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SUMMARY REPORT

STRUCTURAL SEISMIC INVESTIGATIONS OF

GENERAL ELECTRIC TEST REACTOR

OFFICIAL SEAL
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prepared for

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1. INTRODUCTION

This report has been prepared to present a brief summary of the structural seismic investigations of the General Electric Test Reactor (GETR). The objective of this report is to state, in summary form, the investigation results which show that the GETR safety-related structures and equipment meet the demands of the design basis seismic events described in the USNRC May 23, 1980 Safety Evaluation Report. This document will provide the reader with a "road map" with which he can "walk through" the numerous investigations. Specific details of individual analyses and investigations can be found in the relevant reports, which are referenced but not repeated here.

To put matters in proper perspective, it is appropriate to keep in mind that the GETR is a small test reactor with a modest power level of 50Mwth. The system requirements for the design basis seismic events are:

- Safely shut down reactor
- Assure integrity of concrete core structure which supports other systems and components important to safety
- Assure integrity of reactor vessel and canal fuel storage tanks
- Assure capability of providing make-up water to spent fuel storage tanks and reactor vessel

Figure 1-1 shows the plot plan of the GETR, and Figure 1-2 shows the Reactor Building vertical cross-section. The heavy, massive concrete portion of the building, which is the safety-related area, is shown in Figure 1-3. A short summary description of the GETR is given in Table 1-1. The above system requirements are met as follows:

- There is a seismic scram system that will safely shut down the reactor before significant earthquake accelerations occur. The scram initiating sensor is one or both of two pendulum switches set to activate at 0.01 to 0.03g. Scram of the reactor is accomplished in a very short time interval after activation by the rapid downward movement of the control rod assembly due to gravity with assistance by downward flow of the water of the primary system.

- The analyses described herein show that integrity of the concrete core structure which supports other systems and components important to safety is assurred.

- The integrity of the reactor vessel and canal fuel storage tanks is assured by adequacy of the concrete core structure (see Figure 1-3) and the following:

  For the reactor vessel, restraints have been evaluated, modified, or added to meet the seismic criteria for the:

  - Reactor pressure vessel
  - Reactor primary piping
  - Reactor pressure vessel and pool drain lines and poison injection line
  - Permanent pool shielding
  - Primary heat exchanger
  - Pool heat exchanger

  Standpipes were added above the emergency cooling check valves to ensure that water remains over the fuel in the reactor vessel in the unlikely event of loss of water from the pool.

For the canal storage tanks,

- New, structurally stronger tanks were constructed
- Structures were added and equipment was modified to prevent potential missiles from being generated or causing damage by installing:

  Impact structure for the polar crane

  Restraints on the polar crane trolley, missile shield, and refueling bridge

  A canal impact pad to prevent damage due to cask tipping

- Water in the fuel element storage containers (including the reactor pressure vessel) is replenished by a new Fuel Flooding System. This system begins to supply water when the scram pendulum switches activate. A redundent seven-day gravity flow (no power required) supply is designed and has been partially constructed.

Thus, the GETR will safely shut down and stay down during and after a seismic event, and fuel elements will be kept covered by water, i.e. the containers will remain intact and makeup water will be provided.

The structural investigations are essentially divided into chronological phases, where each phase is basically defined by the seismic criteria used in the evaluations. Other differences, such as analytical detail and scope of models occur in the phases, but the main distinction is criteria. For discussion purposes, the recent work performed during the first half of 1980 is identified as Phase 3. The three Phases and the associated basic criteria are:

Phase 1 - Ground acceleration = 0.6g (Calaveras event)
Surface rupture offset = 1.0m (Verona event)

Phase 2 - Ground acceleration = 0.8g (Calaveras event)
Surface rupture offset = 1.0m (Verona event)

Phase 3 - Ground acceleration = 0.75g (Calaveras event)

Ground acceleration = 0.60g combined with
Surface rupture offset = 1.0m (Verona event)

The main features of the three phases are described in the following chapters, with emphasis placed on the recent Phase 3 structural and probabilistic work.

These investigations demonstrate that the GETR Reactor Building and safety-related piping and equipment are adequate to meet the criteria for seismic events on the Calaveras and Verona faults as described in the USNRC May 23, 1980 Safety Evaluation Report.

TABLE 1-1

GENERAL ELECTRIC TEST REACTOR DESCRIPTION

REACTOR DESCRIPTION

POWER	50 MWT
THERMAL NEUTRON FLUX	CORE - 6×10^{14} POOL - 1.5×10^{14}
FUEL ELEMENTS	21 URANIUM ALUMINUM ALLOY
FUEL FOLLOWERS	6 URANIUM ALUMINUM ALLOY
CONTROL RODS	6 BORON STAINLESS STEEL
COOLANT AND MODERATOR	LIGHT WATER
REFLECTOR	BERYLLIUM AND LIGHT WATER
PRIMARY COOLING SYSTEM	
PRESSURE MAXIMUM	150 PSI
TEMPERATURE MAXIMUM	180°F
SINGLE PUMP/HEAT EXCHANGER FLOW	10,000 GPM
SECONDARY COOLING SYSTEM	COOLING TOWER
OPERATING CYCLE	2-3 WEEKS OPERATION (24-HR.) ~3 DAYS DOWN
REACTOR VESSEL AND PRIMARY PIPING	ALUMINUM

