UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket No. 50-142 OL
THE REGENTS OF THE UNIVERSITY OF CALIFORNIA	)	(Proposed Renewal of Facility License)
(UCLA Research Reactor)	)	

CBG MOTION FOR SUMMARY DISPOSITION AS TO CONTENTION XVII

(Seismic)

I. THE MOTION

Pursuant to 10 CFR 2.749 and the Board's Order of July 26, 1982, the Committee to Bridge the Gap (CBG) respectfully moves the Atomic Safety and Licensing Board for partial summary disposition as to Contention XVII.

The contention asserts that the site characteristics of the UCLA reactor are unsuitable in that the reactor is located in a seismically active area, that the existence of three stories of classrooms and offices supported by relatively thin columns above the reactor (added on after the reactor building was completed) create the possibility of the entire structure collapsing onto the reactor core, and that the core itself could be crushed and otherwise damaged were the maximum credible earthquake possible at the site to occur, an event which could release fission products to the environment.

Because of admissions by both the Applicant and the NRC Staff as to the above matters and assertions that neither party intends to present affirmative evidence to the contrary, CBG respectfully

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moves for summary disposition thereon, to which it is entitled as a matter of law, as no genuine dispute exists.

CBC will demonstrate, infra, that there is no dispute as to the following material facts: that the reactor is located in one of the most seismically active regions of the country; that it lies in the path of at least one active earthquake fault; that it is within 2 miles of the Newport-Inglewood Fault which was responsible for the worst earthquake in Los Angeles County in historical times and which is currently viewed as capable of a 7.5 magnitude quake with an annual probability of occurrence of .1%; that it is within 1 mile of the Santa Monica Fault which is also estimated as capable of a 7.5 magnitude earthquake; that it could also be affected by the southern San Andreas Fault along which an 8.3 magnitude earthquake has an accepted probability of occurrence of between 2 and 5% annually; that a major earthquake could bring down the several-story structure that has been added atop the reactor building; that a major earthquake could thus crush the reactor core and break apart the fuel; that this core-crushing could occur from lateral accelerations even without the above structure collapsing; that severe mechanical damage to the fuel could result and fission products escape; and that a major earthquake could cause the Stone Canyon Dam just north of the reactor site to fail and flood the reactor room and cause fission products to escape. Furthermore, that neither Staff nor Applicant has done a detailed seismic analysis of the area nor a detailed structural analysis of the reactor structure and related buildings, both assuming in their respective safety analyses the capability of a severe earthquake causing severe damage to the reactor core.

CBG perceives that, although no dispute exists as to the seismic activity of the site and the capability of a major earthquake causing severe damage to the reactor core with attendant release of fission products, a factual dispute does exist as to the magnitude and acceptability of the attendant radioactive release. Therefore, this latter matter is not appropriate for summary disposition and CBG requests herein only partial summary disposition, to wit: that there is no dispute about the seismic vulnerability of the reactor, but that dispute remains as to the magnitude and acceptability of the attendant fission product release.

II. DISCUSSION

Because there appears no dispute about these matters, the following discussion will be brief. The NRC Staff in its SER has chosen as its design basis accident an earthquake which causes disruption of the reactor core and breaking apart of the reactor fuel, resulting in off-site releases of fission products.[1/] The Applicant has likewise in its revised SAR assumed an earthquake is capable of such damage[2/] and has further conceded the potential for subsequent flooding of the reactor room because of the earthquake and release of radiatioactivity into the floodwaters.[3/] Furthermore, Applicant at the June 30, 1982, prehearing conference (transcript sections formerly in camera, released for public disclosure by Board Order of August 26, 1982) stated that it "would stipulate" that an earthquake could bring down the structure above the reactor and crush the core. There thus appears to be no dispute except as

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1/ SER, 2-6, 14-8
2/ Application, III/8-3 to 8-5
3/ id, III/8-5

to how many Curies of radioactivity could be released due to such an event and what the doses would be to personnel and the public at various distances from the reactor.

1. The reactor is in a seismically active region.--Application, page III/3-1 states: "Southern California is seismically active. . . .In Southern California, the region from the Mohave Desert to beyond the off-shore islands is traversed by a series of active faults. These faults extend from 20 to 50 to many hundreds of miles in length. * * * Earthquakes have occurred in California for a long time in the geologic past, and it is extremely probable that they will recur from time-to-time in the future." Staff's SER says at page 2-6, "Southern California is criss-crossed with geologic faults."

2. The UCLA reactor may be in the path of at least one active earthquake fault.--SER, page 2-6, states: "...it is recognized that the UCLA campus may be in the path of an active seismic fault..."

3. The UCLA reactor is within two miles of the Newport-Inglewood Fault.--Application, as amended, page III/3-1, "The nearest major fault to the reactor site is the Inglewood fault running in a north-westerly direction about two miles east of the campus." Note that the Fault may be closer than two miles and that there is uncertainty as to where it ends; as the Application indicates, it appears to be headed westerly towards campus at its last certain location. (see California Division of Mines Geology map, attached, of the Beverly Hills Quadrangle Special Studies Zone; also Newport-Inglewood Zone map, showing the fault zone further to the west, and TID-25363 by USGS for AEC)

4. The Newport-Inglewood Fault was responsible for the Long Beach Earthquake of 1933. -- California Division of Mines and Geology, "A Review of the Geology and Earthquake History of the Newport-Inglewood Structural Zone", abstract and map attached.

5. The Newport - Inglewood Fault is capable of an earthquake of 7.5 magnitude on the Richter Scale.--Page III/8-3 of Application; FEMA report, supra, p. 15.

6. The current probability of occurrence of a 7.5 magnitude earthquake along the Newport-Inglewood Fault is at least .1% annually, or a one in fifty chance during the proposed twenty-year license period.-- Page III/8-3 of Application. Note that there is a greater probability than .1% annually that one or more damaging earthquakes of somewhat smaller magnitude than the postulated 7.5 quake will occur along the Newport-Inglewood fault. FEMA report, supra, p. 15

7. The Santa Monica Fault Zone is within one mile of the UCLA reactor.-- Map of the Newport-Inglewood Structural Zone and Other Structural Features of the Los Angeles Area, Southern California, by the California Division of Mines and Geology. Note that UCLA sits on the upper plate of the Santa Monica Fault and is quite close to where the Newport-Inglewood Fault Zone and the Santa Monica Fault Zone are believed to intersect. (See also TID-25363)

8. The Santa Monica Fault Zone is capable of a 7.5 magnitude earthquake The document cited by Applicant at page III/8-3, Maximum Credible Rock Acceleration from Earthquakes in California, by Roger Greensfelder, California Division of Mines and Geology, gives the capability as 7½.

9. The reactor could also be affected by an earthquake along the southern San Andreas Fault, which has a capacity of 8.3 magnitude with a probability of occurrence of between 2 and 5% annually, or greater than 50% over the next thirty years.--"An Assessment of the Consequences and Preparations for a Catastrophic California Earthquake: Findings and Actions Taken" Federal Emergency Management Agency, November 1980, page 17

10. A major earthquake could bring down the several-story structure built atop the reactor building and crush the reactor core.--Applicant's counsel indicated on the record of the pre-hearing conference that he "would stipulate" to this matter. Furthermore, Applicant's interrogatory answers [4/] indicate it has no information as to the strength of the supporting columns or other aspects of the structure to indicate otherwise, and that the original seismic specifications or design criteria for the buildings, as well as the drawings of building modifications, have either not been retained or have been lost. In absence of a structural analysis to the contrary, Applicant and Staff have rightly assumed in their safety analyses such damage can occur. Application page III/8-3 and 8-4, also SER 14-8.

11. Mechanical damage to the fuel (i.e. breaks in the cladding and fuel meat) could result from core-crushing.--SER, p. 14-10

12. Core-crushing could result from lateral accelerations in an earthquake, with or without the above structures collapsing.--"Fuel Temperatures in an Argonaut Reactor Core Following a Hypothetical Design Basis Accident" by G.E. Cort of LANL, NUREG/CR-2198, p. 2

4/ Applicant's 5/20/81 interrogatory answers, attached.
Note the virtually complete lack of information possessed by Applicant as to the seismic characteristics of its site and structures.

13. Mechanical damage to the fuel resulting from an earthquake could result in fission products escaping to the environment.-- SER p. 14-8, "...it is postulated that there could be severe mechanical damage to the fuel from the collapsing superstructure and a significant release of fission products."

14. It is conceivable that subsequent flooding of the reactor room could occur as the result of earthquake-induced failure of the Stone Canyon Reservoir which is positioned in the hills to the north of the UCLA campus.-- This is a direct quote from the Application, page III/8-5.5/

15. Subsequent flooding of the reactor could result in the dispersion of fission product releases in the flood water.--This is also a direct quote from Application page III/8-5.

16. Neither Staff nor Applicant has done a detailed seismic analysis of the reactor site nor a detailed structural analysis of the reactor structure and related buildings as to how they would respond to potential earthquakes (i.e., ability to withstand various response spectra without suffering displacement).--SER, page 2-6; Application, III/8-3 ("a detailed seismic analysis is not warranted").

17. Earthquake-induced fission product release could cause doses in unrestricted areas of at least 10 Rem to the thyroid.--SER p. 14-10 concludes that the doses would be 30 Rem to the thyroid, the Battelle Study (p. 26 and 48) referenced in the Application and relied upon by Staff suggest a higher figure. There appears no dispute the figure could be as high as 10 R, the only dispute is how much higher, a matter to be resolved at hearing.

5/ See also the study referenced in the Application, portions attached, that give astonishingly high annual probability figures for a major earthquake capable of destroying the dam and flooding the reactor. Ayyaswamy, et al, Estimates of the Risks Associated with Dam Failure, performed for USAEC.

18. The Uniform Building Code according to which the reactor structure and the building above it were built had no provisions for reactors and has since been substantially strengthened; and buildings built to UBC standards have failed in relatively moderate earthquakes. (Plotkin declaration)

The detailed evidence supporting these undisputed material facts is found in the documents attached, consisting of the declaration of Dr. Sheldon C. Plotkin, a safety engineer specializing in accident analysis; numerous official documents from the government agencies within whose responsibilies and competence seismic and geological matters fall ; and Staff and Applicant documents.

III. CONCLUSION

There is no dispute that the UCLA reactor is in a seismically active area and that the core can be severely damaged in an earthquake, resulting in fission product release. The only matter in dispute is the magnitude and acceptability of the resulting radioactivity release. As a matter of law, CBG is entitled to summary disposition on those matters as to which no genuine dispute exists. Until the matter of the consequences to the public of earthquake-induced radioactivity releases is resolved by the Board, the facts as the possibility of such earthquake-induced damage are material and relevant. The proceeding would be expedited and simplified, and justice served, if partial summary disposion as to Contention XVII were granted.

Respectfully submitted,

Daniel Hirsch
President
COMMITTEE TO BRIDGE THE GAP

STATEMENT OF MATERIAL FACTS AS TO WHICH NO GENUINE DISPUTE EXISTS

1. The reactor is in a seismically active region.

2. The UCLA reactor is in the path of at least one active earthquake fault.

3. The UCLA reactor is within two miles of the Newport-Inglewood fault.

4. The Newport-Inglewood Fault was responsible for the Long Beach Earthquake of 1933.

5. The Newport-Inglewood Fault is capable of an earthquake of a magnitude 7.5 on the Richter Scale.

6. The current probability of occurrence of a 7.5 magnitude earthquake along the Newport-Inglewood Fault is at least .1% annually, or a one in fifty chance during the proposed twenty-year license period.

7. The Santa Monica Fault Zone is within one mile of the reactor.

8. The Santa Monica Fault Zone is capable of a 7.5 magnitude earthquake.

9. The reactor could also be affected by a quake along the southern San Andreas Fault, which has a capacity of 8.3 magnitude with a probability of occurrence of between 2 and 5% annually, or greater than 50% over the next thirty years.

10. A major earthquake could bring down the several-story structure built atop the reactor building and crush the reactor core.

11. Mechanical damage to the fuel (i.e. breaks in the cladding and fuel meat) could result from core-crushing.

12. Core-crushing could result from later accelerations in an earthquake, with or without the above structures collapsing.

13. Mechanical damage to the fuel resulting from an earthquake could result in fission products escaping to the environment.

14. It is conceivable that subsequent flooding of the reactor room could occur as the result of earthquake-induced failure of the Stone Canyon Reservoir which is positioned in the hills to the north of the UCLA campus.

15. Subsequent flooding of the reactor could result in the dispersion of fission product releases in the flood water.

16. Neither Staff nor Applicant has done a detailed seismic analysis of the reactor site nor a detailed structural analysis of the reactor structure and related buildings as to how they would respond to potential earthquakes (i.e., ability to withstand various response spectra without suffering displacement.

17. Earthquake-induced fission product release could cause doses in unrestricted areas of at least 10 Rem to the thyroid.

18. The Uniform Building Code according to which the reactor structure and the building above it were built had no provisions for reactors and has since been substantially strengthened; and building built to UBC standards have failed in relatively moderate earthquakes.

EXHIBIT A

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of THE REGENTS OF THE UNIVERSITY OF CALIFORNIA (UCLA Research Reactor)	)	Docket No. 50-142 (Proposed Renewal of Facility License)

DECLARATION OF DR. SHELDON C. PLOTKIN

I, Sheldon C. Plotkin, do declare:

1. I am President of S.C. Plotkin & Associates, a consulting engineering firm specializing in accident analysis. My professional qualifications are attached hereto.

2. As a member of a review panel established by the Southern California Federation of Scientists to assess fundamental safety aspects of the UCLA nuclear reactor, I have conducted an examination of factors affecting the seismic safety of the facility.

3. This examination consisted of three on-site inspections of the areas external to the Nuclear Energy Lab facility and a separate inspection of the areas within NEL itself. The review also included examination of the available architectural, mechanical, and structural drawings of the reactor building and associated buildings.

4. The purpose of this declaration is to identify facts ascertained in the above review and conclusions drawn therefrom.

5. It is widely recognized that Southern California is very active seismically.

6. The U.S. Federal Emergency Management Agency estimates that an earthquake of Richter Scale magnitude 8.3 along the southern part of the San Andreas Fault has a 2-5% annual probability of occurrence, with greater than a 50% chance in the next thirty years. The effects of such a massive earthquake would be widespread and could readily cause considerable damage at the reactor site.

7. Other faults, of slightly smaller capability and probability of occurrence, could cause even greater structural damage at the reactor site. This is because these faults are extremely near the site.

8. The Newport-Inglewood Fault Zone (estimated capability, 7.5 on the Richter Scale) and the Santa Monica Fault Zone (similar capability) are believed to intersect very near the UCLA campus. While the nearest approaches of these fault zones to the reactor site are uncertain, due to the limited study performed to date and the heavy urbanization which has covered up surface indications, it is well established that the Newport-Inglewood Zone comes within two miles, and the Santa Monica Fault Zone within about one mile of the reactor site. The nearest approach could be much closer.

9. Because of the seismic activity of the region and the nearness of major active faults, a principal concern in a safety review of a reactor in such a location is the ability of the reactor facility and the reactor itself to withstand a major accident without damage. My review of this particular facility leads me to conclude that the particular site characteristics in question are so unfavorable as to make it quite likely that the reactor core could be severely damaged in a major earthquake.

10. The reactor was originally in a two-story building when first constructed. Over the years additional buildings were added on top and to the sides of the original building. These included three stories of classrooms and offices supported by relatively thin columns above the original reactor building. A two story "void area" exists between the upper stories and the original two-story reactor building.

11. The reactor building and the addition on top are structurally independent of the adjacent buildings, separated by a half-foot earthquake "shake," so that the structure atop the reactor building receives no support except for those thin columns.

12. Were a severe earthquake to occur, those columns could buckle or fracture, causing the building above to collapse, accelerating through approximately twenty-four feet until hitting the reactor room ceiling, which could not withstand such an impact. The building above would essentially collapse onto the reactor core, crushing the core.

13. Even were the building above the reactor core not to collapse, lateral accelerations of the reactor itself could cause core-crushing by rapid shifting of the core internals by the tremendous forces involved.

14. The fuel would be severely damaged in either case, with substantial amounts of fission products released.

15. Additional damage to the reactor core could be initiated by such an earthquake in the form of failure of the Stone Canyon Dam just north of the reactor and subsequent flooding of the core, or by earthquake-induced fire.

16. The fact that the reactor structure was built according to the then-current Uniform Building Code provides no assurance whatsoever that it will survive the magnitude of earthquake possible at the site. There was no provision in the UBC for reactors, which must be built to considerably stricter standards than structures posing less risk to public health and safety,

and the UBC has been substantially strengthened since the reactor building and related structures were built. A building built to the UBC standards then in effect could not pass current UBC standards for normal structures, let alone the standards that should be applied to a nuclear reactor.

17. Furthermore, buildings built according to modern Uniform Building Code standards have been substantially damaged in even relatively moderate earthquakes. The Olive View Hospital, built according to the most modern UBC then in effect and dedicated only a few weeks before the 1971 San Fernando 6.4 magnitude earthquake, collapsed during that earthquake. And the County Services Building in Imperial Valley, California, had the steel-reinforced concrete pillars of the building virtually sheered off, even though the building was reportedly engineered to withstand an earthquake of magnitude 8. The Imperial Valley earthquake was only of magnitude 6.6.

18. For the above reasons, it is my opinion that a major earthquake is likely to occur of sufficient magnitude and proximity to the reactor site that severe damage to the reactor core and fuel could occur and result in the release of substantial fission products to the environment.

19. I took the attached eleven photographs of the reactor building and the structure built atop it. They point out some of the features which affect its seismic vulnerability. Photograph 1 shows the three floors of classrooms supported by columns over a two story void area containing equipment for the reactor. The large vertical feature in the center is a sheet metal enclosure encompassing the reactor effluent exhaust stack, which is released from the eighth floor through a small stack in the right hand corner of the windscreen on the roof. The reactor is directly below the three floors of classrooms and the two-story void area. Thus floors one and two are below grade in this picture; the void area represents floors three and four; floors five,six, and seven are classrooms and offices; and the eight floor encompasses the reactor stack.

20. Photo 2 is a view from the courtyard on the third floor; photo 3 is a view of the void area. Photo 4 shows the separation between the building atop the reactor and the adjacent buildings--where I have drawn a circle you can seen the metal plate covering the empty space between the buildings. Photo 5 looks upward along the same view; where I have drawn another circle you can see the ending of the earthquake separation. There is about a half-foot separation designed between the buildings. Photo 6 shows the separation on the left side. Photos 8, 9, 10, and 11 given different views of the metal plates covering the earthquake separations or "shakes." The photographs demonstrate that the sole support for the structure directly above the reactor are a few columns which could give way in an earthquake.

I, Sheldon C. Plotkin, swear under penalty of perjury under the laws of the United States that the foregoing is true and correct to the best of my knowledge and belief.

Executed on August 23, 1982
at Los Angeles, California

Sheldon C. Plotkin, Ph.D.

DR. SHELDON C. PLOTKIN

PROFESSIONAL QUALIFICATIONS

My name is Sheldon C. Plotkin. I am President of S.C. Plotkin & Associates, a consulting engineering firm specializing in accident analysis. I am also a member of several review panels established by the Southern California Federation of Scientists to assess fundamental safety aspects of the UCLA nuclear reactor.

I have over thirty years experience in analysis and design of electronic, electro-mechanical, mechanical, human factors, chemical and computer systems, as well as combinations thereof. My previous employers include:

Los Alamos Scientific Laboratory, Los Alamos, New Mexico -- 1946-7, design and construction of electronic equipment

U.S. Naval Air Missile Test Center, Point Mugu, California -- 1949-50. conducted and evaluated missile flight tests

University of California, Berkeley--1950-56
1950-54, teaching assistant in Engineering Department
1954-56, Project Enginner, in charge of operation of the Cosmic Ray Laboratory

Energy Systems (formerly Levinthal Electronics), Palo Alto, California -- 1956-68
Senior Project Engineer for design and safety of high voltage, high power pulse modulators.

Hoffman Electronics Corporation -- 1959 to 1961
Consultant in the Communications Systems Department

University of Southern California -- 1958 to 1961
Assistant Professor of Engineering

Hughes Aircraft Company, Culver City, California -- 1961 to 1967
Staff Engineer for G&C Advanced Systems Laboratory

TRW Systems, Redondo Beach, California -- 1967 to 1969
Senior Staff Engineer, ESD Systems Engineering Laboratory

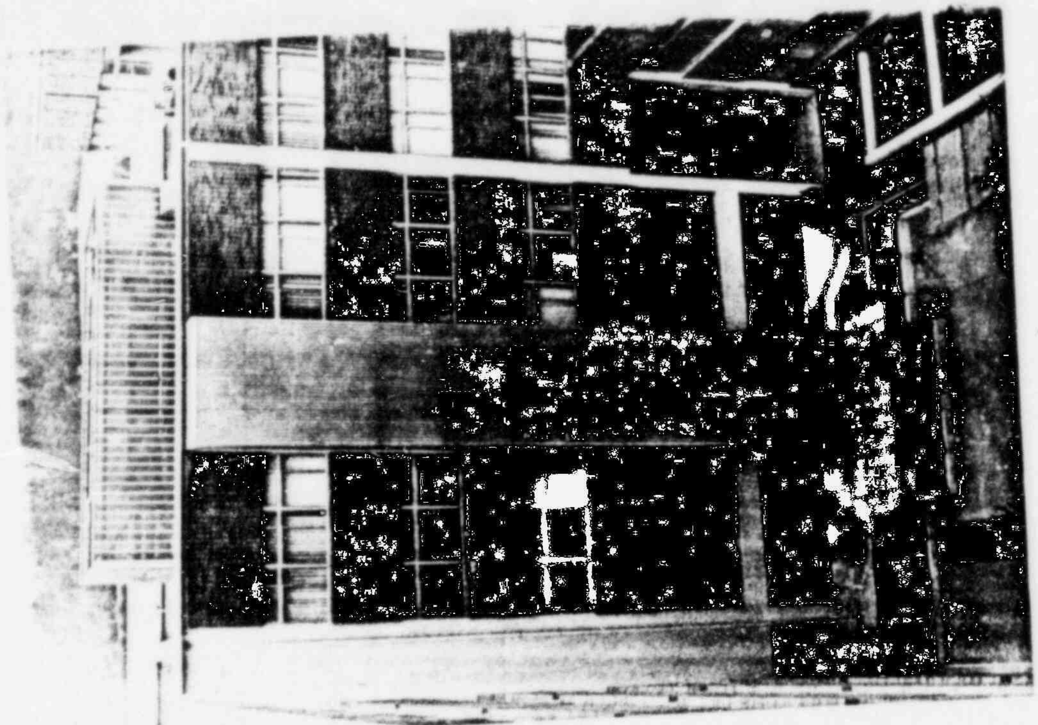
RAND Corporation, Santa Monica, California -- 1969 to 1971
Senior Engineer in the Engineering Sciences Department.

From 1971 to the present I have run a consulting engineering firm which specializes in safety engineering and systems approaches to accident analysis.

I have published several hundred papers, reports, and intra-company documents. Accident and Product Failure Analyses (book). "Introduction to Accident, Safety, and Forensic Engineering" (seminar).

I am a Registered Professional Safety Engineer, and a member of I.E.E.E., Pi Mu Epsilon, Eta Kappa Nu, Sigma Xi, and the Executive Board of the Southern California Federation of Scientists.

