MASTER

A STUDY OF STRUCTURAL ATTACHMENTS OF A POOL TYPE LMFBR VESSEL THROUGH SEISMIC ANALYSIS OF A SIMPLIFIED THREE DIMENSIONAL FINITE ELEMENT MODEL

by

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ABSTRACT

A SIMPLIFIED THREE DIMENSIONAL FINITE ELEMENT MODEL OF A POOL TYPE LMFBR IN CONJUNCTION WITH THE COMPUTER PROGRAM ANSYS IS DEVELOPED AND SCOPING RESULTS OF SEISMIC ANALYSIS ARE PRODUCED. THROUGH THIS STUDY VARIOUS STRUCTURAL ATTACHMENTS OF A POOL TYPE LMFBR LIKE THE REACTOR VESSEL SKIRT SUPPORT, THE PUMP SUPPORT AND REACTOR SHELL-SUPPORT STRUCTURE INTERFACES ARE STUDIED. THIS STUDY ALSO PROVIDES SOME USEFUL RESULTS ON EQUIVALENT VISCOUS DAMPING APPROACH AND SOME IMPROVEMENTS TO THE TREATMENT OF EQUIVALENT VISCOUS DAMPING ARE RECOMMENDED. THIS STUDY ALSO SETS FORTH PERTINENT GUIDELINES FOR DETAILED THREE DIMENSIONAL FINITE ELEMENT SEISMIC ANALYSIS OF POOL TYPE LMFBR (TO BE PUBLISHED IN A SEPARATE PAPER).

[illegible]

was [illegible] that such an analysis can only be accomplished through careful [illegible] dling of [illegible] the work [illegible] fluid-structure interaction and fluid-[illegible] of Ref. (?) [illegible] awaiting publication. This study also concluded that [illegible] of computer program such as ANSYS (a wave front program) for solving a massive [illegible] such as the one described above can be handled with ease. Fig. 1.1 shows the handling of vari[illegible]

[illegible] MEERS in conjunction with the required dynamic degrees [illegible]

Three-dimensional analysis [illegible] above-mentioned [illegible] was attempted [illegible] was decided that such an analysis can only [illegible] difficult [illegible] fluid-structure interaction [illegible] awaiting publication. This study [illegible] of computer program such as [illegible] such as the one [illegible] can be handled with [illegible] of free [illegible] capabilities of [illegible]

In the [illegible] equivalent [illegible] with [illegible] analysis was [illegible] A simplified three-dimensional finite element model [illegible] this proposed equivalent viscous damping approach [illegible] critical structural attachments in a pool-type LMFBR [illegible] present [illegible]

This equivalent viscous damping approach was developed by the authors [illegible] with Ref. (2) and (3).

II. [illegible]uivalent Viscous Damping Approach

The procedures used to determine [illegible] for the [illegible] analysis are consistent with the criteria [illegible] Nuclear Regulatory Commission Standard Review Plan Section 3.7. [illegible] damping values for structures or components will be selected from Regulatory Guide 1.61, "Damping Values for Seismic Design of [illegible]" [illegible] for different [illegible] within each substructure of a pool-type LMFBR. Composite modal damping values will be determined based on an energy proportional damping method.

A procedure using the ANSYS computer program to obtain the response spectrum analysis of a substructured system which includes composite modal damping is outlined in

[illegible]

A. [illegible]

1. [illegible]

2. ANSYS [illegible] and print the total strain energy and kinetic energy of each mode for all elements having the same material number. Although the same material will be used in more than one substructure, a different material number will be assigned for

The final response is obtained by modal summation using POST 7. A linear factor is applied to each modal response to account for its correct equivalent viscous damping. The detailed procedure is as follows:

A. Assumptions

1. One response spectrum is used for ANSYS frequency analysis.

2. ANSYS calculates and prints the total strain energy and kinetic energy for each mode for all elements having the same material number. Although the same material will be used in more than one substructure, a different material number will be assigned for that material in each substructure to obtain the strain energy and kinetic energy for each substructure.

