APPENDIX III

Analysis Using a FEM for a CANDU 6 Reactor Structure Assembly

This Appendix is comprised of the following Tables:

Table III-1 Selected Major Modes and Their Participation Factors*

Mode Number	Frequency Hz	Participation Factors			Remarks
		Q_x	Q_y	Q_z	
1	5.687	1.347	0.0	0.0	C/T transverse mode
2	5.689	0.0	1.091	0.0	C/T vertical mode
3	8.411	0.0	0.0	1.830	End shield axial mode
4	10.079	1.227	0.0	0.0	Calandria transverse mode
5	10.463	0.0	-0.016	0.004	Local mode
6	10.542	0.010	0.040	-0.223	Local mode
7	10.555	-0.063	0.0	-0.015	Local mode
9	11.192	0.0	0.0	-0.457	Significant C/S axial mode
10	11.525	-0.015	0.0	0.0	Local mode
14	14.480	0.0	0.903	-0.163	Calandria vertical mode
15	14.686	-0.076	0.053	0.0	Local mode
16	15.643	0.209	0.026	-0.016	Local mode
17	15.656	0.0	-0.453	0.259	Coupled axial/vertical mode
18	15.784	0.071	-0.108	-0.044	Local mode
19	15.843	0.018	-0.227	0.153	Coupled axial/vertical mode
23	17.017	-0.027	0.799	0.171	Calandria vertical mode
24	22.696	0.806	0.014	0.0	Calandria transverse mode
25	22.767	-0.137	0.46	0.091	Local mode
26	22.985	0.011	0.342	-0.225	Local mode
27	23.142	-0.028	0.122	0.164	Local mode
28	23.396	0.372	0.051	0.0	Local mode
29	23.706	-0.014	-0.462	0.296	Calandria vertical mode
30	23.769	0.0	2.368	0.015	Major calandria vertical mode
31	24.246	0.0	-1.21	-0.615	Calandria vertical mode
32	24.706	0.012	0.0	0.029	Local mode
39	29.631	0.0	0.412	-0.291	Local mode
40	29.639	0.043	-0.015	0.015	Local mode
41	30.031	0.0	-0.316	0.409	Axial/transverse coupled mode

Table III-2
Selected Modal Weights

Mode Number	Frequency Hz	Participation Factors			Remarks
		$(MW)_X$	$(MW)_Y$	$(MW)_Z$	
1	5.687	744	0.0	0.0	
2	5.689	0.0	488	0.0	
3	8.411	0.0	2.8	4,538,920	
4	10.079	4,863,867.	0.0	0.0	
5	10.463	1.8	5.8	0.0	
6	10.542	4.6	73.	2,283	
7	10.555	321	0.0	17.4	
9	11.191	0.0	90	390,854	
10	11.525	46	0.0	0.0	
14	14.480	1.2	128,726.	4,171	
15	14.686	983	485	6.9	
16	15.643	10,102	152	56	
17	15.656	2.8	59,744	19,576	
18	15.784	1,262	2,921	487	
19	15.843	37.7	6,047	2,745	
23	17.017	99	86,129	3,928	
24	22.696	426,780	130	2.1	
25	22.767	302	3,421	132	
26	22.985	1.9	1,717	741	
27	23.142	37	704	1,264	
28	23.396	3,619	67	0.0	
29	23.706	9.9	11,293	4,669	
30	23.769	13	2,760,994	107	
31	24.246	3.3	172,240	44,481	
32	24.709	6.5	0.0	38	
39	29.631	1.76	14,376	7,216	
40	29.639	146	17.6	17.7	
41	30.031	5	20,064	34,615	

Table III-3
Calandria Tubes Lumped Parameters

	Parameter	Value	Remarks
a.	Material Properties Modulus of Elasticity (E) Poisson's ratio	12.97×10^6 psi 0.375	Zircaloy material
b.	Lumped Weights Weight in x direction (transverse). Weight in y direction (vertical). Weight in z direction (axial).	410.52 lbs 410.52 lbs 48 lbs	Equivalent weight Equivalent weight Calandria tube alone
c.	Geometrical Properties Area Polar moment of inertia moment of inertia	3.102 in^2 14.66 in^4 7.331 in^4	C/T alone Equivalent for pressure tube and CT

Table III-4
Vault Model Parameters

Parameter	Values		Remarks
	From Grade Floor to Vault Centre	From Vault Centre to RMD	

a. Material Properties
     Modulus of elasticity
     Poisson's ratio
     Critical damping
	40×10^5 psi
	0.15
	5%
		40×10^5 psi
		0.15
		5%
			Vault concrete properties

b. Lumped Weight
  In x–direction
  In y–direction
  In z–direction
	1383000.0
	1185000.0
	1246000.0
		2392000.0
		2862000.0
		2172000.0
			x = transverse
			y = vertical
			z = axial
			Global Coord.

c. Geometrical Properties
     Area
     Polar moment of inertia
     Moment of inertia (I_2)
     Moment of inertia (I_3)
     Shear factor (SF2)
     Shear factor (SF3)
	55330.2 in^2
	154.71×10^7 in^4
	66.35×10^7 in^4
	88.36×10^7 in^4
	0.55
	0.42
		69196.3 in^2
		171.63×10^7 in^4
		78.77×10^7 in^4
		92.86×10^7 in^4
		0.44
		1.00
			Vault beam properties

Design of CANDU Reactors

Table III-5
Lumped Mass Model Weights

Component	Node No.[1]	Translational Weights (lbf)		
		Axial	Transverse	Vertical
End Wall	263	331,000	*	*
Fixed End Shield	264	937,800	721,000	743,000
Calandria Shell	265	121,000	590,000	862,000
End Wall	266	331,000	*	*
Free End Shield	267	937,800	721,000	743,000
Calandria Tubes	268	10,000	156,000	156,000
End Fitting	269	103,200	39,220	39,220
End Fitting	270	103,200	39,220	39,220
Vault Centre Line	251	1,246,000	1,383,000	1,185,000
Vault Top	252	2,172,000	2,392,000	2,862,000