EXHIBIT B



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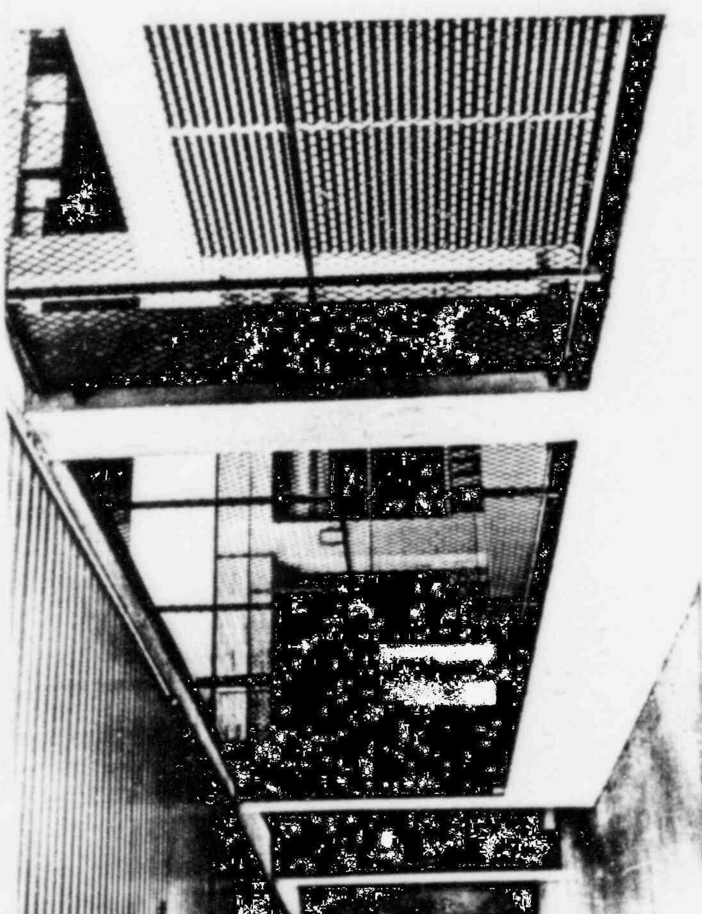

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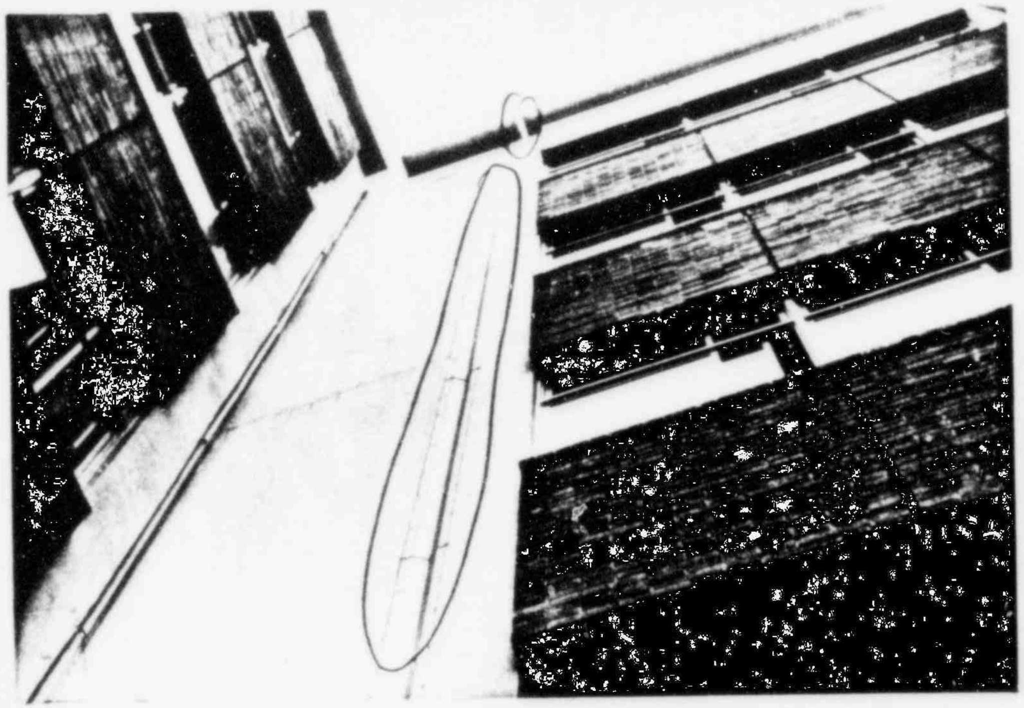

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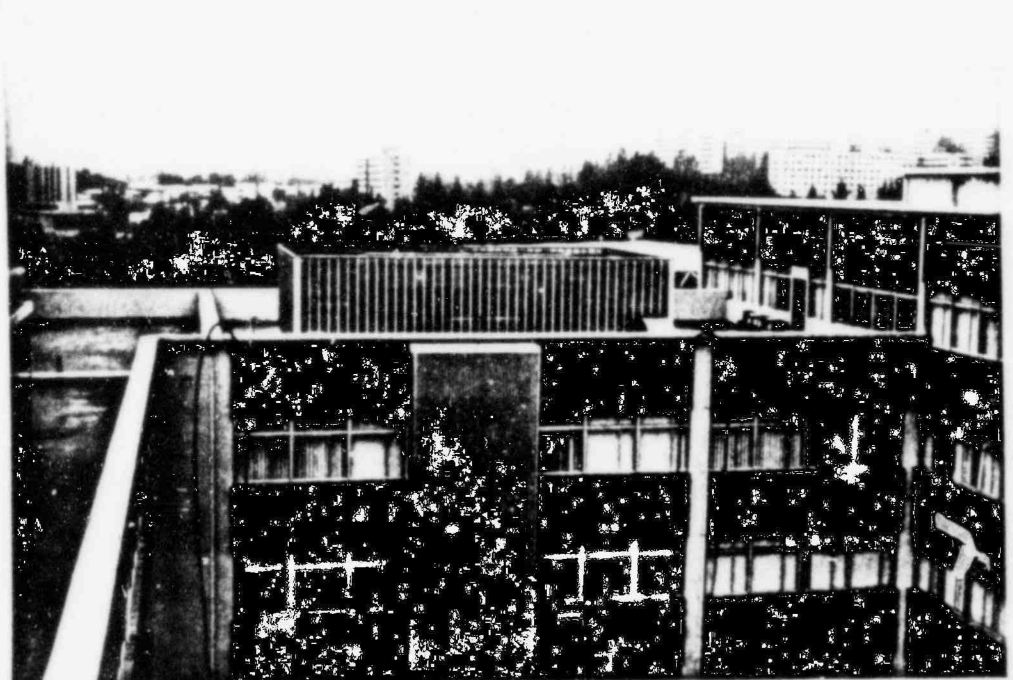

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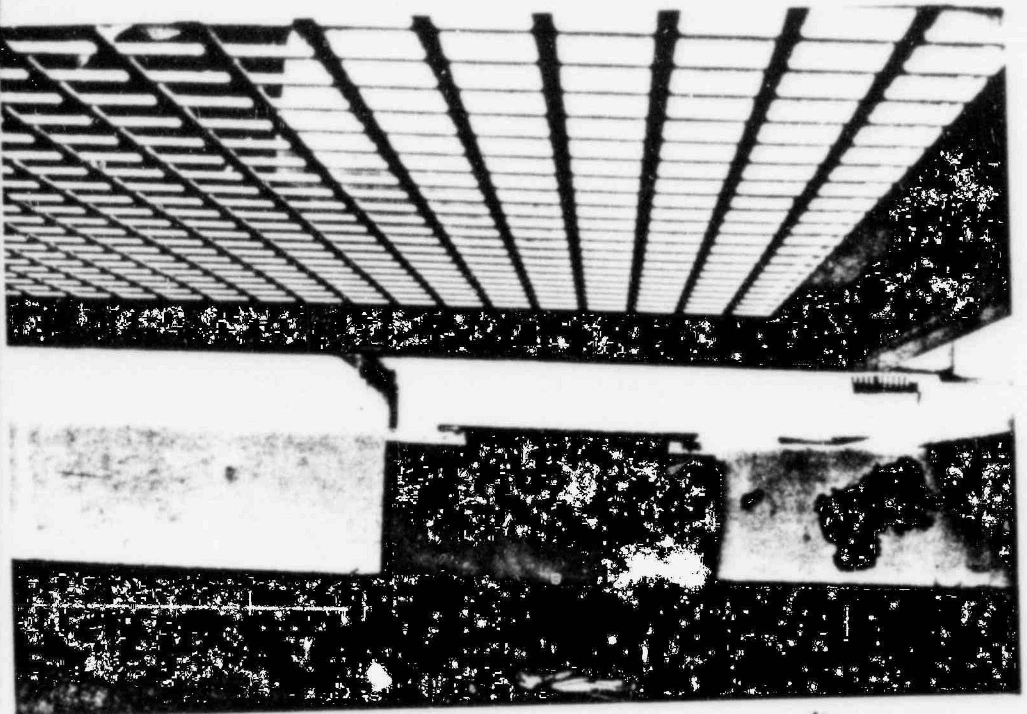

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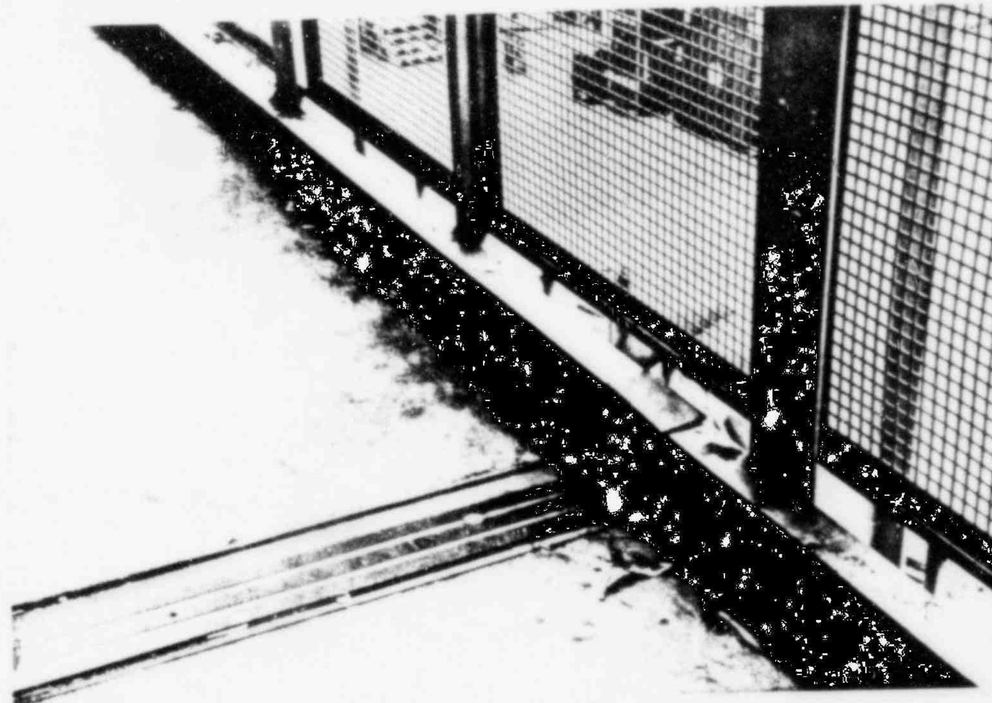

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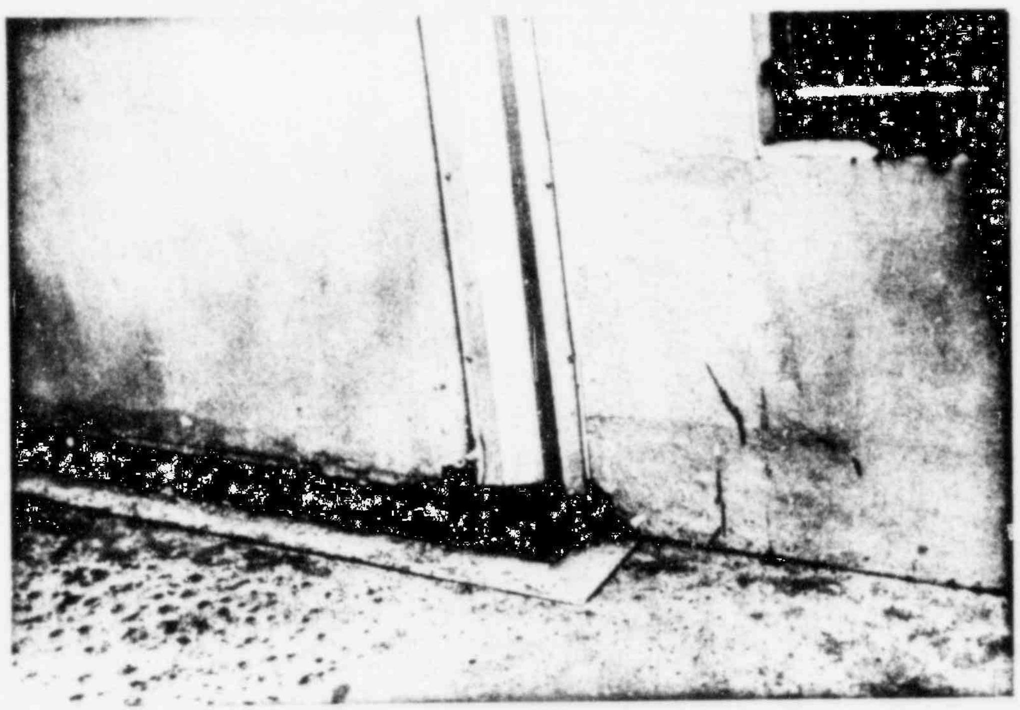

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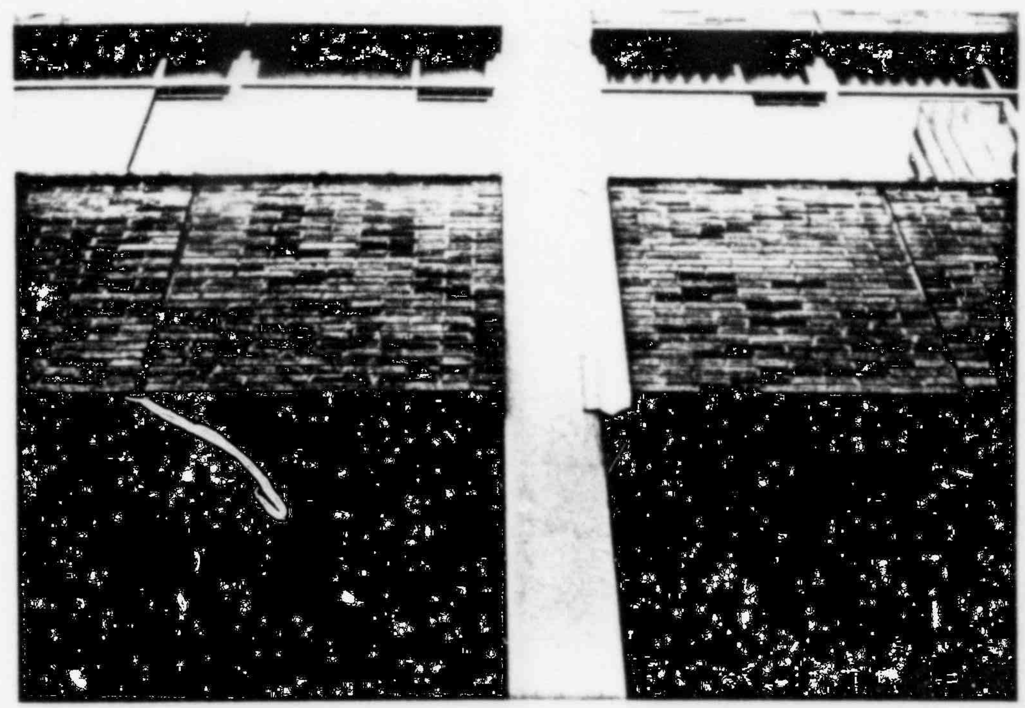

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January 1981

EXHIBIT C

AN ASSESSMENT OF THE CONSEQUENCES AND PREPARATIONS FOR A CATASTROPHIC CALIFORNIA EARTHQUAKE: FINDINGS AND ACTIONS TAKEN

PREPARED BY
FEDERAL EMERGENCY MANAGEMENT AGENCY
FROM ANALYSES CARRIED OUT BY THE
NATIONAL SECURITY COUNCIL
ad hoc COMMITTEE ON ASSESSMENT OF
CONSEQUENCES AND PREPARATIONS FOR
A MAJOR CALIFORNIA EARTHQUAKE

federal emergency
management agency

Washington, D.C. 20472
November 1980

CHAPTER I

EXECUTIVE SUMMARY OF FINDINGS, ISSUES, AND ACTIONS

A. BACKGROUND

After viewing the destruction wrought by the eruption of Mt. St. Helens in Washington State in May 1980, President Carter became concerned about the impacts of a similar event of low probability but high damage potential, namely a catastrophic earthquake in California, and the state of readiness to cope with the impacts of such an event.

As a result of the President's concern, an *ad hoc* committee of the National Security Council was formed to conduct a government review of the consequences of, and preparation for such an event. In addition to the Federal Emergency Management Agency, the Committee included representatives from the Office of Science and Technology Policy, the United States Geological Survey of the Department of the Interior, the Department of Defense, the Department of Transportation, and the National Communications System, at the Federal level; State of California agencies and California local governments at the State and local levels; and consultants from the private sector. During the summer of 1980, the participants in this review prepared working papers on relevant issues and problem areas for the consideration of the *ad hoc* committee. Pertinent facts, conclusions and recommendations were reviewed with the Governor of the State of California. The President reviewed the *ad hoc* committee's findings and approved the recommendations for Federal action. This report summarizes the results of the assessment and notes these actions.

A number of Federal legislative and administrative actions have been taken to bring about, in the near future, an increased capability to respond to such an event. The Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) authorizes a coordinated and structured program to identify earthquake risks and prepare to lessen or mitigate their impacts by a variety of means. The coordination of this program, the National Earthquake Hazards Reduction Program (NEHRP), is the responsibility of the Federal Emergency Management Agency (FEMA), which is charged with focusing Federal efforts to respond to emergencies of all types and lessen their impacts before they occur. The NEHRP has six high-priority thrusts:

- Overall coordination of Federal departments and agencies' programs

- Maintenance of a comprehensive program of research and development for earthquake prediction and hazards mitigation

- Leadership and support of the Federal Interagency Committee on Seismic Safety in Construction as it develops seismic design and construction standards for use in Federal projects

- Development of response plans and assistance to State and local governments in the preparation of their plans

- Analysis of the ability of financial institutions to perform their functions after a creditable prediction of an earthquake as well as after an event, together with an exploration of the feasibility of using these institutions to foster hazard reduction

- An examination of the appropriate role of insurance in mitigating the impacts of earthquakes.

More recently, a cooperative Federal, State, local, and private-sector effort was initiated to prepare for responding to a credible large-magnitude earthquake, or its prediction, in Southern California.

B. SUMMARY

The review provided the overall assessment that the Nation is essentially unprepared for the catastrophic earthquake (with a probability greater than 50 percent) that must be expected in California in the next three decades. While current response plans and preparedness measures may be adequate for moderate earthquakes, Federal, State, and local officials agree that preparations are woefully inadequate to cope with the damage and casualties from a catastrophic earthquake, and with the disruptions in communications, social fabric, and governmental structure that may follow. Because of the large concentration of population and industry, the impacts of such an earthquake would surpass those of any natural disaster thus far experienced by the Nation. Indeed, the United States has not suffered any disaster of this magnitude on its own territory since the Civil War.

The basis for this overall assessment is summarized below and discussed in more detail in the subsequent chapters of this report.

C. LIKELIHOOD OF FUTURE EARTHQUAKES

Earth scientists unanimously agree on the inevitability of major earthquakes in California. The gradual movement of the Pacific Plate relative to the North American Plate leads to the inexorable concentration of strain along the San Andreas and related fault systems. While some of this strain is released by moderate and smaller earthquakes and by slippage without earthquakes, geologic studies indicate that the vast bulk of the strain is released through the occurrence of major earthquakes—that is, earthquakes with Richter magnitudes of 7.0 and larger and capable of widespread damage in a developed region. Along the Southern San Andreas fault, some 30 miles from Los Angeles, for example, geologists can demonstrate that at least eight major earthquakes have occurred in the past 1,200 years with an average spacing in time of 140 years, plus or minus 30 years. The last such event occurred in 1857. Based on these statistics and other geophysical observations, geologists estimate that the probability for the recurrence of a similar earthquake is currently as large as 2 to 5 percent per year and greater than 50 percent in the next 30 years. Geologic evidence also indicates other faults capable of generating major earthquakes in other locations near urban centers in California, including San Francisco-Oakland, the immediate Los Angeles region, and San Diego. Seven potential events have been postulated for purposes of this review and are discussed in chapter II. The current estimated probability for a major earthquake in these other locations is smaller, but significant. The aggregate probability for a catastrophic earthquake in the whole of California in the next three decades is well in excess of 50 percent.

D. CASUALTIES AND PROPERTY DAMAGE

Casualties and property damage estimates for four of the most likely catastrophic earthquakes in California were prepared to form a basis for emergency preparedness and response. Chapter III gives details on these estimates. Deaths and injuries would occur principally because of the failure of man-made structures, particularly older, multistory, and unreinforced brick masonry buildings built before the adoption of earthquake-resistant building codes. Experience has shown that some modern multistory buildings—constructed as recently as the late 1960's but not adequately designed or erected to meet the current understanding of requirements for seismic resistance—are also subject to failure. Strong ground shaking, which is the primary cause of damage during earthquakes, often extends over vast areas. For example, in an earthquake similar to that which occurred in 1857, strong ground shaking (above the threshold for causing damage) would extend in a broad strip along the Southern San Andreas fault, about 250 miles long and 100 miles wide, and include almost all of the Los Angeles-San Bernardino metropolitan area, and all of Ventura, Santa Barbara, San Luis Obispo, and Kern counties.

CHAPTER II

GEOLOGIC EARTHQUAKE SCENARIOS

A. MAJOR EVENTS

For purposes of assessing the consequences of a major California earthquake, scenarios for seven large earthquakes were developed. The scenarios depict expectable earthquakes that could severely impact on the major population centers of California. In each case they are representative of only one possible magnitude of earthquake that could occur on the indicated fault system. On each fault system there is a greater probability of one or more damaging earthquakes of somewhat smaller magnitude than the postulated event. The postulated earthquakes are listed in the following table.

TABLE 1

MAJOR CALIFORNIA EARTHQUAKES

Region	Fault System	Richter Magnitude[1]	Current Annual Probability of Occurrence (Percent)	Likelihood of Occurrence in Next 20-30 Years
Los Angeles-San Bernardino	Southern San Andreas	8.3	2-5	High
San Francisco Bay Area	Northern San Andreas	8.3	1	Moderate
San Francisco Bay Area	Hayward	7.4	1	Moderate
Los Angeles	Newport-Inglewood	7.5	0.1	Moderate-Low

(continued on following page)

TABLE 1

MAJOR CALIFORNIA EARTHQUAKES (Continued)

Region	Fault System	Richter Magnitude[1]	Current Annual Probability of Occurrence (Percent)	Likelihoo of Occurren in Next 20-30 Ye
San Diego	Rose Canyon	7.0	0.01	Low
Riverside San Bernardino	Cucamonga	6.8	0.1	Moderate-Low
Los Angeles	Santa Monica	6.7	0.01	Low

[1] This is the estimated largest magnitude earthquake expected at a reasonab level of probability. The main shock can be expected to be followed by lar aftershocks over a period of weeks or longer. Each large aftershock would b capable of producing additional significant damage and hampering disaster assistanc operations.

These earthquake scenarios represent the largest magnitude events estimated o the basis of a variety of geologic assumptions. The appropriateness of thes assumptions depends on the intent of the analysis and the state of geolog knowledge. Therefore, the resulting estimates may not be appropriate for othe purposes, such as the development of seismic design criteria for a specific site. Th development of such criteria commonly requires detailed analyses of the site and it immediate geologic environment beyond the scope of this report. Consequently detailed site analyses may require modification of the conclusions reached in thi report, particularly fault systems other than the San Andreas and Hayward faults.

B. GEOLOGIC EVIDENCE

Some of the possible earthquakes listed are repeat occurrences of historica events, others are not, but geologic evidence indicates that earthquakes occurred on these faults before settlement of the region. Based on available data, the postulated earthquake magnitudes would be the largest events that could be expected at a reasonable level of probability. They represent a selection of events useful for planning purposes, but are by no means the only such events likely to occur either on these or other fault systems.

