

MEMORANDUM FOR: R. B. Minogue, Director, Office of Nuclear Regulatory Research
FROM: H. R. Denton, Director, Office of Nuclear Reactor Regulation
SUBJECT: NRR RESEARCH NEEDS IN SEISMIC ANALYSIS METHODOLOGY

This memorandum and its enclosures set forth both short term and long-term NRR user needs for improved seismic analysis methodology and recommend pertinent research actions and goals. These recommendations were developed in conjunction with our recent reviews of the Seismic Safety Margins Research Program (SSMRP) and the Long Range Research Plan (NUREG-0784), together with ongoing discussions between RES and NRR staffs pertaining to needed improvements in the confidence and accuracy in seismic analysis methodology.

Enclosure 1 provides NRR's recommendations for the redirection of SSMRP and provides confirmation of NRR's discussions at a meeting of the SSMRP Senior Review Group held on January 26, 1982. Enclosure 2 provides a discussion of our supplementary and long-term needs in terms of guidelines for the development of a comprehensive program plan. The guidelines have been developed to recognize SSMRP's projected accomplishments and limitations and the SSMRP termination date of September 30, 1984. The guidelines recommend activities that can be performed in conjunction with other RES programs, and in cooperation with industry, other government agencies, or foreign governments.

Our needs and programmatic goals for both SSMRP and the comprehensive program plan are summarized as follows:

1. To significantly improve deterministic and probabilistic knowledge of seismic safety levels and margins for older operating plants (SEP), and current generation plants by FY84, and for new standardized plants in the post-1984 time period.
2. To develop a short-term assessment of and a long-term policy for seismic hazards in the eastern United States as indicated by the issues discussed in SECY-82-53, "Possible Relocation of Design Controlling Earthquakes in the Eastern U.S."
3. To include seismic risk estimates in IREP, NREP, and severe accident studies, and to contribute to the development and implementation of the Commission's Safety Goal.

Our staff plans to work closely with the RES staff in the guidance of further SSMRP activities and the development of the program plan. We perceive a high priority need for a better understanding of seismic analysis uncertainties and improved seismic design methods.

Original Signed by
H. R. Denton

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosures: As stated

CRESS:ph
1WILLI-I
3/16/82

DST *MLW*
PWilliams
3/19/82

DST *GK*
GKnighton
3/19/82

DST *RJ*
RJackson
3/19/82

DE *DF*
FSchauer
3/23/82

DE *DF*
RHVollmer
3/24/82

DE *JK*
JKnight
3/23/82

RET *FS*
FSchroeder
3/23/82

DE *RP*
RPurple
3/28/82

DST *SH*
SHanauer
3/27/82

DE *EC*
ECase
4/7/82

ONRR *HR*
HRDenton
4/7/82

- DISTRIBUTIONS
- CENTRAL FILE
- RSCB READING FILE
- PWILLIAMS
- GKNIGHTON
- RJACKSON
- FSCHAUER
- JKNIGHT
- FSCHROEDER
- RPURPLE
- SHANAUER
- RVOLLMER
- ECASE
- HRDENTON

ENCLOSURE 1

REDIRECTION OF SEISMIC SAFETY MARGINS RESEARCH
PROGRAM (SSMRP) TO MEET NRR NEEDS

A meeting of the Senior Research Review Group for SSMRP was held on January 26, 1982, in which NRR representatives discussed significant redirection of SSMRP. This document discusses NRR's needs for improvements in the utility of the SSMRP and constitutes NRR endorsement for a revised SSMRP plan for Phase II. In summary, we believe the program should be redirected toward assessment and validation of the methodology developed by SSMRP in Phase I in preference to continued and augmented applications of the methodology as outlined by RES in its January 18, 1982, memorandum to the Senior Research Review Group.

Our user needs and programmatic goals for SSMRP are:

1. To assess and validate the seismic analysis methodology developed in Phase I.
2. To contribute to the development of a short-term assessment of and long-term policy for seismic hazards in the eastern United States as indicated by the issues discussed in SECY-82-53, "Possible Relocation of Design Controlling Earthquakes in the Eastern U.S."
3. To develop confidence in applying SSMRP methodology to older (SEP) and current generation plants.
4. To contribute to the understanding of seismic risk in PRA studies and in the Commission's Safety Goal, and to promote inclusion of seismic risk estimates in the IREP and NREP.
5. To contribute by the end of FY 84 improved information pertaining to the assessment of seismic events as initiators of and contributors to severe accidents.

6. To be user-oriented in the sense that computer codes developed can be understood and used by other than the developers, and that the component parts of large codes can stand alone and be capable of independent usage or validation.
7. To provide a standard against which industry methods and calculations can be compared.
8. To effectively support and coordinate with other activities dependent on improved seismic analysis information such as equipment qualification requirements and ASME Code development.
9. To assess the potential for reduced competition with other safety considerations through reduction in possibly overly conservative seismic design requirements.

