SEISMIC ANALYSIS OF THE PRIMARY BUILDING OF A BW REACTOR

by

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SYNOPSIS

The analysis of a typical primary building for a BW reactor is performed; the modal analysis tecnique has been used, the response of each mode has been computed and the final results have been obtained by means of the square root of the squares. The floor response spectra have been computed by means of a modified white noise tecnique.

1) INTRODUCTION

The seismic analysis of a typical primary building for a BWR has been performed by a tecnique described as follows:

a) The modal response tecnique has been used, a Newmark spectrum with a base acceleration of 0.24 g has been assumed.

b) The building has been schematized by means of masses and springs for a total of 26 nodes and 27 connecting springs.

c) Each node has a mass and an inertia moment to account for possible rotatory effects, due to the fact that the building is relatively wide and not very tall.

d) Radial simmetry has been assumed in order to compute masses and springs; to account for possible asimmetry effects due to the presence of large pools just under the roof an increase in the rotatory inertia in node 8 has been incorporated.

e) The springs stiffnesses have been computed by means of the membrane shells theory (so automatically accounting for shear effects).

f) The interaction between soil and the structure has been computed by dummy springs as suggested by Whitman [1] ; radiation damping has been introduced in order to account for the energy dispersion in the soil. No better simulation of the soil has been considered necessary due to the uncertainty in the soil property, anyhow a large variation of the soil shear modulus (roughly ± 50%) has been considered. The basic value has been computed by means of Hardin-Drnevitch [2] formula and by introducing a plasticity correction factor derived from ref. [2] .

g) The damping values were as follows

structure 4%   swaying (soil) 25%   rocking (soil) 7%

h) The weighted damping tecnique [3] has been used in order to account for differences in damping inside the structure.

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The damping has been weighted taking into account the e-
nergy content of each spring. Anyhow to account for possi-
ble adverse effects due to the modification of the modal
shapes due to differences in damping no final value higher
tha 10% has been allowed.

2) COMPUTATION OF RESPONSE

The computation of the 52 degrees of freedom system was perfor-
med by means of the standard springs and masses system SYRESP.
The response spectra tecnique was used in order to compute ac-
celerations, shears and moments for each mode, the combination
was performed by the standard "square root of the squares sum"
tecnique.
Nine cases were examined to allow for different hypotheses on
soil stiffness and on the degree of cracking of the main contai-
ner. The most critical case was generally the one in which the
soil stiffness was assumed to be the largest and the cracking
of the container most extensive.
For the computation of the stresses in the structure itself the
highest values, among the ones from the different analyses, were
used. For illustrative purpose in fig. 1 the springs and masses
model is presented; in fig.2 the first modes are depicted.

3) COMPUTATION OF FLOOR RESPONSE SPECTRA

The computation of the floor response spectra was performed by
a modified white noise tecnique [4] which is utilized by the
CFRS program. Basically the code uses the output of the SYRESP
code i.e. frequencies and modal accelerations, assumes the earth
quake is a white noise, and for each mode computes the noise den-
sity so that the accelerations of the structure are the ones
specified by the inputs, then it computes the equipment accele-
ration taking into account the noise filtering through the struc-
ture. As an example fig. 3 is presented, it is the floor respon-
se spectra at the pressure vessel level (node 21 of the model)

[1] Whitman Richart "Design procedures for dynamically loaded
     foundations" J. of Soil Mechs and Found, Nov. 1967

[2] Seed Idriss "Soil moduli and damping factors for dynamic
     response analysis" Rep. N.EERC 70-10, Dec. 1970 .

[3] Biggs Whitman "Soils structure interaction in nuclear power
     plants"

[4] L. Lazzeri "Computation of the floor response spectra by
     the use of a white noise tecnique" CREST Meeting on "Aseismic
     design of Nuclear Power Plants" Pisa, 3/5 Oct. 1972

● NODE

— SPRING
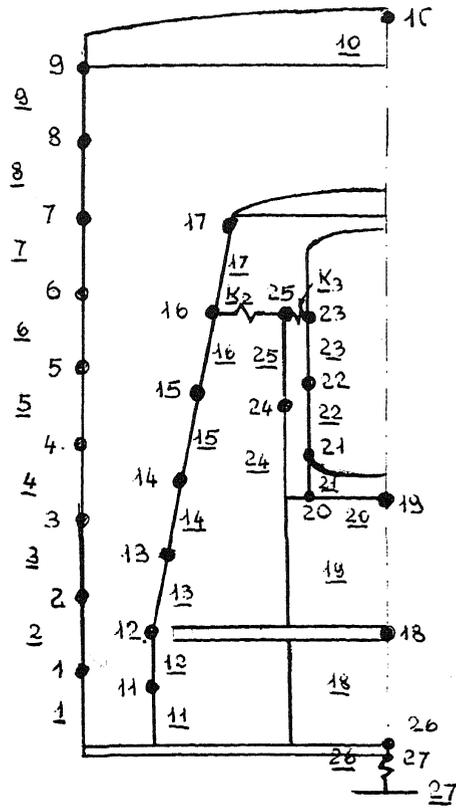
N.	SOIL	CONTAINER
1	hard	no cracking
2	med	no cracking
3	soft	no cracking
4	hard	cracking
5	med	cracking
6	soft	cracking
7	hard	large crack
8	med	large crack
9	soft	large crack