The historic record of seismicity in California is too short to determine confidently how often large earthquakes reoccur. Information on past earthquakes must be gleaned from the geologic record and therefore, presents a picture of past seismicity that is incomplete and not yet fully deciphered. Current knowledge about the recurrence of large earthquakes on specific faults is rudimentary. The probabilities of occurrence shown above are order-of-magnitude estimates and subject to considerable uncertainty, especially for the less probable events.

C. DESCRIPTION OF EVENTS

Following are brief descriptions of postulated events. Figure 1 gives their geographic location.

1. Los Angeles-San Bernardino/Southern San Andreas Fault (Magnitude 8.3)

For the past several thousand years, great earthquakes have been occurring over a 300 km length of the San Andreas fault approximately every 100 to 200 years, 140 years on the average. The last such event took place in 1857. The probability of occurrence of this earthquake is estimated to be currently as large as 2 to 5 percent per year and greater than 50 percent in the next 30 years. The fault skirts the edge of the Los Angeles-San Bernardino metropolitan region, thus most of the urbanized area lies further than 20 miles from the source of strong shaking. Because of the distance, shaking would be more hazardous for large structures than for one- to two-story houses. The long duration of shaking could trigger numerous slides on steep slopes and cause liquefaction in isolated areas.

2. San Francisco Bay Area/Northern San Andreas Fault (Magnitude 8.3)

A repeat occurrence of the 1906 earthquake, in which the San Andreas fault broke over 400 km of its length, would cause severe damage to structures throughout the Bay Area and adjacent regions. The extensive urban development on lowlands and landfill around San Francisco Bay would be especially hard hit and liquefaction in many of these areas would intensify the damage to structures erected on them.

3. San Francisco Bay Area/Hayward Fault (Magnitude 7.4)

The last large events to occur on this fault were in 1836 and 1868. Should a major earthquake occur, severe ground shaking and liquefaction is expected to cause damage throughout the entire circum-bay area nearly as severe as that resulting from a 1906-type earthquake on the San Andreas fault. This earthquake would be of particular concern because of the many dams located along or near the fault.

4. Los Angeles/Newport-Inglewood Fault (Magnitude 7.5)

This earthquake would be a serious threat to the nearby, densely-populated areas of Los Angeles. Shaking would cause extensive structural damage throughout the Los Angeles Basin and liquefaction near the coast would add still more destruction.

5. San Diego Area/Rose Canyon Fault (Magnitude 7.0)

This fault—a segment of an active zone of faults extending from the Newport-Inglewood fault to Northern Mexico—would present the greatest earthquake risk to the San Diego area. Severe damage due to shaking and liquefaction could be expected in the coastal areas. Because of unstable sea-bed sediments in the offshore area, local tsunamis (tidal waves) are possible.

6. Los Angeles/Santa Monica Fault (Magnitude 6.7 and 7.0) and Riverside/San Bernardino/Cucamonga Fault (Magnitude 6.8)

These faults are part of a system of east-west tending faults bordering the northern edge of the Los Angeles basin. This fault system caused the 1971 San Fernando earthquake and is geologically similar to the system that generated the large 1952 Kern County earthquake. Although smaller in magnitude than the earthquakes previously described, these postulated events are potentially quite dangerous because of their vicinity to high population densities in Southern California.

D. EARTHQUAKE EFFECTS

Detailed maps were prepared for each event showing qualitative estimates of ground shaking intensity resulting from each earthquake. These estimates are indicative of the general severity of damage to ordinary structures. Empirical formulae providing quantitative estimates of peak ground motion at various distances from the postulated earthquakes were developed for use in the effects of severe ground shaking on individual structures or critical facilities. No estimates were made of localized effects, such as ground failures related to liquefaction (the complete failure or loss of strength, of a saturated soil due to shaking), landslides, and fault rupture. These effects can be far more destructive than ground shaking alone.

UCLA-ENG-7423

EXHIBIT D

Prepared for the
U.S. Atomic Energy Commission
Division of Research
Under Contract No. AT(04-3)-34 P.A. 205 Mod 2

UCLA-ENG-7423
MARCH 1974

ESTIMATES OF THE RISKS ASSOCIATED WITH DAM FAILURE

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The techniques for calculating flow characteristics in the channels downstream from the dams studied are fairly reliable, although some simplifying assumptions have been made. It is worth noting that the calculations of consequences of dam failure have been compared in one case to the actual observations of flood waters resulting from dam collapse. The St. Francis dam failed in 1928. A wall of water 125 feet high was reported traveling down the canyon beneath the dam. The water wall was 78 feet high 10 miles downstream from the dam. Calculations of the water height at the dam and at 7 miles downstream, using the methodology developed in this study, gave values of 130 feet and 85 feet, respectively. This agreement with observations is considered excellent, and provides support for the calculation technique used.

The consequences of dam failure, in terms of mortalities and property damage, are therefore forecast with an implicit error band. These calculated consequences are predicted on the assumptions made regarding earthquake frequency and intensity, and dam behavior. The conclusions should therefore be regarded as mainly illustrative and very tentative.

4. RESULTS AND DISCUSSION

The assumption of complete and instantaneous dam failure reflects the worst conditions that are theoretically conceivable. However, both experience and theory indicate that such failure, resulting from earthquake action, is a real possibility. With this in mind, estimates have been made of the probabilities of earthquakes in areas containing the California dams studied in this analysis. These dams are listed in Table 1, along with estimates of probabilities of earthquakes with Modified Mercalli intensities of VIII, IX and X for the dam environs. It is assumed† that an earthquake of MM intensity VIII results in a significant probability of dam failure; an earthquake of MM intensity IX results in a substantial probability[6] and an earthquake of MM intensity X results in a high probability. The probabilities listed for earthquakes are those generated by computer analysis adjusted as in Section 1.5 (on computer estimates). The predictions for MM X have the greatest uncertainty, since little empirical basis exists.

Table 2 lists estimates of expected property damage and mortalities due to total and instantaneous failure of the dams investigated (assuming that the dams are filled to capacity when the failure occurs). Mortalities range from as low as 11,000 to as high as 260,000; property damage ranges from $50 million to $720 million.

Table 3 gives estimated flood heights at various reaches downstream of the dams investigated (a reach is a section of the dam channel which is a convenient hydraulic measure taken in order to analyze the downstream flooding. The length of the measure itself may change depending on the particular topography. For example, in the case of the Van Norman Dam three reaches of 12,000 feet each have been selected to investigate the downstream flooding.

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†See Section 7 of this report for the rationale of this assumption.

The first reach is from dam site to a point 12,000 feet downstream; the second reach is 12,000 feet to 24,000 feet, etc.). Floodheights, for the cases investigated, range in the primary reach from 10 feet to 147 feet. The total flood length ranges between 10,000 feet (Lake Chabot Dam) and 40,000 feet (Stone Canyon Dam).

7. COMPUTER PREDICTION OF EARTHQUAKES IN CALIFORNIA BY FAULT THEORY

7.1 Introduction

In an attempt to estimate the seismic risk of an earth dam, one has first to estimate the earthquake intensities and their corresponding probabilities at the dam location. Secondly, one also has to decide what minimum intensity of earthquake leads to a complete failure of an average dam or any specific dam. For the latter task, one can apply some sophisticated methods such as finite element analysis to obtain the structural response of a dam, which presumably can predict the load at which the dam will completely fail. However, since the current state of the art of predicting earthquake probability involves a much greater degree of uncertainty,[1] it may not be well justified to do too many elaborate calculations for the second task. It seems to be a reasonable alternative that one can rely on experts and experienced engineers' opinions on the minimum intensity which will lead an average earth dam to a complete failure.

In a paper on "Foundations and Earth Structures in Earthquakes",[2] Duke indicates that the minimum intensity of shaking to produce damage to the older dams appears to be about VII on the Modified Mercalli scale (see Table 4). However, only two out of eighteen cases which Duke had considered were completely failed. The complete failures resulted in the emptying of the contents of the dam reservoirs (one at intensity VIII, another at IX). In all cases of damaged dams, the dams were constructed without the use of modern compacting control techniques. The minimum intensity for failure could probably be assumed to be somewhere about VIII or even greater.

Table 4

ROSSI-FOREL INTENSITY SCALE (1883)	MODIFIED-MERCALLI INTENSITY SCALE(1930), WOOD AND NAUMANN I	GROUND ACCELERATION a cm/sec	a/g
	I Detected only by sensitive instruments.		
I The shock felt only by experienced observer under very favorable conditions.	II Felt by a few persons at rest, especially on upper floors; delicate suspended objects may swing	-2 -3	
II Felt by a few people at rest, recorded by several seismographs. III Felt by several people at rest; strong enough for the duration or direction to be appreciable.	III Felt noticeably indoors, but not always recognized as a quake; standing autos rock slightly, vibration like passing truck.	-4 -5 -6 -7	.005g
IV Felt by several people in motion; disturbance of movable objects, cracking of floors.	IV Felt indoors by many, outdoors by a few; at night some awaken; dishes, windows, doors disturbed; motor cars rock noticeably.	-8 -9 -10	.01g
V Felt generally by everyone; disturbances of furniture, ringing of some bells.	V Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects.	-20 -30	
VI General awakening of those asleep, ringing of bells, swinging of chandeliers, startled people run outdoors.	VI Felt by all; many frightened and run outdoors, falling plaster and chimneys; damage small.	-40 -50 -60	.05g
VII Overthrow of movable objects, fall of plaster, ringing of bells, panic with great damage to buildings. VIII Fall of chimneys; cracks in walls of buildings.	VII Everybody runs outdoors, damage to buildings varies, depending on quality of construction; noticed by drivers of autos.	-70 -80 -90 -100	0.1g
IX Partial or total destruction of some buildings. X Great disaster; ruins; disturbance of strata, fissures, rockfalls, landslides, etc.	VIII Panel walls thrown out of frames; fall of walls, monuments, chimneys; sand and mud ejected; drivers of autos disturbed.	-200 -300	
	IX Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked. underground pipes broken.	-400 -500 -600	0.5g
	X Most masonry and frame structures destroyed; ground cracked; rails bent, landslides.	-700 -800 -900 -1000	1g
	XI New structures remain standing; bridges destroyed; fissures in ground; pipes broken; landslides; rails bent.	-2000 -3000	
	XII Damage total; waves seen on ground surface; lines of sight and level distorted; objects thrown up into air.	-4000 -5000 -6000	5g

where

$$\mu = \sum_{i}^{f} \sum_{j}^{sg} \mu_{ij} \quad , \quad (f \varepsilon F; \ sg \varepsilon SG) \tag{12}$$

with the summations extending to those segments and faults which are effective at that particular location. The effectiveness of each segment of any fault is to be determined by equation (7).

The probability of earthquake at any location in California with intensity greater than or equal to s up to time t is

$$P(S \geq s, t) = 1 - e^{-\mu t(1 - G(s))} \tag{13}$$

As analogous to equations (2) and (3), the expectation of recurrent time is

$$E[T;s] = \frac{1}{\mu(1 - G(s))} \tag{14}$$

7.3 Discussions on Some of the Code Outputs

Although the first recorded earthquake in the United States was as early as 1534,[1] abundant instrumental data are only available after 1905.[5,9] Thus the relatively short historical record of seismicity in the U.S. may not encompass a long enough time period to represent the true secular seismicity. Predictions based on data obtained under such conditions can only provide a relative earthquake risk guideline.

The conditions of the soil which overlays the bedrock at the site play an important role in the severity of shaking on the ground surface.[9] Soft soil sites usually shake more severly than rock sites. This was demonstrated in the 1906 San Francisco earthquake. Structural damage was consistently greater for buildings erected on filled land, whereas on the higher bedrock hills, damage was much less, even in areas closer to the earthquake center.[15] In general, damage is greater on soft, weak ground, but there are some evidences of an inverse relationship in the case of rigid structures due to soil dynamic amplification effects.[16] In the computer code, it assumes firm soil throughout California for simplification. The firm soil corresponds approximately with fine to medium grained sand in San Francisco area and with marine terrace deposits in the Los Angeles region.[9] For an extra-soft soil site, such as artificially filled sites, the probabilities against intensities probably should be modified upward one unit on the Modified Mercalli scale (for example, the probability of intensity X of an extra-soft site may actually correspond to the probability of intensity XI). On the other hand, for extra firm soil such as igneous, metaigneous, granite and metamorphic rock, the probabilities against intensities probably should be modified downward one (or a fraction more) units on the Modified Mercalli scale (i.e., for extra firm site, the probability of intensity X, for instance, becomes probability of intensity IX or a fraction lower).

Some sources on predicting earthquake recurrent times for a few locations in California provide a check against some parameters such as the soil condition used in the computer code.

A. The Borrego Mountain earthquake of April 9, 1968 was believed to be a 200-year event.[17] The ground acceleration was estimated at about 1 g which roughly corresponds to intensity X.[18] The magnitude was 6.4. The computer predictions are

Intensity (MM scale)	Recurrent Time (yr.)
IX	29.11
X	59.06
XI	167.48

This comparison shows that if the prediction of the reference is valid, the intensity scale of the computer predictions should be lowered about one nit, (i.e., the expectation of the recurrent time for intensity X is about 67.48 years).

3. Reid[19] predicted that about every 100 years an earthquake of April 8, 1906 intensity will repeat at San Francisco. The maximum intensity of the 1906 San Francisco earthquake was XI.[20] The corresponding computer predictions are

Intensity (MM scale)	Recurrent time(years)
X	43.68
XI	143.55
XII	893.27

The prediction for intensity XI seems to be in a reasonable agreement with Reid's. However, as discussed above, the most severe shaking occurred at the site of filled land which is about one intensity scale softer than what was assumed in the computer code. In other words, compared with Reid's prediction, the computer code also predicts that 1906 San Francisco earthquake is roughly a 100-year event provided those parameters used in the code can be considered as of soft soil instead of firm soil.

C. The February 9, 1971 San Fernando earthquake is generally believed to be a 200 year event. The intensity at Van Norman Dam was IX. The computer code predictions for Van Norman Dam are

Intensity (MM scale)	Recurrent time(years)
IX	68.58
X	205.49
XI	36861.80

This comparison shows again that if the intensity scale of the computer code is lowered by one unit, the prediction for intensity IX at Van Norman Dam location then seems more reasonable.

D. At the San Onofre nuclear power plant site, the intensity and corresponding expectancy of earthquakes[21] and the computer predictions are listed below:

INTENSITY (MM SCALE)	RECURRENT TIME (PRED.)	RECURRENT TIME (COMPUTED)
VIII	100 years	49.40 years
IX	600 years	173.96 years
X	-	1081.50 years

Again, the comparison shows that there is about one unit (or slightly more) difference in the Modified Mercalli Intensity Scale between predictions by the computer code and deduction from historical records.

In summary, the computer code based on the fault theory does estimate the relative seismic risks. The parameters assumed for firm soil are more likely associated with a softer soil (about one intensity scale unit difference). The probabilities associated with various earthquake intensities should therefore be modified according to the softness of the soil at the the earthquake site. Keeping these observations in mind, we see that the computer code used herein seems to be a convenient and useful tool that provides a general estimate of the earthquake probabilities in various large regions of California.

Table 5 shows the computer predictions for some earthen dam sites in California. Their locations are indicated in Figure 1.

It is believed that the uncertainties in the predicted recurrence intervals are greatest for the largest earthquakes, e.g., MM X, for which little empirical basis exists.

TABLE 5

EARTHQUAKE PREDICTIONS FOR SOME EARTH DAMS IN CALIFORNIA

DAM NAME	INTENSITY*	PROB./YR.	RECURRENCE TIME (YR)
Lake Chabot	VII	0.22	4
	VIII	0.17	5
	IX	0.12	8
	X	0.057	2 x 10
	XI	0.021	5 x 10
San Andreas Lake	VII	0.20	5
	VIII	0.11	8
	IX	0.044	2 x 10
	X	0.014	7 x 10
	XI	0.0032	3×10^2
San Pablo	VII	0.18	5
	VIII	0.12	8
	IX	0.076	1 x 10
	X	0.032	3 x 10
	XI	0.011	9 x 10
Van Norman	VII	0.10	9
	VIII	0.042	2 x 10
	IX	0.014	7 x 10
	X	0.0049	2×10^2
	XI	0.000027	4×10^4
Lower Franklin	VII	0.084	1 x 10
	VIII	0.036	3 x 10
	IX	0.013	8 x 10
	X	0.0018	6×10^2
	XI	0.00045	2×10^3
Stone Canyon	VII	0.084	1 x 10
	VIII	0.036	3 x 10
	IX	0.012	8 x 10
	X	0.0014	7×10^2
	XI	0.00033	3×10^3
Chatsworth	VII	0.097	1 x 10
	VIII	0.039	3 x 10
	IX	0.013	7 x 10
	X	0.0028	4×10^2
	XI	0.000026	4×10^4

* Modifications, depending on the softness of the soil at the site, are not included. The dotted lines shown are only to remind the reader that, generally for a firm soil site, the intensity scale is off about one unit. See the discussions in Section III.

TABLE 5 (Continued)

EARTHQUAKE PREDICTIONS FOR SOME EARTH DAMS IN CALIFORNIA

DAM NAME	INTENSITY*	PROB./YR.	RECURRENCE TIME (YR)
Encino	VII	0.088	1 x 10
	VIII	0.037	3 x 10
	IX	0.012	8 x 10
	X	0.0013	8 x 10^2
	XI	0.00016	6 x 10^3
Mulholland	VII	0.089	1 x 10
	VIII	0.037	3 x 10
	IX	0.014	7 x 10
	X	0.0031	3 x 10^2
	XI	0.00040	3 x 10^3
San Leandro	VII	0.22	4
	VIII	0.17	5
	IX	0.12	8
	X	0.063	2 x 10
	XI	0.023	4 x 10

Duke and Egouchi[24] gave the following estimates of MM intensities for four of the dam sites of this study as follows:

Dam Name	Intensity	Prob./Yr.
Van Norman	VIII	>0.1
	IX	0.053
	X	0.0080
Stone Canyon	VIII	0.051
	IX	0.019
	X	0.0086
Chatsworth	VIII	0.064
	IX	0.026
	X	0.011
Encino	VIII	0.092
	IX	0.032
	X	0.014

Some basis for comparison between history and the predictions of Table 5 is available. There are 30 hydraulic filled dams in California, one of which currently contains no water, and one has failed. Many of them are restricted to levels well below the spillway. These dams have operated for a total of 1,794 years. One dam failed due to the 1971 San Fernando earthquake after 50 years of operation. One earth dam, which is not included in either Duke's or Sherard's survey, failed in 1963 after 12 years of operation, not the result of an earthquake but due to settling. This dam was a model of modern design and construction. Four and a half hours of notice was available before this failure and evacuation began two and a half hours before the failure. Five people died with an estimated property damage of approximately 15 million dollars.

Figure 1. Some Earth Dams in California.

8. EFFECTS OF EVACUATION ON MORTALITY PREDICTION

8.1 Introduction

The procedure for estimating the effects of evacuation entails initially assuming a particular shape for the evacuation rate histogram. This assumption of the shape is largely based on experience. Figure 2 indicates such a histogram. Based on this, by a numerical integration, an "Integrated Histogram," which predicts the cumulative percentage of the total population evacuated in each hydraulic reach as a function of time, can be obtained. Figure 3 is the integrated histogram. To compute the percent of people evacuated, it is now only necessary to determine the wave head position as a function of time. Through the use of the equation $V_{av} = \{Q_{av}/(A@y_n)\}$, the average wave velocity in each hydraulic reach can be calculated, and hence the wave head position at any specified time can be determined.

In this study, it will be further assumed that the time in which the people in a given hydraulic reach must evacuate is determined solely by the time taken by the wave head to arrive at the middle of such a reach. This assumption results in a time averaging over the reach lengths.

Finally, with a knowledge of the time taken for the wave head to arrive at the middle of any given hydraulic reach and the percentage of the population that can be evacuated from there in the same length of time, an estimate of the number of people evacuated may be made. This estimate is merely the product of the number of people in the reach and the percentage of population which can be evacuated in the available time. The mortality number can now be obtained by subtracting the above estimate from the actual number of people living in the area defined by the chosen hydraulic reach. Since there exists a possibility that fewer people are present in the area during the daytime as compared with the nighttime, the results for the number of people evacuated between the day and the night may differ.

8.2 Evacuation Effects for Stone Canyon Dam

8.2.1 Determination of Water Velocity Within Each Reach:

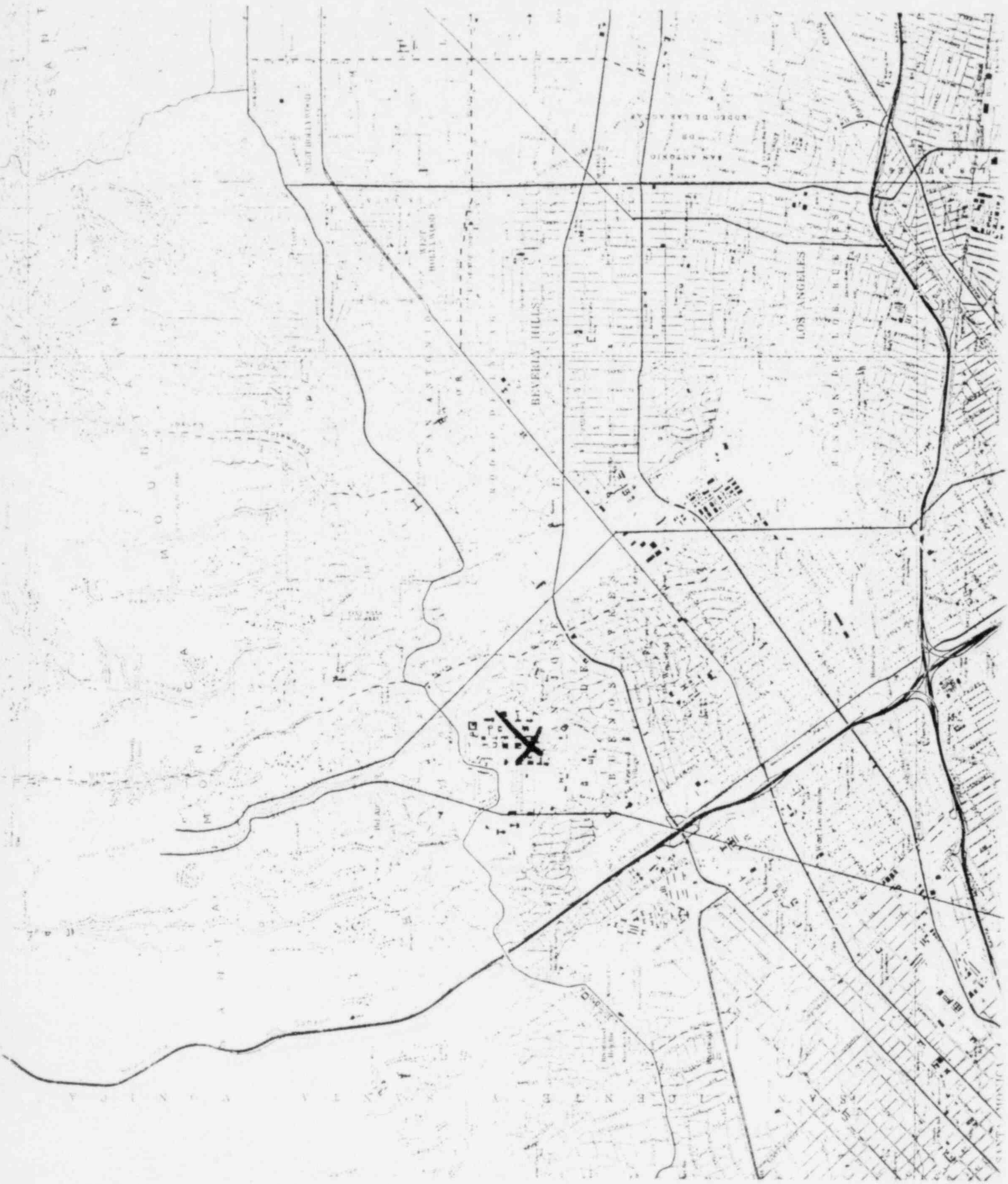
The average water velocity, V_{ave}, is given by $V_{ave} = \frac{Q_{av}}{A(@y_n)}$. Q_{av} is given by (SC.5) as 2.37×10^6 ft^3/sec.

