ARCHITECTURAL PRACTICE AND EARTHQUAKE HAZARDS

A Report

of the

Committee on the Architect's Role in Earthquake Hazard Mitigation

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Foreword

This report was prepared to explore roles for architects in seismic design and post-earthquake response, and to consider the kinds of relationships between architects, structural engineers, clients and others that can promote good seismic design and satisfactory building performance. The committee also was asked to identify any additional training or other preparation from which architects might benefit, in relation to seismic safety.

Architects practicing and teaching in California are a prime audience for the report, although several other audiences should also find it pertinent. Non-architect members of design teams—structural engineers, civil engineers who design structures, and mechanical and electrical engineers—should number among the report's interested readers. In addition, owners, builders, those who put up the money to finance buildings, and the insurers of structures and businesses against losses, also will find the contents highly relevant. Other readers with broader concerns for seismic safety and earthquake preparedness will be interested in ways to encourage improvements in the seismic design of structures built in California.

More specifically, the committee was asked to:

- Identify ways architects might improve the seismic resistance of buildings they design.
- Identify the kinds of relationships between architects and structural engineers that might promote improvements in seismic design.
- Consider how relationships among design professionals, clients, builders, developers and others can facilitate improvements in structural safety.
- Consider roles of architects in the post-earthquake evaluation of structures.
- Identify educational needs with respect to seismic concerns and building performance in earthquakes.

The findings and recommendations are based on committee discussions and unpublished position papers written by committee members. The committee acknowledges its indebtedness to Mr. Eric Elsesser for his position paper's contributions, which were adapted for inclusion in this report.

Architects practicing in California have threefold opportunities to help with seismic design and seismic safety policy. First, as key members of design teams, they are in a unique position to identify opportunities for designing and constructing buildings and other facilities to resist seismic forces. Second, architects can assume professional and leadership roles in promoting community awareness and working for earthquake-hazard mitigation. Third, they can have a distinct role in post-earthquake recovery.

The Architect's Role in Design

As prime design professionals, architects have a unique role in design and construction. The architect is often the only professional with an overall view of all aspects of the design and construction process. The architect serves the client, brings in the structural engineer and other engineering specialties, works closely with the contractor, and ideally, orchestrates the project to facilitate performance and achieve good results. Architects are therefore in a crucial position to influence the seismic safety of structures.

For several reasons this potential is not always fully realized. The opportunity to influence a project's quality and cost is greatest in the earliest phases of the design period, after which it drops precipitously. Initial decisions on a project's structural concepts can do much to determine its ultimate seismic resistance, for better or worse. Thus decisions early in the design period may commit a project to a building configuration or design concept that makes effective lateral-force resistance difficult to achieve. Accordingly, close collaboration from the outset between the architect and structural engineer—as well as the mechanical and electrical engineers—is highly desirable.

A second consideration arises from economic pressures in the design and construction process. In California this is a particular cause for concern, because of possible effects on the seismic resistance of structures. It needs to be more widely understood by owners that simply complying with minimum requirements of the Uniform Building Code may not result in an appropriate seismic design for all situations. Careful attention by qualified and experienced practitioners having a broad knowledge of seismic design is also essential. The earthquake resistance of a structure designed by well-qualified practitioners will almost always be superior to that of a building by designers with less experience in seismic design.

Economic constraints on design and construction practices may result in structures that comply with codes but are nevertheless susceptible to significant damage. They may cause many severe casualties when an earthquake occurs. Even if no lives are lost, poorly performing buildings and their contents can suffer major damage, which can be devastating to occupants, e.g., tenants or businesses forced to vacate or suspend operations.

In the prevailing circumstances, the fees public and private owners appear willing to pay for architectural engineering work are often insufficient to provide the levels of professional service needed for adequate attention to seismic resistance. Consequently, at the outset the buyer or owner should understand the relationship between design and construction costs, and the levels of quality control and building reliability being purchased with the fees budgeted.

While improving building performance is likely to mean some increase in construction and design costs, these added expenses may not be significantly more than those of a structure built to minimal seismic standards. Furthermore, typical kinds of earthquake damage are controllable for very little added expense. In short, owners' decisions to go for the lowest fee in design contract negotiations may save little at the beginning, while proving very costly later in the event of a damaging earthquake.