Our specific recommendations for the redirection and future conduct of SSMRP in order of our priority interest follow:

1. Peer Review: We believe a formal meeting of the Senior Research Review Group consultants listed in NUREG/CR-2015, Vol. I, "SSMRP Phase I Final Report," should be held and documented. It would be desirable to augment this list with an additional consultant or consultants to compensate for the loss of the late N. M. Newmark. The objective of this meeting would be to review the Phase I work and to comment on the development of programs needed to achieve the revised program goals.
2. Availability and Transfer of Methodology: The Phase I output of SSMRP is largely in the form of the three computer codes, HAZARD, SMACS, and SEISIM. We understand that these codes are being documented and should be available for transfer to the technical community shortly. We urge the priority completion of the documentation and transfer of these codes together with supporting codes or other information necessary for independent use. We request that RES budget for the evaluation of the codes by an organization independent of their development.

3. Validation: We recommend prompt initiation of those validation tasks proposed in the January 18 memorandum that could be performed with available, or soon-to-be available, data. The initial portion of this task would be a review and selection of data on the basis of its quality for validation applications. We do not recommend that SSMRP finance new experimental programs but rather make the best use of existing data. Development of recommendations from SSMRP for new experiments that would achieve cost effective and improved validation of SSMRP methodology should be included in this element.
4. Seismic Input: This element of SSMRP should review and integrate on a short-term basis new geologic and seismic information and policy determinations being developed by others, particularly the issues discussed in SECY-80-53, "Possible Relocation of Design Controlling Earthquakes in the Eastern U.S." We do not recommend that this element undertake longer term activities that would be better performed by other RES programs or other government agencies, however.
5. Methodology Simplification and Sensitivity Studies: A limited amount of the simplification work and sensitivity studies proposed in the January 18 memorandum should be performed in close relationship to, and in support of, the validation task. Simplification of SSMRP methodology should be achieved to the extent practicable and where possible include empirical corrections from the validation program. The simplification effort should not result in the exclusion of any significant contributing phenomena. The planned sensitivity studies should investigate the degree to which uncertainties in components of the program (e.g., ground motion) affect the uncertainty level in the overall seismic analysis of nuclear power plants.
6. PRA Applicability and Safety Goal: We remark that better understanding of the factors affecting seismic safety is needed for safety goal development and implementation. At present, uncertainties in both basic data and analytical methods exclude seismic phenomena from NRC's methodology for probabilistic risk assessment. NRR judges this as an unacceptable deficiency for the long term and believes research to resolve this problem

should receive relatively high priority. SSMRP should contribute as much as practical to the reduction of seismic analysis uncertainties and PRA applications as well as set priorities for future research in this area.

7. Applications: Until greater confidence is demonstrated in the SSMRP methodology through the tasks identified above, the undertaking of a BWR seismic analysis should be deferred and the completion of the Zion I seismic analysis should be paced to take advantage of the near-term improvements in confidence in SSMRP methodology expected from the redirected program.

ENCLOSURE 2

GUIDELINES FOR THE DEVELOPMENT OF
SEISMIC ANALYSIS PROGRAM PLAN

It has become apparent that analytical complexities and uncertainties in seismic analyses are greater than were envisioned at the inception of SSMRP, with the result that to date SSMRP has not been able to demonstrate improvement in the accuracy of estimates of seismic risk. Consequently, comprehensive program planning for seismic analysis research is needed:

1. To recognize SSMRP's projected accomplishments and limitations and the SSMRP termination date of September 30, 1984.
2. To provide better integration of SSMRP with other RES programs.
3. To recognize the need for the development of new experimental data for validation and confirmation of SSMRP and other seismic analysis methodologies.
4. To initiate and develop cooperative agreements with industry, other government agencies, and foreign governments to achieve needed experimental data at minimum overall cost to the NRC.

While NRR's user needs and programmatic goals for additional and follow-on seismic analysis research are essentially the same as for SSMRP, it is becoming clear that significant advancements in seismic analysis and confidence in estimates of seismic structural risk cannot be achieved without improved and definitive data in seismic input, soil structure interactions, dynamic structural response, and structural fragility.

We recognize that SSMRP was never intended to fund experiments for methodology validation or to direct or coordinate related RES and other programs. Therefore, we recommend research planning that would accomplish these ends. We foresee

that the research program would have program elements that would largely fall into two groups; those that direct RES-sponsored or co-sponsored research and those that would provide a coordination function with related RES programs.