DLG
6/80

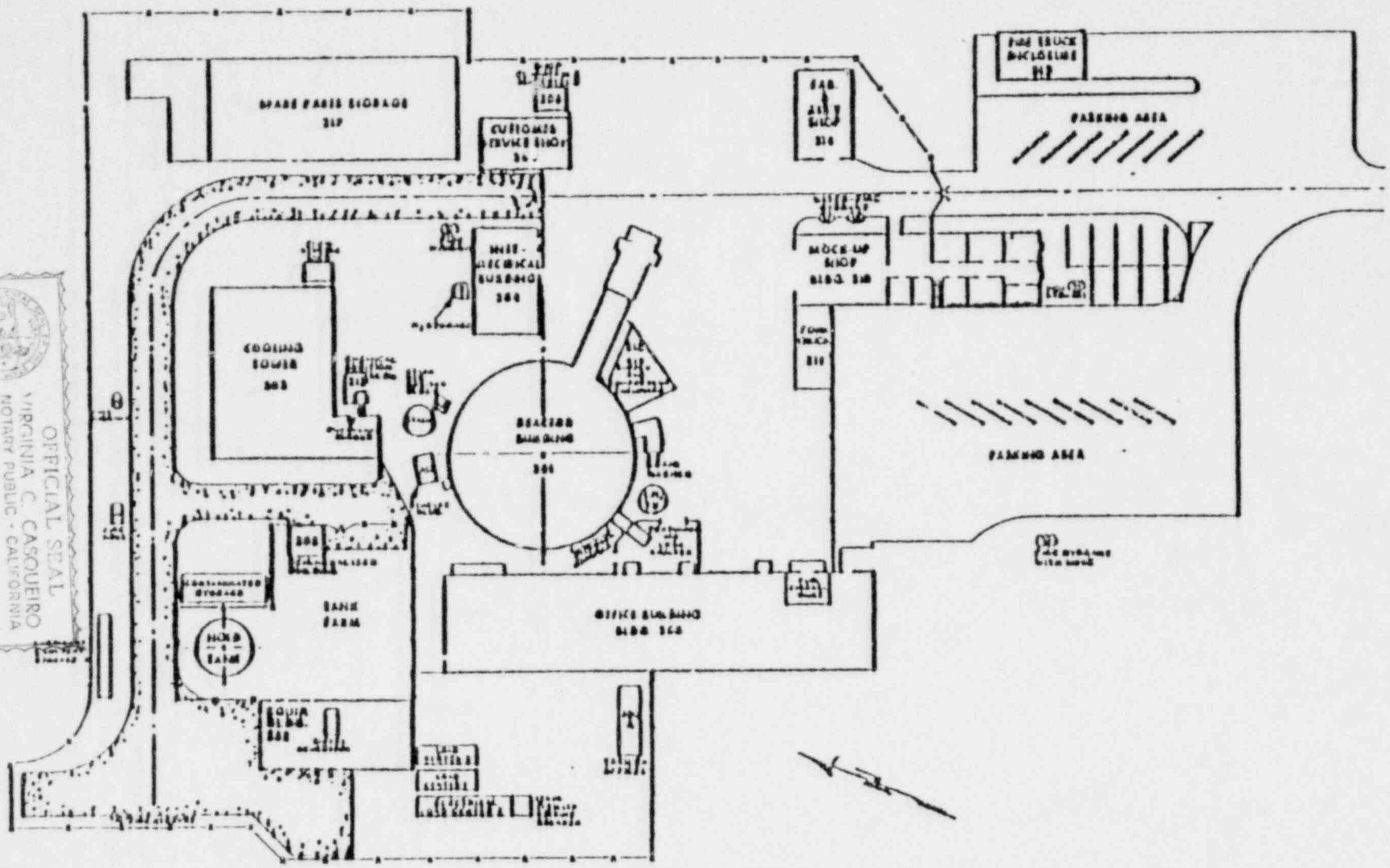

FIGURE 1-1 GETR AREA PLOT PLAN

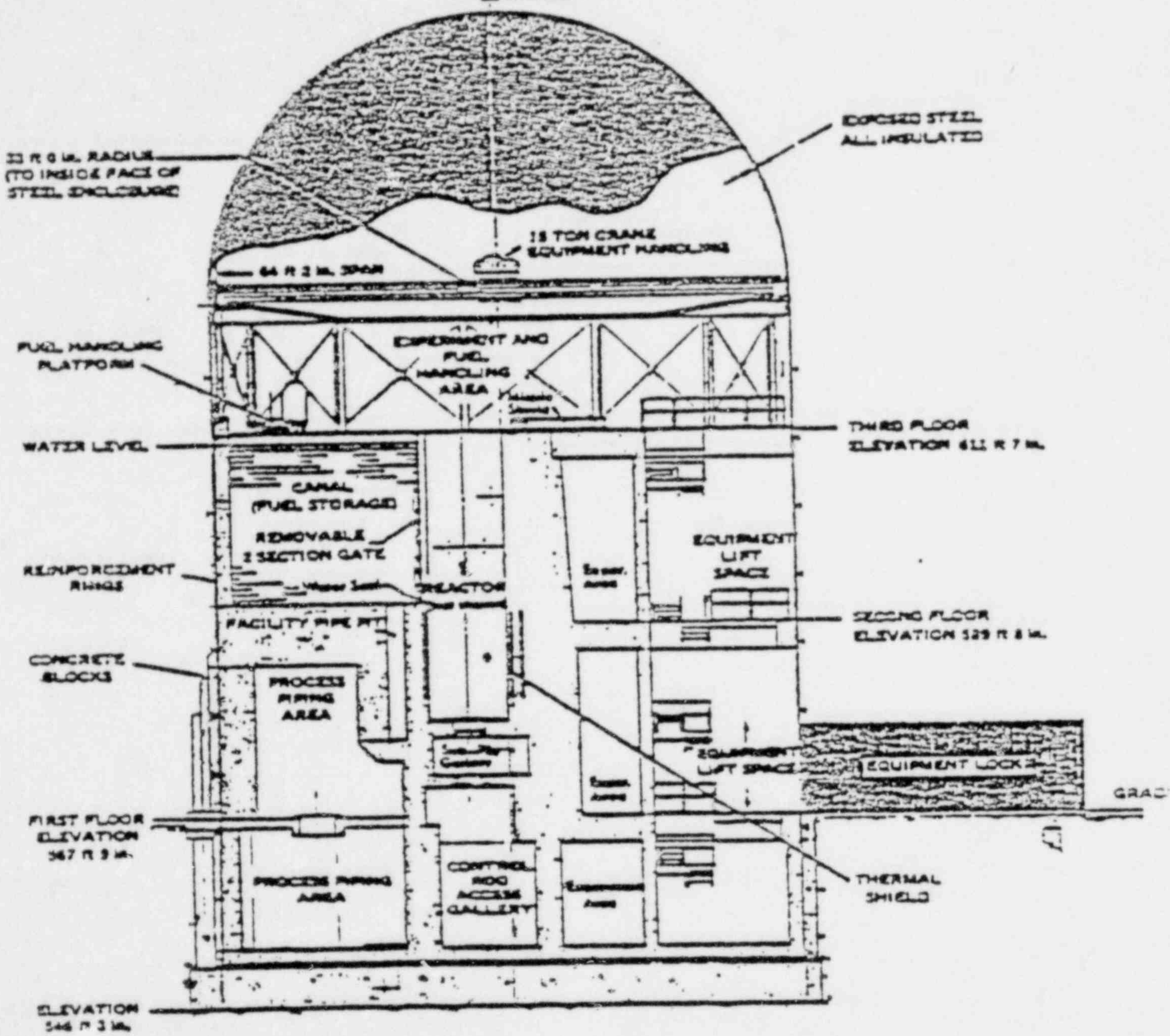

FIGURE 1-2 REACTOR BUILDING CENTERLINE SECTION

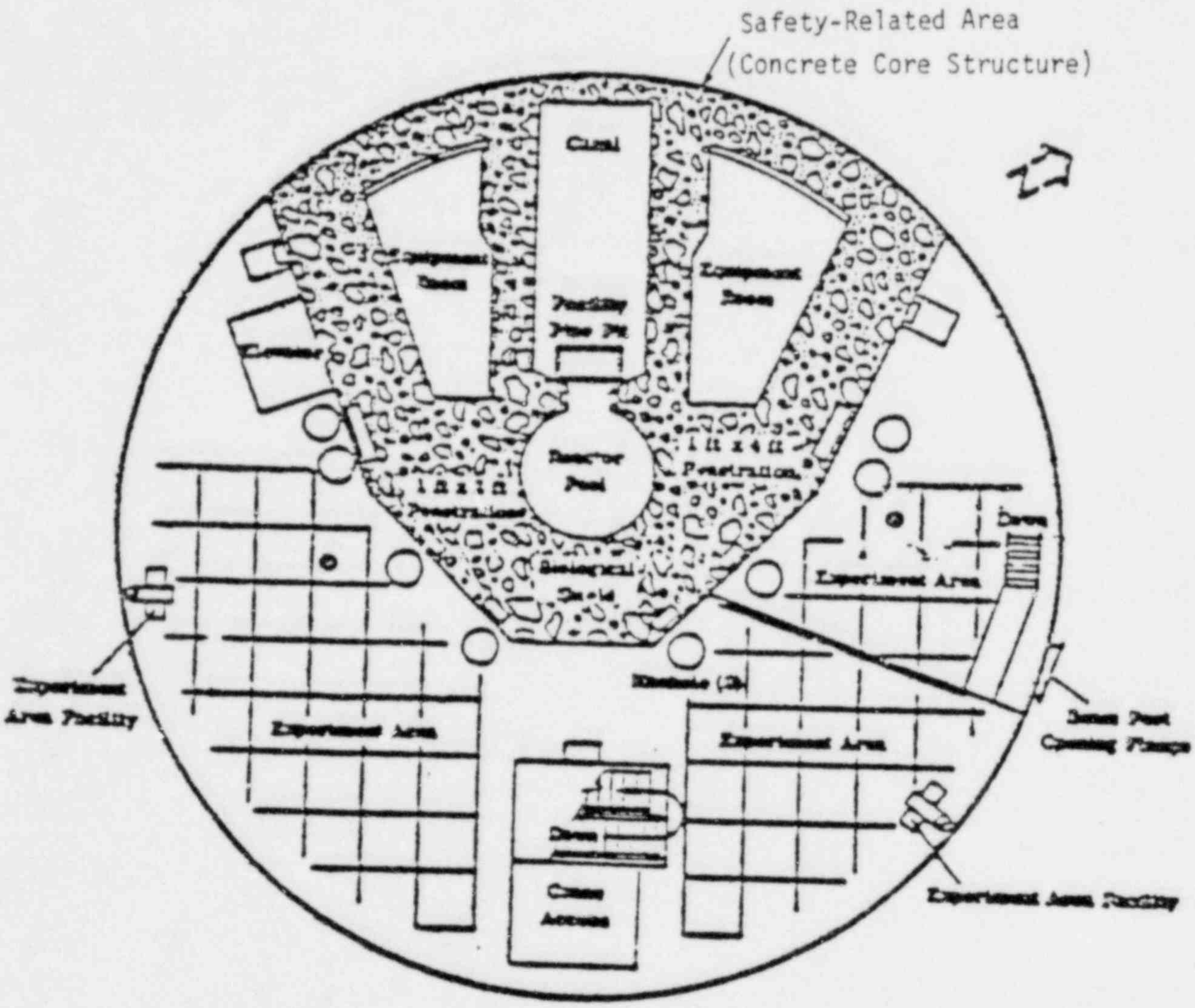

FIGURE 1-3 REACTOR BUILDING SECOND FLOOR PLAN

2. PHASE 1 INVESTIGATIONS

INTRODUCTION

This chapter presents a brief summary of the results of the Phase 1 preliminary analyses of the General Electric Test Reactor (GETR) Reactor Building and safety-related piping and equipment for the effects of earthquake forces induced by vibratory ground motions and a surface rupture offset. The Phase 1 analyses were the initial steps of a comprehensive structural analysis of the Reactor Building. Preliminary results were obtained based on computer and manual computations which demonstrated that conservative estimates of the forces in the concrete core structure induce stresses which are less than the cracking threshold capacities of the concrete. The concrete core strucutre contains and supports the safety-related systems and components necessary for safe shutdown of the reactor. A program of analysis, testing, and modification of safety related piping and equipment was also undertaken.