The recommendations in this report may clarify important design practice issues and provide guidance in dealing with major issues. Implementation of the recommendations may also strengthen the role of California architects in the design and construction process. Moreover the recommendations for improvements in practice can reduce exposure to damage claims and liability suits due to building failures. Accordingly, this report merits careful attention by architects practicing in California, and by all organizations concerned with earthquake safety.

The Architect's Role in Community Leadership

Architects have many opportunities to advocate the creation of a more seismically safe environment, help identify existing earthquake hazards, and avoid the creation of new ones. They can pursue these objectives in cooperation with other design and construction professionals, community organizations, schools, and public and business leaders. Their efforts might include advocacy of earthquake safety in public forums, in addition to encouraging design and construction projects that embody improved standards of lateral-force resistance.

Architects are frequently involved in the seismic strengthening of existing buildings—many of which are older structures, some with architectural merit, historic character, or long-term associations with community life. Where possible, these values should be preserved, and architects can help by mediating between the needs of structural retrofit technology and the goals of historic and architectural preservation. Thus they are in a position to promote improved seismic safety, while also seeking to maintain intrinsic values that might be lost.

Approaches to seismic hazard abatement depend on a community's physical environment, and its social, economic and political circumstances. Influential factors include the prevalence of hazardous buildings, the availability of alternative affordable housing, the demography and composition of the community, economic pressures for redevelopment, and the ability to obtain economic and fiscal resources to help pay for mitigation of earthquake hazards.

Architects can help formulate appropriate mitigation strategies for their communities. First, they can work as advocates for sensible and prudent seismic safety programs. Second, they can help address the needs of displaced residents for affordable housing or alternative commercial space. Third, they can promote mitigation plans that respect and preserve the historic fabric of the community through architecturally sensitive retrofit designs. Fourth, they can join in multidisciplinary research efforts to advance new technologies and directions in earthquake hazard mitigation activities.

To capitalize on these many opportunities for playing more effective roles, and to strengthen the profession's community and educational leadership, the California Council, American Institute of Architects (CCAIA) should promote a strengthening of architects' earthquake awareness and knowledge of seismic design considerations.

Needed: Improved Seismic Awareness and Better Teamwork

The seismic resistance of buildings is a major concern in a state prone to earthquakes. The conceptual stages of a building's design involve decisions by the design team and owner that can do much to determine a structure's seismic performance. Accordingly, owners, architects and engineers should collaborate closely, starting at the very beginning of the design process. A good grasp of seismic design considerations, plus good architect and engineer teamwork, can lead to the construction of buildings with enhanced resistance to the lateral forces of earthquakes.

As things stand, some architects may need to improve their understanding of design requirements for improved seismic resistance. Furthermore, working relationships among owners, architects and engineers may not be sufficiently close. We therefore recommend steps to improve seismic design practice and to promote strengthened architect-engineer collaboration.

Design Practice Aids

Each construction job involves unique circumstances, but use of common methods, procedures, and documentation by design-team members can facilitate better awareness of mutual responsibilities and promote improved seismic design. Several of these aids are discussed below, including checklists, guides and other sample documents. Their appropriate use by design teams could help clarify task assignments, reduce uncertainties, promote teamwork, and improve seismic design.

Use of such aids could also help design teams explain to owners and others the level of building performance in earthquakes that a proposed project budget is likely to buy, and what it is not likely to assure. Used in contract negotiations, such aids may facilitate a better match between owners' expectations and realistic anticipated building performance. Accordingly professional organizations representing architects, engineers and owners are urged to collaborate in developing and publicizing the value of and availability of practice and documentation aids such as those suggested herein.

Strengthening Seismic Design Practice

The uniqueness of every construction project requires the exercise of professional judgment and a multitude of design and construction decisions. In the interest of strengthening seismic design practice, architects should consider certain concepts and procedures, adapting them to their own individual approaches. The considerations outlined in Table 1 are proposed as options for improving design practice, rather than as standards of accepted practice.

TABLE 1

Options For Improving Architectural Seismic Design Practice

1. Participate in continuing education programs, with special attention to seismic design and performance.

2. Participate in post-earthquake site visits to examine damage and study patterns of structural behavior.

3. Participate in the development of seismic codes and guidelines, work on code committees, and promote the use of design guidelines.