Reach	Length (ft.)	Approximate y_n in ft.	$A \times 10^{-4}$ in ft.^{2}	V_{ave} (ft./sec.)
1	0 - 8,000	~124	4.0082	59
2	8,000 - 16,000	~ 20	12,2270	19
3	16,000 - 24,000	~ 16	17.9050	13
4	24,000 - 32,000	~ 16	23.5450	10
5	32,000 - 40,000	~ 16	30.8650	8

Schematic Diagram of Wave Front Position

vs. Length of Time After Break:

0 ft.	0 min.
4,000 ft.	
8,000 ft.	2.26 min.
12,000 ft.	5.77 min.
16,000 ft.	9.28 min.
20,000 ft.	14.41 min.
24,000 ft.	19.54 min.
28,000 ft.	26.21 min.
32,000 ft.	32.88 min.
36,000 ft.	41.21 min.
40,000 ft.	49.54 min.

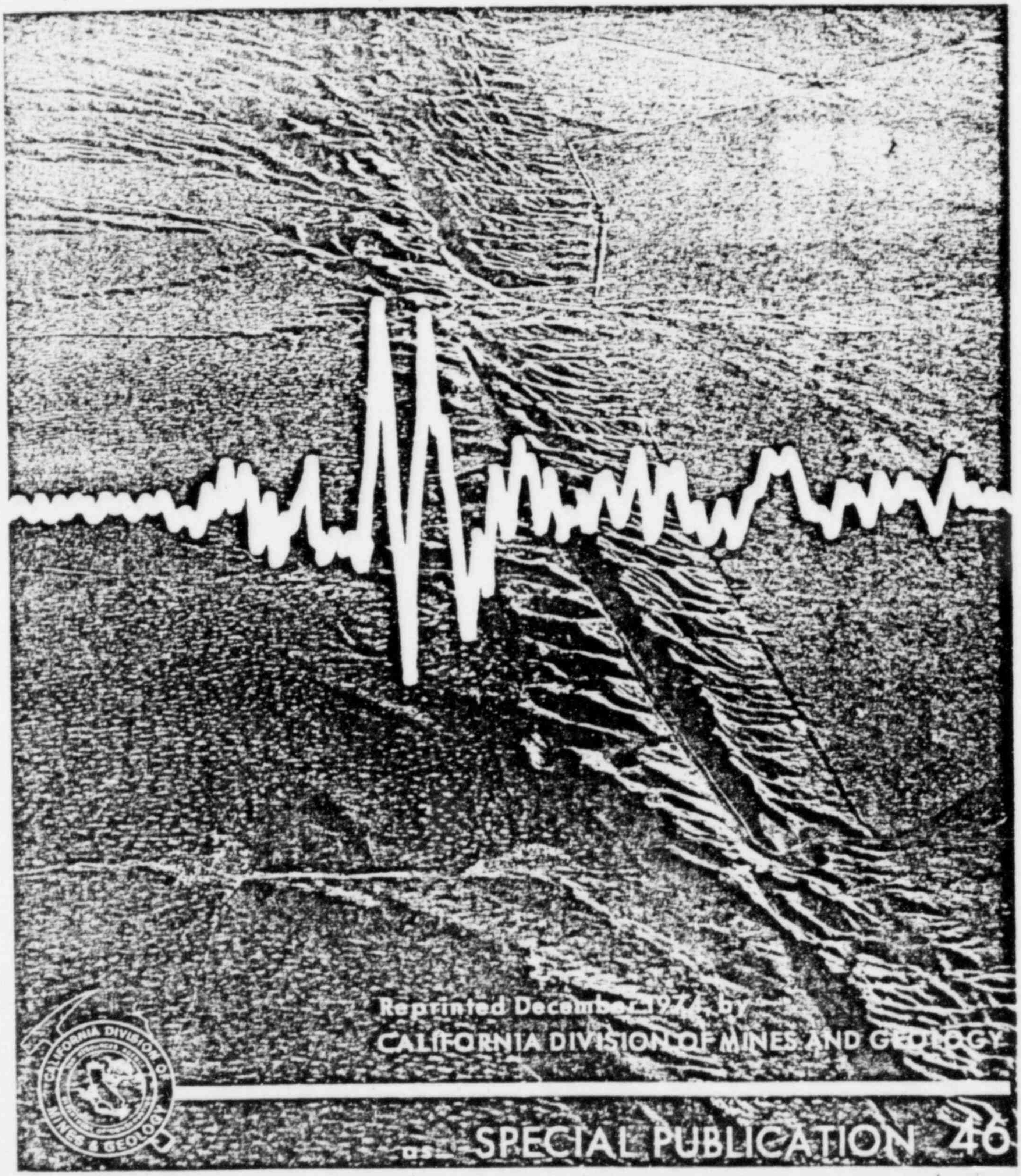


SCFP-1
Flood Plain Below the Stone Canyon

EXHIBIT E

Second Report of the Governor's Earthquake Council

September 1974



Reprinted December 1974 by
CALIFORNIA DIVISION OF MINES AND GEOLOGY

as SPECIAL PUBLICATION 46

GOVERNOR'S EARTHQUAKE COUNCIL

RONALD REAGAN, GOVERNOR
STATE OF CALIFORNIA

ROOM 1115 RESOURCES BUILDING • 1416 NINTH STREET • SACRAMENTO 95814

September 30, 1974

The Honorable Ronald Reagan
Governor, State of California
State Capitol
Sacramento, California 95814

Dear Governor Reagan:

The Second Report of the Governor's Earthquake Council is transmitted herewith. It contains a summary of the progress that has been achieved on the 26 recommendations that were set forth in the first report of the Council submitted to you November 24, 1972.

Since its appointment by you in January 1972 your Earthquake Council and its several committees, subcommittees, and task forces have identified the major earthquake-related problems that beset California and have implemented activities aimed to alleviate or eliminate them. The Council has worked with the Legislature's Joint Committee on Seismic Safety toward this end. Considerable progress has been made, but the mission is by no means completed. Earthquake preparedness is a never-ending responsibility.

In the last few years rapid strides have been taken in the advancement of earthquake engineering, and serious attention has been focused on socioeconomic problems relating to future disasters in the State. These advances were stimulated by the San Fernando earthquake of February 9, 1971, which was particularly distressing not only due to the death and destruction wrought but also because of the realization that this was a comparatively mild shock (magnitude 6.4, Richter scale) by comparison with the great historical California earthquakes such as the 1857 Tehachapi and 1906 San Francisco temblors, both of which are believed to have exceeded magnitude 8 on this same scale. Great earthquakes will occur again in California at times presently unpredictable. Because of the increased population and consequent developments, more people and facilities will be exposed to their ravages. Therefore, a continuous effort to increase our preparedness for these future events must be sustained. This effort deserves our support.

Sincerely yours,

James G. Stearns
Chairman

Enclosure

INTRODUCTION

Following the disastrous San Fernando earthquake of February 1971, Governor Ronald Reagan created the Governor's Earthquake Council, which he charged with responsibility for preparing recommendations of whatever kind for reducing losses in future California earthquakes.

The Council has consisted of 35 members representing federal, state, and local agencies, universities, and representatives of the public and private sectors. The tasks of the Council have been determined and directed by a Steering Committee composed of representatives from the interests noted. Working committees on Research and Investigation and on Preparedness and Response (see organization chart) considered the needs for further research in the fields of seismology, engineering, and geology and proposed procedures for reducing earthquake hazards in structures and improving response to earthquake emergencies.

Through the efforts of these committees the First Report of the Governor's Earthquake Council was distributed in November 1972. That report consists of 26 major recommendations for reducing earthquake losses. Recommendations 1 through 14 were developed primarily by the Research and Investigations Committee and Recommendations 15 through 24 by the Preparedness and Response Committee. Recommendations 25 and 26, which concern the term of the Governor's Earthquake Council and consideration of a successor body, were originated by the Steering Committee. All 26 recommendations were approved by the Governor, who issued instructions that steps be taken to assure their implementation.

Recommendation No. 1 of the First Report called for the creation of a coordinating body consisting of representatives from state agencies and universities to assist with the implementation of the remaining recommendations. The Governor's Interagency Earthquake Committee was appointed for this purpose. A number of task forces and subcommittees were also formed to consider specific recommendations (see table of organization).

The Second Report of the Governor's Earthquake Council was assembled by the Committee from reports submitted to it by the working groups. It consists of abstracts of these reports and contains for each recommendation a brief introductory statement, a review of progress achieved during 1973-74, and a summary of proposed future actions. The complete reports of the task forces and subcommittees upon which these abstracts are based are preserved in Sacramento in the files of the Committee.

OLIVE VIEW HOSPITAL FOLLOWING THE SAN FERNANDO
EARTHQUAKE OF FEBRUARY 9, 1971
(Recommendation No. 7)

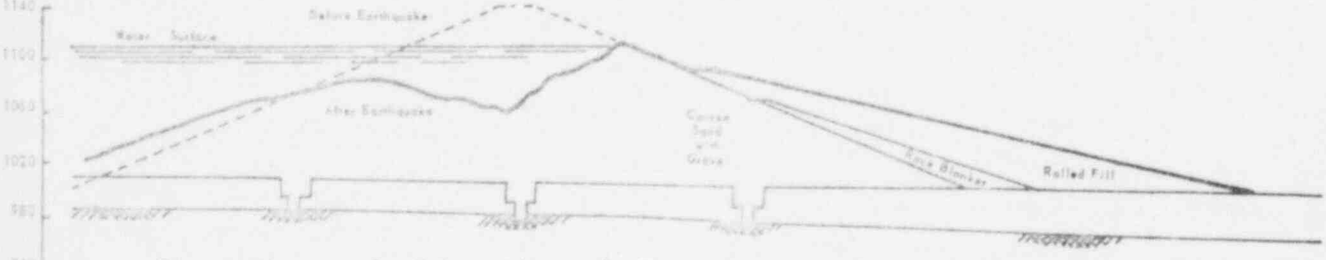
Three people were killed at this facility and damage was estimated at about $60 million.

Research programs are now proceeding with the objectives of developing better understanding of the ground motions that occur during severe earthquakes and improving the seismic criteria required for designing structures to withstand them.

Plans submitted for all new hospitals in California now must be accompanied by a report which evaluates geologic hazards including seismic history of the sites proposed. These reports are prepared in accordance with guidelines published by CDMG. (Photo courtesy CDMG)

LOWER SAN FERNANDO DAM, LOS ANGELES COUNTY
(Recommendation No. 4)

This dam, which was severely damaged during the San Fernando earthquake of February 1971, is typical of the hydraulic fill dams which were constructed between 1870 and 1935. The susceptibility of this type dam to liquefaction during an earthquake is clearly evident. As a result of the near failure of Lower San Fernando Dam. DWR has required the owners of each of 29 such dams in the State to conduct dynamic stability analyses. In general, although all studies have not been completed, those dams in the Sierra Nevada have been found satisfactory; whereas most of those in the coastal areas, where seismic expectancy is greater, have been found deficient. Removal, repair, or replacement is being considered for the potentially unstable structures. (Photo courtesy DWR)



Profiles of Van Norman Dam Before and After the San Fernando Earthquake of February 9, 1971

HIGHWAY 5 INTERCHANGE FOLLOWING THE SAN FERNANDO EARTHQUAKE OF FEBRUARY 9, 1971--AN AERIAL VIEW
(Recommendation No. 2)

Critical facilities such as this severely damaged highway interchange must be cleared and service restored as rapidly as possible after an earthquake. Technical studies must therefore begin immediately before useful data are obliterated by the emergency operations.

Recommendation No. 2 provides for expeditious and coordinated postearthquake investigation and prompt dissemination of information. Arrangements have been made with the California Wing, Civil Air Patrol, to provide aerial photographic surveys on short notice thereby preserving observations of damaged facilities which could be destroyed before ground parties have an opportunity to conduct on-site examinations. (Photo courtesy DWR)

EXHIBIT F

A REVIEW OF THE GEOLOGY AND EARTHQUAKE HISTORY OF THE NEWPORT-INGLEWOOD STRUCTURAL ZONE, SOUTHERN CALIFORNIA

1974

CALIFORNIA DIVISION OF MINES AND GEOLOGY

PREPARED IN COOPERATION WITH THE COUNTY OF LOS ANGELES, DEPARTMENT OF COUNTY ENGINEER AND THE LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

SPECIAL REPORT 114

Special Report 114

A REVIEW OF THE GEOLOGY AND EARTHQUAKE HISTORY OF THE NEWPORT-INGLEWOOD STRUCTURAL ZONE, SOUTHERN CALIFORNIA

This report is based on work completed in 1972.

By

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1974

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Prepared in cooperation with the
County of Los Angeles, Department of County Engineer
and the Los Angeles County Flood Control District

ABSTRACT

The Newport-Inglewood structural zone trends northwesterly from Newport Mesa to the Cheviot Hills along the western side of the Los Angeles basin. This belt of domal hills and mesas, formed by the folding and faulting of a thick sequence of sedimentary rocks, is the surface expression of a major zone of deformation.

Near-surface faults associated with the uplifts act as barriers to the flow of ground water across the zone. The level of the water table east of the zone is thereby raised. In addition, the barriers help to prevent the contamination of the fresh water supply by blocking the intrusion of sea water.

Anticlinal upwarping of predominantly marine sedimentary rocks, combined with associated complex faulting, provides traps for large quantities of petroleum and natural gas. The cumulative production of more than a dozen oil fields along the zone exceeds 2.5 billion barrels of oil. Some of the fields have been producing for 45 to 50 years.

The Newport-Inglewood structural zone, commonly referred to as the Inglewood fault by seismologists, is seismically active. The largest and most destructive of the numerous earthquakes that have occurred along the zone during historic time was the Long Beach earthquake of March 10, 1933. The epicenter of this 6.3 magnitude shock lay offshore near Newport Beach whereas the aftershock activity extended along the zone northwestward to Signal Hill. Most of the 120 deaths and more than $40 million in damage resulted from the failure of inadequately constructed buildings due to strong seismic shaking of the weak alluvial materials upon which they were built. Notable among the lesser shocks also discussed in this review are the 1920 Inglewood earthquake (4.9 magnitude), and some during the 1940s with which was associated subsurface faulting that damaged oil wells in the Dominguez and Rosecrans oil fields.

No surface faulting along known faults has been observed resulting from historic earthquakes. Surface geologic effects of earthquakes include: surface cracking of alluvial materials due to lurching or settling; development of mud or sand craters where water has been ejected during a shock; landslides or rockfalls from sea cliffs and roadcuts; elevation changes, both positive and negative; changes in the level of the water table in wells; and disruption of structures built on or in the ground such as pipelines, roads, and bridges.

Differential subsidence is associated with at least three of the oil fields along the zone; Inglewood (totals about 5.6 feet); Long Beach (totals about 2.0 feet); and Huntington Beach (totals about 5.1 feet). Surface faulting, in the form of earthcracks, appears to be related to subsidence in the Baldwin Hills. Failure of the Baldwin Hills reservoir in 1963 has been attributed to displacement across earthcracks.

The *en echelon* arrangement of the uplifts along the zone, combined with evidence for right-lateral strike-slip offsets along some of the longer exposed or near-surface faults, has led many to postulate that the aligned structures are the result of deformation at depth along a through-going strike-slip fault. First-motion studies of earthquakes tend to support the concept of a right-lateral fault at the depth of origin of earthquakes. Near the surface, however, the picture is complicated locally by evidence for normal, reverse, and left-lateral faulting.

This paper contains speculations on the significance of the abrupt change in trend of the zone north of Dominguez Hill, which leads to the inference that the Newport-Dominguez-Playa del Rey trend may be the major structure with the Dominguez-Baldwin Hills reach considered an offshoot of it.

The nature, extent, and direction of continuations of the zone beyond its known limits within the Los Angeles basin are discussed. Based upon the review of all information currently available, it is tentatively concluded that the portion of the zone north of the Baldwin Hills curves toward the west of the Cheviot Hills oil field and is overridden by northward-dipping reverse faults of the Santa Monica Mountains frontal fault system.

Southeast of Newport Beach, where the Newport-Inglewood structural zone trends out to sea, the continuation of the zone can be inferred to extend as far south as Laguna Beach on the basis of the locations of epicenters. Farther to the southeast, between Laguna Beach and Oceanside, recent intensive subbottom profiling surveys reveal the presence of numerous faults, one of which has been called the South Coast Offshore fault. This feature can be traced for 40 miles approximately coinciding with the edge of the continental shelf 2 to 7 miles offshore. The known and inferred similarities between the onshore Newport-Inglewood structural zone and the South Coast Offshore fault provide a cogent argument for concluding that the Newport-Inglewood zone does extend offshore parallel to the southern California coast and that the South Coast Offshore fault is a continuation of the Newport-Inglewood zone.

EXHIBIT G

NUREG/CR-2198

Fuel Temperatures in an Argonaut Reactor Core Following a Hypothetical Design Basis Accident (DBA)

Prepared by

G.E. Cort

June 1981

Los Alamos National Laboratory
Los Alamos, NM 87545

for the

Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

NRC FIN A7122

the "graphite stack can safely withstand the 0.25 G maximum earthquake loading". The review also concluded that vertical motion was unlikely to dislodge the stack of graphite blocks and that large deformations in any direction would be resisted by the biological shield.

The acceleration forces that should be applied to the ARGONAUT for seismic analysis will depend on local conditions such as the distance from the nearest fault. Therefore, it cannot be estimated whether 0.25 g's ground acceleration would be conservative or unconservative. However, if we assume an extreme acceleration of 1 g's, the maximum compressive stress in the graphite is still less than one-tenth the compressive strength. Because the blocks are not interlocked, tensile stresses should not occur. There may be some chipping at corners and abrasion from compressive shear, but these small changes in geometry should not adversely affect the heat transfer. [redacted] The probability and extent of crushing cannot be predicted without dynamic structural analysis. The dynamic analysis of the seismic response of an HTGR core (Ref. 1) that was completed at Los Alamos in 1975 is an example of the type of modeling needed to predict lateral crushing. It is interesting that the maximum impact force between adjacent graphite blocks with a 1 g's horizontal base acceleration was calculated as 0.3 MN (67,000 lb). [redacted]

[redacted] blocks. These components are interlocked and supported by the reinforced concrete shield. Even though the concrete in the shield may crack and spall, it is difficult to imagine that large displacements could occur that would allow these interlocked components to fall.

[redacted]. Any crushing that takes place will tend to "squeeze the air out" from between the fuel plates so that heat conduction to the surrounding graphite will be improved relative to the uncrushed state.

EXHIBIT H

LOS ANGELES COUNTY

BUILDING LAWS

Official Compilation

Edited and Proofread by the Los Angeles County
Division of Building and Safety

1 9 5 8
EDITION

by

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS
PACIFIC COAST BUILDING OFFICIALS CONFERENCE
SUBSIDIARY
610 SOUTH BROADWAY • LOS ANGELES 14, CALIFORNIA

E

F

Roof Loads (Cont'd.)

When the form factor, as determined by wind tunnel tests or other recognized methods, indicates vertical or horizontal loads of lesser or greater severity than those produced by the loads herein specified, the roof structure may be designed accordingly.

Snow load, full or unbalanced, or wind load shall be considered in place of loads as set forth in Table No. 23-B, where such loading will result in larger members or connections.

Reduction of Live Loads

Sec. 2306. The following reductions in unit live loads as set forth in Table No. 23-A for floors shall be permitted in the designing of columns, piers, walls, foundations, trusses, beams, and flat slabs.

Except for places of public assembly, and except for live loads greater than 100 pounds per square foot, the design live load on any member supporting one hundred and fifty square feet (150 sq. ft.) or more may be reduced at the rate of 0.08 per cent per square foot of area supported by the member. The reduction shall not exceed 60 per cent nor "R" as determined by the following formula:

$$R = 23.1\left(1 + \frac{D}{L}\right)$$

WHERE

R=Reduction in per cent

D=Dead load per square foot of area supported by the member

L=Unit live load per square foot of area supported by the member

For storage live loads exceeding 100 pounds per square foot, no reduction shall be made except that design live loads on columns may be reduced 20 per cent.

Wind Pressure

Sec. 2307. (a) General. Buildings and structures and every portion thereof shall be designed and constructed to resist the wind pressure as specified in this Section. All bracing systems both horizontal and vertical shall be designed and constructed to transfer the wind loads to the foundations.

(b) Wind Pressure. For purposes of design the wind pressure shall be taken upon the gross area of the vertical projection of buildings and structures at not less than 15 pounds per square foot for those portions of the building less than sixty feet (60') above ground and at not less than 20 pounds per square foot for those portions more than sixty feet (60') above ground.

The wind pressure upon roof tanks or other exposed roof structures and their supports shall be taken as not less than 30 pounds per square foot of the gross area of the plane surface, acting in any direction. In calculating the wind pressure on circular tanks, towers, or stacks this pressure shall be assumed to act on six-tenths of the projected area.

[For roof signs, see Chapter 62.]

Wind Pressure (Cont'd.)

On open-framed structures the area used in computing wind pressure shall be one and one-half times the net area of the framing members exposed to the wind.

Greenhouses, lath houses, and agricultural buildings shall be designed for a wind pressure of not less than 10 pounds per square foot.

(c) Design. The overturning moment calculated from the wind pressure shall in no case exceed two-thirds of the dead load resisting moment.

The weight of earth superimposed over footings may be used to calculate the dead load resisting moment.

(d) Combined Wind and Live Loads. For the purpose of determining stresses all vertical design loads except the roof live load and crane loads shall be considered as acting simultaneously with the wind pressure.

Live Loads Posted

Sec. 2308. The live loads for which each floor or part thereof of a commercial or industrial building is or has been designed shall have such designed live loads conspicuously posted by the owner in that part of each story in which they apply, using durable metal signs, and it shall be unlawful to remove or deface such notices. The occupant of the building shall be responsible for keeping the actual load below the allowable limits.

Retaining Walls

Sec. 2309. Retaining walls shall be designed to resist the lateral pressure of the retained material in accordance with accepted engineering practice. Walls retaining drained earth may be designed for pressure equivalent to that exerted by a fluid weighing not less than 30 pounds per cubic foot and having a depth equal to that of the retained earth. Any surcharge shall be in addition to the equivalent fluid pressure.

Footing Design

Sec. 2310. See Section 2805.

Walls and Structural Framing

Sec. 2311. Walls and structural framing shall be erected true and plumb in accordance with the design. Bracing shall be placed during erection wherever necessary to take care of all loads to which the structure may be subjected.

Lateral Bracing (Earthquake Regulations)

Sec. 2312. (a) General. Every building or structure and every portion thereof, except Type V buildings of Group I occupancy which are less than twenty-five feet (25') in height, and minor accessory buildings, shall be designed and constructed to resist stresses produced by lateral forces as provided in this Section. Stresses shall be calculated as the effect of a force applied horizontally at each floor or roof level above the foundation. The force shall be assumed to come from any horizontal direction.

All bracing systems both horizontal and vertical shall transmit all forces to the resisting members and shall be of sufficient extent and detail to resist the horizontal forces provided for in this Section and shall be located symmetrically about the center of mass of the building or the building

Lateral Bracing (Cont'd.)