The seismic criteria used in the Phase 1 investigations consisted of a vibratory ground motion with a horizontal ground acceleration of 0.6g, a vertical acceleration of 0.4g, one meter surface rupture offset, and a combined load case consisting of a one meter offset and a 0.1g ground acceleration (Reference 1).

The Phase 1 investigations were divided into two main categories:

- Reactor Building
- Safety-Related Piping and Equipment

The investigations for the Reactor Building are briefly summarized in the following text as background historical information only; therefore no "flow chart" for the investigations is presented. The investigations of piping and equipment are summarized in the discusions of the Phase 2 and Phase 3 investigations (Chapter 3 and 4 respectively), and are not presented in this Chapter to avoid duplication. For detailed summaries of the comprehensive Phase 2 and Phase 3 investigations, the reader should refer to Chapters 3 and 4 respectively. These chapters summarize investigations which demonstrate that the GETR Reactor Building and safety-related piping and equipment are adequate to resist the seismic motions postulated for the site.

REACTOR BUILDING

The Phase 1 investigations of the Reactor Building were divided into two main parts, consistent with the loading criteria:

- Vibratory Ground Motions (from Calaveras event - 0.6g)
- Surface Rupture Offset (from Verona event - 1.0m)

These investigations are described in detail in

- "Seismic Analysis of Reactor Building, General Electric Test Reactor, Phase 1" (Reference 1).

The investigations were further divided into tasks and subtasks as follows:

- Vibratory Ground Motion Effects
  - Criteria Basis
  - Analytical Representation
    - Structural Model
    - Soil Springs
  - Analytical Procedures
  - Concrete Wall Capacities

- Analysis for Surface Rupture Offset
  - Basis for Analysis
  - Postulated Ground Surface Analysis Cases
  - Structure Response -- Simple Support Case
  - Structure Response -- Cantilever Support Case
  - Structure Response -- Wall Loading Case
  - Superposition of Vibratory and Ground Rupture Effects

Detailed descriptions of the above tasks are presented in Reference 1.

The vibratory ground motion analysis showed that the shear and tensile stresses in the concrete surrounding the reactor pool and fuel storage canal (see Figure 2-1) for the 0.6g case were much less than their capacities; therefore, the pool and canal will remain uncracked.

The surface rupture offset analysis showed that the concrete surrounding the pool and canal will remain intact during a postulated surface rupture offset. It was found that the exterior basement wall may deform due to lateral soil pressures, and floor slabs outside of the concrete core structure at the foundation, first, second, and third floor levels may crack and yield in a ductile manner. However, the concrete in the concrete core structure portion of the Reactor Building will not be affected. This conclusion also applied for the case of combined surface rupture offset and vibratory ground motion. Such deformations can be tolerated without jeopardizing the safety-related portion of the Reactor Building.

In conclusion, the vibratory and ground rupture analyses demonstrated that the concrete which surrounds the pool and canal (see Figure 2-1) will remain intact in the event of the criteria earthquake.

The following chapters continue the summarization of the seismic investigations of the GETR Reactor Building and safety-related piping and equipment.

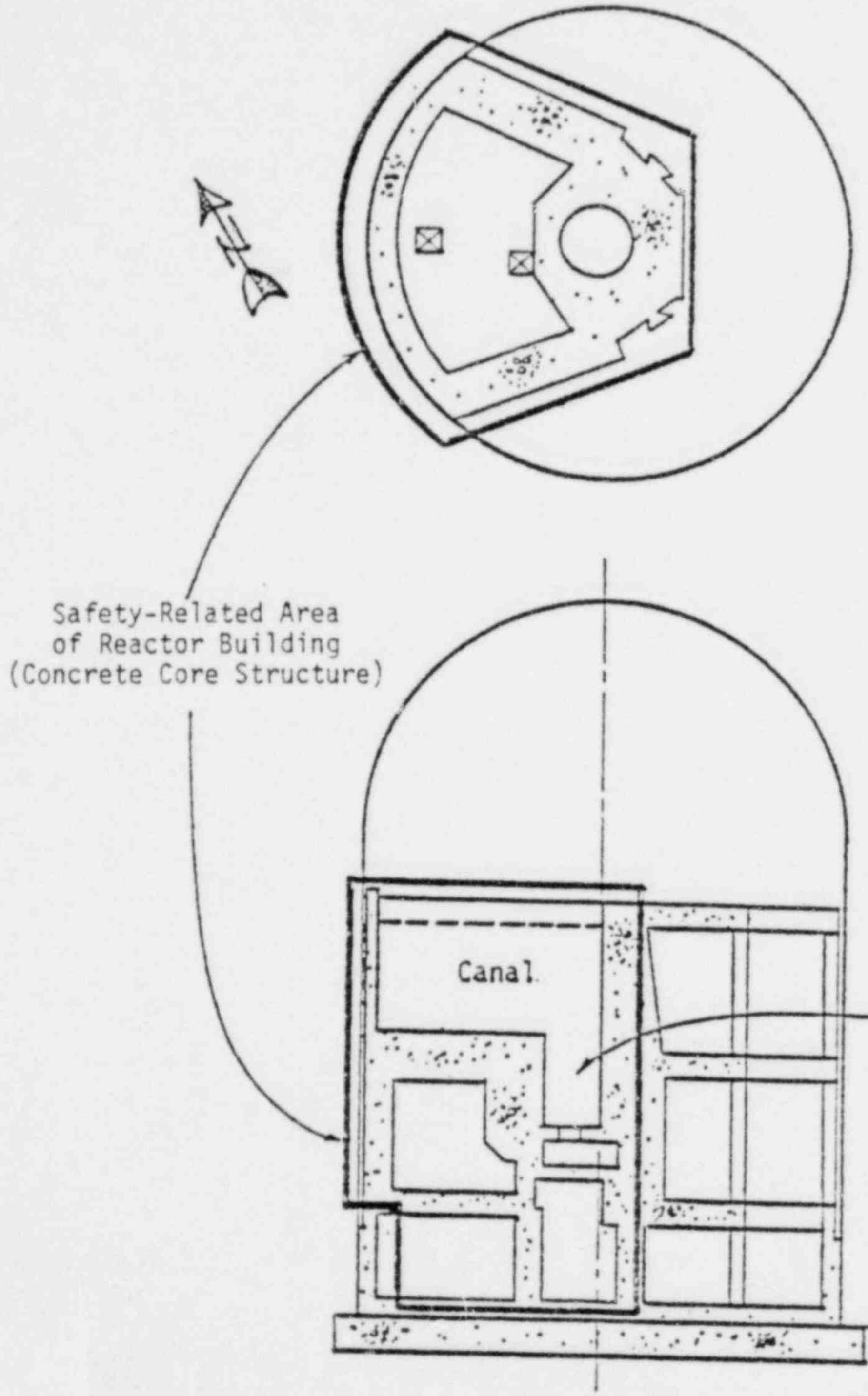

FIGURE 2-1 SAFETY RELATED AREA OF REACTOR BUILDING

3. PHASE 2 INVESTIGATIONS

INTRODUCTION

This chapter summarizes the results of the Phase 2 investigations of the General Electric Test Reactor (GETR) Reactor Building and safety-related piping and equipment for the effects of forces induced by earthquake vibratory ground motions or a postulated surface rupture offset. The vibratory ground motion which might occur at the GETR site because of an earthquake on the Calaveras fault was used as a basis for the analyses. Even though it was concluded that the possibility of surface offset of the Verona fault can be safely disregarded, a conservative hypothetical surface rupture offset of one meter was assumed in the analyses to affirm that the Reactor Building could safely withstand such a ground offset.

The Phase 2 investigations were part of a comprehensive structural analysis of the Reactor Building and the GETR safety-related components and systems. Phase 2 was performed to verify the conclusions of Phase 1 and consisted of more detailed analyses.

The seismic criteria used in Phase 2 consisted of a vibratory ground motion with a ground acceleration of 0.8g, a one meter surface rupture offset, and a combined loading case consisting of a one meter offset and a 0.15g ground acceleration. The 0.8g criterion value is larger than the 0.6g value used as the basis for analyses presented in the Phase 1 report (Ref. 1). The 0.6g value is an extremely conservative value; however, to expedite the review process and to eliminate any concern regarding the level of conservatism associated with the analyses, a 0.8g value was used in the Phase 2 investigations summarized in this chapter.

The Phase 2 investigations were divided into two main categories, each of which is summarized in the following text.