fig 1   DYNAMIC MODEL

asc (g)

analysis 7
node   21
damping   1%

Frequency (cps)
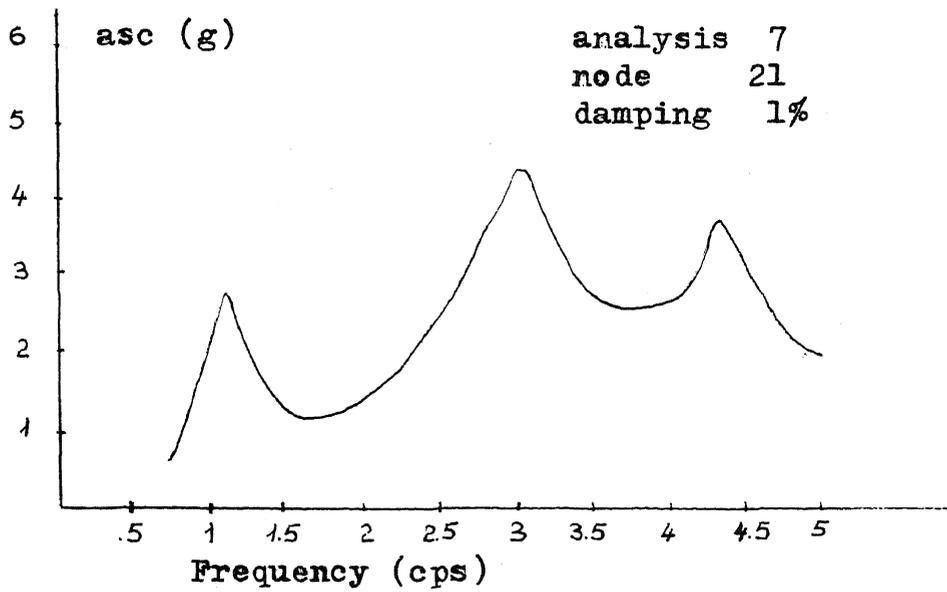
fig 3   Typical Floor response spectrum

Analysis 7

Mode	1	2	3
Freq	1.14	2.96	4.31
Damp	10%	10 %	6%
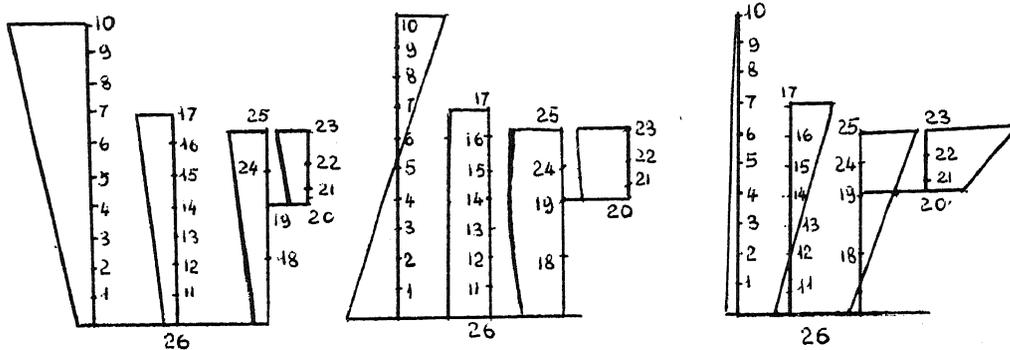
fig 2a Typical mode shapes

critical analysis as
indicated
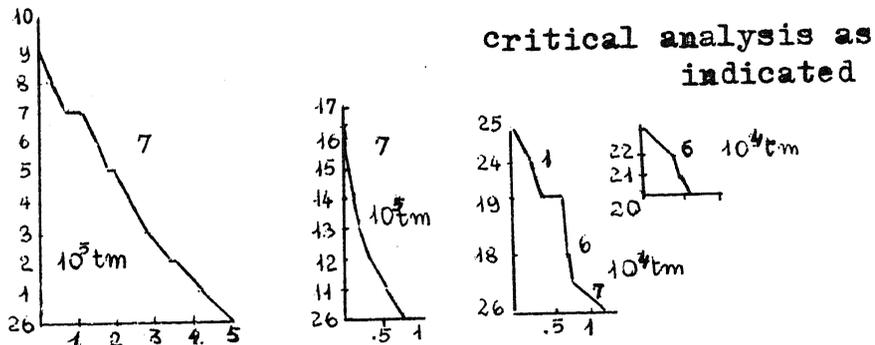
fig 2b Typical design moments

Table 1
Eigenfrequencies in the different analyses

Mode	Analysis								
	1	2	3	4	5	6	7	8	9
1	1.15	0.96	0.76	1.15	0.96	0.76	1.14	0.96	0.76
2	3.01	2.53	2.03	2.99	2.53	2.03	2.96	2.51	2.03
3	4.87	4.76	4.68	4.66	4.54	4.46	4.31	4.18	4.09
4	7.08	7.02	6.97	6.84	6.80	6.76	6.54	6.52	6.51
5	8;12	8.00	7.92	7.96	7.88	7.82	7.85	7.79	7.74
6	10.9	10.9	10.9	10.9	10.8	10.7	10.8	10.6	10.5
7	12.2	12.1	12.1	11.9	11.8	11.8	11.6	11.6	11.5