B. Calculation of Equivalent Viscous Damping Factors

1. Equivalent viscous damping factors are calculated for each substructure using the strain energy proportion in Equation II.1 for each mode considered in the analysis.

$$D_{KR} = \frac{\sum_{j=1}^{nm} \sum_{i=1}^{ne} E_{ijR} d_j}{\sum_{j=1}^{nm} \sum_{i=1}^{ne} E_{ijR}} \qquad \text{(II.1)}$$

where

D_{KR} = equivalent viscous damping factor for R^{th} mode for the K^{th} substructure;

E_{ijR} = strain energy ($\phi^T K \phi$) for i^{th} element of finite element mesh and j^{th} material of the K^{th} substructure;

d_j = fraction of critical damping for j^{th} material of the K^{th} substructure;

ne = number of elements;

nm = number of materials;

ϕ = modal vector obtained from frequency analysis of the entire system.

ANSYS computes and prints D_{KR} for each substructure for every mode. Note that $D_{KR} = d_j$ for substructures consisting of one material.

[illegible]

$$D_R = \frac{\sum [illegible]}{\sum [illegible]} \quad [illegible]$$

$$D'_R = \frac{\sum [illegible]}{\sum [illegible]} \quad [illegible]$$

where

[illegible]

lated by Eqn. [illegible];

[illegible]

C. Total Response Calculation

[illegible] POST 7 post p[illegible] linear factors are calculated which [illegible] used to scale the [illegible] in a given mode.

$$F_R = \frac{U_{DR}}{U_{OR}} \quad [illegible]$$

where

F_R = the linear multiplier for R^{th} mode;

U_{DR} = the spectral value corresponding to frequency of R^{th} mode and damping D_R (or D'_R);

U_{OR} = the spectral value corresponding to frequency of R^{th} mode and damping [illegible]

[illegible]

[illegible] method;

D_R, D'_R [illegible] factors [illegible] figures [illegible] II.5 and II.6, respectively. [illegible] H_{OR} may be obtained [illegible] the form [illegible] values as [illegible] II.1

D. Response Spectra Analysis [illegible] ANSYS [illegible] Composite Modal Damping [illegible]

Use [illegible] frequency [illegible] to get [illegible] modal damping [illegible].

Calculate [illegible] viscous damping factor using strain energy proportional damping for each substructure in each mode (equation II.1).

Calculate equivalent viscous damping factor for each mode in the entire system by using substructure energy as the weight function (equation II.2 or II.3).

Use damping factors to obtain linear factors (FR) for each mode.

Obtain system response through modal summation using POST 7 of ANSYS and FR multipliers.

[illegible]

four [illegible] with the [illegible] model. They were simplified to be modeled by pipe [illegible]. [illegible] removable [illegible] was also simplified to be modeled as pipe elements at the center of the model. Spring elements were used at several locations along the skirt [illegible] to repre[illegible]

[illegible]