- Reactor Building
- Safety-Related Piping and Equipment

REACTOR BUILDING

The investigations of the seismic adequacy of the GETR Reactor Building focused on the safety-related concrete core structure as shown in Figure 3-1. These investigations showed that the core structure will remain intact undamaged as a result of the postulated seismic events. An extensive series of analyses were undertaken to demonstrate the adequacy of the Reactor Building, which included:

- Static and Dynamic Analyses
- Linear and Nonlinear Analyses
- Lumped Mass and Finite Element Analyses

The investigations were divided into three main parts, consistent with the loading criteria:

- Vibratory Ground Motion Analyses (from Calaveras event - 0.80g)
- Hypothetical Surface Rupture Offset Analyses (from Verona event - 1.0m)
- Post-Offset Analyses (from event after surface rupture offset - 0.80g,

These investigations are described in detail in:

- "Seismic Analysis of Reactor Building, General Electric Test Reactor, Phase 2" (Reference 2).

Figure 3-2 presents a "flow chart" or "road map" of the overall Phase 2 investigations of the Reactor Building. Pertinent chapters in Reference 2 are shown in this figure to assist the reader in locating descriptions of specific investigations.

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Vibratory Ground Motion Analyses

The vibratory ground motion analyses of the Reactor Building were divided into numerous tasks and subtasks, each of which is described in detail in Chapter 2 of Reference 2. These tasks and subtasks were as follows:

- Criteria Basis
- Linear Elastic Analyses
  - Structural Model
  - Soil Springs
  - Analytical Procedures
    - Eigenvalue Solution
    - Time History Response Analysis
    - Generation of Floor Response Spectra and Envelope Spectra for Design
- Parametric Studies
  - Influence of Variation in Soil Shear Modulus and Average Area of Contact Between the Building and the Underlying Soil
  - Influence of Variation in Modal Damping
  - Contribution of Torsion
  - Foundation Embedment Effects
- Nonlinear Analyses -- Model A
  - Potential Uplift at Foundation Slab-Soil Interface
  - Potential Sliding Effects
    - Foundation Slab-Soil Interface
    - Interior Concrete-Foundation Slab Interface
- Nonlinear Analyses -- Model B
- Stress Analyses
  - Using Manual Computations
  - Using a Finite Element Model

Figure 3-3 presents a flow chart of the Phase 2 analyses for vibratory ground motions. Pertinent chapters or main chapter sections in Reference 2 are shown on Figure 3-3 to assist the reader in locating descriptions of specific investigations.

Surface Rupture Offset Analyses

The surface rupture offset analyses were also divided into tasks and subtasks, each of which is described in detail in Chapter 3 of Reference 2. These tasks and subtasks were as follows:

- Basis for Analysis
- Hypothetical Surface Rupture Offset Cases
- Linear Elastic Static Analysis
  - Model of Reactor Building Structure and Computer Program
  - Boundary Conditions
  - Analytical Procedures and Results of Analysis
  - Analysis of Reactor Building Floor Slabs

Figure 3-4 presents a flow chart for the Phase 2 analyses for the surface rupture offset load case. Included in this figure are the possible cases or physical situations which could occur depending on the location of the surface rupture offset under the Reactor Building. Pertinent chapter subheadings are shown on Figure 3-4 to assist the reader in locating descriptions of specific investigations.

Post Offset Analyses

The post-offset analyses were divided into tasks as described in Chapter 4 of Reference 2. These tasks were as follows.

- Criteria Basis
- Analytical Procedures
- Results

In the Phase 1 analysis (Reference 1), it was shown that a residual ground acceleration of 0.1g (0.15g in the Phase 2 analysis) is the largest realistic value which might occur after the hypothetical surface offset. However, to demonstrate that the portion of the Reactor Building which supports and protects the safety-related systems and components could resist a major ground motion which might occur subsequent to the hypothetical surface offset, a vibratory ground motion analysis of the concrete core structure using an extremely conservative value of 0.8g was conducted.

Conclusions

The results of the vibratory ground motion analyses indicated that the maximum shear and tensile stresses which could occur in the concrete structure surrounding the pool and storage canal, if the GETR were subjected to a 0.8g ground acceleration, would be much less than the cracking threshold capacities. Therefore, the pool and storage canal concrete will not be damaged and will remain uncracked. Furthermore, the concrete core structure to which restraints are anchored for safety-related systems and components necessary to safely shut down and safely maintain the GETR following the criterion seismic events would remain undamaged.

The results of the surface rupture offset analyses also showed that the concrete surrounding the pool and storage canal would be undamaged and would not fail during the hypothetical surface rupture offset. It was found that portions of the exterior basement wall may suffer cracking and deformation due to lateral soil pressures, and the slabs at the foundation, first, second, and third floor levels may crack and yield in a ductile manner. However, the maximum shear and tensile stresses which could occur in the massive concrete walls and slabs which form the concrete core structure portion of the Reactor Building housing the pool and the storage canal (Figure 3-1) are well below the cracking threshold stresses.

The results of the post-offset analyses showed that, for the extremely conservative criterion ground acceleration of 0.80g, stability of the Reactor Building would be maintained and the stresses in the concrete core portion of the Reactor Building would be considerably less than the threshold cracking values.

Finally, based on the above investigations and analyses, it was concluded that the detailed analyses performed for the maximum vibratory ground motion and hypothetical surface rupture offset demonstrate that the concrete which surrounds the pool and storage canal will not be damaged in the event that major earthquake motions and/or surface rupture occurs at the GETR site.

SAFETY-RELATED PIPING AND EQUIPMENT

All safety-related piping and equipment has been shown to be adequate to meet the specified seismic criteria, or modified to do so. The following reports describe the seismic investigations of the piping and equipment in detail.

- "Seismic Analysis of Primary System and Reactor Pressure Vessel," (Reference 3)
- "Seismic Analysis of Primary Heat Exchanger," (Reference 4)
- "Seismic Analysis of Reactor Pressure Vessel and Pool Drain Lines and Poison Injection Line," (Reference 5)
- "Seismic Analysis of Fuel Flooding System," (Reference 6)
- "Qualification of Safety-Related Valves," (Reference 7)
- "Analysis of Lateral Restraints to Contain Heat Exchanger HE102," (Reference 8)

- "Evaluation of GETR Primary Cooling System and Pipe Restraints 1-2, 1-4, 1-6, and 1-7," (Reference 9)
- "Analysis of Control Rod and Incore Shuttle Assemblies," (Reference 10)

In summary, it was demonstrated by analysis, by modification and analysis, or by testing that all safety related piping and equipment have adequate strength to resist the motions induced by the postulated seismic events.

CONCLUSIONS

The detailed investigations, analyses, modifications, and testing performed during the Phase 2 structural investigations clearly demonstrated that the GETR Reactor Building concrete core structure and safety-related piping and equipment are adequate to resist the very conservative seismic motions postulated for the site.

