Seismic Reevaluation

Clinical Research Center Building Excerpt

UCLA Center for Health Sciences
Los Angeles, California

Submitted to:
UCLA Capital Programs
1060 Veteran Avenue
Los Angeles, California 90095

ESI Job No.
06-G116

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EXECUTIVE SUMMARY

This report presents the results of a seismic reevaluation performed on major buildings in the UCLA Center for Health Sciences. Buildings included in the reevaluation are:

- Biomedical Library
- Brain Research Institute
- Clinical Research Center
- Medical Center (South Tower)
- Neuropsychiatric Institute and Hospital
- Outpatient Wing
- Reed Research Building
- School of Medicine East
- School of Medicine West
- School of Public Health

Each of these buildings has been evaluated in prior seismic studies.[1, 2] These earlier studies evaluated the buildings as part of a hospital complex under the jurisdiction of the Office of Statewide Health Planning and Development (OSHPD). The hospital seismic criteria are more stringent than those applied to other buildings on the UCLA campus The purpose of this report is to present an opinion of the seismic rating of these buildings based on a consistent set of non-hospital criteria.

The seismic evaluation was conducted in accordance with the general requirements in FEMA 356, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*.[3] A post-1994 Northridge Earthquake seismic evaluation[2] reported varying degrees of damage to the buildings, and this information was considered in this seismic reevaluation.

This report was peer reviewed by the California State University Seismic Review Board (SRB) under contract to the University of California Office of the President. The peer review process included an independent review of the structural drawings for each building, an independent review of the earthquake response spectrum used in the reanalysis, a review of the appropriateness of the analytical method used in the evaluation, a site visit, and a review of the report text.

Based on their review of the structural drawings, the SRB requested additional tasks to be undertaken to confirm the seismic ratings for some buildings. These additional tasks have been completed and the results are reflected in the final rating recommendations.

Two ratings are presented for each building. The first is the rating from the University of California (UC) Seismic Policy and the second is adapted from the Division of the State Architect (DSA) seismic rating system. The budgetary priorities reflected in the UC Seismic Rating definitions were not considered in developing the seismic ratings in this report.

The ratings for the subject buildings are presented in Table 1. For some buildings, a limited scope of work believed capable of raising the rating by at least one category appeared evident, and a brief description is presented in Table 1. For other buildings a limited upgrade did not appear likely.

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[1] Robert Englekirk Consulting Structural Engineers, Inc., "Seismic Study and Recommendations for Center for Health Sciences, University of California, Los Angeles," April 20, 1990.
[2] Lee Burkhardt Liu, "Architectural/Engineering Evaluation, University of California Los Angeles Center for Health Sciences," February 22, 1995.
[3] American Society of Civil Engineers, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*. FEMA 356, Washington, DC: Federal Emergency Management Agency, November 2000.

Table 1
Summary of Center for Health Sciences Seismic Ratings

Building/Component Name	UC Seismic Rating	DGS Seismic Rating	Comments[4]
Biomedical Library	**POOR**	**V**	Addition of new shear walls at east end of the building is expected to change the rating to FAIR and IV.
Brain Research Institute	**FAIR**	**IV**	
Clinical Research Center	**FAIR**	**IV**	
Medical Center (South Tower)	**POOR**	**V**	
Neuropsychiatric Institute and Hospital			
Tower and Auditorium	**FAIR**	**IV**	Serious damage to low-rise portions of the building is not expected to significantly impact the seismic behavior of the Tower.
Low-rise (Low-rise A and B)	**POOR**	**V**	Addition of new shear walls in both Low-rise A and B are expected to change the rating to FAIR and IV.
Outpatient Wing	**POOR**	**V**	
Reed Research Building			
Tower	**FAIR**	**IV**	Serious damage to the bridge is not expected to significantly impact the seismic behavior of the Tower.
Bridge	**POOR**	**V**	Installation of more robust vertical support at east end of bridge is expected to change the rating to FAIR and IV
School of Medicine East	**POOR**	**V**	Addition of shear wall beneath the discontinuous shear wall would change the rating to FAIR and IV.
School of Medicine West	**POOR**	**V**	
School of Public Health	**POOR**	**V**	Addition of shear walls in east-west direction and completion to the ground of shear walls at north end of building is expected to change the rating to FAIR and IV

[4]A brief description is presented only for those buildings where a limited seismic upgrade capable of raising the rating by at least one category appeared evident.

1.0 GENERAL

This report presents the results of a seismic reevaluation performed on major buildings in the UCLA Center for Health Sciences (CHS). Figure 1.1 locates the CHS on the UCLA campus.

Buildings included in the reevaluation are listed below and are shown in Figure 1.2:

