RIL File

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

MAR 16 1982

130

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Robert B. Minogue, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER, No. 130
"EXPERIMENTAL VERIFICATION OF COMPUTER SIMULATIONS OF PIPING RESPONSE USING HEISSDAMPFREAKTOR SEISMIC TESTS"

Introduction

During 1979, the Office of Nuclear Regulatory Research of the Nuclear Regulatory Commission negotiated a cooperative effort to conduct seismic research with Kernforschungszentrum Karlsruhe (KfK). This research was to take place at the Heissdampfreaktor (HDR), a decommissioned superheated steam reactor located approximately 50 kilometers east of Frankfurt, West Germany, on the north shore of the Main River. By mutual agreement with KfK, and with an endorsement from the Office of Nuclear Reactor Regulation, emphasis was given to predicting the response of the recirculation loop piping system when excited by the detonation of buried explosives located in the soil near the containment building. The purpose of this research is to determine how well advanced computer models of nuclear power plant piping systems could estimate simulated seismic behavior by comparing blind post-test analytical predictions with experimental observations.

Two NRC contractors were used to make the predictions of recirculation system seismic response as follows:

(i) ANCO Engineers, Inc. installed accelerometers in the room containing the recirculation loop piping, and in December 1979, measured the motion of this room when a 5 kg. explosive charge was detonated. Additionally, ANCO provided earlier developed computer models of the recirculation piping and the results of snapback and shaker tests which they performed in 1975. These latter test results serve as a basis for estimating dynamic parameters used in the computer model.

(ii) EG&G Idaho developed a computer model of the recirculation loop piping. Using this model and the measured motions recorded by ANCO as inputs, recirculation loop piping response was calculated at locations on the piping where the HDR staff had placed instrumentation. HDR instrumentation of interest consisted of accelerometers and strain gages placed on the piping.

Results

Predictions were made for Test V651, Run 4.00. Of the twelve channels of data funded by NRC, ten successfully recorded information. These data gave motions of the inner and outer walls, and ceiling and floor of the room containing the recirculation piping system. Analysis of the data revealed that the thick concrete walls comprising the boundaries of the room suffered negligible elastic deformation and that the room moved essentially as a rigid body. Rigid body rocking and twisting of the recirculation piping room were apparent. Initially, all support points were assumed to experience the same uniform motion. Subsequently, an analysis was performed considering the effects of independent support motion.

Two computer models were used in these investigations. The ANSYS model was used only for uniform support motion studies, while the NUPIPE model also considered independent support motions. Equipment considered in the modeling included the recirculation piping, reactor vessel, two recirculation pumps and various piping supports.

Early detailed results of the efforts are given in Reference 1 while final detailed results are given in Reference 2. The principal findings are:

- Eigenfrequencies and mode shapes agreed well with experimental results.
- At a number of node locations, predicted response accelerations fell within about 20% of observed response. However, differences by a factor of 2 or 3 in over- and under-prediction occurred at several locations.
- Even with some experimental data for developing models of support behavior, support response to simulated seismic inputs was not accurate.
- Using independent support motions in the computer simulations had little effect on predicted response in this specific test.

Predictions independently computed by West German researchers were somewhat similar to those of NRC contractors. German supervisors reported that there were generally good comparisons between predicted and observed eigenparameters, as was the case with EG&G. Using piping strains instead of piping accelerations, German authorities reported that errors by factors of 2 were generally evident. Codes used by the Germans include ASKA and SAP.

Evaluation

The following two facts contribute to a strong basis for inferring conclusions.

1. West German researchers have arrived independently at results compatible to those obtained b EG&G Idaho.

2. To validate the adequacy of their computer modeling and in response to comments from NRR reviewers, EG&G researchers undertook modeling refinements and sensitivity studies, particularly with regard to the integration and sampling time step, the influence of multiple independent supports and modes with frequencies in the range beyond the original 33 hertz.

It is concluded based on this research that even in controlled and idealized situations in which researchers had the benefit of redundant and compatible experimentally determined measured input, and in addition, had access to prior testing to determine dynamic parameters and to confirm modeling details, differences of a factor of 2 or more may occur in estimating piping motions and strains and support reactions. This may be the practical limit of accuracy which can be expected from current piping analysis practice used in seismic safety evaluations.

Additional information on this work may be obtained from Dr. John O'Brien (x35860) of the Mechanical/Structural Engineering Branch, DET.

Robert B. Minogue

Robert B. Minogue, Director
Office of Nuclear Regulatory Research

References

1. NUREG/CR-1913, "HDR Response-Experimental and Analytical," Finicle et al., Feb. 1981.

2. NUREG/CR-2463, "Experimental and Analytical Results of Blast Induced Seismic Studies at HDR," Thinnes et al., Nov. 1981.

1. West German researchers have arrived independently at results compatible to those obtained b EG&G Idaho.

2. To validate the adequacy of their computer modeling and in response to comments from NRR reviewers, EG&G researchers undertook modeling refinements and sensitivity studies, particularly with regard to the integration and sampling time step, the influence of multiple independent supports and modes with frequencies in the range beyond the original 33 hertz.

It is concluded based on this research that even in controlled and idealized situations in which researchers had the benefit of redundant and compatible experimentally determined measured input, and in addition, had access to prior testing to determine dynamic parameters and to confirm modeling details, differences of a factor of 2 or more may occur in estimating piping motions and strains and support reactions. This may be the practical limit of accuracy which can be expected from current piping analysis practice used in seismic safety evaluations.

Additional information on this work may be obtained from Dr. John O'Brien (x35860) of the Mechanical/Structural Engineering Branch, DET.

Original signed by:
ROBERT B. MINOGUE
Robert B. Minogue, Director
Office of Nuclear Regulatory Research

Record Note:
This RIL has been reviewed and approved by the Mechanical Engineering Branch, NRR. The "Evaluation" section of this RIL was revised to reflect the views of Mr. Minogue. We have discussed this revision with NRR in a meeting on 3/15/82, and they have accepted the revision. John O'Brien

RES Files
Subject File No.
Task No.
Research Request No. RR-NRR-79-11
FIN No. A 6306
NUREG No.
Docket No.
Rulemaking No.
Other NUREG/CR 1913
Return NRC-318 NUREG/CR 2463
to RES, Yes ✓ No

See previous concurrence sheets

DET:MSEB	DET:MSEB:SL	DET:MSEB:C	DD:DET	DET:DIR	RES:DD	RES:DIR
JO'Brien:sp	JRichardson	WFAnderson	LCShao	GAArlotto	DFRoss	RBMinogue
2/18/82	2/19/82	2/19/82	2/23/82	2/23/82	3/ /82	3/16/82

SUMMARY

This RIL describes cooperative research undertaken by the U.S. Nuclear Regulatory Commission and Kernforschungszentrum Karlsruhe. It is concluded as a result of in situ experiments conducted at the Heissdampfreaktor under highly control and idealized situations that advanced computer models used to predict nuclear power plant piping response may over- and underestimate observed response by a factor of 2 or greater.