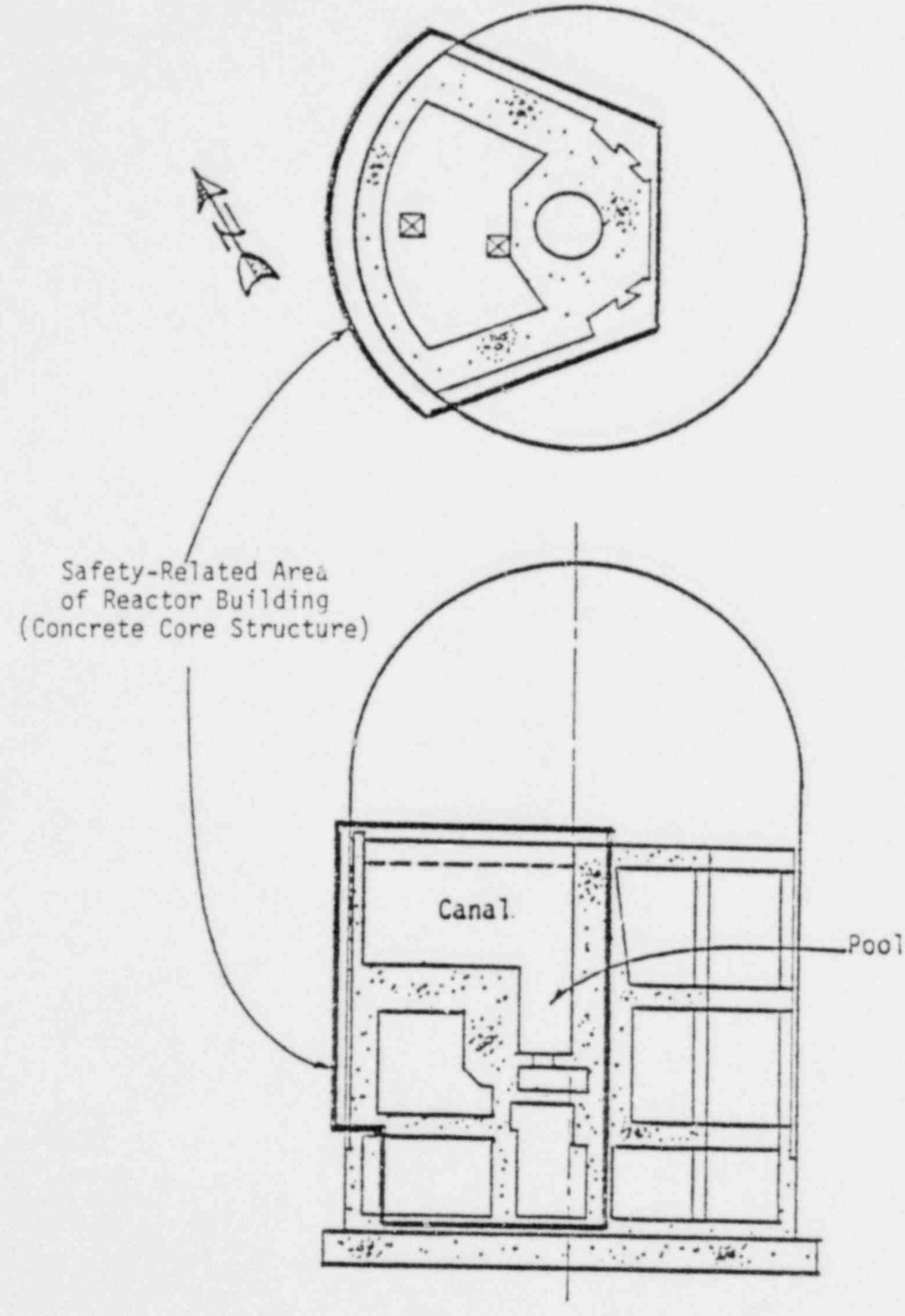

FIGURE 3-1 SAFETY-RELATED AREA OF REACTOR BUILDING

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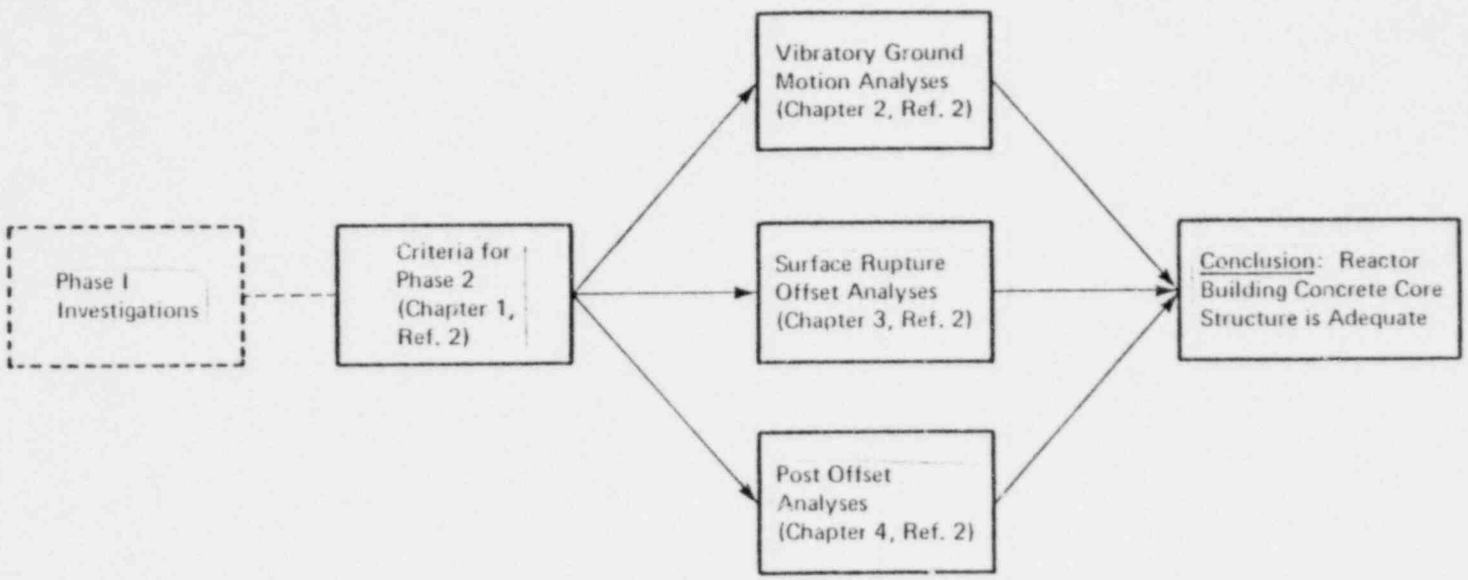