4. Work with structural engineers who are experienced in seismic design.

5. Develop seismic goals and expectations for each project, jointly with the owner and other members of the design team. (See Table 3.)

6. Ensure that conceptual and schematic designs are developed with joint architect/engineer participation.

7. Develop a scope-of-work definition (a division of tasks between architect, engineer and builder) for incorporation in each architect/engineer contract.

8. Develop formal architect/engineer interaction techniques to deal with basic seismic issues, such as a professional interaction guide for all critical aspects of design (site characteristics, configuration, structural system and performance, and nonstructural components). (See Table 2.)

9. Develop seismic performance guidelines and evaluation reports. (See p. 13.)

10. Seek appropriate compensation for seismic design (based on defined scope-of-work and services.) (See Table 4.)

11. Educate owners on seismic design issues.

12. Educate builders on seismic design issues. Encourage owners to discuss seismic design issues with builders.

13. Provide independent expert design review for major projects.

Professional Interaction in Seismic Design

Architects and engineers, as well as the public, have an interest in close professional interaction between the members of design teams. Adapting model processes of interaction to specific projects, and using common guidelines highlighting key seismic design issues needing resolution, may greatly facilitate communication within architect-engineer design teams. (See checklist, Table 2.)

Consistent and methodical use of such guidelines and checklists may materially improve quality control and seismic-design performance. Architects and structural engineers practicing in California are encouraged to consider incorporating versions of these model interaction processes into their practice manuals. Professional interaction and agreement also will be furthered if principal members of design teams utilize such project checklists. Joint efforts by the architectural and structural engineering professions could refine and develop such guidelines, explaining their merits to members and promoting their availability to all practicing professionals.

TABLE 2

Seismic Design Checklist to Facilitate
Architect/Engineer Interaction

Item	**Minor Issue**	**Moderate Issue**	**Significant Issue**	**Resolution**
Goals				
Life Safety				
Damage Control				
Continued Post-earthquake Function				
Site Characteristics				
Near Fault				
Ground Failure Possibility (Landslide, Liquefaction, Subsidence)				
Soft Soil (Long Periods, Amplification, Duration)				
Accessibility (Lifelines, Access/Egress)				
Adjacency (Up-slope or Down-slope Conditions, Collapse-hazard Buildings Nearby)				
Building Configuration				
Height				
Size Effect				
Architectural Concept				
Vertical Discontinuity				
Soft Story				
Setback				
Offset				
Resistance Elements				
Plan Discontinuity				
Re-entrant Corner				
Eccentric Mass or Stiffness				
Adjacency-Pounding Possibility				
Structural System				
Dynamic Resonance				
Diaphragm Versatility				
Torsion				
Redundancy				
Deformation Compatibility				
Out-of-Plane Vibration				
Unbalanced Resistance				

TABLE 2
(continued)

Seismic Design Checklist to Facilitate
Architect/Engineer Interaction

Item	**Minor Issue**	**Moderate Issue**	**Significant Issue**	**Resolution**
Resistance Location				
Drift/Interstory Effect				
Strong Column/Weak Beam Condition				
Structural Performance				
Ductility				
Inelastic Demand				
Constant or Degrading Stiffness				
Damping				
Energy Dissipation Capacity				
Yield/Fracture Behavior				
Special System (e.g., Base Iso.)				
Mixed System				
Repairability				
Nonstructural Components				
Cladding, Glazing				
Deformation Compatibility				
Mounting System				
Random Infill				
Ceiling Attachment				
Partition Attachment				
Rigid				
Floating				
Replaceable Partitions				
Stairs				
Rigid				
Detached				
Elevators				
MEP Equipment				
Special Equipment				
Computer/Communications Equipment				
Special Building Contents				

Preparation of a statement on seismic goals and expectations can help design team members and owners agree on goals that are reasonably in line with resources available. Before construction begins, agreement by the design team and the owner, including the construction manager, if involved, on a project's goals and expectations can help achieve the desired level of performance and limit later surprises due to unexpected earthquake damage. This objective will be promoted by making a seismic goals and expectations statement part of a project's building program documents.