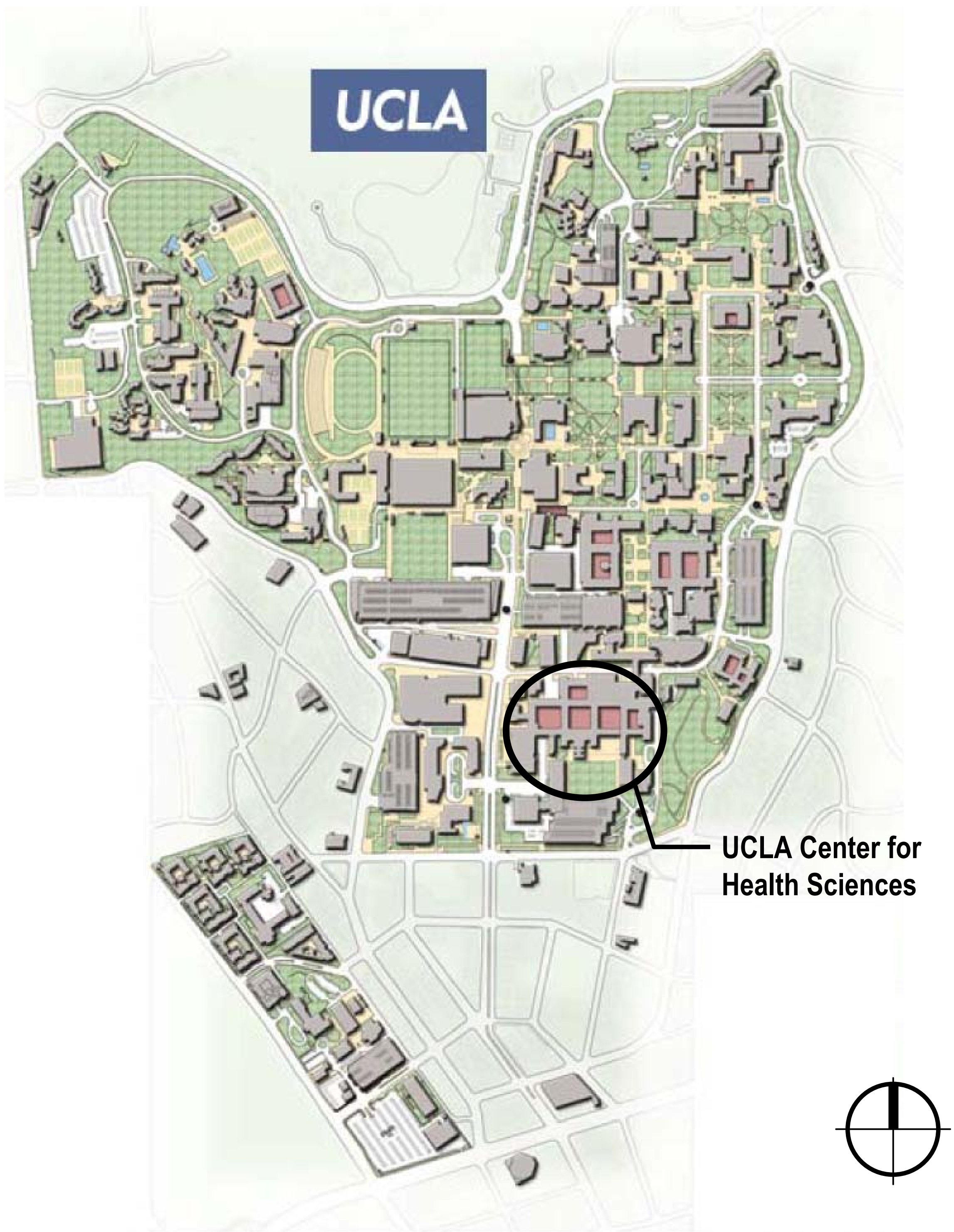
- Biomedical Library
- Brain Research Institute
- Clinical Research Center
- Medical Center (South Tower)
- Neuropsychiatric Institute and Hospital (see Figure 1.3 for configuration of low-rise portion)
- Outpatient Wing
- Reed Research Building
- School of Medicine East
- School of Medicine West
- School of Public Health

Each of these buildings has been evaluated in prior seismic studies.[1,2] These earlier studies evaluated the buildings as part of a hospital complex under the jurisdiction of the Office of Statewide Health Planning and Development (OSHPD). The hospital seismic criteria are more stringent than those applied to other buildings on the UCLA campus The purpose of this report is to present an opinion of the seismic rating of these buildings based on a consistent set of non-hospital criteria.

This report outlines the methodology used in the analysis, the seismic environment of the UCLA campus, and the results of the seismic evaluation for each building. Detailed recommendations to mitigate identified deficiencies will be part of a subsequent task and are not reported herein. For some buildings, however, a limited scope of work believed capable of raising the rating by at least one category appeared evident. For other buildings, a limited upgrade did not appear likely. Where applicable, these conceptual upgrades are presented in the section discussing each building.

The seismic reevaluation was conducted in accordance with the general requirements in FEMA

[1] Robert Englekirk Consulting Structural Engineers, Inc., "Seismic Study and Recommendations for Center for Health Sciences, University of California, Los Angeles," April 20, 1990.
[2] Lee Burkhardt Liu, "Architectural/Engineering Evaluation, University of California Los Angeles Center for Health Sciences," February 22, 1995.



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Seismic Reevaluation Study
CHS Vicinity Plan

Figure 1.1

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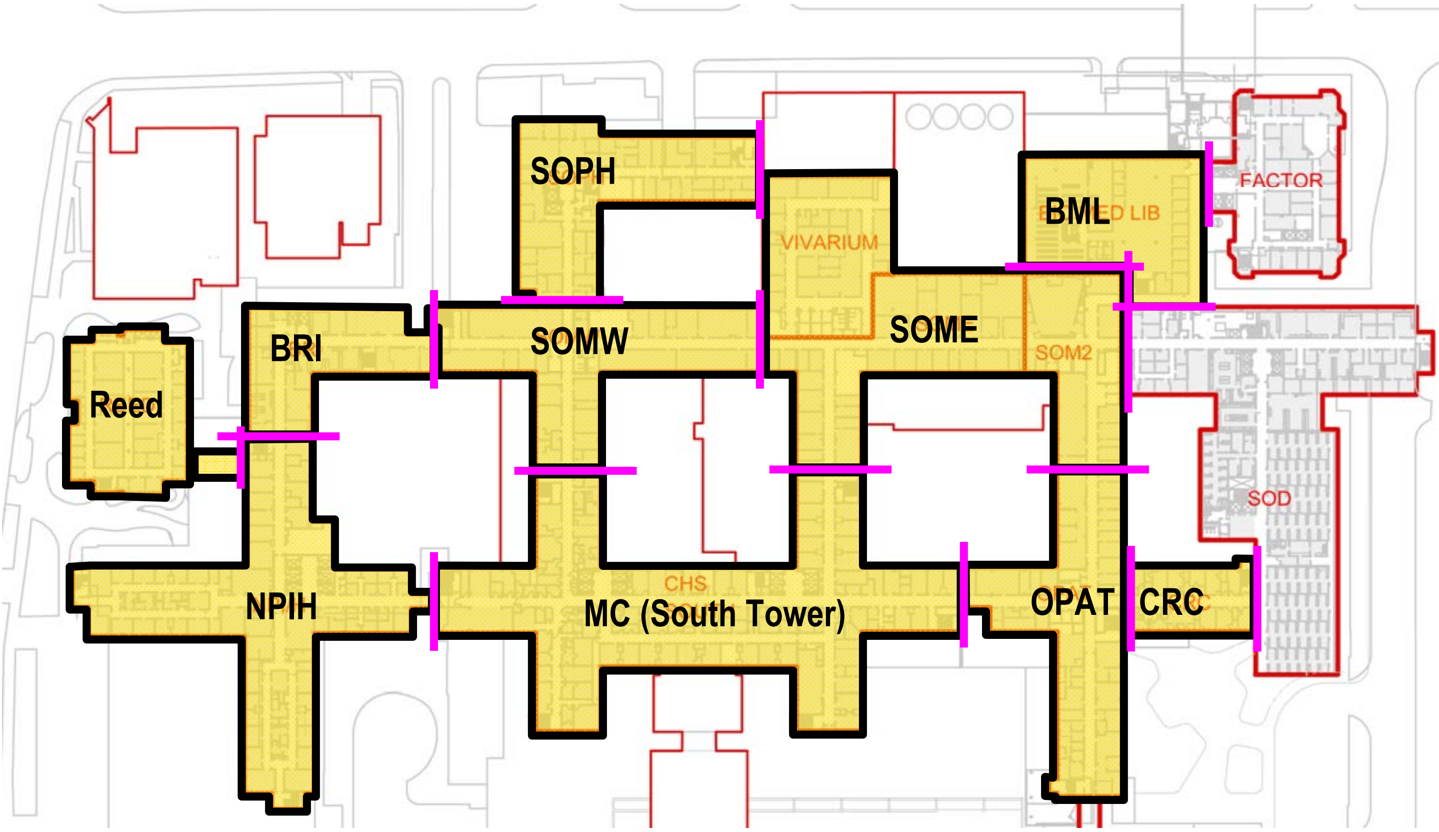