FIGURE 3-2 REACTOR BUILDING PHASE 2 INVESTIGATIONS

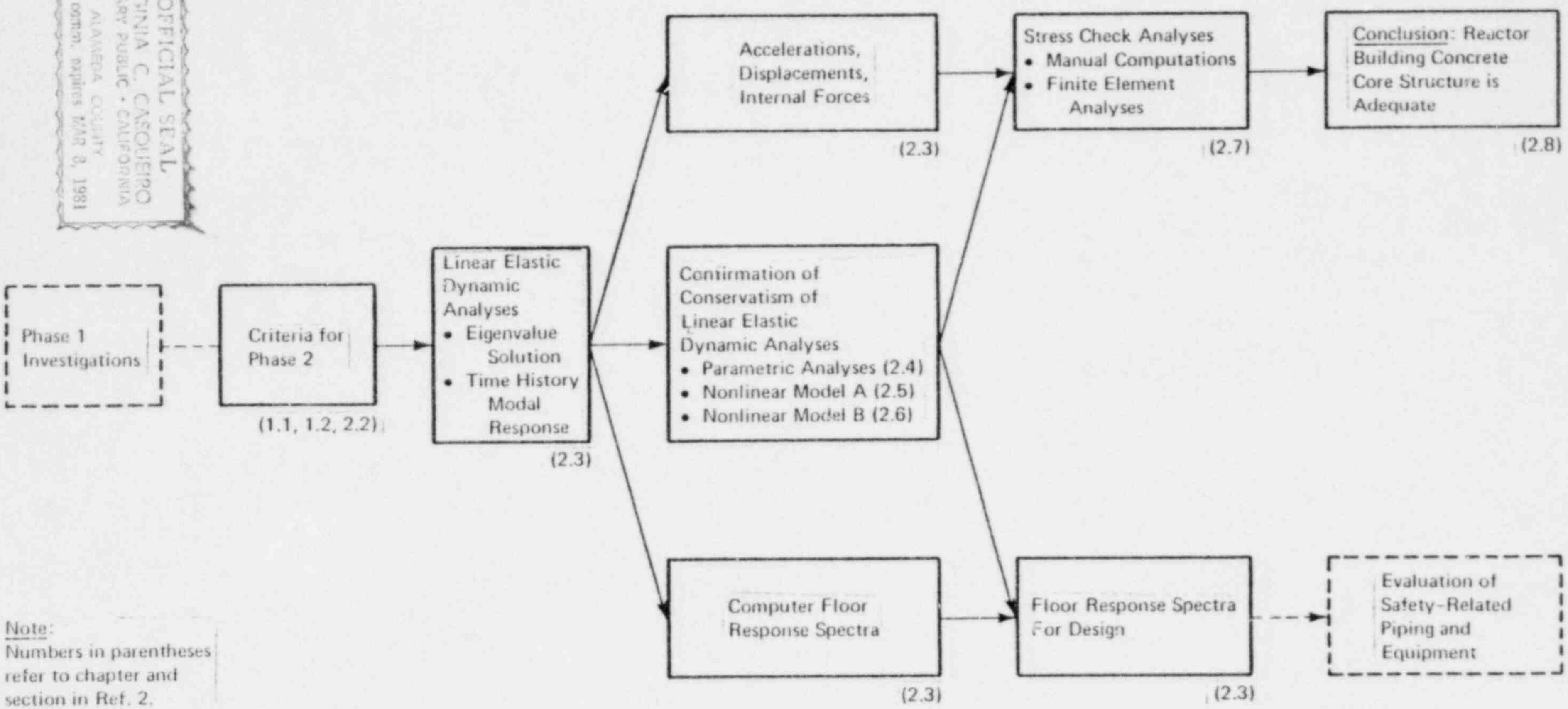

FIGURE 3-3 REACTOR BUILDING VIBRATORY GROUND MOTION ANALYSES

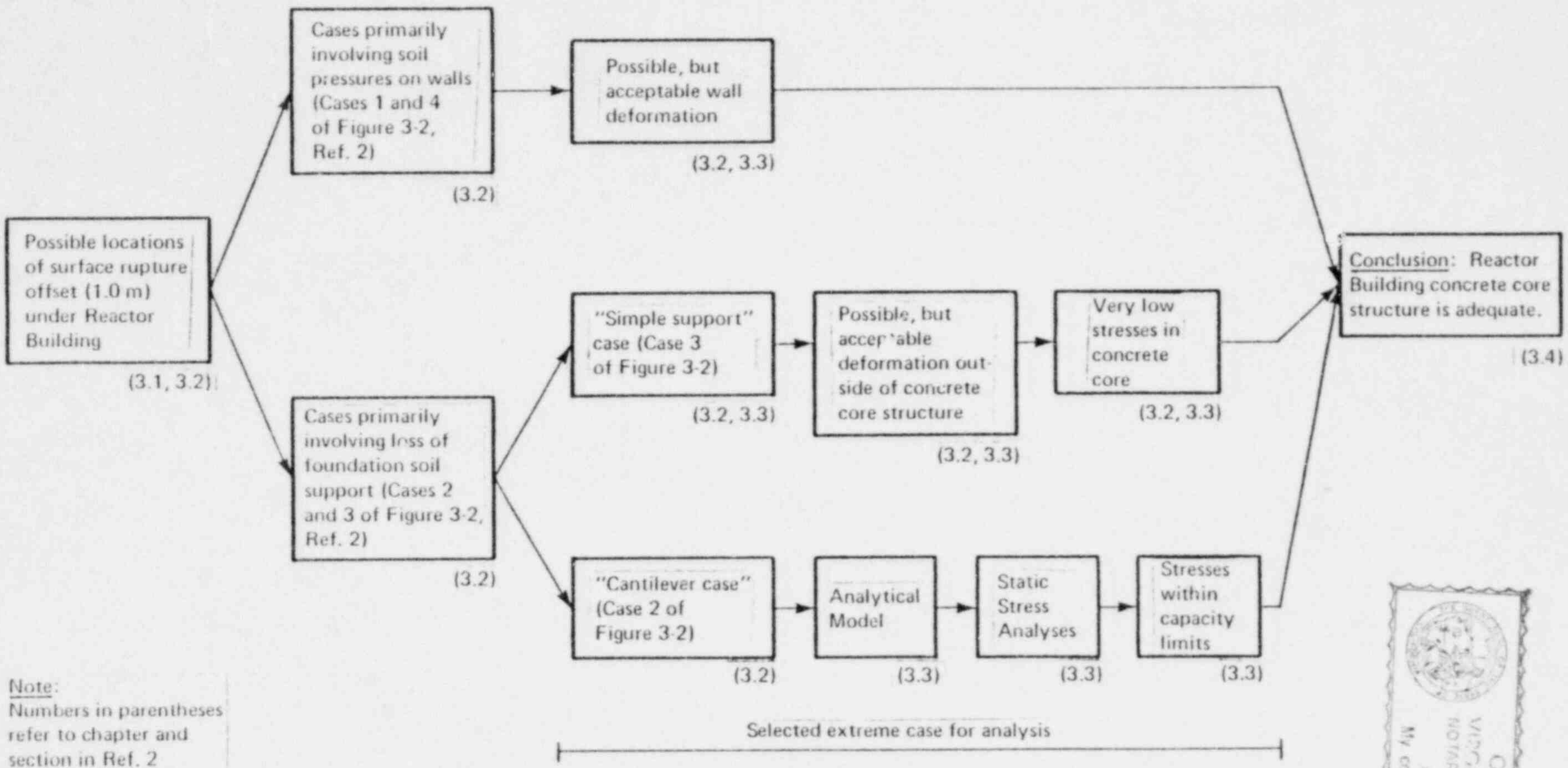

FIGURE 3-4 SURFACE RUPTURE OFFSET ANALYSES

4. PHASE 3 STRUCTURAL INVESTIGATIONS

The structural investigations of Phase 3 emphasized the concrete core structure of the Reactor Building, and drew heavily on the work of the previous phases (Ref. 1 and 2). It is important to review the sequence of events during Phase 3 as an aid in understanding the various reports and supplements which were issued. The main events were:

- Review of seismic criteria and selection of 0.6g for a Calaveras event and 0.4g/1.0m for a Verona event
- Evaluation of adequacy of Reactor Building to withstand the above criteria
- Issuance of criteria by USNRC of 0.75g for a Calaveras event and 0.6g/1.0m for a Verona event
- Reevaluation of adequacy of Reactor Building to withstand USNRC criteria (as well as provide supplementary information requested by USNRC)

Figure 4-1 presents a flow chart of the Phase 3 investigations. A brief synopsis of each of the Phase 3 reports is as follows:

"Review of Seismic Design Criteria for the GETR Site" (Reference 11)
This report presented a review of the seismic design criteria proposed and used for the evaluation of the GETR Reactor Building, an assessment of the near field earthquake effects including studies of structural damage (or lack thereof) resulting from such earthquakes, the results of analyses to determine ground wave transit time effects, and resulting conclusions and recommendations. The studies in this report were made in response to

questions and comments raised by NRC staff and its consultants. This report presented the following recommendations.

- A ground acceleration value of 0.6g anchored to Regulatory Guide 1.60 spectra should be used for vibratory motions induced at the site by an earthquake event on the Calaveras fault.
- A ground acceleration of 0.4g anchored to Regulatory Guide 1.60 spectra should be used for vibratory motions induced at the site by an event on the Verona fault.
- For vertical motions, accelerations equal to two thirds of the horizontal accelerations should be used, anchored to Regulatory Guide 1.60 spectra.

<u>"Additional Investigations to Determine Effects of Vibratory Motions Due to an Earthquake on the Calaveras Fault" (Reference 12)</u>

This report presented the results of additional investigations to determine the effects of vibratory motion due to an earthquake on the Calaveras fault (with a ground acceleration of 0.6g as selected by EDAC/GE and 0.75g as selected by the USNRC). The main objective of this report was to demonstrate that the concrete core structure of the Reactor Building is adequate to withstand three components of ground motion (whereas the original Phase 2 Analyses, Ref. 2, were performed for one component with a maximum amplitude of 0.8g). This report concluded (1) that it was unnecesary to make additional detailed stress analyses for the postulated Calaveras event comprised of three components, and (2) that the Reactor Building is adequate to withstand motions induced by postulated seismic events on the Calaveras fault.

<u>"Additional Investigations to Determine the Effects of Combined Vibratory Motions and Surface Rupture Offset Due to an Earthquake on the Postulated Verona Fault" (Reference 13)</u>

This report presented the results of additional investigations to demonstrate that the Reactor Building is adequate to withstand combined vibatory motions (with a maximimum ground acceleration of 0.4g) and a surface rupture offset on the postulated Verona fault. Included in this report were the procedures used for selection of appropriate load combination cases, description of the analytical methods and model, and the results of the detailed stress analyses and checks against capacities. This report demonstrated that the Reactor Building is clearly adequate, with a substantial margin of safety, to withstand a ground acceleration of 0.4g as recommended by EDAC/GE combined with a surface rupture offset of 1.0m.

"Expanded Description of Soil Pressure Analyses" (Reference 14)
An expanded description of the soil pressure analyses originally described in Reference 13 above was presented in this report. Additional technical detail was incorporated regarding the soil pressure analyses as well as an extension of the work to include a ground acceleration of 0.6g. This report showed that consideration of the soil pressures beneath the Reactor Building for the combined load case of vibratory motion and surface rupture offset demonstrates that there are physical limits on the magnitude of loadings to be combined.

"Evaluations for 0.6g Ground Acceleration Case" (Reference 15)
This report presents a supplementary discussion of the adequacy of the GETR Reactor Building to withstand the maximum ground acceleration of 0.6g caused by a seismic event on the postulated Verona fault, and was prepared as a supplement to Reference 13 in response to the issuance of the revised criteria (0.60g/1.0m) issued by the USNRC. This report summarized past relevant investigations and demonstrated that the GETR Reactor Building is adequate to withstand the postulated combined load case of the maximum ground acceleration of 0.6g and a one meter surface rupture offset beneath the Reactor Building.

"Summary Report, Probabilistic Investigations of the General Electric Test Reactor" (Reference 16)

This report summarized the probabilistic investigations performed for GETR, and focused on the determination of suitable combined parameter values for the surface rupture offset and vibratory ground motion load case. These combined parameter values formed one of the bases for the selected analysis case described in Reference 13. (See also Chapter 5 of this summary report.)

"Conservatisms in the Seismic Evaluation of the GETR Reactor Building" (Reference 17)

A discussion of the conservatisms in the seismic evaluations of the GETR Reactor Building was presented in this report. The qualitative conclusion that the actual total safety margin of the seismic adequacy of the GETR Reactor Building is substantially above the values determined by the conservative seismic analyses was demonstrated.