TABLE NO. 23-C—HORIZONTAL FORCE FACTORS

PART OR PORTION	VALUE OF "C"	DIRECTION OF FORCE
Floors, roofs, columns, and bracing in any story of a building or the structure as a whole**	$\frac{[0.60]}{N\dagger + 4\frac{1}{2}}$	Any direction horizontally
Exterior bearing and non-bearing walls, interior bearing walls and partitions, interior non-bearing walls and partitions over ten feet (10') in height, masonry fences over six feet (6') in height.	[0.20] With a minimum of five pounds per square foot	Normal to surface of wall
Cantilever parapet and other cantilever walls, except retaining walls	[1.00]	Normal to surface of wall
Exterior and interior ornamentations and appendages	[1.00]	Any direction horizontally
When connected to or a part of a building: towers, tanks, towers and tanks plus contents, chimneys, smokestacks, and penthouses.	[0.20]	Any direction horizontally
Tanks, elevated tanks, smokestacks, standpipes, and similar structures not supported by a building.	[0.10]	Any direction horizontally

**Where wind load as set forth in Section 2307 would produce higher stresses, this load shall be used in lieu of the factor shown.

† N is number of stories above the story under consideration, provided that for floors or horizontal bracing, N shall be only the number of stories contributing loads.

shall be designed for the resulting rotational forces about the vertical axis.

(b) **Horizontal Force Formula.** In determining the horizontal force to be resisted, the following formula shall be used:

$$F = CW$$

WHERE

"F" equals the horizontal force in pounds,

"W" equals the total dead load, tributary to the point under consideration.

EXCEPTIONS: 1. For warehouses, "W" shall equal the total dead load plus 50 per cent of the vertical design live load tributary to the point under consideration.

Lateral Bracing (Cont'd.)

2. For tanks, "W" shall equal the total dead load plus the total live load.

Machinery or other fixed concentrated loads shall be considered as part of the dead load.

"C" equals a numerical constant as shown in Table No. 23-C.

(c) **Foundation Ties.** In the design of buildings of Types I, II, and III, where the foundations rest on piles or on soil having a safe bearing value of less than 2000 pounds per square foot, the foundations shall be completely interconnected in two directions approximately at right angles to each other. Each such interconnecting member shall be capable of transmitting by both tension and compression at least 10 per cent of the total vertical load carried by the heavier only of the footings or foundations connected. The minimum gross size of each such member if of reinforced concrete shall be twelve inches by twelve inches (12" x 12") and shall be reinforced with not less than the minimum reinforcement specified in Section 2620. If the interconnecting members are of structural steel, they shall be designed as provided in Section 2702, and encased in concrete. A reinforced concrete slab may be used in lieu of interconnecting tie members, providing the slab thickness is not less than one forty-eighth of the clear distance between the connected foundations; also providing the thickness is not less than six inches (6").

Interconnecting slabs shall be reinforced with not less than eleven-hundredths square inch (.11 sq. in.) of steel per foot of slab in a longitudinal direction and the same amount of steel in a transverse direction. The bottom of such slab shall be not more than twelve inches (12") above the tops of at least 80 per cent of the piers or foundations. The footings and foundations shall be tied to the slab in such a manner as to be restrained in all horizontal directions.

(d) **Plans and Design Data.** With each set of plans filed, a brief statement of the following items shall be included:

1. A summation of the dead and live load of the building, floor by floor, which was used in figuring the shears for which the building is designed.

2. A brief description of the bracing system used, the manner in which the designer expects such system to act, and a clear statement of any assumptions used. Assumption as to location of all points of counterflexure in members must be stated.

3. Sample calculation of a typical bent or equivalent.

(e) **Detailed Requirements.** 1. **Bonding and tying.** Cornices and ornamental details shall be bonded in the structure so as to form an integral part of it. This applies to the interior as well as to the exterior of the building.

2. **Overturning moment.** In no case shall the calculated overturning moment of any building or structure due to the

Lateral Bracing (Cont'd.)

forces provided for in this Section exceed two-thirds of the moment of stability of such building or structure. Moment of stability shall be calculated using the same loads as used in calculating the overturning moment.

3. **Additions.** Every addition to an existing building or structure shall be designed and constructed to resist and withstand the forces provided for in this Section, and in any case where an existing building or structure is increased in height all portions thereof affected by such increased height shall be reconstructed to resist and withstand the forces provided for in this Section.

4. **Alterations.** No existing building or structure shall be altered or reconstructed in such a manner that the resistance to the forces provided for in this Section will be less than that before such alteration or reconstruction was made; provided, however, that this provision shall not apply to non-bearing partitions, and shall not apply to other minor alterations which are made in a manner satisfactory to the Building Department.

5. **Building separations.** All portions of buildings and structures shall be designed and constructed to act as an integral in resisting lateral forces unless structurally separated by a distance of at least one inch (1"), plus one-half inch (½") for each ten feet (10') of height above twenty feet (20').

The details of sliding fragile joints shall be made satisfactory to the Building Official.

(f) **Intention or Interpretation of Lateral Force Provisions.** These lateral force requirements are intended to make buildings earthquake-resistive. The provisions of this Section apply to the buildings as a unit and also to all parts thereof, including the structural frame or walls, floor and roof systems, and other structural features.

The provisions incorporated in this Section are general and, in specific cases, may be interpreted or added to as to detail by rulings of the Building Official in order that the intent shall be fulfilled.

Anchorage

Sec. 2313. Concrete or masonry walls shall be anchored to all floors and roofs which provide lateral support for the wall or are required to provide stability for the wall. Such anchorage shall be capable of resisting the horizontal forces specified in this Section or a minimum force of 200 pounds per linear foot of wall, whichever is the larger.

CHAPTER 24—MASONRY

Scope

Sec. 2401. All masonry shall conform to the regulations of this Code.

Definitions

Sec. 2402. For the purpose of this Chapter certain terms are defined as follows:

DIMENSIONS. Dimensions given are nominal; actual dimensions of unit masonry may not be decreased by more than one-half inch (½").

GROSS CROSS-SECTIONAL AREA OF HOLLOW UNITS, the total area including cells of a section perpendicular to the direction of loading. Re-entrant spaces are included in the gross area, unless these spaces are to be occupied in masonry by portions of adjacent units.

MASONRY UNIT, any brick, tile, stone, or block conforming to the requirements specified in Section 2403.

Materials

Sec. 2403. The quality and design of masonry materials used structurally in buildings or structures shall conform to the requirements specified in this Chapter and to the following standards:

MATERIALS AND DESIGN	U.B.C. DESIGNATION
Building Brick	
Clay or Shale	24- 1-58
Sand-Lime	24- 2-58
Concrete	24- 3-58
Concrete Masonry Units	
Hollow Load-Bearing	24- 4-58
Solid Load-Bearing	24- 5-58
Hollow Non-Load-Bearing	24- 6-58
Structural Clay Tile	
For Walls—Load-Bearing	24- 7-58
For Walls—Nonbearing	24- 8-58
For Floors	24- 9-58
Gypsum	
Partition Tile or Block	24-10-58
General	24-11-58
Reinforced	24-12-58
Cast Stone	24-13-58
Cement	
Portland Cement	26- 1-58
Air-Entraining Portland Cement	24-14-58
Masonry Cement	24-15-58
Lime	
Quicklime	24-16-58
Hydrated Lime for Masonry Purposes	24-17-58
Mortar	
Other than Gypsum	24-18-58
Aggregates for Mortar	24-19-58
Testing	
Brick	24-20-58
Gypsum	24-21-58

UNIFORM BUILDING CODE

EXHIBIT I

1979 EDITION

E

(e) **Anchorage Requirements.** Adequate anchorage of the roof to walls and columns, and of walls and columns to the foundations to resist overturning, uplift and sliding shall be provided in all cases.

(f) **Solid Towers.** Chimneys, tanks and solid towers shall be designed and constructed to withstand the pressures as specified by this section, multiplied by the factors set forth in Table No. 23-G.

(g) **Open Frame Towers.** Radio towers and other towers of trussed construction shall be designed and constructed to withstand wind pressures specified in this section, multiplied by the shape factors set forth in Table No. 23-H.

Wind pressures shall be applied to the total normal projected area of all the elements of one face (excluding ladders, conduits, lights, elevators, etc., which shall be accounted for separately by using the indicated factor for these individual members).

(h) **Miscellaneous Structures.** Fences less than 12 feet in height, greenhouses, lath houses and agricultural buildings shall be designed for the horizontal wind pressures as set forth in Table No. 23-F except that, if the height zone is 20 feet or less, two-thirds of the first line of listed values may be used. The structures shall be designed to withstand an uplift wind pressure equal to three-fourths of the horizontal pressure.

(i) **Moment of Stability.** The overturning moment calculated from the wind pressure shall in no case exceed two-thirds of the dead load resisting moment.

The weight of earth superimposed over footings may be used to calculate the dead load resisting moment.

(j) **Combined Wind and Live Loads.** For the purpose of determining stresses, all vertical design loads except the roof live load and crane loads shall be considered as acting simultaneously with the wind pressure.

> EXCEPTION: Where snow loading is required in the design of roofs, at least 50 percent of such snow load shall be considered acting in combination with the wind load. The building official may require that a greater percentage of snow load be considered due to local conditions.

Earthquake Regulations

Sec. 2312. (a) General. Every building or structure and every portion thereof shall be designed and constructed to resist stresses produced by lateral forces as provided in this section. Stresses shall be calculated as the effect of a force applied horizontally at each floor or roof level above the base. The force shall be assumed to come from any horizontal direction.

Structural concepts other than set forth in this section may be approved by the building official when evidence is submitted showing that equivalent ductility and energy absorption are provided.

Where prescribed wind loads produce higher stresses, such loads shall be used in lieu of the loads resulting from earthquake forces.

(b) **Definitions.** The following definitions apply only to the provisions of this section:

BASE is the level at which the earthquake motions are considered to be imparted to the structure or the level at which the structure as a dynamic vibrator is supported.

BOX SYSTEM is a structural system without a complete vertical load-carrying space frame. In this system the required lateral forces are resisted by shear walls or braced frames as hereinafter defined.

BRACED FRAME is a truss system or its equivalent which is provided to resist lateral forces in the frame system and in which the members are subjected primarily to axial stresses.

DUCTILE MOMENT-RESISTING SPACE FRAME is a moment-resisting space frame complying with the requirements for a ductile moment-resisting space frame as given in Section 2312 (j).

ESSENTIAL FACILITIES—See Section 2312 (k).

LATERAL FORCE-RESISTING SYSTEM is that part of the structural system assigned to resist the lateral forces prescribed in Section 2312 (d) 1.

MOMENT-RESISTING SPACE FRAME is a vertical load-carrying space frame in which the members and joints are capable of resisting forces primarily by flexure.

SHEAR WALL is a wall designed to resist lateral forces parallel to the wall.

SPACE FRAME is a three-dimensional structural system without bearing walls, composed of interconnected members laterally supported so as to function as a complete self-contained unit with or without the aid of horizontal diaphragms or floor-bracing systems.

VERTICAL LOAD-CARRYING SPACE FRAME is a space frame designed to carry all vertical loads.

(c) **Symbols and Notations.** The following symbols and notations apply only to the provisions of this section:

C = Numerical coefficient as specified in Section 2312 (d) 1.

C_p = Numerical coefficient as specified in Section 2312 (g) and as set forth in Table No. 23-J.

D = The dimension of the structure, in feet, in a direction parallel to the applied forces.

δ_i = Deflection at level i relative to the base, due to applied lateral forces, $\sum f_i$, for use in Formula (12-3).

$F_i F_n F_x$ = Lateral force applied to level i, n or x, respectively.

F_p = Lateral forces on a part of the structure and in the direction under consideration.

F_t = That portion of V considered concentrated at the top of the structure in addition to F_n.

f_i = Distributed portion of a total lateral force at level i for use in Formula (12-3).

g = Acceleration due to gravity.

$h_i h_n h_x$ = Height in feet above the base to level i, n or x respectively.

I = Occupancy Importance Factor as set forth in Table No. 23-K.

K = Numerical coefficient as set forth in Table No. 23-I.

Level i

I = Level of the structure referred to by the subscript i.

i = 1 designates the first level above the base.

Level n

= That level which is uppermost in the main portion of the structure.

Level x

= That level which is under design consideration.

x = 1 designates the first level above the base.

N = The total number of stories above the base to level n.

S = Numerical coefficient for site-structure resonance.

T = Fundamental elastic period of vibration of the building or structure in seconds in the direction under consideration.

T_s = Characteristic site period.

V = The total lateral force or shear at the base.

W = The total dead load as defined in Section 2302 including the partition loading specified in Section 2304 (d) where applicable.

EXCEPTION: W shall be equal to the total dead load plus 25 percent of the floor live load in storage and warehouse occupancies. Where the design snow load is 30 psf or less, no part need be included in the value of W. Where the snow load is greater than 30 psf, the snow load shall be included; however, where the snow load duration warrants, the building official may allow the snow load to be reduced up to 75 percent.

$w_i w_x$ = That portion of W which is located at or is assigned to level i or x respectively.

W_p = The weight of a portion of a structure or nonstructural component.

Z = Numerical coefficient dependent upon the zone as determined by Figures No. 1, No. 2 and No. 3 in this chapter. For locations in Zone No. 1, Z = 3/16. For locations in Zone No. 2, Z = 3/8. For locations in Zone No. 3, Z = 3/4. For locations in Zone No. 4, Z = 1.

(d) **Minimum Earthquake Forces for Structures.** Except as provided in Section 2312 (g) and (i), every structure shall be designed and constructed to resist minimum total lateral seismic forces assumed to act nonconcurrently in the direction of each of the main axes of the structure in accordance with the following formula:

$$V = ZIKCSW \quad \text{.......... (12-1)}$$

The value of K shall be not less than that set forth in Table No. 23-I. The value of C and S are as indicated hereafter except that the product of CS need not exceed 0.14.

The value of C shall be determined in accordance with the following formula:

$$C = \frac{1}{15\sqrt{T}} \quad \text{.......... (12-2)}$$

The value of C need not exceed 0.12.

The period T shall be established using the structural properties and deformational characteristics of the resisting elements in a properly substantiated analysis such as the following formula:

$$T = 2\pi\sqrt{\left(\sum_{i=1}^{n} w_i\delta_i^2\right) \div \left(g\sum_{i=1}^{n} f_i\delta_i\right)} \quad \text{.......... (12-3)}$$

where the values of f_i represent any lateral force distributed approximately in accordance with the principles of Formulas (12-5), (12-6) and (12-7) or any other rational distribution. The elastic deflections, δ_i, shall be calculated using the applied lateral forces, f_i.

In the absence of a determination as indicated above, the value of T for buildings may be determined by the following formula:

$$T = \frac{0.05h_n}{\sqrt{D}} \quad \text{.......... (12-3A)}$$

Or in buildings in which the lateral force-resisting system consists of ductile moment-resisting space frames capable of resisting 100 percent of the required lateral forces and such system is not enclosed by or adjoined by more rigid elements tending to prevent the frame from resisting lateral forces:

$$T = 0.10N \quad \text{.......... (12-3B)}$$

The value of S shall be determined by the following formulas, but shall be not less than 1.0:

For T/T_s = 1.0 or less $\quad S = 1.0 + \frac{T}{T_s} - 0.5\left[\frac{T}{T_s}\right]^2$

.... (12-4)

For T/T_s greater than 1.0 $\quad S = 1.2 + 0.6\frac{T}{T_s} - 0.3\left[\frac{T}{T_s}\right]^2$

.... (12-4A)

WHERE:

T in Formulas (12-4) and (12-4A) shall be established by a properly substantiated analysis but T shall be not less than 0.3 second.

The range of values of T_s may be established from properly substantiated geotechnical data, in accordance with U.B.C. Standard No. 23-1, except that T_s shall not be taken as less than 0.5 second nor more than 2.5 seconds. T_s shall be that value within the range of site periods, as determined above, that is nearest to T.

When T_s is not properly established, the value of S shall be 1.5.

> **EXCEPTION:** Where T has been established by a properly substantiated analysis and exceeds 2.5 seconds, the value of S may be determined by assuming a value of 2.5 seconds for T_s.

(e) Distribution of Lateral Forces. 1. Structures having regular shapes or framing systems. The total lateral force V shall be distributed over the height of the structure in accordance with Formulas (12-5), (12-6) and (12-7).

$$V = F_t + \sum_{i=1}^{n} F_i \quad \text{. . . . . (12-5)}$$

The concentrated force at the top shall be determined according to the following formula:

$$F_t = 0.07TV \quad \text{. (12-6)}$$

F_t need not exceed $0.25V$ and may be considered as 0 where T is 0.7 second or less. The remaining portion of the total base shear V shall be distributed over the height of the structure including level n according to the following formula:

$$F_x = \frac{(V - F_t)\, w_x h_x}{\sum_{i=1}^{n} w_i h_i} \quad \text{. . . . . (12-7)}$$

At each level designated as x, the force F_x shall be applied over the area of the building in accordance with the mass distribution on that level.

2. **Setbacks.** Buildings having setbacks wherein the plan dimension of the tower in each direction is at least 75 percent of the corresponding plan dimension of the lower part may be considered as uniform buildings without setbacks, provided other irregularities as defined in this section do not exist.

3. **Structures having irregular shapes or framing systems.** The distribution of the lateral forces in structures which have highly irregular shapes, large differences in lateral resistance or stiffness between adjacent stories, or other unusual structural features, shall be determined considering the dynamic characteristics of the structure.

4. **Distribution of horizontal shear.** Total shear in any horizontal plane shall be distributed to the various elements of the lateral force-resisting system in proportion to their rigidities considering the rigidity of the horizontal bracing system or diaphragm.

Rigid elements that are assumed not to be part of the lateral force-resisting system may be incorporated into buildings provided that their effect on the action of the system is considered and provided for in the design.

5. **Horizontal torsional moments.** Provisions shall be made for the increase in shear resulting from the horizontal torsion due to an eccentricity between the center of mass and the center of rigidity. Negative torsional shears shall be neglected. Where the vertical resisting elements depend on diaphragm action for shear distribution at any level, the shear-resisting elements shall be capable of resisting a torsional moment assumed to be equivalent to the story shear acting with an eccentricity of not less than 5 percent of the maximum building dimension at that level.

(f) Overturning. Every building or structure shall be designed to resist the overturning effects caused by the wind forces and related requirements specified in Section 2311 or the earthquake forces specified in this section, whichever governs.

At any level the incremental changes of the design overturning moment, in the story under consideration, shall be distributed to the various resisting elements in the same proportion as the distribution of the shears in the resisting system. Where other vertical members are provided which are capable of partially resisting the overturning moments, a redistribution may be made to these members if framing members of sufficient strength and stiffness to transmit the required loads are provided.

Where a vertical resisting element is discontinuous, the overturning moment carried by the lowest story of that element shall be carried down as loads to the foundation.

(g) Lateral Force on Elements of Structures and Nonstructural Components. Parts or portions of structures, nonstructural components and their anchorage to the main structural system shall be designed for lateral forces in accordance with the following formula:

$$F_p = ZIC_pW_p \quad \text{. . . . . (12-8)}$$

The values of C_p are set forth in Table No. 23-J. The value of the I coefficient shall be the value used for the building.

> **EXCEPTIONS:** 1. The value of I for panel connectors shall be as given in Section 2312 (j) 3 C.
>
> 2. The value of I for anchorage of machinery and equipment required for life safety systems shall be 1.5.

The distribution of these forces shall be according to the gravity loads pertaining thereto.

For applicable forces on diaphragms and connections for exterior panels, refer to Sections 2312 (j) 2 D and 2312 (j) 3 C.

(h) Drift and Building Separations. Lateral deflections or drift of a story relative to its adjacent stories shall not exceed 0.005 times the story height unless it can be demonstrated that greater drift can be tolerated. The displacement calculated from the application of the required lateral forces shall be multiplied by $(1.0/K)$ to obtain the drift. The ratio $(1.0/K)$ shall be not less than 1.0.

All portions of structures shall be designed and constructed to act as an integral unit in resisting horizontal forces unless separated structurally by a distance sufficient to avoid contact under deflection from seismic action or wind forces.

(i) Alternate Determination and Distribution of Seismic Forces. Nothing in Section 2312 shall be deemed to prohibit the submission of properly substantiated technical data for establishing the lateral forces and distribution by dynamic analyses. In such analyses the dynamic characteristics of the structure must be considered.

(j) Structural Systems. 1. Ductility requirements. A. All buildings designed with a horizontal force factor $K = 0.67$ or 0.80 shall have ductile moment-resisting space frames.

B. Buildings more than 160 feet in height shall have ductile moment-resisting space frames capable of resisting not less than 25 percent of the required seismic forces for the structure as a whole.

> **EXCEPTION:** Buildings more than 160 feet in height in Seismic Zones Nos. 1 and 2 may have concrete shear walls designed in accordance with Section 2627 or braced frames designed in conformance with Section 2312 (j) 1 G of this code in lieu of a ductile moment-resisting space frame, provided a K value of 1.00 or 1.33 is utilized in the design.

C. In Seismic Zones No. 2, No. 3 and No. 4 all concrete space frames required by design to be part of the lateral force-resisting system and all concrete frames located in the perimeter line of vertical support shall be ductile moment-resisting space frames.

> **EXCEPTION:** Frames in the perimeter line of the vertical support of buildings designed with shear walls taking 100 percent of the design lateral forces need only conform with Section 2312 (j) 1 D.

D. In Seismic Zones No. 2, No. 3 and No. 4 all framing elements not required by design to be part of the lateral force-resisting system shall be investigated and shown to be adequate for vertical load-carrying capacity and induced moment due to $3/K$ times the distortions resulting from the code-required lateral forces. The rigidity of other elements shall be considered in accordance with Section 2312 (c) 4.

E. Moment-resisting space frames and ductile moment-resisting space frames may be enclosed by or adjoined by more rigid elements which would tend to prevent the space frame from resisting lateral forces where it can be shown that the action or failure of the more rigid elements will not impair the vertical and lateral load resisting ability of the space frame.

F. Necessary ductility for a ductile moment-resisting space frame shall be provided by a frame of structural steel with moment-resisting connections (complying with Section 2722 for buildings in Seismic Zones No. 3 and No. 4 or Section 2723 for buildings in Seismic Zones No. 1 and No. 2) or by a reinforced concrete frame (complying with Section 2626 for buildings in Seismic Zones No. 3 and No. 4 or Section 2625 for buildings in Seismic Zones No. 1 and No. 2).

> **EXCEPTION:** Buildings with ductile moment-resisting space frames in Seismic Zones No. 1 and No. 2 having an importance factor I greater than 1.0 shall comply with Section 2626 or 2722.

G. In Seismic Zones No. 3 and No. 4 and for buildings having an importance factor I greater than 1.0 located in Seismic Zone No. 2, all members in braced frames shall be designed for 1.25 times the force determined in accordance with Section 2312 (d). Connections shall be designed to develop the full capacity of the members or shall be based on the above forces without the one-third increase usually permitted for stresses resulting from earthquake forces.

Braced frames in buildings shall be composed of axially loaded bracing members of A36, A440, A441, A501, A572 (except Grades 60 and 65) or A588 structural steel; or reinforced concrete members conforming to the requirements of Section 2627.

H. Reinforced concrete shear walls for all buildings shall conform to the requirements of Section 2627.

I. In structures where $K = 0.67$ and $K = 0.80$, the special ductility requirements for structural steel or reinforced concrete specified in Section 2312 (j) 1 F, shall apply to all structural elements below the base which are required to transmit to the foundation the forces resulting from lateral loads.

2. Design requirements. A. Minor alterations. Minor structural alterations may be made in existing buildings and other structures, but the resistance to lateral forces shall be not less than that before such alterations were made, unless the building as altered meets the requirements of this section.

B. Reinforced masonry or concrete. All elements within structures located in Seismic Zones No. 2, No. 3 and No. 4 which are of masonry or concrete shall be reinforced so as to qualify as reinforced masonry or concrete under the provisions of Chapters 24 and 26. Principal reinforcement in masonry shall be spaced 2 feet maximum on center in buildings using a moment-resisting space frame.

C. Combined vertical and horizontal forces. In computing the effect of seismic force in combination with vertical loads, gravity load stresses induced in members by dead load plus design live load, except roof live load, shall be considered. Consideration should also be given to minimum gravity loads acting in combination with lateral forces.

