systems and interconnected equipment to a consistent seismic margin.

It should also be recognized that the lumped mass spectra used on the NMP2 Project have been developed through a conservative process.

The conservatisms are:

- The smoothed ground response spectra for seismic events presented in Section 3.7.1 of the FSAR as Figure Nos. 3.7A-1 and 3.7A-2 represent the definition, for design purposes, of the site vibratory motion. It is not intended to represent a particular future earthquake but to provide assurance of satisfactory performance over the broad range of frequencies possible from earthquakes. Therefore, it has significant amplifications over a broad frequency range. However, actual earthquakes are more narrow-banded and would produce lower responses for the same peak ground acceleration than the design spectra.

- Additionally, in order to generate floor response spectra at the lumped mass locations, an artificial time history of ground acceleration is developed whose spectra envelope the smoothed spectra (FSAR Figure Nos. 3.7A-3 through 3.7A-17). Examination of these figures demonstrates that the artificial time history has more energy than the smoothed spectra, resulting in conservative lumped-mass model seismic ARS, when transmitted through the building model.

- In performing a time history dynamic analysis of the structure, structural damping must be considered. The values used for the NMP2 plant structures are in accordance with those recommended by the NRC staff (1). More realistic estimates of actual structural damping (2), (3), (10), suggest values in the 7 percent through 15 percent range for vibrations causing structures to be at or just below yield. If the spectral accelerations of the smoothed ground response spectra for 5 percent and 10 percent damping are compared in the frequency range of 2 to 6 cps (highest amplification), the use of conservative structural damping alone overestimates the response by 40 percent.

- Systems on NMP2 use the ARS with conservative oscillator dampings, in accordance with NRC Regulatory Guide 1.61, as shown below:

  1. Cable tray supports for the NMP2 Project have been designed using 4 percent damping for OBE and 7 percent damping for SSE, while testing of actual cable tray systems indicates typical damping values in the 10 percent to 20 percent range (4).

  2. Piping on NMP2 has been designed for 2 and 3 percent damping and equipment has been designed for a 3 percent damping under an SSE event. Vibration tests on piping systems show that actual damping is significantly higher than these values (5, 6, and 7), and that piping analysis is conservative due to the use of low values of damping in the analysis.

A study has been performed which modeled floor flexibility in the vertical direction. This study included more realistic damping values and seismic input. The results of this study demonstrate that NMP2 original assumptions adequately represent the responses for equipment and floor designs.

In addition, experience to date has indicated that damage to structures during seismic events has occurred due to lateral excitation and that vertical excitation has not had a significant impact (8 and 9). No evidence suggested that vertical excitation of equipment contributed to failure. It is obvious, therefore, that current state-of-the-art nuclear power plant design procedures provide adequate margins of safety.

Therefore, the method of developing ARS used in the qualification of systems and equipment for the NMP2 Project, when considered within the context of the whole methodology, beginning with site seismicity and ending with the evaluations of systems and equipment, represents a conservative design process. The inherent conservatism in the representative ground input motion, structural and equipment damping, and evidence from performance during actual seismic events provides ample assurance of structural integrity.

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