"Review of Seismic Adequacy of Piping and Equipment, General Electric Test Reactor" (Reference 18)

This document presented the results of a review of the seismic adequacy of the safety-related piping and equipment supported in the Reactor Building of the General Electric Test Reactor. This review was undertaken to confirm that the safety-related piping and equipment is adequate to resist the seismic motions postulated for the GETR site by the USNRC in their letter of 23 May 1980 (ground acceleration of 0.75g due to a seismic event on the Calaveras fault, and an acceleration of 0.6g combined with a surface rupture offset of 1.0 meter due to a seismic event on the postulated Verona fault.) This report demonstrated that the piping and equipment as originally analyzed and modified meats these criteria.

The conclusions of the Phase 3 investigations are summarized in Chapter 6 of this report.

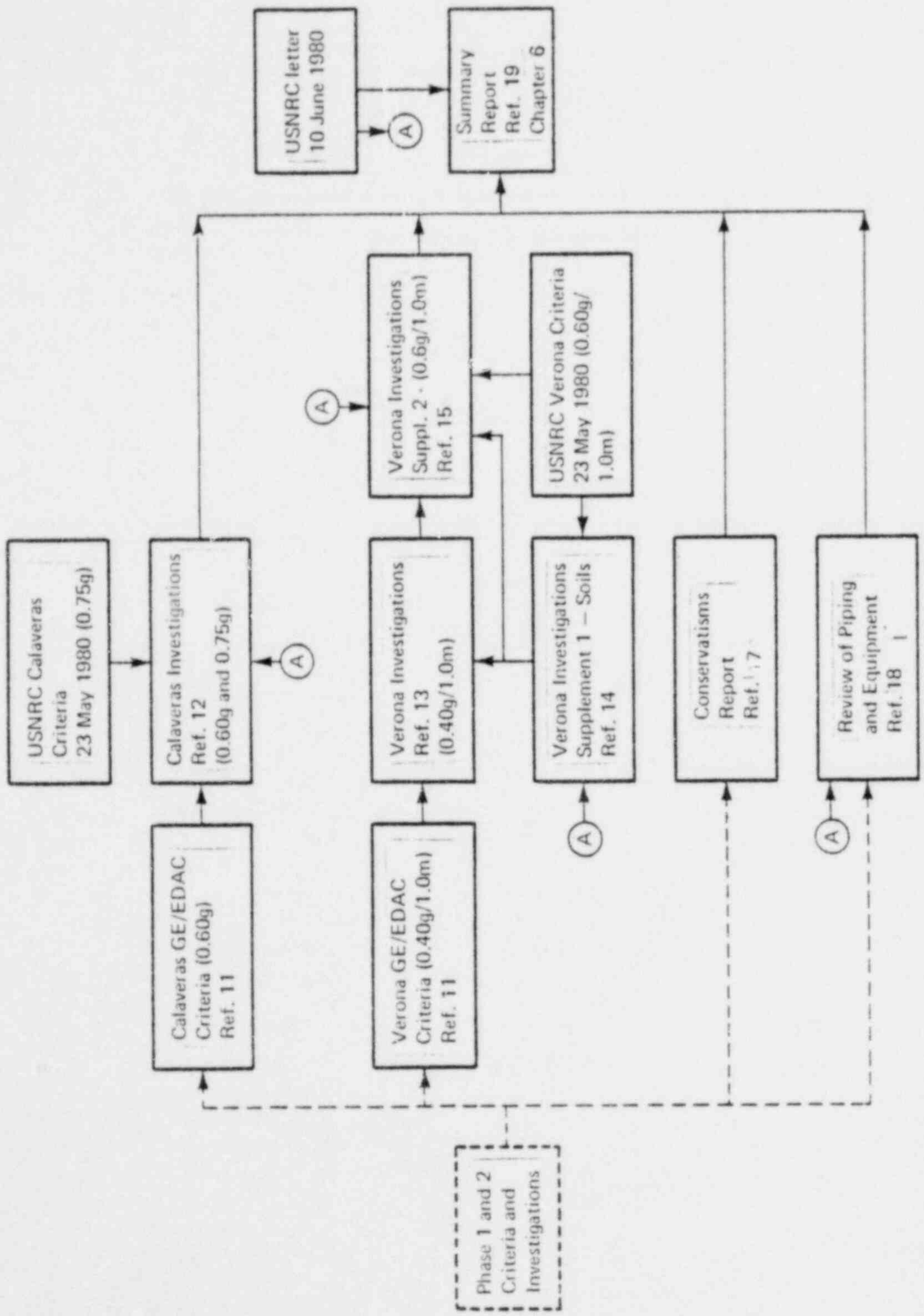

FIGURE 4-1 PHASE 3 INVESTIGATIONS

5. PHASE 3 PROBABILISTIC INVESTIGATIONS*

A probabilistic analysis was conducted to determine combined earthquake parameter values for surface rupture offset and vibratory ground motion. The results of this analysis are presented in Figure 5-1, which shows the interaction curve for the two types of earthquake effects. In this figure, Reactor Building cantilever length is plotted as the parameter representing surface rupture offset (see insert in Figure 5-1 for schematic definition of cantilever length) and effective ground acceleration is plotted as the parameter representing vibratory ground motion. The probability of points above (i.e., outside) this curve is sufficiently low that these values should not be considered in the structural analysis of the Reactor Building.

General Electric Company believes that surface rupture offset of any size should not be considered as a design basis event beneath the Reactor Building. However, if offset must be considered, the values on the interaction curve shown in Figure 5-1 represent a rational basis for selecting combined earthquake parameters, since the points on the interaction curve correspond to cases where the calculated probability of an offset beneath the Reactor Building is 10 times the allowable value.

Using an alternate probabilistic approach it is shown that the average cantilever length is 3 feet, conservatively assuming that an offset intersects the reactor foundation. This result reflects the physical reality that it is unlikely that a cantilever case will occur even if a future offset intersects the reactor foundation. It is more likely that simple beam support or wall loading cases, which impose low stresses in the safety-related concrete, will occur.

* Text prepared by Jack R. Benjamin & Associates, Inc.

Three feet is an appropriate value of the cantilever length parameter to be used in a structural analysis which combines both vibratory and offset effects, where the effective ground acceleration parameter is selected to be a maximum value. More rational parameter values for a combined analysis are shown in Figure 5-1, which are based on balancing the probabilities of both surface rupture offset and vibratory ground motion. A summary of the analysis leading to the interaction curve and the derivation of the alternate probabilistic approach are presented in a separate report (Ref. 16.)