1. Cooperative Programs: We believe a program element should be established to develop cooperative domestic and international programs which are needed both as a source of seismic data and to minimize overall costs to the NRC. These would include cooperative programs with industry groups such as EPRI and government agencies such as the National Science Foundation, DOE, and the USGS. The program element should survey both industry groups and government agencies to identify both domestic and international programs that relate to NRC seismic analysis goals. It may result that the objectives of certain program elements become strongly dependent on domestic and international cooperative programs not under direct control of RES. We view this as an acceptable and desirable practice, but we recommend developing agreements to include a degree of NRC financial or other form of participation that would assure that the agreed-upon research would meet NRC objectives and quality standards.

2. SSMRP Validation Assistance: In conjunction with the SSMRP validation study recommended in Enclosure 1, maximum use of currently available data should be made in the early establishment of benchmarks and standard problems. The research program should assist SSMRP by including an element to establish on an international basis the extent of existing seismic data which could contribute to a valid data base. Examples we recommend for early consideration are the 1979 Imperial Valley earthquake (NUREG/CR-1913) and the Heissdampfreactor (HDR) testing program (NUREG/CR-1913 and NUREG/CR-2463). The response of the El Centro steam plants in the 1979 earthquake may indicate that our present seismic methods contain improper modeling features. The HDR program illustrates poor fidelity of existing methods for the dynamic analysis of piping. In addition, the EPRI SIMQUAKE program should receive early review and the National Science Foundation should be surveyed for relevant information. Arrangements to acquire pertinent Japanese seismic data should be made as soon as possible. Notice should be taken of the Earthquake Engineering Research Center of the University of California and the relationship it maintains with institutions in Japan, Taiwan, Yugoslavia, and Turkey.

3. Seismic Hazard and Ground Motion: A program element should be established to interface with SSMRP and other RES and non-RES programs in seismology and geology that will provide both short-term and long-term information on seismic hazards and ground motion. While we believe major research in these activities should be directed and funded by others, a program element within the seismic analysis program is necessary to both encourage and benefit from this research. This program element would address the long-term implications of SECY-82-53, "Possible Relocation of Design Controlling Earthquakes in the Eastern U.S."
4. Soil Structure Interaction: The soil structure interaction (SSI) portion of the research program should receive a major emphasis. We believe much undue conservatism and artificially high seismic risk assessments could derive from the uncertainties present in the calculational models. The EPRI report, "Specifications of Input Motions for Seismic Analysis of Soil-Structure Systems Within a Nonlinear Analysis Framework (EPRI-NP-2097) points out the complexities of the local seismic wave field. This report is pessimistic on the current ability of simplified analysis methods to adequately cope with complex seismic wave motions and the material nonlinearities of soil. We believe there is a strong need for further research to understand the variations in local earthquake ground motions due to local geological or soil conditions.
5. Seismic Instrumentation Program: We recommend a program element that would provide for a vigorous program of seismic instrumentation. In this program, seismic instruments would be installed in selected existing structures, not necessarily nuclear power plants, located in active earthquake regions. Both domestic and international locations should be considered. The number and location of the structures selected should be sufficient that the occurrence of a major earthquake would have a high probability of yielding seismic information that, when recorded, would provide useful information about seismic energy translation and attenuation, ground motion characteristics, soil-structure interactions, and the dynamic behavior of the instrumented structures.

For domestic locations, the selected contractor(s) would study, recommend, install, and maintain as necessary, seismic instruments in the selected structures so that both the earthquake motions and the necessary aspects of understanding the structural behaviors during an earthquake can be recorded. The instrumentation program would require both free-field instruments and the instruments in the structure itself. Instruments should be placed that would be relevant to both the shell type of structures (i.e., containments) and frame/shearwall type of structures. Instrument locations should permit the behavior of the structure and response spectra at key elevations to be recorded. Instruments should also be placed at strategic locations, such as the center and edges of the basemat, with common time signals, so that torsion and tipping of a structure can be determined. Instrumentations in soils should be placed at various depths below the instrumented structures.

Agreements for seismic instrumentation at foreign locations should provide in general for the same type of instrument placement to be achieved by the domestic contractor.

From a cost-benefit standpoint, we consider this portion of the research programs of high value and if well planned should attract cooperative funding from industry and government agencies.

6. Containment Model Tests for Dynamic Loads: The research plan should provide for the design, construction, instrumentation, and testing of containment models for dynamic loads. The plan should consider in situ and shaker tests with due consideration of test economy and data reliability. The model tests should be so designed that the most pertinent data for the variables in the analytical methods that are used to predict the dynamic behavior of containments may be secured systematically. The plan should also consider models and tests with or without SSI phenomenon. As this research is likely to be costly, maximum use of cooperative agreements with the domestic nuclear industry and international agencies should be attained. NRC should avoid expensive commitments in this area and fund only those aspects necessary to secure appropriate cooperative agreements. The research planning should carefully consider model size and scale-up

parameters. The feasibility of timed ground explosions on models or existing structures should be investigated.