D. **Diaphragms.** Floor and roof diaphragms and collectors shall be designed to resist the forces determined in accordance with the following formula:

$$F_{px} = \frac{\sum_{i=x}^{n} F_i}{\sum_{i=x}^{n} w_i} w_{px} \qquad \text{(12-9)}$$

WHERE:

F_i = the lateral force applied to level *I*.

w_i = the portion of *W* at level *I*.

w_{px} = the weight of the diaphragm and the elements tributary thereto at level *x*, including 25 percent of the floor live load in storage and warehouse occupancies.

The force F_{px} determined from Formula (12-9) need not exceed $0.30ZIw_{px}$.

When the diaphragm is required to transfer lateral forces from the vertical resisting elements above the diaphragm to other vertical resisting elements below the diaphragm due to offsets in the placement of the elements or to changes in stiffness in the vertical elements, these forces shall be added to those determined from Formula (12-9).

However, in no case shall lateral force on the diaphragm be less than $0.14ZIw_{px}$.

Diaphragms supporting concrete or masonry walls shall have continuous ties between diaphragm chords to distribute, into the diaphragm, the anchorage forces specified in this chapter. Added chords may be used to form sub-diaphragms to transmit the anchorage forces to the main cross ties. Diaphragm deformations shall be considered in the design of the supported walls. See Section 2312 (j) 3 A for special anchorage requirements of wood diaphragms.

3. **Special requirements.** A. **Wood diaphragms providing lateral support for concrete or masonry walls.** Where wood diaphragms are used to laterally support concrete or masonry walls the anchorage shall conform to Section 2310. In Zones No. 2, No. 3 and No. 4 anchorage shall not be accomplished by use of toenails or nails subjected to withdrawal; nor shall wood framing be used in cross-grain bending or cross-grain tension.

B. **Pile caps and caissons.** Individual pile caps and caissons of every building or structure shall be interconnected by ties, each of which can carry by tension and compression a minimum horizontal force equal to 10 percent of the larger pile cap or caisson loading, unless it can be demonstrated that equivalent restraint can be provided by other approved methods.

C. **Exterior elements.** Precast or prefabricated nonbearing, nonshear

wall panels or similar elements which are attached to or enclose the exterior shall be designed to resist the forces determined from Formula (12-8) and shall accommodate movements of the structure resulting from lateral forces or temperature changes. The concrete panels or other similar elements shall be supported by means of cast-in-place concrete or mechanical connections and fasteners in accordance with the following provisions:

Connections and panel joints shall allow for a relative movement between stories of not less than two times story drift caused by wind or $(3.0/K)$ times the calculated elastic story displacement caused by required seismic forces, or ½ inch, whichever is greater. Connections to permit movement in the plane of the panel for story drift shall be properly designed sliding connections using slotted or oversized holes or may be connections which permit movement by bending of steel or other connections providing equivalent sliding and ductility capacity.

Bodies of connectors shall have sufficient ductility and rotation capacity so as to preclude fracture of the concrete or brittle failures at or near welds.

The body of the connector shall be designed for one and one-third times the force determined by Formula (12-8). Fasteners attaching the connector to the panel or the structure such as bolts, inserts, welds, dowels, etc., shall be designed to insure ductile behavior of the connector or shall be designed for four times the load determined from Formula (12-8).

Fasteners embedded in concrete shall be attached to or hooked around reinforcing steel or otherwise terminated so as to effectively transfer forces to the reinforcing steel.

The value of the coefficient *I* shall be 1.0 for the entire connector assembly in Formula (12-8).

(k) Essential Facilities. Essential facilities are those structures or buildings which must be safe and usable for emergency purposes after an earthquake in order to preserve the health and safety of the general public. Such facilities shall include but not be limited to:

1. Hospitals and other medical facilities having surgery or emergency treatment areas.
2. Fire and police stations.
3. Municipal government disaster operation and communication centers deemed to be vital in emergencies.

The design and detailing of equipment which must remain in place and be functional following a major earthquake shall be based upon the requirements of Section 2312 (g) and Table No. 23-J. In addition, their design and detailing shall consider effects induced by structure drifts of not less than $(2.0/K)$ times the story drift caused by required seismic forces nor less than the story drift caused by wind. Special consideration shall also be given to relative movements at separation joints.

(l) Earthquake-recording Instrumentations. For earthquake recording instrumentations see Appendix, Section 2312 (l).

TABLE NO. 23-A—UNIFORM AND CONCENTRATED LOADS

USE OR OCCUPANCY		UNIFORM LOAD[1]	CONCENTRATED LOAD
CATEGORY	DESCRIPTION		
1. Armories		150	0
2. Assembly areas[4] and auditoriums and balconies therewith	Fixed seating areas	50	0
	Movable seating and other areas	100	0
	Stage areas and enclosed platforms	125	0
3. Cornices, marquees and residential balconies		60	0
4. Exit facilities[5]		100	0[8]
5. Garages	General storage and/or repair	100	[3]
	Private pleasure car storage	50	[3]
6. Hospitals	Wards and rooms	40	1000[2]
7. Libraries	Reading rooms	60	1000[2]
	Stack rooms	125	1500[2]
8. Manufacturing	Light	75	2000[2]
	Heavy	125	3000[2]
9. Offices		50	2000[2]
10. Printing plants	Press rooms	150	2500[2]
	Composing and linotype rooms	100	2000[2]
11. Residential[6]		40	0[8]
12. Rest rooms[7]			
13. Reviewing stands, grand stands and bleachers		100	0
14. Roof deck	Same as area served or for the type of occupancy accommodated		
15. Schools	Classrooms	40	1000[2]
16. Sidewalks and driveways	Public access	250	[3]
17. Storage	Light	125	
	Heavy	250	
18. Stores	Retail	75	2000[2]
	Wholesale	100	3000[2]

[1]See Section 2306 for live load reductions.
[2]See Section 2304 (c), first paragraph, for area of load application.
[3]See Section 2304 (c), second paragraph, for concentrated loads.
[4]Assembly areas include such occupancies as dance halls, drill rooms, gymnasiums, playgrounds, plazas, terraces and similar occupancies which are generally accessible to the public.
[5]Exit facilities shall include such uses as corridors serving an occupant load of 10 or more persons, exterior exit balconies, stairways, fire escapes and similar uses.
[6]Residential occupancies include private dwellings, apartments and hotel guest rooms.
[7]Rest room loads shall be not less than the load for the occupancy with which they are associated, but need not exceed 50 pounds per square foot.
[8]Individual stair treads shall be designed to support a 300-pound concentrated load placed in a position which would cause maximum stress. Stair stringers may be designed for the uniform load set forth in the table.

TABLE NO. 23-B—SPECIAL LOADS[1]

USE		VERTICAL LOAD	LATERAL LOAD
CATEGORY	DESCRIPTION	(Pounds Per Square Foot Unless Otherwise Noted)	
1. Construction, public access at site (live load)	Walkway See Sec. 4406	150	
	Canopy See Sec. 4407	150	
2. Grandstands, reviewing stands and bleachers (live load)	Seats and footboards	120[2]	See Footnote 3
3. Stage accessories, see Sec. 3902 (live load)	Gridirons and fly galleries	75	
	Loft block wells[4]	250	250
	Head block wells and sheave beams[4]	250	250
4. Ceiling framing (live load)	Over stages	20	
	All uses except over stages	10[5]	
5. Partitions and interior walls, see Sec. 2309 (live load)			5
6. Elevators and dumbwaiters (dead and live load)		2 x Total loads[6]	
7. Mechanical and electrical equipment (dead load)		Total loads	
8. Cranes (dead and live load)[7]	Total load including impact increase	1.25 x Total load[7]	0.10 x Total load[8]
9. Balcony railings, guard rails and handrails	Exit facilities serving an occupant load greater than 50		[illegible]
	Other		[illegible]
10. Storage racks	Over 8 feet high	Total loads[9]	See Table No. 23-J

(Footnotes on following page)

FOOTNOTES FOR TABLE NO. 23-B

[1]The tabulated loads are minimum loads. Where other vertical loads required by this code or required by the design would cause greater stresses they shall be used.

[2]Pounds per lineal foot.

[3]Lateral sway bracing loads of 24 pounds per foot parallel and 10 pounds per foot perpendicular to seat and footboards.

[4]All loads are in pounds per lineal foot. Head block wells and sheave beams shall be designed for all loft block well loads tributary thereto. Sheave blocks shall be designed with a factor of safety of five.

[5]Does not apply to ceilings which have sufficient total access from below, such that access is not required within the space above the ceiling. Does not apply to ceilings if the attic areas above the ceiling are not provided with access. This live load need not be considered acting simultaneously with other live loads imposed upon the ceiling framing or its supporting structure.

[6]Where Appendix Chapter 51 has been adopted, see reference standard cited therein for additional design requirements.

[7]The impact factors included are for cranes with steel wheels riding on steel rails. They may be modified if substantiating technical data acceptable to the building official is submitted. Live loads on crane support girders and their connections shall be taken as the maximum crane wheel loads. For pendant-operated traveling crane support girders and their connections, the impact factors shall be 1.10.

[8]This applies in the direction parallel to the runway rails (longitudinal). The factor for forces perpendicular to the rail is 0.20 × the transverse traveling loads (trolley, cab, hooks and lifted loads). Forces shall be applied at top of rail and may be distributed among rails of multiple rail cranes and shall be distributed with due regard for lateral stiffness of the structures supporting these rails.

[9]A load per lineal foot to be applied horizontally at right angles to the top rail.

[10]Vertical members of storage racks shall be protected from impact forces of operating equipment or racks shall be designed so that failure of one vertical member will not cause collapse of more than the bay or bays directly supported by that member.

TABLE NO. 23-C—MINIMUM ROOF LIVE LOADS[1]

ROOF SLOPE	METHOD 1			METHOD 2		
	TRIBUTARY LOADED AREA IN SQUARE FEET FOR ANY STRUCTURAL MEMBER			UNIFORM LOAD[2]	RATE OF REDUCTION r (Percent)	MAXIMUM REDUCTION R (Percent)
	0 to 200	201 to 600	Over 600			
1. Flat or rise less than 4 inches per foot. Arch or dome with rise less than one-eighth of span	20	16	12	20	.08	40
2. Rise 4 inches per foot to less than 12 inches per foot. Arch or dome with rise one-eighth of span to less than three-eighths of span	16	14	12	16	.06	25
3. Rise 12 inches per foot and greater. Arch or dome with rise three-eighths of span or greater	12	12	12	12	No Reductions Permitted	
4. Awnings except cloth covered[3]	5	5	5	5		
5. Greenhouses, lath houses and agricultural buildings[4]	10	10	10	10		

[1]Where snow loads occur, the roof structure shall be designed for such loads as determined by the building official. See Section 2305 (d). For special purpose roofs, see Section 2305 (e).

[2]See Section 2306 for live load reductions. The rate of reduction r in Section 2306 Formula (6-1) shall be as indicated in the table. The maximum reduction R shall not exceed the value indicated in the table.

[3]As defined in Section 4506.

[4]See Section 2305 (e) for concentrated load requirements for greenhouse roof members.

TABLE NO. 23-D—MAXIMUM ALLOWABLE DEFLECTION FOR STRUCTURAL MEMBERS[1]

TYPE OF MEMBER	MEMBER LOADED WITH LIVE LOAD ONLY (L.L.)	MEMBER LOADED WITH LIVE LOAD PLUS DEAD LOAD (L.L. + K D.L.)
Roof Member Supporting Plaster or Floor Member	L/360	L/240

[1]Sufficient slope or camber shall be provided for flat roofs in accordance with Section 2305 (f).

L.L. = Live load

D.L. = Dead load

K = Factor as determined by Table No. 23-E

L = Length of member in same units as deflection

TABLE NO. 23-E—VALUE OF "K"

WOOD		REINFORCED CONCRETE[2]	STEEL
Unseasoned	Seasoned[1]		
1.0	0.5	$[2 - 1.2 (A'_s/A_s)] \geq 0.6$	0

[1]Seasoned lumber is lumber having a moisture content of less than 16 percent at time of installation and used under dry conditions of use such as in covered structures.

[2]See also Section 2609.

A'_s = Area of compression reinforcement.

A_s = Area of nonprestressed tension reinforcement.

TABLE NO. 23-F—WIND PRESSURES FOR VARIOUS HEIGHT ZONES ABOVE GROUND[1]

HEIGHT ZONES (in feet)	WIND-PRESSURE MAP AREAS (pounds per square foot)						
	20	25	30	35	40	45	50
Less than 30	15	20	25	25	30	35	40
30 to 49	20	25	30	35	40	45	50
50 to 99	25	30	40	45	50	55	60
100 to 499	30	40	45	55	60	70	75
500 to 1199	35	45	55	60	70	80	90
1200 and over	40	50	60	70	80	90	100

[1]See Figure No. 4. Wind pressure column in the table should be selected which is headed by a value corresponding to the minimum permissible, resultant wind pressure indicated for the particular locality.

The figures given are recommended as minimum. These requirements do not provide for tornadoes.

TABLE NO. 23-G—MULTIPLYING FACTORS FOR WIND PRESSURES—CHIMNEYS, TANKS AND SOLID TOWERS

HORIZONTAL CROSS SECTION	FACTOR
Square or rectangular	1.00
Hexagonal or octagonal	0.80
Round or elliptical	0.60

TABLE NO. 23-H—SHAPE FACTORS FOR RADIO TOWERS AND TRUSSED TOWERS

TYPE OF EXPOSURE	FACTOR
1. Wind normal to one face of tower	
Four-cornered, flat or angular sections, steel or wood	2.20
Three-cornered, flat or angular sections, steel or wood	2.00
2. Wind on corner, four-cornered tower, flat or angular sections	2.40
3. Wind parallel to one face of three-cornered tower, flat or angular sections	1.50
4. Factors for towers with cylindrical elements are approximately two-thirds of those for similar towers with flat or angular sections	
5. Wind on individual members	
Cylindrical members	
Two inches or less in diameter	1.00
Over two inches in diameter	0.80
Flat or angular sections	1.30

TABLE NO. 23-I—HORIZONTAL FORCE FACTOR *K* FOR BUILDINGS OR OTHER STRUCTURES[1]

TYPE OR ARRANGEMENT OF RESISTING ELEMENTS	VALUE[2] OF *K*
1. All building framing systems except as hereinafter classified	1.00
2. Buildings with a box system as specified in Section 2312 (b)	1.33
3. Buildings with a dual bracing system consisting of a ductile moment-resisting space frame and shear walls or braced frames using the following design criteria: a. The frames and shear walls shall resist the total lateral force in accordance with their relative rigidities considering the interaction of the shear walls and frames b. The shear walls acting independently of the ductile moment-resisting portions of the space frame shall resist the total required lateral forces c. The ductile moment-resisting space frame shall have the capacity to resist not less than 25 percent of the required lateral force	0.80
4. Buildings with a ductile moment-resisting space frame designed in accordance with the following criteria: The ductile moment-resisting space frame shall have the capacity to resist the total required lateral force	0.67
5. Elevated tanks plus full contents, on four or more cross-braced legs and not supported by a building.	2.5[4]
6. Structures other than buildings and other than those set forth in Table No. 23-J	2.00

[1]Where wind load as specified in Section 2311 would produce higher stresses, this load shall be used in lieu of the loads resulting from earthquake forces.

[2]See Figures Nos. 1, 2 and 3 in this chapter and definition of Z as specified in Section 2312 (c).

[3]The minimum value of KC shall be 0.12 and the maximum value of KC need not exceed 0.25.

The tower shall be designed for an accidental torsion of 5 percent as specified in Section 2312 (e) 5. Elevated tanks which are supported by buildings or do not conform to type or arrangement of supporting elements as described above shall be designed in accordance with Section 2312 (g) using C_p = .3.

TABLE NO. 23-J—HORIZONTAL FORCE FACTOR C_p FOR ELEMENTS OF STRUCTURES AND NONSTRUCTURAL COMPONENTS

PART OR PORTION OF BUILDINGS	DIRECTION OF HORIZONTAL FORCE	VALUE OF C_p[1]
1. Exterior bearing and nonbearing walls, interior bearing walls and partitions, interior nonbearing walls and partitions—see also Section 2312 (j) 3 C. Masonry or concrete fences over 6 feet high	Normal to flat surface	0.3[1]
2. Cantilever elements: a. Parapets	Normal to flat surfaces	0.8
b. Chimneys or stacks	Any direction	
3. Exterior and interior ornamentations and appendages	Any direction	0.8
4. When connected to, part of, or housed within a building:		
a. Penthouses, anchorage and supports for chimneys and stacks and tanks, including contents		
b. Storage racks with upper storage level at more than 8 feet in height, plus contents	Any direction	0.3[2,3]
c. All equipment or machinery		
5. Suspended ceiling framing systems (applies to Seismic Zones Nos. 2, 3 and 4 only)	Any direction	0.3[4]
6. Connections for prefabricated structural elements other than walls, with force applied at center of gravity of assembly	Any direction	0.3[1]

[1]C_p for elements laterally self-supported only at the ground level may be two-thirds of value shown.

[2]W_p for storage racks shall be the weight of the racks plus contents. The value of C_p for racks over two storage support levels in height shall be 0.24 for the levels below the top two levels. In lieu of the tabulated values steel storage racks may be designed in accordance with U.B.C. Standard No. 27-11.

Where a number of storage rack units are interconnected so that there are a minimum of four vertical elements in each direction on each column line designed to resist horizontal forces, the design coefficients may be as for a building with K values from Table No. 23-I, CS = 0.2 for use in the formula $V = ZIKCSW$ and W equal to the total dead load plus 50 percent of the rack-rated capacity. Where the design and rack configurations are in accordance with this paragraph, the design provisions in U.B.C. Standard No. 27-11 do not apply.

[3]For flexible and flexibly mounted equipment and machinery, the appropriate values of C_p shall be determined with consideration given to both the dynamic properties of the equipment and

(Continued)

FOOTNOTES FOR TABLE 23-J—(Continued)

machinery and to the building or structure in which it is placed but shall be not less than the listed values. The design of the equipment and machinery and their anchorage is an integral part of the design and specification of such equipment and machinery.

For essential facilities and life safety systems, the design and detailing of equipment which must remain in place and be functional following a major earthquake shall consider drifts in accordance with Section 2312 (k).

Ceiling weight shall include all light fixtures and other equipment which is laterally supported by the ceiling. For purposes of determining the lateral force, a ceiling weight of not less than 4 pounds per square foot shall be used.

The force shall be resisted by positive anchorage and not by friction.

See also Section 2309 (b) for minimum load and deflection criteria for interior partitions.

TABLE NO. 23-K
VALUES FOR OCCUPANCY IMPORTANCE FACTOR I

TYPE OF OCCUPANCY	I
Essential Facilities	1.5
Any building where the primary occupancy is for assembly use for more than 300 persons (in one room)	1.25
All others	1.0

See Section 2312 (k) for definition and additional requirements for essential facilities.

Uniform Building Code

International Conference of Building Officials
Whittier CA

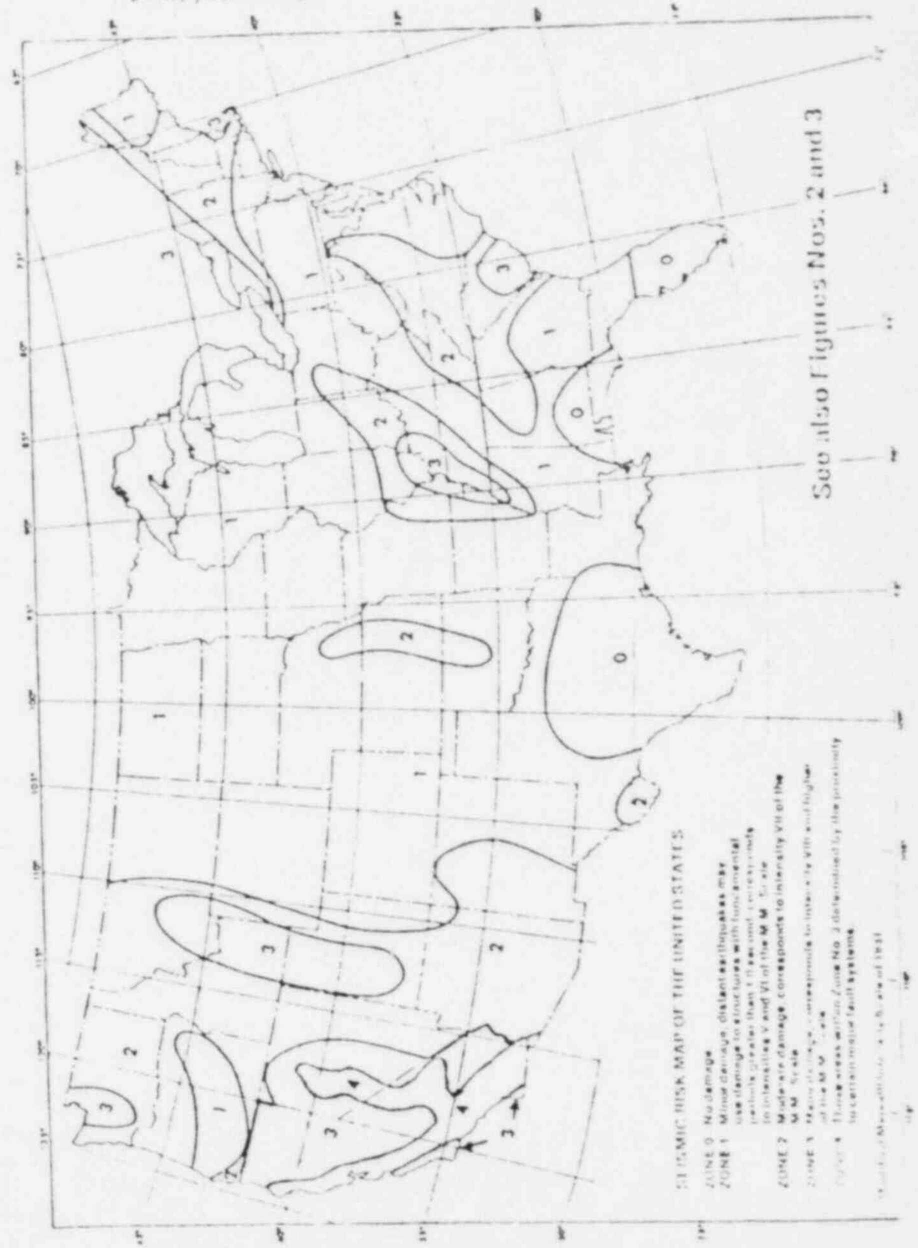

FIGURE NO. 1—SEISMIC ZONE MAP OF THE UNITED STATES
For areas outside of the United States, see Appendix Chapter 23

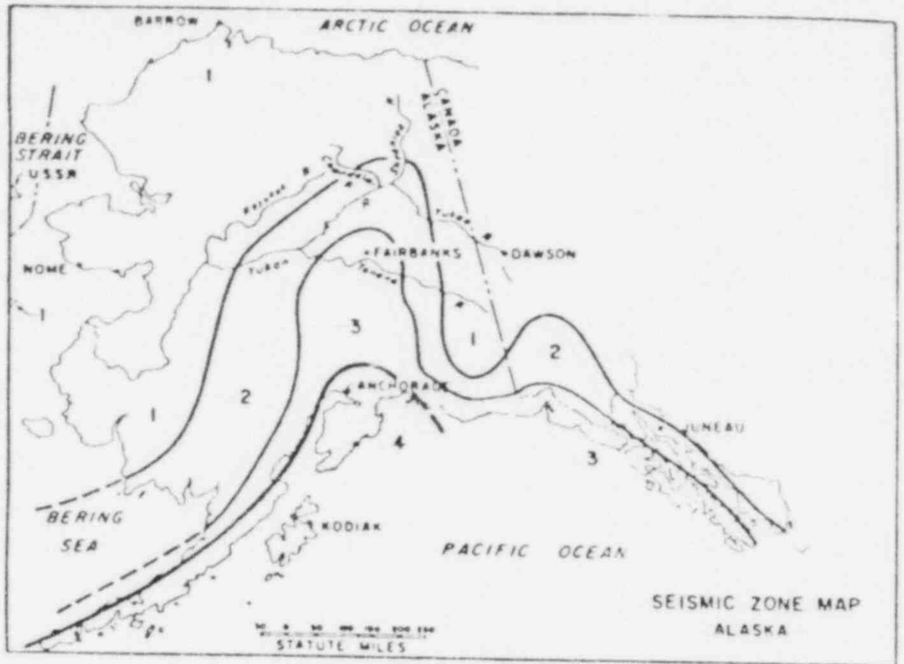

FIGURE NO. 2

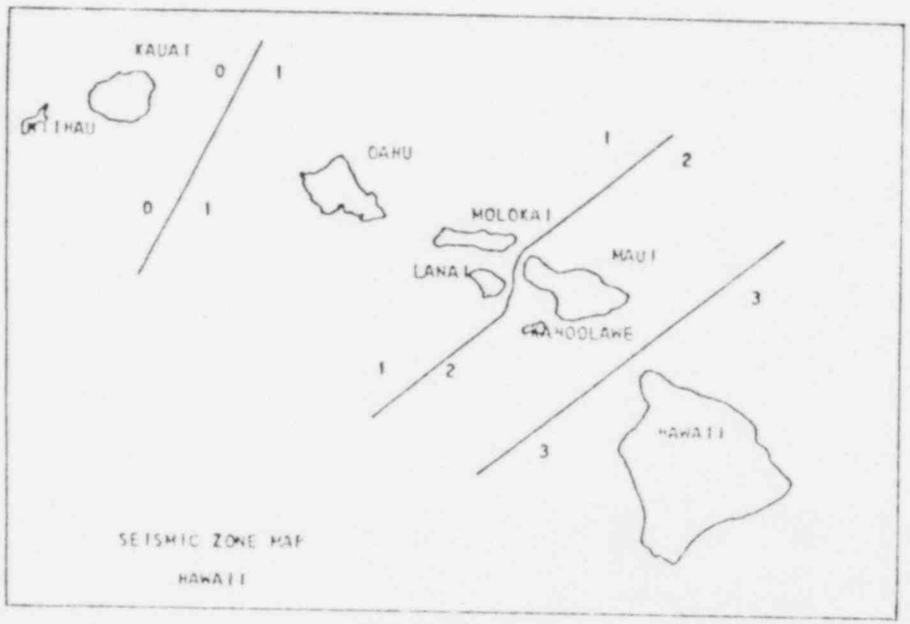

FIGURE NO. 3

FIGURE NO. 4

EXCEPTION: A separation shall not be required for such rooms with equipment serving only one dwelling unit.