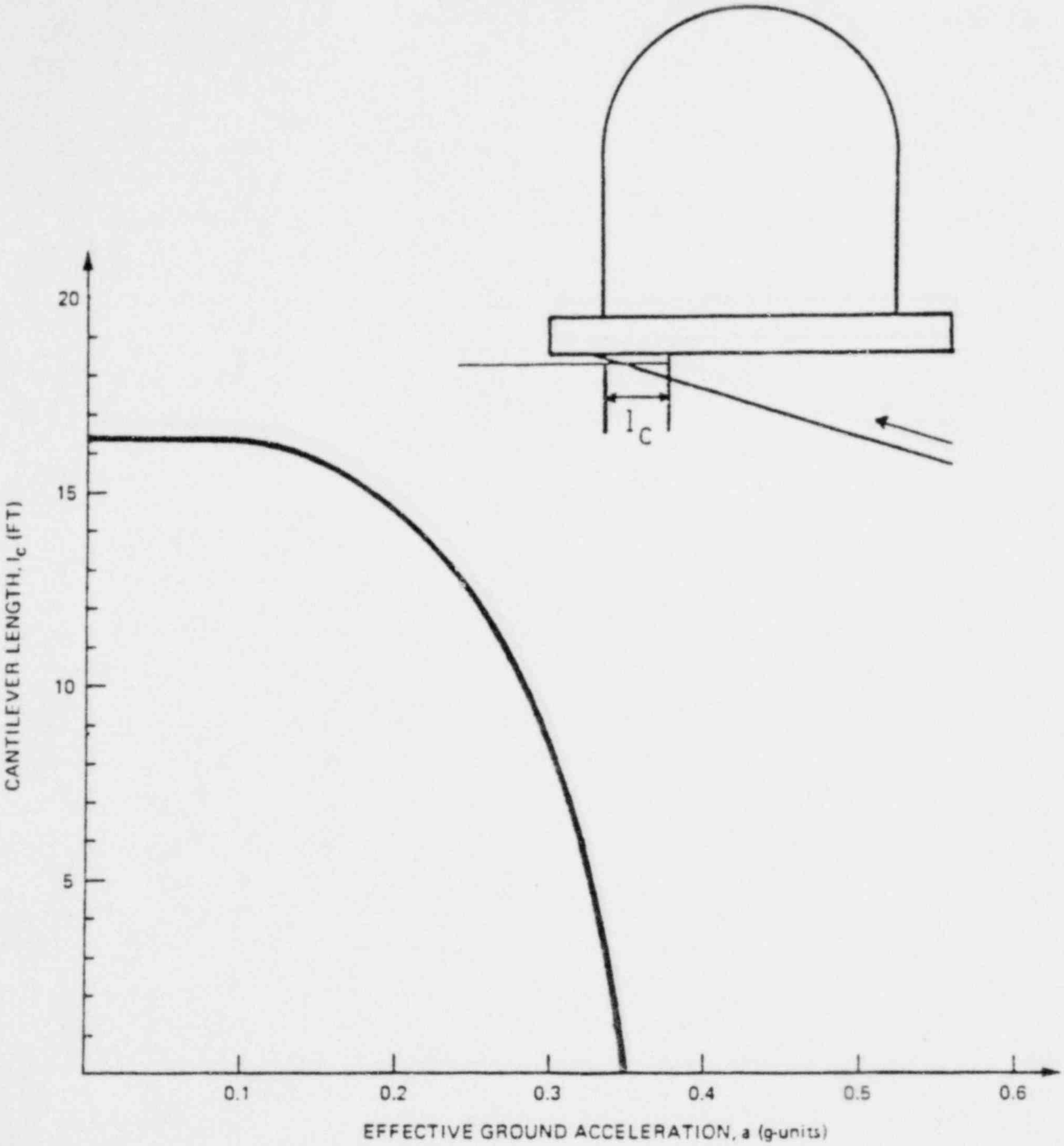

FIGURE 5-1 COMBINED PARAMETER INTERACTION CURVE

6. CONCLUSIONS

The Phase 3 investigations described in the previous chapters clearly demonstrate that the GETR Reactor Building and associated safety-related piping and equipment are adequate to meet the criteria for seismic events on the Calaveras and Verona faults as described in the USNRC May 23, 1980 Safety Evaluation Report. It was also demonstrated that many conservatisms exist in the procedures used to evaluate the GETR Reactor Building and equipment for seismic effects. Each of these conservatisms over-estimates response and under-estimates capacities. In addition, the conservatisms are cumulative; the total margin of safety is the product of many individual margins.

Figure 6-1 represents a graphical summary description of the investigations made of the adequacy of the GETR Reactor Building to withstand seismic events on both the Calaveras and Verona faults. The vertical axis on this figure represents ground acceleration and the horizontal axis denotes unsupported length, which is the physical configuration which analytically represents the worst case which can be envisioned for the surface rupture offset due to an earthquake on the Verona fault. The only load combinations which need to be considered based on probabilistic considerations are those beneath the solid curved line of Figure 6-1. The only load combinations which need to be considered based on physical considerations (local soil pressures) are those which are below the dotted band and 0.6g limiting acceleration on Figure 6-1. It is evident that the conservative capacity contour based on incipient cracking envelopes the possible combined load cases due to a Verona event as well as meeting the criterion for a Calaveras event. Consideration of the conservatisms mentioned above would, in effect, lower the requirements for the loading shown on Figure 6-1 and raise the conservative capacity, thus increasing the margin of safety above that shown.

Figure 6-1 thus graphically demonstrates that the concrete core structure of the Reactor Building is adequate to withstand without damage the combined load case of vibratory ground motion and surface rupture offset due to postulated seismic events on the hypothetical Verona fault as well as postulated seismic events on the Calaveras fault. Also, consideration and quantification of all individual margins of safety would result in a total margin of safety significantly above (and likely on the order of at least two times) that conservatively determined by the seismic evaluations of the GETR reactor building.

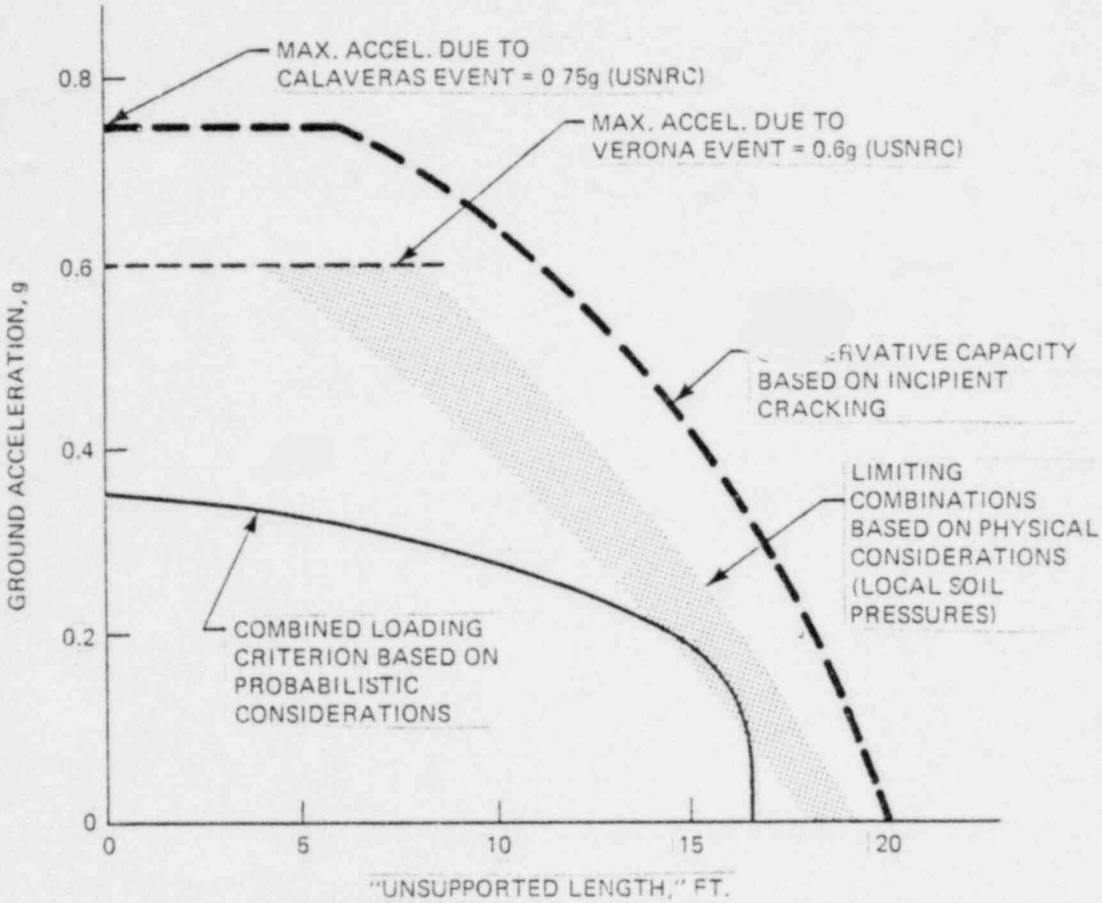

FIGURE 6-1 LOADING VS. CAPACITY

REFERENCES

REFERENCES

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PHASE 2

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PHASE 3

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APPENDIX A

USNRC (R. A. Clark) Letter to GE (R. W. Darmitzel)

10 June 1980

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

June 10, 1980

Docket No. 50-70

Mr. R. W. Darmitzel, Manager
Irradiation Processing Product Section
Vallecitos Nuclear Center
General Electric Company
P. O. Box 460
Pleasanton, California 94566

Dear Mr. Darmitzel:

On May 23, 1980 we issued our position regarding the proper geologic and seismic design bases for the General Electric Test Reactor (GETR). The design bases we specified are more severe than those upon which your structural analyses are based. By letters dated April 23 and May 8, 1980, you submitted reports regarding the effects of various combinations of vibratory ground motion and surface offset. As a result of our review of your reports as well as discussions with our consultants, we find that additional information, as indicated below, is necessary before we can complete our evaluation of the GETR seismic design.

You are requested to provide additional information justifying the ability of the facility, including all essential structures, systems and components, to meet the loadings associated with the design bases specified in our May 23, 1980 evaluation. This information should include, for both the maximum vibratory ground motion case and the combined surface rupture and vibratory ground motion case, a description of the combined effects (e.g. stresses, response spectra) at the highly affected regions and how these effects were determined. All design basis loads, including seismic loads due to motion in two horizontal and one vertical direction, should be considered in determining the combined effects. If, in your determination of the loadings associated with our specified design bases, you intend to rely on your analysis of "incipient local yielding" of the supporting soils (May 8, 1980 submittal) you must provide these analyses for our review.

Please inform us of your response schedule within seven days of the date of this letter.

Sincerely,

OFFICIAL SEAL
VIRGINIA C. CASQUEIRO
NOTARY PUBLIC - CALIFORNIA
ALAMEDA COUNTY
My comm. expires MAR 8, 1981

Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

cc: See next page

EDAC