See Table 3 for a preparation of goals and expectations statements. The architect should organize the discussion of appropriate goals and statements, and ensure that they are fully understood by the owner and design team. The architectural and structural engineering professions should consider collaborating on a manual on the preparation of such statements.

The California Council of the American Institute of Architects (CCAIA) and the Structural Engineers Association of California (SEAOC) should encourage the preparation and use of seismic goals and expectations statements on all California projects where such use is considered appropriate. The contents of such statements can then be agreed on by the principal parties—design team, contractor, and owner—and made part of each project's building program documents.

TABLE 3

Seismic Goals and Expectations

A. Earthquake Performance of Structural Systems

Earthquake effects	Damage			
	No Life Threatening Collapse	Repairable Damage: Evacuation	Repairable Damage: No Evacuation	No Significant Damage
Low-Moderate				
Mod-Large				
Large				

B. Earthquake Performance of Non-structural Systems

Earthquake effects	Damage			
	No Life Threatening Collapse	Repairable Damage: Evacuation	Repairable Damage: No Evacuation	No Significant Damage
Low-Moderate				
Mod-Large				
Large				

C. Function Continuance: Structural/Nonstructural

Earthquake effects	Time to Reoccupy			
	6 months +	To 3 months	To 2 weeks	Immediate (hours)
Low-Moderate				
Mod-Large				
Large				

Notes:
1) Effects of Nearby Earthquakes:
   Low-Moderate: Up to Richter M 6.5
   Moderate-Large: Richter M 6.5-7.5
   Large: Richter M 7.5 +
2) Classification of earthquake effects and extent of anticipated damage may be modified by site conditions—such as poor soils, ground failure potential, or vulnerable adjacent structures—which may result in stronger shaking and greater damage.

Agreement on a project's seismic goals and expectations makes possible the preparation of specific seismic performance guidelines—as well as a seismic performance evaluation—for each building type, configuration, and structural system under active consideration. Performance guidelines and evaluation reports prepared in the early stages of each design project can be used in design-team discussions with the owner and contractor, to facilitate a meeting of minds on major issues of seismic design.

Each seismic performance evaluation can present the design-team's professional opinion regarding key questions about the structure and the site, such as the following:

1. Does the structure's configuration have important implications for its seismic performance?
2. What are the probable linear and nonlinear behaviors of the structure and its principal components during ground motion?
3. In an earthquake are the building and its main components likely to prove brittle and experience degrading behavior, or is ductile performance and stable behavior a reasonable expectation?
4. Is the building likely to exhibit unbalanced nonlinear behavior, and if so what are the implications for its earthquake performance?
5. What is the structure's potential for dissipating earthquake energy without suffering undue damage?
6. What is the degree of drift and deformation compatibility?
7. If the structure is damaged, how difficult and costly are repairs likely to be?
8. Is the building's serviceability and continued function an important consideration?
9. Is the site on or adjacent to an active earthquake fault?
10. Would the site geology be likely to increase ground shaking intensity in an earthquake?
11. Is the site stable?
12. Is the site subject to liquefaction?
13. Are the up-slope and down-slope environments near the site stable?
14. Are building separations adequate to prevent battering (pounding) during an earthquake?
15. Are adjacent buildings collapse hazards?
16. Are hazardous materials stored or used in the vicinity of the site?
17. Will site access and egress be secure against earthquake-caused obstruction?
18. Are transportation, communication and utility lifeline systems vulnerable to disruption or failure?
19. Is the site in an area that is subject to inundation in case of dam failure, or susceptible to tsunami or seiche damage or flooding?

Scope-of-Work Guidelines and Agreements

Costs and economic pressures tend to restrict the time made available for design. Working within limited budgets, architects and engineers, while following customary practice, may nevertheless leave some design tasks to engineers employed by contractors or vendors (e.g., precast cladding panels, windows, stairs, and elevators). At times, unless carefully monitored, this can reduce building quality and performance to levels that may be less than desirable with respect to seismic safety.