(m) **Alternates.** No alternate method of obtaining the fire protection and safety required by this section may be used unless the Board of Appeals, including as a voting member for this purpose the chief of the fire department, finds that such alternate method provides protection and safety equivalent to that required herein.

Chapter 23

EARTHQUAKE INSTRUMENTATION

Earthquake Recording Instrumentation

Sec. 2312. (l) 1. **General.** In Seismic Zones No. 3 and No. 4 every building over six stories in height with an aggregate floor area of 60,000 square feet or more, and every building over 10 stories in height regardless of floor area, shall be provided with not less than three approved recording accelerographs.

2. **Location.** The instruments shall be located in the basement, midportion, and near the top of the building. Each instrument shall be located so that access is maintained at all times and is unobstructed by room contents. A sign stating "Maintain Clear Access to This Instrument" shall be posted in a conspicuous location.

3. **Maintenance.** Maintenance and service of the instruments shall be provided by the owner of the building subject to the approval of the building official. Data produced by the instruments shall be made available to the building official upon his request.

4. **Instrumentation of existing buildings.** All owners of existing structures selected by the jurisdiction authorities shall provide accessible space for the installation of appropriate earthquake-recording instruments. Location of said instruments shall be determined by the jurisdiction authorities. The jurisdiction authorities shall make arrangements to provide, maintain and service the instruments. Data shall be the property of the jurisdiction, but copies of individual records shall be made available to the public upon request and the payment of an appropriate fee.

SEISMIC ZONE TABULATION

For Areas Outside the United States

Location	Seismic Zone	Location	Seismic Zone
ASIA		Keflavik	3
Turkey		PACIFIC OCEAN AREA	
Ankara	2	Caroline Island	
Karamursel	3	Koror, Paulau	2
ATLANTIC OCEAN AREA		Ponape	0
Azores	2	Johnston Island	1
Bermuda	1	Kwajalein	
CARIBBEAN SEA		Mariana Islands	3
Bahama Islands	1	Guam	3
Canal Zone	2	Saipan	3
Leeward Islands	3	Tinian	3
Puerto Rico	3	Marcus Island	
Trinidad Island	2	Okinawa	3
NORTH AMERICA		Philippine Islands	3
Greenland	1	Samoa Islands	3
Iceland		Wake Island	0

EXHIBIT J

from CBG's July 31, 1981, Interrogatories
to the NRC Staff
as to
the Safety Evaluation Report

33. Please describe all control blade malfunctions at the UCLA reactor individually, by date, describing incident, and outlining cause.

34. On what specific factual basis does Staff determine the control blade system to be reliable through the proposed license period?

35. What control blade malfunctions is Staff aware of at other Argonaut reactors? Please describe all such instances individually by date, reactor, description of incident, and cause.

36. What efforts has Staff made to ascertain what control blade problems have been experienced by other Argonaut reactors?

37. Is a bicycle-type chain used in the control rod drive system? If so, has it ever failed? Give details if known.

38. Has the control blade logic system at UCLA ever failed? If so, please describe each such incident.

39. SER states "The graphite prism is surrounded by a biological shield of both conventional and heavy (magnetite) aggregate concretes." SER states further the shield was designed in the late 1950's.

a. Reactor was designed in the late 1950's to operate at 10 kw in a building with no members of the public on floors above. Both conditions have since changed. Please detail with specificity all alterations to biological shield (and other shielding) since reactor was originally designed. In particular, please describe by drawing and description placement of all paraffin and lead.

b. What is the density of the magnetite and the conventional concretes?

c. What is the minimal thickness of the concrete shield?

d. What level (in curies and in mrem/hr. dose contact) of activation products has the shield acquired to date,&what level could be expected by end of license period (year 2000) if operating licensed limit were met for the next 20 years?

e. Applicant asserts maximum dose from streaming radiation outside biological shield is 200 mr/hr. Does Staff have any independent information by which to measure that assertion? If so, please provide said information.

X 40. SER states, "This shield was designed in the late 1950's with an adequate factor of safety against seismic forces for a Zone 3 earthquake area."

a. Precisely what is the numerical size of the "adequate factor of safety"?

b. Against what criteria does Staff determine the shield to have "an adequate factor of safety."? Please specify the particular code sections, industry standards, or other standards.

c. Precisely how much acceleration in the vertical & horizontal E-W, N-s) directions was the biological shield designed to withstand?

d. What is the largest capable fault near the reactor site?

e. How close is the nearest approach of said fault to the reactor site?

f. What is the accelerogram--that is, the shape of the curve of acceleration--for that fault at the reactor site in the worst case scenario?

g. What is the maximum ground acceleration possible and maximum possible magnitude in Richter Scale for that fault?

h. Show by calculation and reference how the maximum credible earthquake at the largest capable fault near the reactor site could be withstood by the reactor's biological shield.

i. Have earthquake design standards for reactor components such as biological shields changes since the late 1950s? If so, please detail how they have changed as such changes would relate to current standards for building a biological shield for a research reactor at the UCLA site.

j. Does the reactor have a seismic scram device other than the embedded switches in the monolithic shield? If so, please detail the nature of said device.

SER p. 1-6

41. Please describe all notification received by the Commission from UCLA at the time of the additional construction next to and on top of the reactor building in 1968. (Give title and date of all documents related thereto)

42. Please describe all analyses done by the Commission prior to 1974 of the effects of the new construction done in 1868 in terms of radiation protection to the public and seismic risk to the reactor. Give title and date of all documents related to said analyses.

43. Describe in detail all shielding additions made related to the new potential areas for public radiation exposure.

44. Was the Commission notified in advance of said construction, and did it grant approval for the 1968 building additions?

45. Did the Commission analyze, prior to 1974, the effects to public health of having the Math Science building constructed next to the reactor building and the placement of the exhaust stack where it now is in relation to the MS air inlet? If so, please provide said analysis if not, please explain why not.

than "precipitation, runoff or rising ground water." Please provide all analyses that have been made of risk of flooding of the reactor from causes other than these. Intervenor in this question refers to the risk of flooding the reactor, not the risk from flooding it.

133. The paragraph about "Hydrology" does not address the question of contamination of ground water. Please provide all analysis done by Staff regarding that matter.

134. The paragraph about "Hydrology" does not address the question of whether wells exist in the vicinity or not. Please provide all information Staff can produce as to the existence of wells on campus or in the vicinity.

SER 2-6

X 135. SER states: "Though it is recognized that the UCLA campus may be path of an active seismic fault, it is difficult to determine and verify the degree of activity of such faults and the potential damage that can occur to the reactor or reactor building."

a. Which particular active seismic fault may UCLA be in the path of?

b. When was it most recently active, what was the size of the associated seismic event (in Richter Scale and in ground acceleration maximum), what damage occurred from said activity?

c. Please provide the information asked in 135b above for seismic activity prior to the most recent seismic event along that fault.

d. Precisely why is it difficult to determine and verify the degree of activity of such faults? Particularly address why such determination is difficult in this case but has been accomplished in other reactor proceedings.

e. Precisely why is it difficult to determine the potential damage that can occur to the reactor or reactor building from such faults? Again, particularly address why such determination has been possible in other reactor proceedings.

f. Please provide all analyses performed by Staff in an attempt to "determine and verify the degree of activity of such faults and the potential damage that can occur to the reactor or reactor building" and indicate what difficulties were encountered in performing such analyses.

g. Please show by calculation and reference the shape of the accelerogram of the SSE at this site, the maximum ground motion (in each direction) associated with it, and the response spectra of the reactor and the reactor building in such a SSE.

h. Please provide all Newmark-type analyses performed for this site.

i. What is the maximum acceleration the reactor core is capable of sustaining without damage in the east-west, north-south, and vertical directions?

j. What is the specific potential event at the principal capable fault which limits reactor design at the UCLA site?

k. What is the strain energy release on that fault which is the limiting condition for reactor design at the UCLA site?

l. What is the accelerogram that would be associated with the event identified in 135j above?

m. What damage related to the 1971 earthquake was Applicant referring to in its 1976 and 1977 Annual (Specialized Activity) Reports?

n. What other seismically-related damage is Staff aware of for the reactor?

136. SER states: "In order to circumvent these factors, the staff obtained laboratory analyses of the impacts of earthquake induced core disruption on Argonaut-type reactors."

a. Did Staff specifically request dose estimates and/or fission product release estimates in case of earthquake-induced fracturing of the fuel?

b. Precisely where in each study can such estimates be found?

c. Los Alamos study deals with one earthquake effect--reduction of cooling to plates following scram; Battelle study considers briefly changes in core geometry, with another consideration of flooding, and elsewhere a consideration of reactivity accidents, fire, and chemical reactions, each considered separately. Please provide all analyses of fission product release and dose estimates consequential to an accident initiated by earthquake but which resulted in an occurrence which combined two or more of the effects the laboratory studies analyzed singly. For example, reduction in cooling following a temperature rise caused by earthquake-induced reactivity insertion. Please provide all analyses performed by or for Staff of such common-mode events; i.e. the possible permutations of two or more events caused by same initiating event (earthquake).

SER p. 3-1

137. Please provide all facts you can produce that support the statement that the reactor is "in a well drained location."

X 138. a Master's thesis prepared by Richard Lee Rudman entitled "Simulation of Earthquake-Induced Vibrations in a UCLA Reactor Fuel Bundle" dated 1968 refers to the October 1966 vibration tests of producing accelerations of a maximum of .01 g rather than the .1g reported in the SER. Please indicate which is the correct figure and show all facts you can produce to support that answer.

139. Please show, by calculation and reference (including page # and paragraph) the extrapolation that produces accelerations of .5g.

X 140. What analysis has Staff performed to verify the Applicant's conclusions from the "out-of-core fuel element vibration tests"? In particular, what analysis has Staff undertaken as to the effects of power oscillations in conjunction with other seismically induced reactor effects? Please show said analyses.

X 141. Does Staff consider the Uniform Building code in effect at the time of the reactor's construction to include design considerations for seismic forces adequate for construction of a reactor in the Los Angeles region today? Please show all NRC guides or other documents that indicate adequate seismic design for reactor construction in seismically-active regions can be met by following the guidelines of the 1959 Uniform Building Code.

142. SER states: "According to the information in the application, neither the reactor facility or other campus structures suffered any structural damage due to the severe earthquakes in 1952 and 1971."

a. Describe all efforts made by Staff to ascertain the accuracy of the information from the Application cited above and provide all independent information obtain by Staff.

EXHIBIT K

from Staff's March 17, 1982, Responses
to CBG's Interrogatories
as to
the Safety Evaluation Rept.

Interrogatory Number 39

(d)-(e). No information available.

Interrogatory Number 40

(a). Presumably the design requirements contained in the Uniform Building Code requirements include an adequate safety factor as do all structural design guides. For detailed information see the Uniform Building Code and associated references.

(b). Uniform Building Code - However SER indicates that public safety is only minimally affected by a seismically induced collapse of the superstructure onto the reactor.

(c). Refer to the Uniform Building Code.

(d)(e). Staff did not consider it necessary to determine the size or location of any faults since the analysis in the SER assumed that a maximum damaging earthquake would occur.

(f). See (d)(e).

(g). See (d)(e).

(h). See (d)(e).

(i). No information.

(j). No.

Interrogatory Number 43

None.

Interrogatory Number 44

No. This was not required.

Interrogatory Number 50

No

assumed that they would verify the various prevalent meterologícal conditions from which subsequent calculations of dilution and concentration can be developed.

Interrogatory Number 129

See correspondence referenced in responses 127 and 128.

Interrogatory Number 132

(a). Two visits.

(b). April and September, 1980.

(c). I don't recall the total number of hours.

Interrogatory Number 134

No information. Well construction and/or use was not considered in the SER.

Interrogatory Number 135

No information.

Interrogatory Number 138

No information.

Interrogatory Number 140

None.

Interrogatory Number 141

SER indicates a severe earthquake would have little effect on local or regional safety from consequences to the UCLA reactor. Accordingly, no analyses were done.

Interrogatory Number 144

Unknown.

<u>EXHIBIT L</u>

from CBG's 4/20/81 Interrogatories to Applicant

from CBG's 4/20/81
Interrogatories

INTERROGATORIES AS TO CONTENTION XVII

"Seismic"

Intervenor herein incorporates by reference pages i through vii of this submission relating to definitions and general provisions to be used in answering these interrogatories.

1. Have the person(s) preparing the answers to these interrogatories read the definitions and general provisions for these interrogatories which are set forth on pages i through vii above?

2. Has any person or persons, other than Applicant's attorneys, furnished information of any type whatsoever used by Applicant in answering the following interrogatories or provided other assistance in the preparation of the following interrogatories? If so,

a. Please identify each and every such person.

b. Please state the number of each interrogatory with respect to which that person was consulted.

c. Please indicate the nature of the information or other assistance which that person supplied to Applicant in preparation of the answers to these interrogatories.

3. Page 10 of the NEL 1966-1967 Annual (Specialized Activity) Report indicates "A U.S. Coast and Geodetic Survey strong motion seismograph is presently housed in Engineering Unit I at UCLA. Early in 1968 the strong motion seismograph will be moved to the Nuclear Energy Laboratory and the

reactor will be instrumented."

a. How long prior to 1968 was the strong motion seismograph housed in Engineering Unit I at UCLA?

b. Was it indeed moved to NEL in 1968?

c. If the answer to 3b is negative, was it moved to NEL at some other time?

d. If the answer to 3c is affirmative, when was it moved?

e. Is the strong motion seismograph still in place at NEL?

f. If not, where is it located?

g. In what form(s) do data from that seismograph exist?

h. Does Applicant have any records of data from that seismograph?

i. If the answer to h is affirmative, specify all such records Applicant has in its possession, including the period of time covered by said records, and whether Applicant will produce said records absent a formal motion to produce?

j. What other records of data from that seismograph exist or may exist but are or may be in the possession of others than Applicant, and in whose possession are those records (including institution, name of custodian of records, address, and phone number.)?

k. What is meant by the statement quoted in 3 above that "the reactor will be instrumented."? Precisely what kinds of instruments were to be associated with the reactor, and precisely where were they to be placed?

4. What other seismographs or other seismic instruments exist on the UCLA campus? Please specify the type of instrument, its precise location on the campus, the nature and period of time of records of data from said instrument, the custodian of said records, and whether Applicant

will produce said records absent a formal motion to produce.

5. Besides those instruments identified in response to interrogatories 4 and 3, specify all instruments which might provide data or other indications of the response of the NEL reactor and/or Boelter Hall to seismic activity.

a. Please indicate the nature of the instrument, its precise location, the period of time it has or had been in place, the nature of the data produced and the form in which it is or was recorded, the custodian of such records, and whether Applicant will produce said records absent a formal motion to produce.

6. Page 10 of the 1966-1967 Annual (Specialized Activity) Report indicates that Professor Matthiessen "is conducting a two-year vibration study of the reactor building and its associated laboratory. These experiments have been conducted while part of the building has been under construction and provide detailed information about the building response."

a. What were the results of the two-year vibration study?

b. Were any seismic vulnerabilities of the building or the reactor indicated or suggested during the study?

c. If so, precisely what vulnerabilities were indicated or suggested?

d. If no vulnerabilities were suggested or indicated during the study, does Applicant contend the study was comprehensive and exhaustive enough to support a conclusion of no seismic vulnerability?

e. What published reports, papers, articles, or books resulted from the study? Please specify date of publication & journal or publisher.

f. What unpublished reports, papers, articles, or manuscripts resulted from the study? Will Applicant produce said materials absent a formal motion to produce?

g. What data was generated in the course of the study, in what form is that data, who is its custodian, and will Applicant produce records of said data absent a formal motion to produce?

7. Page 9 of the 1966-67 Annual (Specialized Activity) Report refers to "vibration tests of reactor structures" and concludes: "Despite core accelerations reaching 0.1 G, the reactor operated without any anomalous behavior."

a. What is the maximum core acceleration possible (in the N-S, E-W, and vertical directions) from a maximum earthquake affecting the reactor?

b. If the maximum core accelerations possible are greater than 0.1 G, what relevance does Applicant contend the vibration tests have for indicating reactor response during a maximum earthquake?

c. Did the scram mechanism shut the reactor down at any point during the vibration tests?

d. If not, at what level of core acceleration would the reactor scram automatically?

e. How was the answer to 7d determined? Please provide all calculations, and indicate all studies, reports, and other documents that support the answer to 7d and indicate whether Applicant will produce said documents absent a formal motion to produce.

f. Has the scram mechanism that is to shut the reactor down automatically in case of earthquake ever been tested? If so, please give dates of said tests, results of said tests, and indicate all documents related to said tests and whether Applicant will produce said documents absent a formal motion to produce.

8. Page III/3-2 of Application states, "The Uniform Building Code, representing the accumulated wisdom of the engineering profession in this field, takes specific account of the earthquake hazard. Virtually none of the structures built according to the specifications of this Code have suffered any damage from earthquakes."

a. Do these two sentences appear verbatim in the UCLA 1960 Hazards Analysis on page 9?

b. If the answer to 8a is affirmative, what specific efforts were made by Applicant to determine that the accuracy of that statement had not been altered in the twenty years since it had been written?

c. When was the Uniform Building Code, according to which the UCLA reactor building was built, written?

d. Has it been revised since? If so, please indicate the date of the revisions.

e. Does the Uniform Building Code that was in effect at the time of the construction of the UCLA reactor and the reactor building take specific account of building code provisions for reactors and reactor buildings? If so, please specify the sections of the Code that so apply.

f. According to applicable regulations today, could a nuclear reactor building be built today according to the Uniform Building Code provisions in effect when the UCLA reactor was built?

g. If the answer to 8f is affirmative, please cite the various regulation sections which support that answer.

h. If the answer to 8f is negative, please cite the various regulation sections which support that answer.

i. Did Applicant assess the experience of Code-complying structures during the Imperial Valley earthquake of October 15, 1979, prior to making the above-quoted statement in its Application for license renewal?

j. Did Applicant assess the experience of Code-complying structures during the Imperial Valley earthquake of October 15, 1979, prior to making the above-quoted statement in its Application for license renewal?

k. If the answer to i or j is affirmative, please indicate how that assessment was made and what its results were.

l. If the answer to i or j is negative, please indicate on what basis Applicant determined the 1960 statement to still be applicable in 1980, absent a review of such recent earthquake experience.

m. Please indicate all UCLA geologists, geophysicists, earth scientists, structural engineers, or other specialists in seismic strength of structures who were consulted prior to making the above-quoted statement in 1980 and the nature of the information they provided.

n. Please indicate all non-UCLA geologists, geophysicists, earth scientists, structural engineers, or other specialists in seismic strength of structures who were consulted prior to making the above-quoted statement in 1980 and the nature of the information they provided.

o. Please indicate all geologists, geophysicists, earth scientists, structural engineers, or other specialists in seismic strength of structures who have been consulted subsequent to the above-quoted statement being submitted in the Application and the nature of the information they provided.

9. Page 9 of the 1966-67 Annual (Specialized Activity) Report refers to "vibration tests of reactor structures" and concludes: "Despite core accelerations reaching 0.1 G, the reactor operated without any anomalous behavior."

a. a Master's thesis prepared by Richard Lee Rudman entitled "Simulation of Earthquake-Induced Vibrations in a UCLA Reactor Fuel Bundle" dated 1968 refers to the October, 1966, vibration tests and states: "there were no scrams and power operation could be controlled manually or by the automatic controller despite the vibrations and peak accelerations in the core area of 0.01g". Which is the correct figure for peak core accelerations--0.01 G or 0.1 G? (Rudman quote from p. 1 of thesis.)

b. Please indicate the cause of the discrepancy.

10. The master's thesis by Rudman referred to in interrogatory 9a states: "Vitti has shown that increasing the space between adjacent fuel plates results in a positive reactivity change. The moderator gap between adjoining fuel plates is approximately one-half of the optimum moderating distance. The present plate spacing is a nominal 0.137 in. while the spacing required for optimum neutron thermalization was experimentally determined by Vitti to be 0.290 in." (p. 3)

a. "Since the reactor lattice spacing is optimized for minimum crititical mass, any structural rearrangements which might result from a severe earth shock would reduce reactivity." (Application, page III/3-2). Please explain the apparent contradiction between the Rudman statement and that from the Application.

b. If there is a contradiction, which statement is correct?

c. On what basis does Applicant make its answer to 10b?

d. Rudman indicates in his thesis that on one run of the 1966 vibration tests a power oscillation was detected. His thesis concluded that seismically-induced vibrations could cause positive reactivity effects and power changes, but that at the rate of core accelerations being studied the effects from that alone would not be catastrophic. How does Applicant respond to Rudman's conclusions of possible positive reactivity effects which contrast with Applicant's statement quoted in 10a above that any severe seismic effect would reduce reactivity?

11. Page III/3-1 of the Application states: "The nearest major fault is the Inglewood fault running in a north-westerly direction about two miles east of the campus."

a. Smith and Matthiesen's "Vibration Testing and Earthquake Response of Nuclear Reactors" at page 16 indicates that the Inglewood fault is "considered responsible for the 1933 Long Beach earthquake." Does Applicant take issue with this statement by Smith and Matthiesen?

b. If the answer to 11a is negative, why was this information not included in the Application when discussing area seismology and the Inglewood fault in particular?

c. Has Applicant assessed the ground motion, building accelerations, degree of destruction, and other relevant seismic information from the 1933 Long Beach earthquake as these relate to the maximum earthquake possible along the Inglewood fault and the possible effects of such a maximum earthquake upon the reactor structure and upon Boelter Hall?

d. If the answer to 11c is affirmative, please indicate the results of that assessment and describe all documents in Applicant's possession which provide information useful in that assessment and whether Applicant will produce said documents absent a formal motion to produce?