Legend

BML	Biomedical Library
BRI	Brain Research Insitute
CRC	Clinical Research Center
MC	Medical Center (South Tower)
NPIH	Neuropsychiatric Institute and Hospital
OPAT	Outpatient Wing
Reed	Research Research Building
SOME	School of Medicine East
SOMW	School of Medicine West
SOPH	School of Public Health
(magenta line)	Seismic Separation

Figure shows configuration of the buildings at Second Floor

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Seismic Reevaluation Study

Buildings included in the Seismic Reevaluation

Figure 1.2

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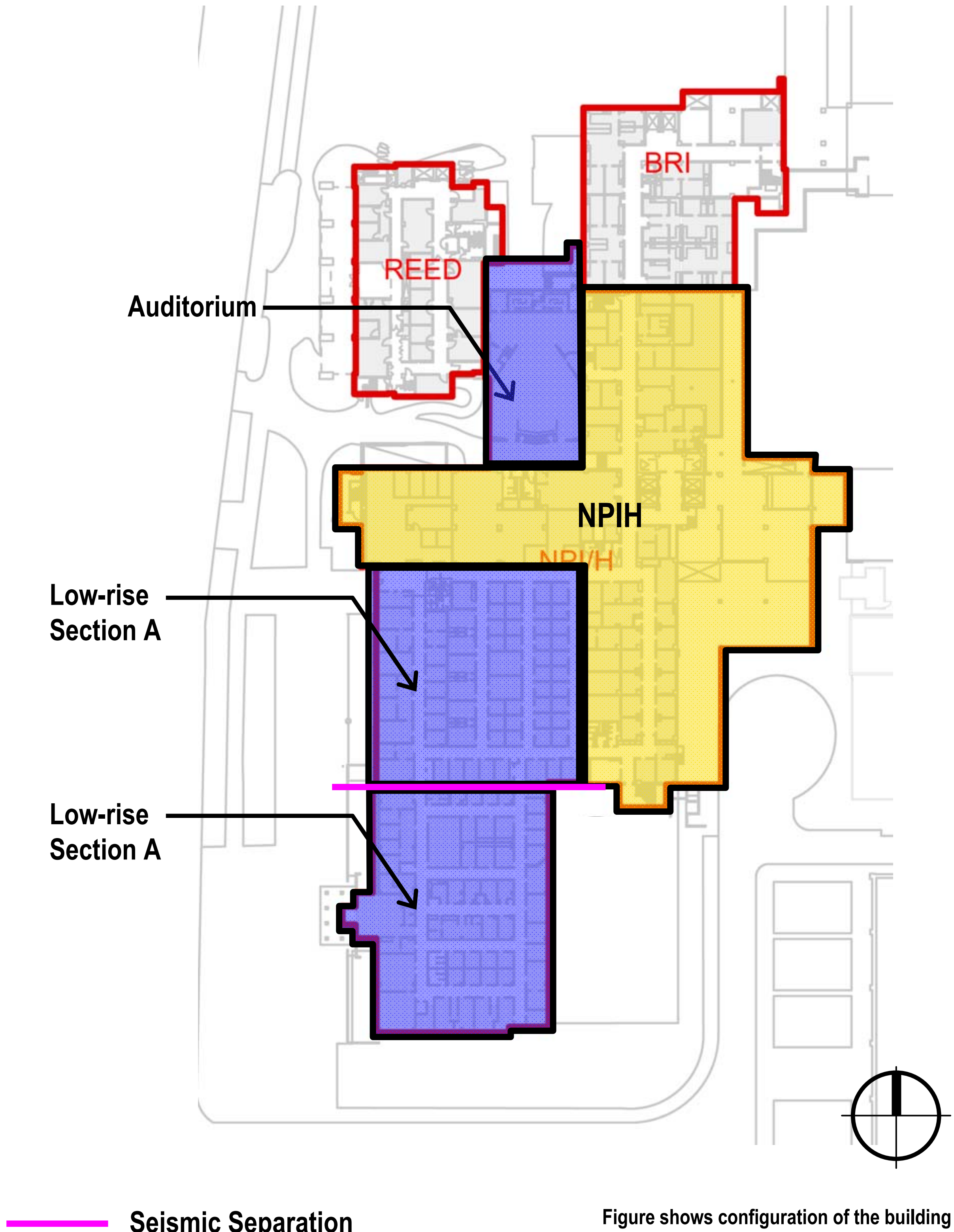

Figure shows configuration of the building at Level C (lowest level of Sub-Basement

356, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*[3]. A post-1994 Northridge Earthquake seismic evaluation[2] reported varying degrees of damage to the buildings, and this information was considered in this reevaluation.

Two seismic ratings are presented for each building in Section 5. The first is the rating from the University of California (UC) Seismic Policy and the second is adapted from the Division of the State Architect (DSA) seismic rating system. The budgetary priorities reflected in the UC Seismic Rating definitions were not considered in developing the seismic ratings in this report.

This report was peer reviewed by the California State University Seismic Review Board (SRB) under contract to the University of California Office of the President. The peer review process included an independent review of the structural drawings for each building, an independent review of the earthquake response spectrum used in the reanalysis, a review of the appropriateness of the analytical method used in the evaluation, a site visit, and a review of the report text.