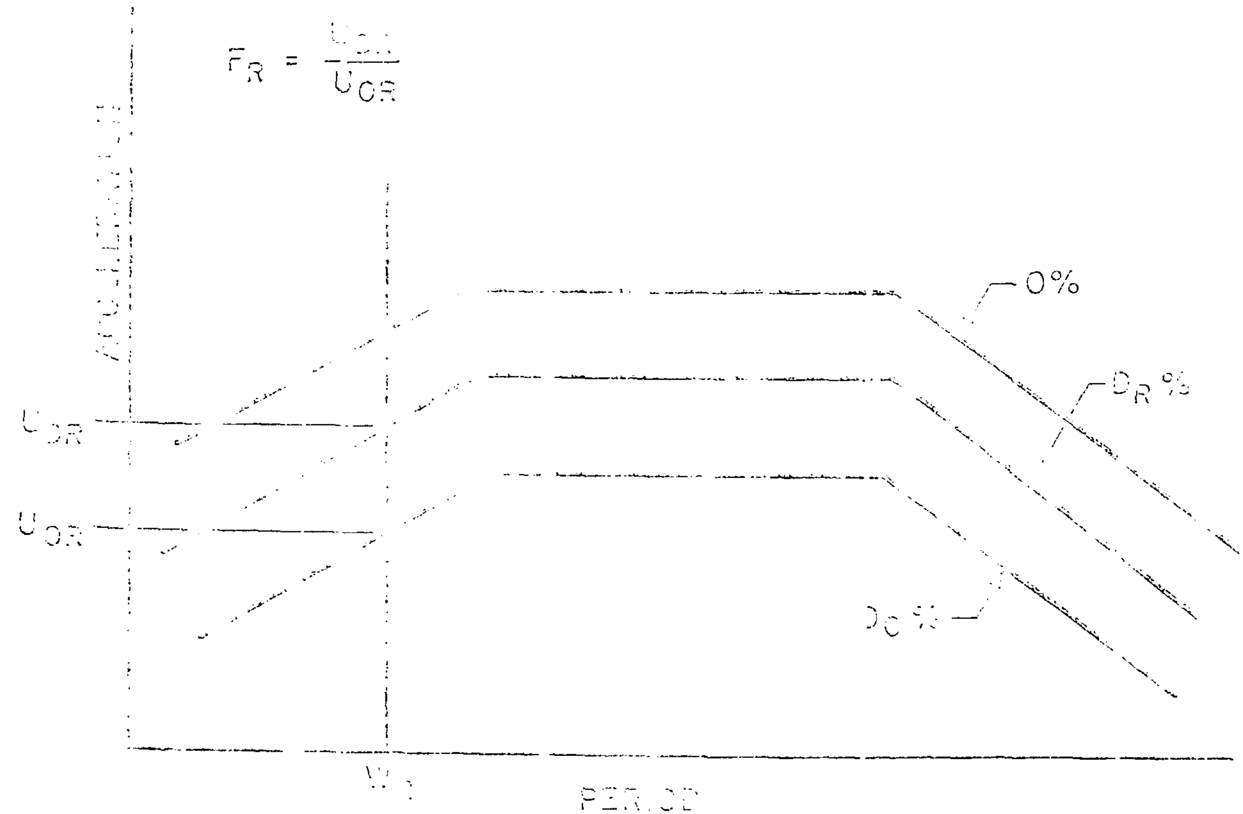
A [illegible] of the [illegible] [illegible] accele [illegible] was used as input [illegible]. The dynamic response of [illegible] obtained. The [illegible] employed to generate the [illegible] spectra [illegible] in the [illegible]. The 2% damping [illegible] spectra [illegible] and [illegible] (OB [illegible] [illegible] with 0. [illegible]

IV. C[illegible]

In this p[illegible] procedure for the determination of equivalent viscous damping [illegible] junction with a soil-structure [illegible] is presented. A simplified three-dimensional [illegible] element [illegible] this equivalent viscous damping procedure. This simplified three-dimensional finite

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]
[illegible]	2	[illegible]	2
[illegible]	3	[illegible]	[illegible]
[illegible]	4	[illegible]	[illegible]
[illegible]	5	[illegible]	2
[illegible]	6	Large Rot[illegible]	4
[illegible]	7	Small Rotation [illegible]	4
[illegible]	8	Removable Reactor	4
[illegible]	9	Guard Vessel	4
[illegible]	10	Skirt Support/Reinforced Concrete	4/7
SPX711	11	IHX3-Bolt Cone/Steel/Fluid	7/4/10
SPX712	12	Piping of IHX3	2
SPX813	13	Pump 2-Bolt Cone/Steel/Fluid	7/4/10
SPX914	14	IHX4-Bolt Cone/Steel/Fluid	7/4/10
SPX915	15	Piping of IHX4	2
SPY116	16	Primary Vessel	4
SPY217	17	Thermal Baffle	4
SPY318	18	Redan	4
SPY419	19	Fixed Reactor	4
SPY520	20	Trapped Fluid	10
SPFL	21	Free Fluid	10