7. Structural Fragilities: A program element should be established that either directs or coordinates with RES and other programs in the acquisition of empirical data on structural fragilities of piping and safety-related equipment.
8. Data Assemblage: The research plan should provide for orderly assemblage of field and model test data into "handbook" type format for seismic data for nuclear power plants. The first step would be the review of existing data which would include a "validation" procedure for inclusion in the handbook. The validation procedure would consist of a review of the data for the accuracy of its individual components and statistically assess error limits of those composite measurements (such as floor response spectra) that would be potentially useful for benchmarking or standard problem development. A judgment would then be made pertaining to the usefulness and limitations of the data.

As data become available from the seismic instrumentation program or the model test program, they would be similarly validated for inclusion in the handbook with the expectation that these new data would be of substantially higher accuracy.

9. Calculations and Advanced Code Development: The research plan should provide for the establishment of NRC-endorsed benchmarking points and standard problems from the validated data assemblage. These would be used by the SSMRP program, successor RES programs, and industry groups. Early calculations would be made to check methodologies and modeling assumptions against validated existing data. These checks and forthcoming additional data would be expected to lead to modified and improved analytical approaches.

The research program plan should consider whether the SSMRP activity, new RES contractors, or industry should develop additional and potentially semi-empirical seismic analysis methods. Whatever combination of advanced

code developers emerge, the research results should be made available for NRR review on a continuing basis. The resulting packages should include computer programs in a format that NRR can use to perform independently, or have performed, calculations against the benchmark points or standard problems using its own inputs and modeling assumptions. The principal component parts of each computer code should be separable and capable of independent validation.

10. Applicability to PRA: In addition to satisfying the quality needs for seismic analysis, the research end products, including computer codes, should, where appropriate and feasible, be consistent for use with current probabilistic risk assessment methodology. To achieve this goal, the Division of Systems and Reliability Research should be involved in both the planning and management of the analytical and computational aspects of the benchmarking research.
11. Equipment Qualification and Piping Design: A program element(s) should be established that either directs or coordinates with RES research in equipment qualification and in piping design.
12. Regulatory Requirements: It is likely that improved seismic analysis will lead to changes in regulatory requirements in some form. The research program plan should include provisions for assessing the value/impact of any changes in regulatory requirements that become RES recommendations as a result of research findings.
13. BNL Program on Benchmarking Structural Engineering Computer Codes -FIN:A3234: We endorse the subject research program for the work period 8/30/31 through 6/82. We are particularly interested in that portion investigating the extent to which predictive methods are supported by experimental data. We expect this work should aid in confirming the needs for experimental data we perceive at this time. Our endorsement of programs proposed by BNL for further work in this area will await our review of the overall research plan. However, we would be pleased to see BNL perform calculations in forthcoming studies because of previous favorable experience in seismic analysis with this laboratory. BNL has developed several computer codes

for SSI under previous NRC contracts, and in the area of computing facility, there is a direct line linked between the NRC terminal and BNL computers. An input made at BNL could have the output (result) delivered at the NRC terminal and vice versa. This has proven to be timely and effective for the NRC staff.

BIBLIOGRAPHY

1. Bush, S. H., Letter to N. J. Palladino, August 20, 1981.
2. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants."
3. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants."
4. P. D. Smith et al., "Seismic Safety Margin Research Program, Phase I Final Report - Overview," Lawrence Livermore Laboratory, NUREG/CR-2015, Vol. 1 (UCRL-53021), Vol. 1, April 1981.
5. Earthquake Engineering Research Center, University of California, EERC News, September 1981.
6. Murray, R. C. et al., "Equipment Response at the El Centro Steam Plant During the October 15, 1979 Imperial Valley Earthquake," Lawrence Livermore Laboratory, NUREG/CR-1665, October 1980.
7. Finkle, D. P. et al., "HDR Response-Experimental and Analytical," EG&G, Idaho, NUREG/CR-1913 (EGG-EA-5261), February 1980.
8. Thinnes, G. L. and Rahl, "Experimental and Analytical Results of Blast Induced Seismic Studies at HDR," Idaho National Engineering Laboratory, NUREG/CR-246, November 1981.
9. Knott, S. and Tang, H. T., "Seismic Testing," EPRI Journal, Vol. 6, No. 8, October 1981, p. 14.
10. Moriwaki, Y., et al., "Specification of Input Motions for Seismic Analysis of Soil-Structure Systems Within a Nonlinear Analysis Framework," Electric Power Research Institute, EPRI NP-2097, Project 810-9, October 1981.
11. Harold R. Denton to Robert B. Minogue, Memo, "RES Budget Reduction," December 10, 1981.