Based on their review of the structural drawings, the SRB requested additional tasks to be undertaken to confirm the seismic ratings for some buildings. These additional tasks have been completed and the results are reflected in the final rating recommendations.

These additional tasks included:

1. **Biomedical Library:** Confirmation that the asymmetric layout of shear walls and the large discontinuity in the diaphragm at the book stack area resulted in unacceptably high seismic demands on the short shear wall at the east end of the building.
2. **Neuropsychiatric Institute and Hospital:** Confirmation that the low-rise sections at the south end of the building do not have an adequate independent seismic system or an adequate connection to the tower portion to provide a reliable lateral load path.
3. **Outpatient Wing:** Confirmation that more detailed modeling of the building, particularly above the original roof level, substantiates the anticipated poor seismic performance of the building.
4. **Reed Research Building:** Confirmation that the building diaphragm at the north side of the building has sufficient capacity to transfer the seismic demands necessary to develop the adjacent shear walls.
5. **School of Medicine East:** Confirmation that demands on the discontinuous shear wall will not be mitigated sufficiently by the participation of shear walls at the south end of the building. Included in this task was the request to explicitly consider the flexibility of diaphragms connecting the southern shear walls to the remainder of the building.

[3] American Society of Civil Engineers, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*. FEMA 356, Washington, DC: Federal Emergency Management Agency, November 2000.

The results of the additional analysis are discussed in the section addressing each building. The SRB did not request additional analysis of the other buildings. The SRB was of the opinion that the original analysis of these buildings was sufficient to justify the recommended seismic rating.

2.0 SEISMIC RATINGS

All buildings at UCLA are to be assigned a seismic rating applied according to the University of California Seismic Policy.[4] For budgetary analysis purposes, the Legislative Analyst also requires that buildings be rated according to the system used by the Division of the State Architect (DSA). Table 2.1 summarizes these two rating systems. The budgetary priorities reflected in the UC Seismic Rating definitions were not considered in developing the recommended ratings in this report.

There is some ambiguity in the application of ratings by the two systems that may not lead to consistency of interpretation. As a part of this seismic reevaluation, a concordance between the two rating systems was developed by the SRB. Table 2.2 summarizes the relationship between the two rating systems.

The ratings in this seismic reevaluation are consistent with the concordance outlined in Table 2.2.

[4] University of California, "UC Seismic Safety Policy for Purchased and Leased Buildings," April 20, 2000.

TABLE 2.1
University of California and Division of the State Architect Seismic Ratings

UC Rating	Description Based on UC Seismic Policy	
GOOD	"Good" seismic performance rating would apply to buildings and other structures whose performance during a major seismic disturbance is anticipated to result in some structural and/or nonstructural damage and/or falling hazards" that would not significantly jeopardize life. Buildings and other structures with a "Good " rating would have a level of seismic resistance such that funds need not be spent to improve their seismic resistance to gain greater life safety, and would represent an acceptable level of earthquake safety.	
FAIR	"Fair" seismic performance rating would apply to buildings and other structures whose performance during a major seismic disturbance is anticipated to result in structural and nonstructural damage and/or falling hazards that would represent low life hazards. Buildings and other structures with a "Fair" seismic performance rating would be given a low priority for expenditures to improve their seismic resistance and/or to reduce falling hazards so that the building could be reclassified "Good."	
POOR	"Poor" seismic performance rating would apply to buildings and other structures whose performance during a major seismic disturbance is anticipated to result in significant structural and nonstructural damage and/or falling hazards that would represent appreciable life hazards. Such buildings or structures either would be given a high priority for expenditures to improve their seismic resistance and/or to reduce falling hazards so that the building could be reclassified as "Good," or would be considered for other abatement programs, such as reduction of occupancy.	
VERY POOR	"Very Poor" seismic performance rating would apply to buildings and other structures whose performance during a major seismic disturbance is anticipated to result in extensive structural and nonstructural damage, potential structural collapse, and/or falling hazards that would represent high life hazards. Such buildings or structures either would be given the highest priority for expenditures to improve their seismic resistance and/or to reduce falling hazards so that the building could be reclassified "Good," or would be considered for other abatement programs such as reduction of occupancy.	
DSA Rating		
Risk Level	*Aspect*	*Anticipated Results*
I	Building:	Potentially no structural damage: repairable, if any. Negligible non-structural damage: repairable.
	Risk to Life:	Negligible.
	Systems:	All systems will probably remain operational.
	Occupancy:	Immediate, with only negligible disruption during clean-up.
II	Building:	Negligible structural damage: repairable. Minor non-structural damage: repairable.
	Risk to Life:	Negligible.
	Systems:	Minor disruptions for hours to days.
	Occupancy:	Minor disruptions, return within hours.
III	Building:	Minor structural damage: repairable. Moderate non-structural damage: extensive repair.
	Risk to Life:	Minor
	Systems:	Disruption of systems for days to months.
	Occupancy:	Return within weeks, with minor disruptions.
IV	Building:	Moderate structural damage: substantial repair. Substantial non-structural damage: extensive repair.
	Risk to Life:	Moderate
	Systems:	Disruption of systems for months to years.
	Occupancy:	Partially to totally vacated during repairs.
V	Building:	Substantial structural damage: partial collapse likely: repair may not be cost effective. Extensive non-structural damage: repair may not be cost effective.
	Risk to Life:	Substantial.
	Systems:	Total disruption of systems: repair may not be cost effective.
	Occupancy:	Totally vacated during repairs.
VI	Building:	Extensive structural damage, partial to total collapse likely: repair may not be cost effective. Extensive non-structural damage; repair may not be cost effective.
	Risk to Life:	Extensive, but not imminent. Extrication protracted and difficult.
	Systems:	Total disruption of systems: repair may not be cost effective.
	Occupancy:	Totally vacated during repairs (if repairable).
VII	Building:	Unstable under existing vertical loads or earthquake.
	Risk to Life:	Imminent threat to occupants and/or adjacent property.
	Systems:	Total disruption of systems: most likely not repairable.
	Occupancy:	Should be vacated until structural upgrading is accomplished.