12. In the third floor equipment room, is there a demineralized water system or part thereof? if yes,

a. describe precisely the system or the part thereof

b. whether a tank of water is there and if so, the size of the tank and volume of water contained therein

13. On the eight floor in the area inside the windscreen wherein is contained the reactor exhaust stack, is there an airconditioning apparatus? If so,

and calculations and identify all documents from which this answer was taken. Will Applicant provide all such documents absent a formal motion to produce?

e. What level of accelerations are the sample, core and top shielding secured against

i) in the upward vertical direction

ii) in the E-W direction

iii) in the N-S direction

iv) laterally

f. Please provide all facts and calculations upon which the answer to e was made. Identify all documents upon which it was based. Will Applicant produce all such documents absent a formal motion to produce?

g. Please provide a drawing of secured experiments in an irradiation port showing the spacer and graphite plug and means of inserting the experiment into the port. What precisely is the spacer made of, and on what is it supported, and how is it secured?

h. Please provide all facts, and calculations upon which this statement is based: "Cohesive forces sufficient to produce downward accelerations greater than 1 g are unlikely." Please identify all studies, experiments, articles, literature searches, reports, and other documents upon which that statement is based. Will Applicant produce said documents absent a formal motion to produce?

i. The above-quoted statement concludes: "The sample would not move relative to the core." Please provide all facts and calculations upon which that conclusion is based. Please identify all documents known to Applicant which support or contradict that conclusion. Will Applicant produce all such documents in its possession absent a formal motion to produce?

j. Has Applicant done any tests to confirm the statement quoted at the beginning of this interrogatory? If so, please identify all such tests, their dates, and results; also any records that document those tests. Will Applicant produce those records absent a formal motion to produce?

k. Would not an upward acceleration send the sample flying out of the reactor core? Please provide all facts and calculations that support or contradict your answer, and indicate whether you will produce said documents in your possession absent a formal motion to produce?

l. Would not the building falling on the reactor have a far greater impact force upon the reactor than the effect of the ground motion acceleration alone on the reactor?

m. Could not the building fall on the reactor from the first wave of the quake and land upon the reactor at the moment that the second wave or motion produced a downward acceleration or upward acceleration?

n. Does Applicant contend that it is impossible for a dynamic effect of an earthquake event to include several forces acting upon the reactor in different directions within short intervals of each other, the resonance effect of which could jerk the sample out of the core area?

o. Could a "ping-pong" type reaction occur that could cause the sample to bounce out of the reactor core?

p. Could an earthquake crush a sample container? If so, could the contents be squirted out of the core area, or trickle down out of the core area? Please give all facts, diagrams, and calculations in your possession that relate to your answer and identify all documents so related and indicate whether you will produce said documents absent a formal motion to produce

q. Does Applicant contend that no acceleration greater than 1 g in any direction is possible at this reactor? If so, provide all facts that support that contention, indicate all documents that support it, and indicate whether you will produce said documents absent a formal motion to produce?

27. What is the most likely accelerogram spectrum to which the reactor design must be tested?

a. Has it been so tested?

b. What document(s) is answers to #27 and 27a based on?

c. Will Applicant produce said document(s) without a formal motion to produce?

28. Since Applicant has found a natural frequency within the reactor based on its experimental vibration testing, what dynamic tests has Applicant done at that frequency to simulate true earthquake dynamic conditions?

29. What failure testing (testing to failure) of the reactor's control blade system has been done to assure that they cannot be made to break off, fallout, jump out, or other-wise move relative to the reactor core during an earthquake or other severe shock, causing a sudden reactivity insertion and a potentially destructive power excursion?

30. What analyses have been done indicating the force, twisting, shifting, bending, etc. the blades can withstand without breaking;

a. What analyses have been done showing what force would be necessary to bound the blades out of the core?

b. What is the structurally weakest point for the control blade system?

c. What documents are the above answers to interrogatory 30-30b based and will Applicant produce the documents absent a formal motion to produce?

31. Would an earthquake causing the collapsing building to fall at 1 g onto the reactor structure cause additional accelerations of two or three g's?

a. What failure testing and other dynamic analyses have been done to determine what effect such an impact on the reactor coupled with ground motion would have on the control blades and their position relative to the core? (e.g., flipping control blade up with an upward force and then smack it with a 3 g downward force and see where it flips up and breaks.)

b. What documents is above answer based on and will Applicant produce said document(s) absent a formal motion to produce?

32. Why is Applicant using the "seismic Zone" classification and the Uniform Building Code zoning system as a criterion for evaluation?

a. What does the seismic zone classification system have to do with nuclear reactors?

b. What does the Uniform Building Code have to do with nuclear reactors?

c. What document(s) are in Applicant's possession that support or contradict the answers contained above, and will Applicant produce said document(s) absent a formal motion to produce?

33. What is the principal capable fault which limits reactor design at the UCLA site?

34. What is the specific potential event at that fault which limits reactor design at the UCLA site?

a. What is the strain energy release on that fault which is the limiting condition for reactor design here?

b. What is the accelerogram that would be associated with the event identified in #34 above?

35. What data are in Applicant's possession regarding response of UCLA's structures to the 1971 earthquake? Will Applicant produce said data absent a formal motion to produce?

36. What is the specific damage that occurred to the UCLA reactor from the 1971 earthquake referenced in the 1976 Annual (Specialized Activity) Report on page 3: "The Feburary 1971 earthquake gave rise to minor problems that worsened with time and ultimately required a major maintenance effort in 1972."

a. Precisely, detail each and every problem that the earthquake gave rise to.

b. Precisely detail exactly how each problem worsened with time.

c. Precisely detail the maintenance effort made in 1972 to deal with these problems.

d. What documents are in Applicant's possession (including but not limited to engineering change orders, maintenance logs, etc.) that relate to a,b,and c above. Will Applicant produce said documents absent a formal motion to produce?

37. Applicant's answer of 8-27-80 to NRC staff question 13 indicates that the control/shim blades are "firmly fixed to horizontal drive shafts."

a. Precisely how are they fixed to the drive shafts?

b. What is the thickness and width of the blade at the point of connection to the drive shaft?

c. What is the blade material at the point of connection with the drive shaft?

d. What is the thickness and material composition of the drive shaft at the point of connection?

e. What is the lifetime use of those blades before the connection with the drive shaft becomes questionable?

f. What force can that point of connection between blade and drive shaft successfully withstand?

g. What failure testing experience and/or other tests and/or analyses is Applicant aware of regarding the connection point between the blades and the drive shaft?

h. What documents are in Applicant's possession that above answers are based on, and will Applicant produce said documents absent a formal motion to produce?

38. What is the thickness of the magnesium shroud wall around the control blades?

39. Applicant's 8-27-80 answer to NRC staff question 13 indicates "In regard to the 'frozen-blade' senario with all four blades locked, it may be remarked that the reactor has been operated in a simulation of this mode for many consecutive hours." Please detail the dates, nature, and results of this simulation and all documents relating to it. Will Applicant produce

said documents absent a formal motion to produce?

40. What were the accelergrams and maximum accelerations at UCLA associated with the '52 and '71 earthquakes and how would those compare to the expected maximum possible? What documents are in Applicant's possession that the answer is based on, and will Applicant produce said document(s) absent a formal motion to produce?

41. What data does Applicant possess regarding the seismic experience of the UCLA area during the Long Beach earthquake of 1933? What document(s) is answer based upon, and will Applicant produce said document(s) absent a formal motion to produce?

42. Were any buildings built according to Uniform Building Code standards damaged in Long Beach or nearby because of the Long Beach earthquake? What document(s) is answer based upon, and will Applicant produce said document(s) absent a formal motion to produce?

43. What is the failure point for the top floor of the reactor building--what is the shear stress that can be withstood before it fails? What document(s) is answer based upon, and will Applicant produce said document(s) absent a formal motion to produce?

44. The UCLA Daily Bruin of April 30, 1980, indicates that "University architects are currently conducting a study of buildings on all UC campuses to rank them according to their need for seismic renovation."

a. What is the precise rank of the reactor building, and out of how many in the list?

b. What specific findings were made about the reactor building?

c. What is the precise name of the seismic study referenced in the above Bruin article?

d. What other seismic studies related to the reactor building and other buildings on the UCLA campus is Applicant aware of?

e. Will Applicant produce those studies identified in c and d which are in its possession absent a formal motion to produce?

45. What is the Maximum Design Earthquake for which this reactor was originally built to withstand.

a. Identify all documents upon which your answer is based.

b. Is Applicant willing to produce all said documents in its possession absent a formal motion to produce?

46. What is the Maximum Design Earthquake Applicant currently believes reactor could withstand?

a. Identify all documents upon which your answer is based.

b. Is Applicant willing to produce all said documents in its possession absent a formal motion to produce?

47. What is the Maximum Earthquake the reactor could possibly experience given its siting?

a. Identify all documents upon which your answer is based.

b. Is Applicant willing to produce all said documents in its possession absent a formal motion to produce?

48. Precisely on which pages and which sections of pages in the Application does the information required by 10 CFR 50.34(b)(1) appear?

a. Please provide all information required by 10 CFR 50.34(b)(1) that does not already appear in the Application.

49. A press statement released by the Chancellor of UC Berkeley about the Applicant's research reactor there indicates a number of seismic studies and analyses and scenarios have been prepared about the reaction of the Applicant's reactor in Berkeley to a potential seismic event. Please describe with specificity the types of analyses Applicant has conducted regarding seismic questions of its Berkeley reactor. Please identify each and every such study or document, prepared by Applicant or by others, in Applicant's possession and whether Applicant will produce said documents absent a formal motion to produce.

EXHIBIT M

Applicant's Interrogatory Answers dated 5/20/81 from Applicant's Interrogatory Answers dated 5/20/81.

(CONTENTION XVII)

<u>Applicant's Response To Interrogatory No. 3.</u>

a. [redacted]

b. It was moved to NEL, probably in 1968 but the date in not known for sure.

c. Not applicable.

d. Not applicable.

e. [redacted]

f. [redacted]

g. [redacted]

h. Not to applicant's knowledge.

i. Not applicable.

j. Unknown, but possibly the USGS, Menlo Park, California.

k. This likely pertains to accelerometers used in comjunction with the vibration testing studies. Applicant does not know precisely where they were placed.

Applicant's Response To Interrogatory No. 4.

Applicant is aware that the State of California Division of Mines and Geology placed approximately ten accelerometers in or on the Math-Science Structure directly above the reactor building sometime in the late 1970's. This activity was not related to reactor operations but apparently to the fact that the Math-Sciences Building has been the subject of several dynamic response tests during and since its construction. To applicant's knowledge the earlier studies were reported in masters thesis which can probably be located in the engineering library under thenames R. Shannman, J. Scott and B. Bunce. Applicant's staff have not examined this literature. To applicant's knowledge the Division of Mines is using Kinemetrics accelerometer systems, Model CR-1, although it is believed that no records have been generated yet by this system since its installation. Apparently the testing is part of a larger sample testing of buildings in Los Angeles that is being conducted by the Division of Mines. H. LaGesse of the Division of Mines is the individual who services the instruments and collects any data: California Divisions of Mines, 2811 O Street, Sacramento.

Applicant's Response To Interrogatory No. 5.

Applicant is unaware of any instruments other than those described in the vibration studies of C.B. Smith, those installed by the Bureau of Mines, and the USGS instrument.

a. Not applicable.

Applicant's Response To Interrogatory No. 6.

a. [redacted] The results should be reported in "A Simulation of Earthquake Effects on the UCLA Reactor Using Structural Vibrators" by Matthiesen and Smith, October 1966.

b. [redacted]

c. [redacted].

d. [redacted]

e. Unknown.

f. Unknown.

Applicant's Response To Interrogatory No. 7.

a. Applicant objects to the question on the grounds that it is vague, ambiguous and uncertain.

b. [redacted]

c. [redacted] but see operating logs.

d. [redacted] but see any reports made from the study referenced in Interrogatory no. 6.

e. Not applicable.

f. [redacted]

Applicant's Response To Interrogatory No. 8.

a. [redacted]

b. [redacted]

c. [redacted]

d. [redacted]

e. [redacted]

f. [redacted]

g. Not applicable.

h. Not applicable.

i. [redacted]

j. [redacted]

k. Not applicable.

l. There was no reason to believe that that earthquake experience was relevant.

m. [redacted]

n. [redacted]

o. [redacted]

Applicant's Response To Interrogatory No. 9.

a. Applicant objects to the question on the grounds that [redacted]

[redacted]

b. See response above.

Applicant's Response To Interrogatory No. 10.

a. In practice, the mass is mass minimized under a constant volume constraint, and the Rudman/Vitti statement represents a more general situation. Realization of the positive reactivity effect requires a physical expansion of the core and the addition of water. There is no contradiction.

b. Not applicable.

c. See response to a, above.

d. [redacted]

Applicant's Response To Interrogatory No. 11.

a. [redacted]

b. The statement adds little to the discussion; in any case, applicant [redacted]

c. [redacted]

d. Not applicable.

Applicant's Response To Interrogatory No. 12.

Yes.

a. The system provides demineralized water upon demand.

b. There are three vessels, one of which contains a resin de-ionizing bed. The system volume is not more than 100 gallons.

Applicant's Response To Interrogatory No. 13.

Yes.

a. Applicant objects to the question on the grounds that the question seeks information which applicant cannot provide without conducting extensive scientific and engineering studies and evaluations. The applicant has neither the time, nor the personnel, nor the resources to conduct such studies.

b. See response above.

Applicant's Response To Interrogatory No. 14.

a. The floor panels are approximately 6 inches.

b. Reinforced concrete.

c. Yes.

d. [redacted]

e. Approximately 2000 square feet.

f. Approximately 625 square feet.

g. [redacted]

h. [redacted]

i. [redacted]

j. [redacted]

k. [redacted]

l. [redacted]

m. [redacted]

n. Reinforced concrete of approximately 150 pounds per cubic foot.

o. O; ten tons.

p. It is not.

q. [redacted]

r. Unknown.

s. [redacted]

t. Applicant objects to the question on the grounds that the information sought is privileged material that has been held in strict confidence by applicant in order to insure the security of the facility and its contents, including its critical records and documents.

u. Approximately three weeks.

v. Applicant objects to the question on the grounds that it is vague, ambiguous and uncertain.

w. Probably the center.

Applicant's Response To Interrogatory No. 15.

a. Reinforced concrete.

b. [redacted] requires detailed examination of working drawings and specifications.

c. [redacted]

d. [redacted]

e. [redacted]

f. [redacted]

g. [redacted]

h. [redacted] response above.

i. [redacted] nor [redacted] such [redacted]

j. [redacted]

k. [redacted]

l. [redacted]

m. [redacted]

n. [redacted]

o. [redacted]

p. [redacted]

Applicant's Response To Interrogatory No. 16.

[redacted]

a. See response above.

b. Not applicable.

c. Not applicable.

d. None; [redacted]though applicant [redacted] the Inglewood fault is the most likely seismological feature to cause a severely destructive earthquake at UCLA.

Applicant's Response To Interrogatory No. 17.

[redacted]

a. Not applicable.

b. Not applicable.

c. Not applicable.

d. Not applicable.

Applicant's Response To Interrogatory No. 18.

[redacted]

a. Not applicable.

b. Not applicable.

c. Not applicable.

d. Not applicable.

Applicant's Response To Interrogatory No. 19.

[redacted]

a. Not applicable.

b. Not applicable.

c. Not applicable.

d. Not applicable.

Applicant's Response To Interrogatory No. 20.

[redacted]

a. Not applicable.

b. Not applicable.

c. Not applicable.

d. Not applicable.

Applicant's Response To Interrogatory No. 21.

[redacted]

a. Not applicable.

b. Not applicable.

c. Not applicable.

Applicant's Response To Interrogatory No. 22.

The seismic scram interlocks are not specifically earthquake sensors, and are referred to by applicant as "closure sensors." They are conventional microswitches, six in number, wired in series, and are actuated by displacements of the shield blocks.

a. Assuming the sensor is actuated, the sensor response time is almost instantaneous. The shut down time in dictated by rod drop time (less than one second) or time to dump core water (approximately 20 seconds to dump 20% of the water). After either of these events, the power level will decay exponentially from the prompt-drop level on an 80 second period.

b. Displacements of approximately one-eighth to three-sixteenths inches will actuate the sensors.

c. Not to applicant's knowledge.

d. Circuit continuity is checked prior to each reactor start-up. Positioning is checked whenever shield blocks are moved for core maintenance.

e. Not applicable.

f. Not to applicant's knowledge.

g. None, except for what applicant has mentioned in response to these interrogatories.

h. None.

i. No.

j. Yes.

k. Unknown.

l. None.

m. Applicant is undecided at this time and will make a determinaton as to the documents it will produce only after a request for production is received.

Applicant's Response To Interrogatory No. 23.

[redacted]

a. [redacted]

[redacted]e.

c. [redacted].

Applicant's Response To Interrogatory No. 24.

[redacted]

[redacted].

[redacted].

[redacted]e.

Applicant's Response To Interrogatory No. 25.

[redacted]

a. [redacted]

b. N[redacted]

c. N[redacted]e.

Applicant's Response To Interrogatory No. 26.

a. Yes.

b. Those that would bond (in tension) the foundation to any underlying soil that might be hypothesized to accelerate downward at more than one g.

c. [redacted] Applicant is undecided at this time and will make a determinaton as to the documents it will produce only after a request for production is received.

d. Anything less than one g. The facts are normally expressed by the physical laws of Sir Isaac Newton (1642-1727), English mathematician and natural philosopher.

e. [redacted]d.

f. Not applicable.

g. See Exhibit B.

h. It is a general observation to the effect that most soils have negligible tensile strength. [redacted] instead on the absence of any facts, information or documents which would contradict applicant's response.

i. It is a general conclusion based upon the stated premises and [redacted].

j. [redacted]

k. Applicant objects to the question on the grounds that it is vague, ambiguous and uncertain.

l. [redacted]

m. [redacted]

n. [redacted]

o. Applicant objects to the question on the grounds that it is vague, ambiguous and uncertain.

p. [redacted]

q. [redacted]

<u>Applicant's Response To Interrogatory No. 27.</u>

[redacted]

<u>Applicant's Response To Interrogatory No. 28.</u>

[redacted]

<u>Applicant's Response To Interrogatory No. 29.</u>

[redacted]

Applicant's Response To Interrogatory No. 30.

[redacted]

[redacted]

[redacted]

[redacted]

Applicant's Response To Interrogatory No. 31.

[redacted]

a. [redacted]

b. Not applicable.

Applicant's Response To Interrogatory No. 32.

[redacted]; the items are merely relevant factors.

a. [redacted]

b. [redacted].

c. None.

Applicant's Response To Interrogatory No. 33.

[redacted]

Applicant's Response To Interrogatory No. 34.

[redacted]

[redacted]

b. Not applicable.

Applicant's Response To Interrogatory No. 35.

To applicant's knowledge the only data that may be in existence relates to routine maintenance reports, work orders, etc. Applicant is undecided at this time and will make a determinaton as to the documents it will produce only after a request for production is received.

Applicant's Response To Interrogatory No. 36.

Applicant's staff believes that the attribution of a water leak to the earthquake was found, upon core entry, to be either erroneous or at least not clearly related to the earthquake. Applicant's staff believes that the leak source was ultimately traced to corrosion in piping that was embedded in concrete below the core rather than piping or fuel box failure within the core. To the extent that the applicant has knowledge of the information requested it is contained in applicant's records and documents, although such records and documents are likely to be incomplete particularly for the earlier years of reactor operations. The following records and documents are the main sources of such information as applicant has available: documents no. 1, 2, 3, 5a and 10.

a. See response above.

b. See response above.

c. See response above. Applicant has observed that the imbedded piping was abandoned and new piping was substituted by core drilling for passage through the concrete. New fuel boxes were built to adapt to the new piping.

d. See response above. Applicant is undecided at this time and will make a determinaton as to the documents it will produce only after a request for production is received.

Applicant's Response To Interrogatory No. 37.

a. The information requested can be found in the following records and documents: document no. 41.

b. See response above.

c. See response above.

d. See response above.

e. Unknown.

f. Unknown.

g. None.

h. See a above.

Applicant's Response To Interrogatory No. 38.

Approximately one-eighth inch.

Applicant's Response To Interrogatory No. 39.

To the extent that the applicant has knowledge of the information requested it is contained in applicant's records and documents, although such records and documents are likely to be incomplete particularly for the earlier years of reactor operations. The following records and documents are the main sources of such information as applicant has available: document no. 1.

Applicant's Response To Interrogatory No. 40.

[redacted]

Applicant's Response To Interrogatory No. 41.

[redacted]

Applicant's Response To Interrogatory No. 42.

Not to applicant's knowledge; it is unlikely that the Uniform Building Code was in effect.

Applicant's Response To Interrogatory No. 43.

[redacted]

Applicant's Response To Interrogatory No. 44.

The Daily Bruin article is in error. The University has contracted with outside consultants to prepare a study of UC buildings. The study is to establish priorities for the funding of seismic studies by the state in the future. The current study is not a seismic study at all. The study is in progress but it is expected that the study will be completed and reported to the state within the next several months. The buildings will apparently be ranked according to square footage, occupancy, type construction, reconstruction costs and other factors. The entire "findings" for each building will be contained on a single line entry and will consist only of the type factors mentioned above. On the basis of the rankings the state will decide for which buildings it will fund seismic studies.

a. See response above.

b. See response above.

c. Unknown.

d. None.

e. Applicant is undecided at this time and will make a determinaton as to the documents it will produce only after a request for production is received.

Applicant's Response To Interrogatory No. 45.

[redacted]

a. Not applicable.

b. Not applicable.

Applicant's Response To Interrogatory No. 46.

[redacted]

a. Not applicable.

b. Not applicable.

Applicant's Response To Interrogatory No. 47.

[redacted]

EXHIBIT SHEET

Exhibit

A	Declaration of Dr. Sheldon C. Plotkin
B	Photographs taken by Dr. Plotkin
C	FEMA Report selections
D	Estimates of the Risks Associated with Dam Failure 6/ selections
E	Photos of 1971 Olive View Hospital Quake Damage and related items from Second Report of the Governor's Earthquake Council
F	Abstract from California Division of Mines and Geology Special Report 114 "A Review of the Geology and Earthquake History of the Newport-Inglewood Structural Zone, Southern California", 1974
G	portion of NUREG/CR-2198
H	1958 Uniform Building Code
I	1979 Uniform Building Code
J	portions of CBG's July 31, 1981 Interrogatories to NRC Staff as to the SER
K	portions of Staff's responses to said Interrogatories
L	portions of CBG's 4/20/81 Interrogatories to Applicant
M	portions of Applicant's 5/20/81 responses to said Interrogatories 7/
N	portions of Preliminary Geologic Environmental Map of the Greater Los Angeles Area, California (A Study Pertinent to Nuclear Facility Siting and Design) prepared by National Center for Earthquake Research, USGS, prepared on behalf of USAEC, 1970 8/
O	Map of the Newport-Inglewood Structural Zone and Other Structural Features of the Los Angeles Area, Southern California, by California Division of Mines and Geology, 1974 9/
P	Map of Beverly Hills Quadrangle Special Studies Zone by California Division of Mines and Geology 10/

6/ prepared under AEC contract by UCLA School of Engineering; two of the authors were Thomas Hicks, the late Director of NEL, and David Okrent, formerly on Radiation Use Committee, currently on Radiation Safety Committee, at UCLA.

7/ emphasis has been added by underlining key admissions

8/ reactor site location has been added by an "+" mark

9/ reactor site location has been added by an "+" mark

10/ the map only shows the faults within the special studies zone, marked by straight-line segments connecting encircled turning points; in this case, all that is shown is one trace of the Newport-Inglewood Fault, indicating its proximity to UCLA and possible even closer proximity due to uncertainties about its endpoint.

a. Not applicable.

b. Not applicable.

Applicant's Response To Interrogatory No. 48.

No information is required.

a. Not applicable.

Applicant's Response To Interrogatory No. 49.

Not to the knowledge of applicant's staff.