To enhance performance, all the principal parties—designers, owners, contractors, and sub-contractors—should clearly understand the scope of design work involved in construction projects, and the assignment of responsibilities and tasks. Agreement should be reached on the budgeting of adequate fees to pay for the necessary services. Scope-of-work agreements seek to allocate and assign tasks properly, and to budget adequate fees to do what is needed. Lack of agreement early in a project's life may increase the likelihood of omitting tasks, budgeting insufficient funds for necessary design services, or making other compromises that can adversely affect building quality and seismic performance. In negotiating such agreements, architects and engineers are encouraged to educate owners on the benefits of retaining design teams to observe construction and review implementation of design, in the interest of achieving good structural results through effective quality control. Reducing the likelihood of future claims is another valuable benefit.

Scope-of-work agreements can be based on guidelines such as those in Table 4. Use of such guidelines in negotiating agreements may assist design professionals in their efforts to convince owners that providing for modest additional amounts of professional time during design and construction may yield large dividends in the long run. Scope-of-work agreements could also be valuable tools for architects to use in defining and clarifying their roles in design and construction.

The architectural and structural engineering professions should be encouraged to develop and publicize the availability of reference guidelines such as those suggested in Table 4. CCAIA and SEAOC should be encouraged to promote use of such guidelines by practicing professionals wherever appropriate, adapted to the unique circumstances of individual projects. Owners should be encouraged to retain architects and engineers to monitor the construction processes in all projects. In negotiations with owners and builders, design teams should be encouraged to seek the allocation of sufficient funds to pay for appropriate services to improve the seismic performance of the structures they design, including site review or on-site observation during construction. Where it is appropriate, scope-of-work agreements should be incorporated into building contracts.

TABLE 4

Design Scope-of-Work Guidelines

Construction Item	Activity					
	Design	**Corrdinate**	**Check**	**Shop DWGS**	**Sign/Stamp**	**Field Review**
Foundation	SE	A	G	SE	SE	A,SE
Superstructure						
Steel Frame	SE	A	SE	SE	SE	A,SE
Concrete Frame	SE	A	SE	SE		A,SE
P/T Floors	V	SE	SE	SE	V,SE	
Open Web Joists	V	SE	SE	SE	V,SE	
Cladding						
Precast	V	A,SE	SE	SE	V	A,SE
Metal	V	A	SE	A	V	A
Glass	V	A	A	A	-	A
Stairs	A,SE	A	SE	SE	V,SE	A,SE
Elevator	V	A	SE	A,SE	V	A,SE
Ceilings	A	A	SE	A		A
Equipment	V	A	SE	A	V,SE	A,SE
MEP Systems	MEP	A	SE	MEP	MEP	MEP

Note: This table represents a hypothetical project and should not be taken as a suggestion for assigning specific responsibilities, which must be uniquely established for each project.

Key:
- A = Architect
- SE = Structural Engineer
- MEP = Mechanical, electrical, plumbing services
- V = Vendor or manufacturer of prefabricated components
- G = Geotechnical Engineer

Peer Review of Architectural Firms

In addition to encouraging use of consistent documentation and procedures, some professions use organizational peer reviews or performance audits to evaluate the methods and procedures of individual practitioners and firms. Project-specific peer reviews may also consider the design and other features of individual projects.

In a typical design profession organizational peer review, several experienced architects or engineers spend several days studying a participant firm's stated policies and procedures, and comparing them to what is actually being done. Because they are effective in improving standards of practice, such organizational peer reviews ought to be used more widely by the design professions.

Some insurance companies already recognize the value of peer review in architecture, offering significant premium reductions as incentives for submitting to a peer-review process, or taking special exams or other actions intended to improve performance. For example, the Design Professionals Insurance Company (DPIC) reimburses its policyholders for all monies spent for an organizational peer review up to a maximum of $6,000. An organizational peer review examines policyholder practices in general management, professional development, project management, human resources management, financial management and business development.

The Design Professional's Insurance Company also reimburses its structural engineering policyholders for technical peer reviews that evaluate individual projects, from conceptual design through design calculations, contracts, shop drawing review, and field observation. All costs of technical peer reviews of structural engineering firms insured by DPIC are paid by DPIC. (August 30, 1991 letter from DPIC)

The architectural and engineering professions should seek wider use of such incentives by the insurance industry, based on peer reviews and other methods of strengthening standards of practice. Moreover in California it is imperative that peer reviews include seismic safety concerns.