Table 2.2
Concordance between UC Seismic Ratings and DSA Seismic Ratings
(Prepared by CSU Seismic Review Board)

Level[1]	Definitions based upon CBC requirements for existing buildings, and FEMA-356[2]	Implied Risk to Life[3]	Implied Damageability[4]	DSA	UC
I	An existing building evaluated as meeting or exceeding the requirements FEMA-356 S-1 performance in MCE	Negligible	0% to 10%		
II	An existing building evaluated as meeting or exceeding the requirements FEMA-356 S-1 performance in 475-year return period earthquake ground motions.	Insignificant	0% to 10%		
III	An existing building evaluated as meeting or exceeding the requirements of Division VI-R using the unreduced seismic hazard (Sec. 643A.8.1.2); the building may have been retrofitted to achieve this condition. Alternative: CBC Division VI compliant, or FEMA-356 S-2 performance in 475-year return period earthquake ground motions.	Slight	5% to 20%	III	Good
IV	An existing building evaluated as meeting the requirements of Division VI-R using the reduced seismic hazard (Sec. 1643A.8.1.1); the building may have been retrofitted to achieve this condition. Alternative: FEMA 356 S-3 performance in 225-year return period earthquake ground motions.	Small	10% to 25%	VI	Fair
V	An existing building evaluated as not meeting the requirements of Division VI-R using the reduced seismic hazard, but evaluated as meeting these requirements if the base shear demand reduction factor H was reduced to 0.5. Alternative: FEMA-356 S-4 performance in 225-year return period earthquake ground motions.	Serious	20% to 50%	V	Poor
VI	An existing building evaluated as not meeting the minimum requirements for Level V designation and not requiring Level VII designation.	Severe	40% to 100%	VI	Very Poor
VII	A building evaluated as posing an immediate life-safety hazard under gravity loads. The building should be evacuated and posted as dangerous until remedial actions are taken to assure the building can support CBC prescribed dead and live loads.	Dangerous	100%		

Notes:

1. Earthquake Damageability levels are indicated by Roman numerals I through VII. Assignments are to be made following a professional assessment of the building's expected seismic performance as measured by the referenced technical standard and earthquake ground motions. Equivalent Arabic numerals, fractional values, or plus or minus values are not to be used and are undefined.
2. Division VI-R refers to the requirements of Division VI-R of Chapter 16A of the CBC, 2001. FEMA-356 refers to *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*, published by the Federal Emergency Management Agency, Washington, D.C., 2000, or to subsequently issued ASCE Standard 7 by the American Society of Civil Engineers. MCE is the maximum considered earthquake as defined by FEMA-356. In each case the preferred definition is the California Building Code citation.
3. *Implied Risk to Life* is a subjective measure of the threat of a life threatening injury or death that is expected for an average building in compliance with the indicated technical requirements. The terms *negligible* through *dangerous* are not specifically defined, but are linguistic indications of the relative degree of hazard posed to an individual occupant.
4. *Implied Damageability* is the level of damage expected to the average building in compliance with the indicated technical requirements when a building code level earthquake occurs. Damage is measured as the ratio of the cost to repair the structure divided by the current cost to reconstruct the structure from scratch. Such assessments are to be completed to the requirements of ASTM E-2026, where the damage ratio is the SEL evaluated at Level 1 or higher in order to be considered appropriate.
5. In those cases where the engineer making the assessment using the requirements for a given rating level conclude that the expected seismic performance is consistent with a one-level higher or lower level rating, this alternative rating level may be assigned if and only if an independent technical peer reviewer concurs in the evaluation. The peer review must be completed consistent with the requirements of Section 3420, 2007 CBC.

3.0 METHODOLOGY

Except as noted, a nonlinear finite element models were developed for each building. Where deemed appropriate, structural properties for the finite elements were idealized to reflect representative conditions throughout the building. The models were subjected to seismic demands based on a site-specific response spectrum. When nonlinear finite element models were developed for a given building, the evaluation utilized a static nonlinear analysis (i.e. push-over analysis).

Buildings in the CHS generally fall into two basic categories: concrete framed structures with concrete shear walls and steel framed structures with concrete shear walls with and without concrete moment frames. In modeling the existing structures the following limit states were based on FEMA-356. Material strengths were obtained from the drawings and adjusted to account for estimated strength based on recommendations in FEMA-356.

No testing, either destructive or non-destructive, was performed as a part of this reevaluation. Where evidence of damage was described in the 1994 post-Northridge Earthquake seismic evaluation, this information was considered in developing the model.

3.1 Concrete Framed Structures with Shear Walls

For concrete framed structures with shear walls, the following basic modeling assumptions were used.

Concrete Spandrel Beam: (FEMA-356, table 6-7)

Acceptable plastic hinge rotation (radians)

- Immediate Occupancy: 0.15%
- Life Safety: 0.5%
- Collapse Prevention: 1%

Concrete Column: (FEMA-356, table 6-8)

Acceptable plastic hinge rotation (radians)

- Immediate Occupancy: 0.5%
- Life Safety: 0.5%
- Collapse Prevention: 0.5%

Shear Wall: Inelastic shear wall elements were composed of both steel inelastic fibers and inelastic concrete fibers combined with shear layers. Both inelastic steel and concrete fibers were modeled as elastic-perfectly-plastic behavior without strength loss. The following material properties were assumed:

Shear Walls:

Flexural Behavior Modeling: Inelastic shear wall elements were used composed of both steel inelastic fibers and inelastic concrete fibers. The inelastic steel and concrete fibers were modeled as elastic-perfectly-plastic behavior without strength loss. The following material properties were assumed:

- Reinforcing steel: f_y = as specified on the drawings but generally 40 ksi, E_s = 29000 ksi,
- Concrete: f'_c= as specified on the drawings but generally 3 ksi, E_c = 3122 ksi, Poisson's ratio = 0.2.
- Concrete shear modulus: $G = 0.4E_c$ = 1249 ksi (slender wall) and $G = 1.5\rho E_s$ ksi (squat wall and where ρ is wall horizontal reinforcement ratio)
- Self-weight of shear walls was considered. Unit weight density = $8.68*10^{-5}$ (kips per cubic inch).

Shear Behavior Modeling: Elastic-perfectly-plastic shear material property within shear wall element was used. Shear strength degradation is considered based on FEMA 356 Table 6-19. I

- V_o (nominal shear strength of shear wall) = $2\sqrt{f'_c} + \rho f_y$.

In most cases, coupling beams between the shear walls were not modeled since they would fail after a small number of cycles of loading but would not be expected to significantly degrade the overall seismic performance of the subject buildings. Unless noted, boundary elements of the shear wall were not modeled as composite sections since a connection between the steel wide flange and the shear wall was not detailed on the structural drawings. In addition, the boundary elements were not well confined.