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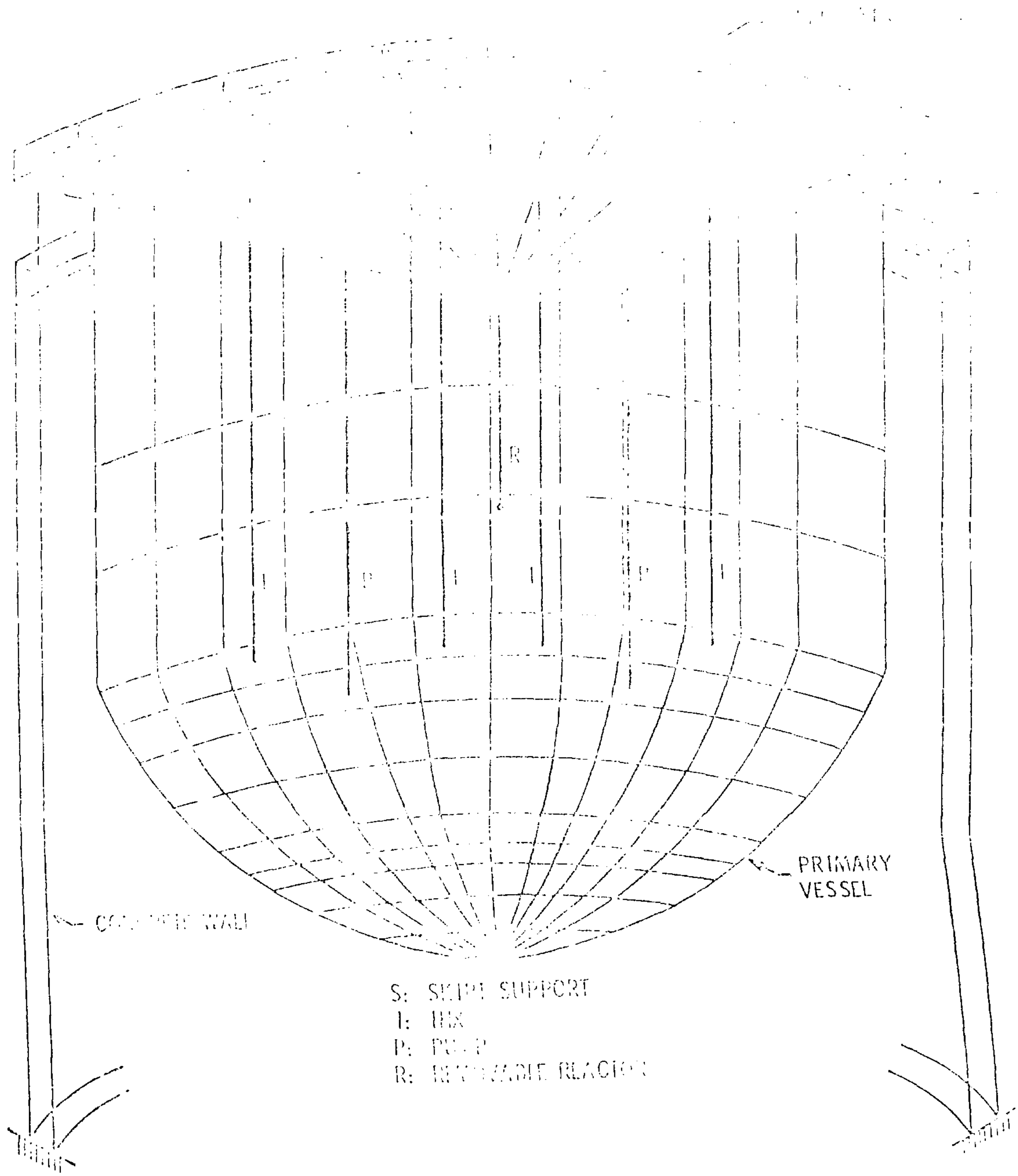
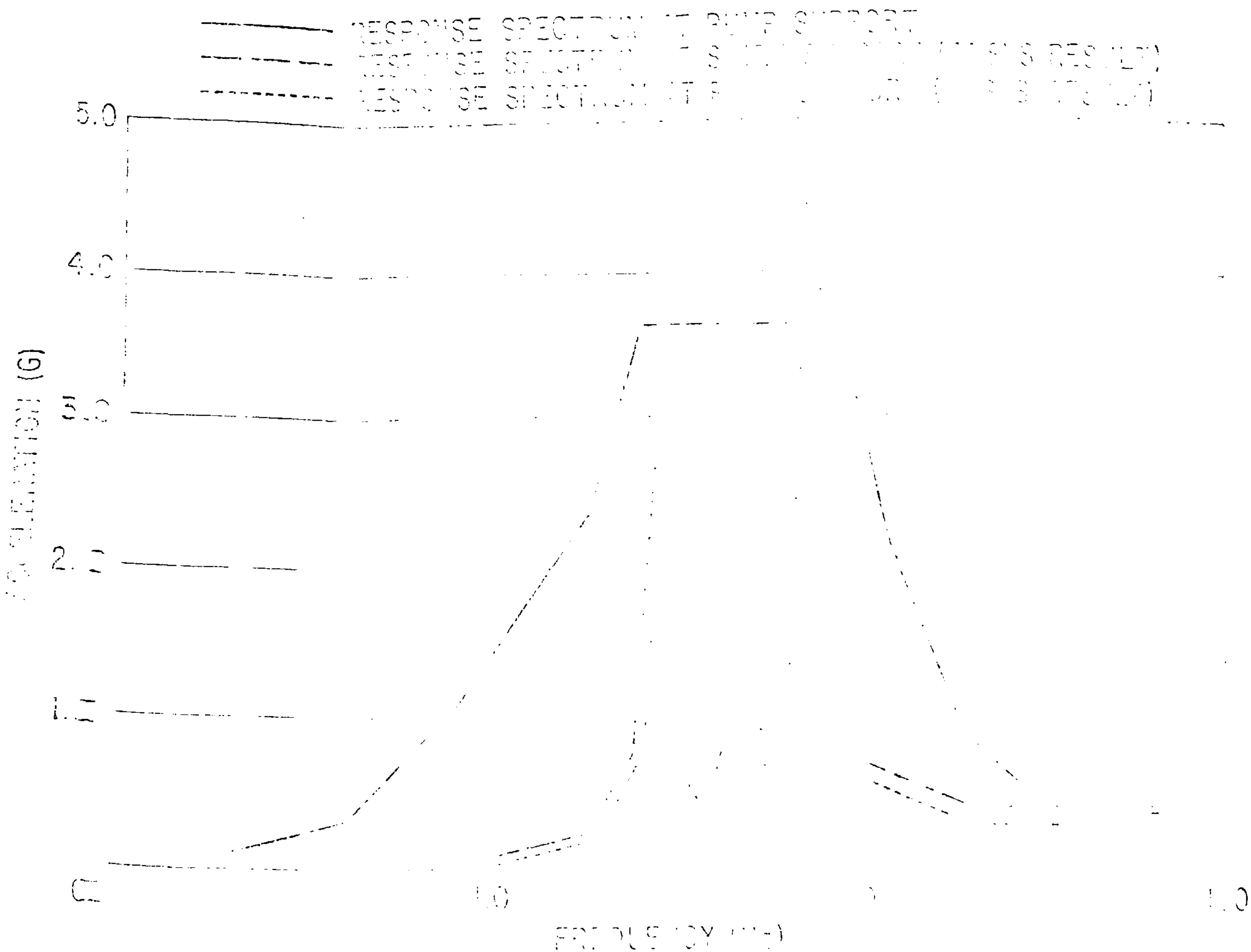

PRIMARY
VESSEL
S: SKIRT SUPPORT
I: IHX



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