Spandrel Beams and Wide Flange Steel Beams:

The spandrel beams were modeled with expected plastic hinge rotation at two ends of the beam, and these two plastic hinges are connected by an elastic beam segment. No rigid end zone was modeled based on the beam-column connection details observed on the structural drawings. The following material properties were assumed:

- Reinforcing steel: f_y = as specified on the drawings but generally 40 ksi, E_s = 29000 ksi,
- Concrete: f'_c = as specified on the drawings but generally 3 ksi, E_c = 3122 ksi, Poisson's ratio = 0.2.
- 0.5 I_{gross} for both moment of inertia was used about local axis 2 and 3

The wide flange steel beam was modeled as two FEMA beam elements to represent the chord rotation model, which anticipates an inflection point located at the midspan of the beam and plastic hinges at the two ends of the beam. No rigid end zone was modeled. F_y = 36 ksi was assumed. Strength loss effects were considered for both spandrel beams and wide flange steel beams. As appropriate, composite action considering the steel beam in the spandrel beam was considered in developing the model.

- Reinforcing steel: f_y = as specified on the drawings but generally 40 ksi, E_s = 29000 ksi,
- Concrete: f'_c= as specified on the drawings but generally 3 ksi, E_c = 3122 ksi, Poisson's ratio = 0.2.
- Concrete shear modulus: $G = 0.4E_c$ = 1249 ksi (slender wall) and $G = 1.5\rho E_s$ ksi (squat wall and where ρ is wall horizontal reinforcement ratio)
- Self-weight of shear walls was considered. Unit weight density = $8.68*10^{-5}$ (kips per cubic inch).
- V_o (nominal shear strength of shear wall) = $2\sqrt{f'_c} + \rho f_y$.

Spandrel Beam: The spandrel beams were modeled with expected plastic hinge rotation at two ends of the beam, and these two plastic hinges are connected by rigid end zones and elastic beam segment. The rigid end zone size is assumed to be the actual size of spandrel beam and column. Strength loss effects were considered in this case. The following material properties were assumed:

- Reinforcing steel: f_y = as specified on the drawings but generally 40 ksi, E_s = 29000 ksi
- Concrete: f'_c= as specified on the drawings but generally 3 ksi, E_c = 3122 ksi, Poisson's ratio = 0.2.
- To account for cracked sections, $0.5I_{gross}$ was used for moments of inertia about local axes 2 and 3.

Concrete Column: The concrete columns were modeled with expected plastic hinge rotation at top and bottom of the column, and these two plastic hinges are connected by rigid end zones and elastic column segment. The rigid end zone size is assumed to be the actual size of spandrel beam and column. V2-V3 shear interaction strength sections are used in the mid-height of the columns to monitor the shear demand in the columns. The monitor basis was adjusted for each building. Plastic hinge rotations at two ends of the column were modeled. The following material properties were assumed:

- Reinforcing steel: f_y = as specified on the drawings but generally 40 ksi, E_s = 29000 ksi,
- Concrete: f'_c= as specified on the drawings but generally 3 ksi, E_c = 3122 ksi, Poisson's ratio = 0.2.
- Strength loss effects were not considered for these elements.
- To account for the cracked section, $0.5I_{gross}$ was used for moments of inertia about local axes 2 and 3.

Target drifts were obtained by the coefficient method based on FEMA-356.

3.2 Steel Framed Structures with Shear Walls

For steel framed structures with shear walls, the following basic modeling assumptions were used.

Steel Columns:

Except as noted, the steel column size at mid-height of the building was taken as the typical column size to simplify the modeling process. The steel column is modeled as two FEMA column elements to represent the chord rotation model, which anticipates an inflection point located at the mid-height of the column and plastic hinges at top and bottom of the column. No rigid end zone was modeled based on review of beam-column connection details on the structural drawings.

- Plastic hinge rotations at two ends of the column were modeled.
- F_y = 36 ksi was assumed.
- Strength loss effects were not considered.
- Latticed columns were modeled by WF steel columns with equivalent area.

Virtual Strain Gage Locations:

As a part of the nonlinear analysis, virtual strain gages were placed in the analytical model for the purpose of monitoring the level of strain at selected locations in the structure.

- Shear Walls: Virtual shear strain gages were located within each shear wall element to monitor the shear stress yielding in the shear wall yielding shear strain. The monitoring basis was adjusted for each building.
- Virtual axial tension/compression strain gages were located along two ends of shear walls and along the wall height. For the tensile strain gage, ε_y = 0.00137 (steel yielding strain) was used to monitor if the outermost steel fiber in shear wall yielded. For the compressive strain gage, ε_c = 0.003 (concrete maximum compressive strain) was used to monitor if the outermost concrete fiber in shear wall fails in compression.
- Spandrel Beams: Beam plastic hinge rotation (radians) was monitored at 0.15%, 0.5%, and 1%.
- Wide Flange Steel Beams: Beam chord rotation (radians) was monitored at $1.0\theta_y$, $2.0\theta_y$, $3.0\theta_y$, $4.0\theta_y$, and $5.0\theta_y$.
- Steel Columns: Column chord rotation (radians) was monitored at $0.5\theta_y$, $1.0\theta_y$, $1.5\theta_y$, $2.0\theta_y$, and $3.0\theta_y$.

3.3 Floor Alignment and Pounding Considerations

Although the seismic gaps between some buildings are relatively small given the flexibility of these structures, the floor levels throughout the CHS are aligned from one building to another. Should the seismic gaps between buildings close and pounding occur, it is not anticipated that the structural performance of the building will be modified in a significant manner. Localized falling hazard damage may occur in the vicinity of the seismic gaps due to damage to the exterior brick cladding. Pounding was not considered to be a significant limit state and was not modeled explicitly.

4.0 GEOTECHNICAL AND SITE SEISMICITY PARAMETERS

A contemporary geotechnical investigation of the site was not available for this seismic reevaluation; however, a “Foundation Investigation" for Wurdeman & Becket Architects by L.T. Evans, Foundation Engineer, dated April 19, 1949, and a “Foundation Investigation Hospital Units A and B Project 995350 UCLA” for Welton Becket & Associates by L.T. Evans, Inc., Foundation Engineers, dated December 13, 1965, were available for reference.

Based on the recommendations therein, allowable bearing capacity is assumed to be approximately 6000 pounds per square foot for spread footings and 5000 pounds per square foot for continuous footings. Allowable bearing pressures for use in building design contain an implicit settlement criterion that is inappropriate for establishing the ultimate bearing strength of the soil. Allowances for increased ultimate bearing strengths have been used in the analysis.

The site is located near several significant earthquake faults, as shown in Figure 4.1. Seismic demand was based on a 475-year return period response spectrum with 5% damping ratio. An estimate of the earthquake ground motion response spectrum was obtained from a site-specific seismic hazard study at a nearby site[7] and was used in the evaluations. The response spectrum is shown in Figure 4.2.

Coefficients used in the FEMA 356 method were B_s = 1.0, B_1 = 1.0, S_{xs} = 1.26g, S_{x1}= 0.64g, and T_s = 0.508 sec. For the purposes of this study, it is believed that this ground motion reasonably reflects the anticipated earthquake ground motion at the CHS site. The peer review confirmed this conclusion.

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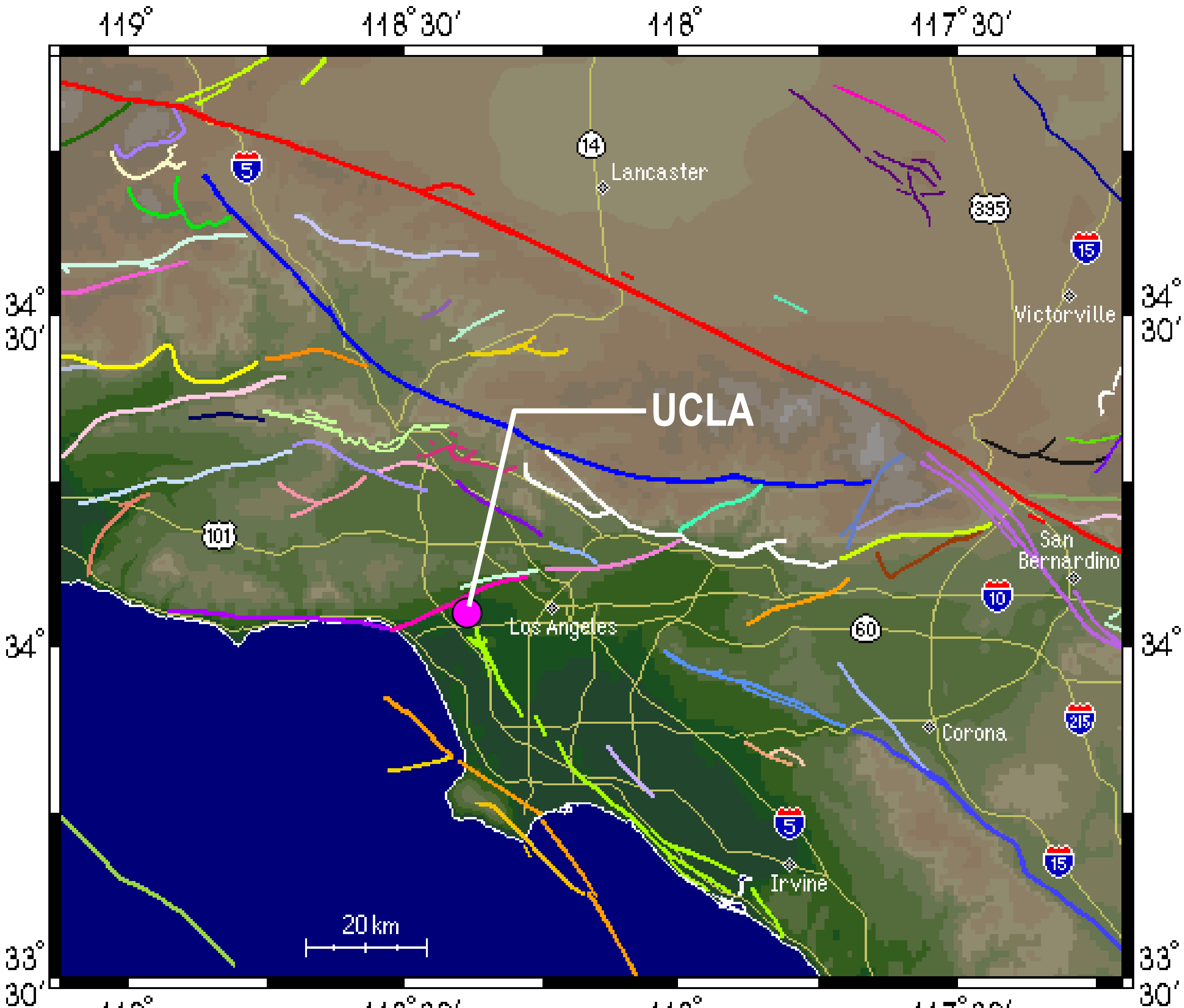
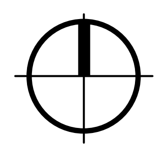
[5] Geobase, “Geotechnical report for J. Vernon Luck Sr. Research Laboratory,” Project 204.23.01, 1999.





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Regional Fault Map

Figure 4.1

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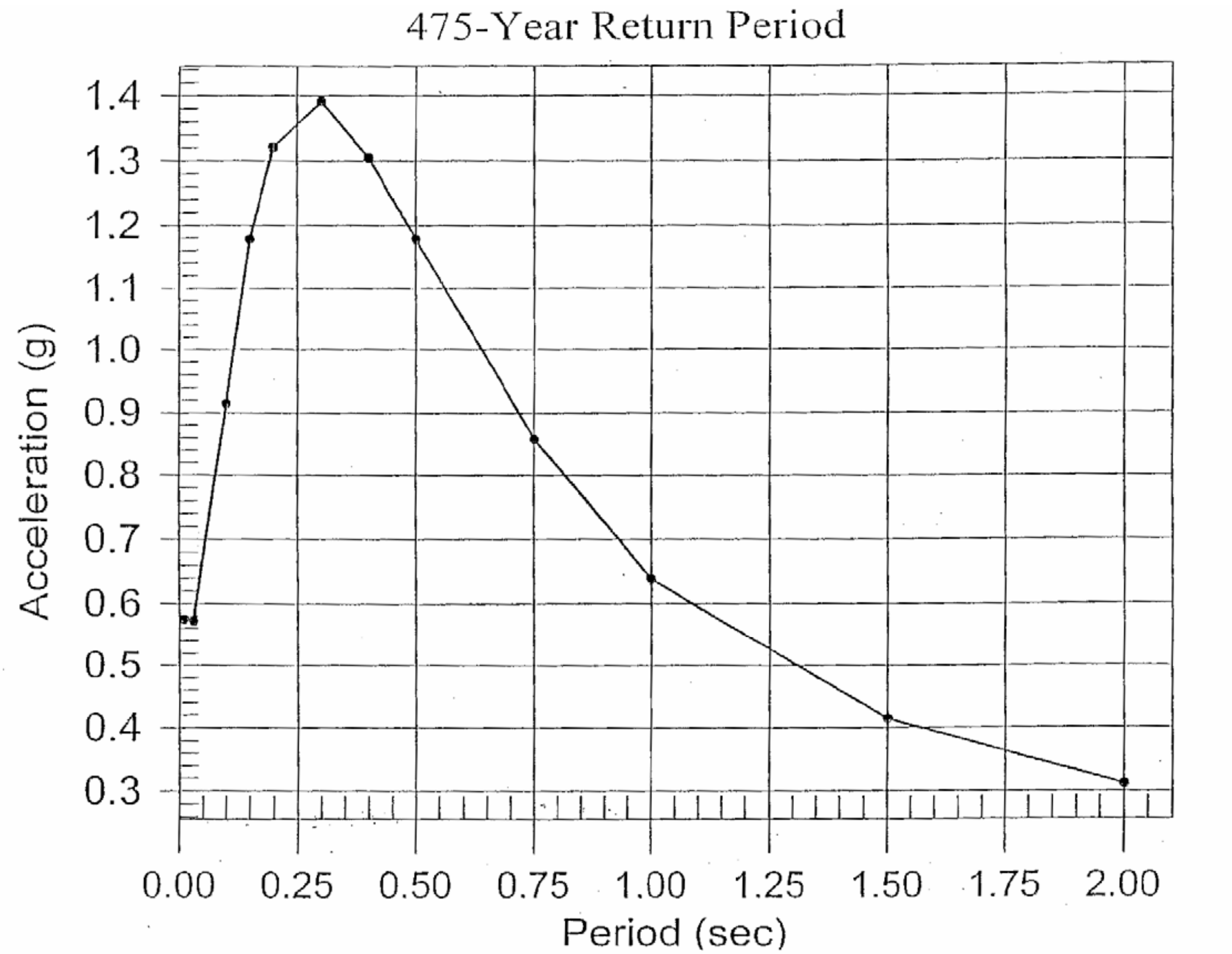

Response spectrum. 475-year estimated average return period. Reference: Geobase, Geotechnical report for J. Vernon Luck Sr. Research Laboratory, Project 204.23.01, 1999.

8.0 CLINICAL RESEARCH CENTER

8.1 BUILDING LOCATION

The subject building is located at the UCLA Center for Health Sciences, as shown in Figure 1.2.

8.2 BUILDING DESCRIPTION

8.2.1 Physical Description

The Clinical Research Center is a reinforced concrete building constructed from drawings prepared by Welton Becket and Associates Architects and Murray Erick Associates, Structural Engineers. Based on the date of the drawings, it is assumed that the Clinical Research Center was designed according to the 1948 Edition of the *Uniform Building Code*.

The building consists of three stories above grade with a Basement (Level A), and a partial Sub–Basement (Level B). A small penthouse and machine room extends above the roof. The plans also show a fourth floor, but this has not been built. The plan for the typical floor is a rectangle having a North-South dimension of 48.25 feet and an East-West dimension of 98.25 feet.

The floor-to-floor height between the Sub-Basement (Level B) and Basement (Level A) is 13'-6". The floor-to-floor height between the Basement (Level A) and First Floor is 14'-6". The floor-to -floor height between the First Floor and Second Floor is 16'-0". The typical floor-to-floor height above the Second Floor is 13'-6". The overall height of the building above the first floor to the roof is 43 feet.

The structure is separated from the Outpatient Wing on the west by a ten inch seismic gap.

To our knowledge, no major structural repairs or modifications have been made to the building except routine maintenance. The Clinical Research Center was not included in a formal earthquake damage evaluation following the 1994 Northridge Earthquake.

8.2.2 Foundations

Reinforced concrete spread footings support column loads. Continuous footings of reinforced concrete support bearing wall loads. Concrete basement retaining walls span vertically between floor slabs. The retaining walls themselves have continuous footings along their length.

8.2.3 Vertical Load Carrying System

Gravity loads from the building and the occupants and furnishings are carried by a system of reinforced concrete floors consisting of concrete slabs, concrete joists and beams, concrete columns and bearing walls. Typical column dimensions vary but are approximately 22 inches by 22 inches. Longitudinal reinforcement decreases with height from approximately nine #11 bars to approximately six #10 bars. Longitudinal reinforcement is arranged in a circular pattern. Transverse reinforcement for the typical column consists of #4 spiral ties at approximately two inches on center.

The penthouse and machine room are framed in structural steel.

8.2.4 Seismic Load Resisting System

The building employs the same type of lateral force resisting systems in both the transverse and longitudinal directions. Lateral resistance against earthquake forces in the transverse (North-South) direction is mostly provided by the strength and stiffness of the concrete walls on Lines 33 and 38 between Lines F and F acting as structural walls between the Sub-Basement (Level B) or Basement (Level A) and the Roof. These walls are placed at the extreme ends of the building with respect to the building plan, Lateral resistance against earthquake forces in the longitudinal (East-West) direction is provided by the stiffness of the concrete walls on Line D and G between Lines 33 and 34 acting as structural wall between the Sub-Basement (Level B) or Basement (Level A) and the Roof. Lateral resistance is also provided by the stiffness of the exterior concrete frames consisting of deep spandrel beams acting with short columns between Roof and the First Floor.

The Penthouse and Machine Room employs the same type of lateral force resisting systems in both the transverse and longitudinal directions. Lateral resistance against earthquake forces in both directions is provided by X-braced and knee-braced frames.

8.3 SEISMIC REEVALUATION

Based upon a review of the structural drawings, a structural analysis of the building and the seismic evaluation criteria outlined elsewhere in this report, it is recommended that the UC Seismic Rating be characterized as “FAIR” and the Division of the State Architect Seismic Rating be characterized as “IV”.

The seismic behavior of the building is characterized by a sufficient amount of shear walls to limit significant lateral displacements despite the eccentric nature of the shear wall distribution and well-confined concrete columns that are expected to maintain sufficient vertical load capacity despite high shear demands created by strong beam-weak column configuration of the exterior frame. It is anticipated that the building will sustain significant amounts of structural damage during a large earthquake but that the vertical load carrying system will remain globally intact.