CCAIA's Professional Liability Project Steering Committee has issued a highly favorable report on peer review, strongly encouraging member firms to consider voluntary participation in peer reviews:

> Every design firm, whether a one-person firm or a 100-person firm, has something to gain from an objective review of how their business is managed. Peer review offers the valuable opportunity to gain insight into how your business practices and management techniques are working and how they could be improved. ("Peer Review," January 1988)

The CCAIA committee recommended the peer review program of the American Consulting Engineers Council (ACEC), which focuses on six areas: overall management, development and maintenance of technical competence, project management, human resources, financial management, and business development. The Seismic Safety Commission should work jointly with CCAIA to encourage the inclusion of seismic design considerations in peer review evaluation procedures. Peer review audits should include examination of seismic design practice, professional interaction between architects and engineers, and use of the guides and procedures suggested in this report.

Concern about the inadequacy of the national architectural examination in testing on seismic design prompted California authorities to prepare and administer their own state test. The new California exam was specially formulated to include seismic concerns that architects designing in earthquake regions should know about. The exam specifications were rewritten to ensure inclusion of questions demonstrating that those admitted to the profession qualify for a minimum standard of seismic practice. The leadership shown by the California Board of Architectural Examiners (CBAE) is highly commendable, and California's action subsequently influenced the national examination in architecture as administered by the National Council of Architectural Registration Boards (NCARB).

The state board should continue to take all reasonable steps needed to ensure that all who successfully complete the architectural licensing process authorizing practice in California possess high levels of seismic awareness and competence. It is imperative that all candidates who acquire licenses for practice in a seismic region like California be properly tested for knowledge of the principles of good seismic design.

Prompted in part by the example of CBAE, on October 13, 1988, the Seismic Safety Commission adopted Resolution No. 88-2, "Testing of Civil Engineer License Candidates on Seismic Principles." In summary, the commission resolved that:

- "civil engineers practicing in the State of California must be knowledgeable of and be tested on seismic principles to assure the safety and adequacy of facilities they are responsible for,"
- "the term 'seismic principles' should be interpreted broadly as it applies to a wide variety of civil engineering activities,"
- "applicants should demonstrate their understanding of these principles on the licensing test in a way that is applicable to real situations," and
- "understanding these principles will allow civil engineers with responsible charge for project location, design, and construction to exercise the trust that we, the people of the State of California, place in them."

The resolution was adopted to show Commission support for measures to strengthen the seismic design portions of the test given to civil engineering license candidates in California.

The respective California state licensing boards presently require architects and civil engineers to limit their practices to areas in which they have demonstrated competence. Both boards, however, need to emphasize the importance of these requirements by vigorously enforcing all such board rules and actively promoting greater awareness of the requirements.

The Potentials of Architectural Education

Especially because of California's earthquake hazard, architectural education in this state should give special attention to good seismic design. It is in the public interest that all architecture students who graduate with a professional degree and enter the profession should be familiar with the principles of earthquake-resistant design.

Strengthening Educational Programs

In the United States, architecture and engineering are considered distinct professions and follow separate educational careers. For best results, however, practicing architects and engineers need to work in close collaboration. Through joint programs, schools of architecture and engineering can promote early development of architectural students' understanding of architect-engineer team relationships and responsibilities.

Further, the seismic-design awareness of graduating architecture students needs to be strengthened, especially if they are to practice in California. Interdisciplinary programs can educate architecture students in the fundamentals of good seismic design, the seismic consequences of various design decisions, and methods of analyzing structures for seismic resistance. All schools of architecture that prepare students for practice in California should offer and require adequate instruction in the basic principles of seismic design, where possible in collaboration with schools of engineering.

Improving Faculty Awareness

Architectural school faculty members are not, however, typically well versed in seismic design principles. Moreover the many competing demands on curricula and teaching time have limited the attention given to the crucial responsibilities of architects for the earthquake resistance of structures they design. Concerted efforts are needed to ensure that architecture school faculty become more fully acquainted with the importance of seismic design and the proper role of architects in ensuring the seismic resistance of structures built in earthquake regions.

To this end, symposia and seminars should be developed to familiarize architectural school faculty members with seismic design, emphasize its importance to the architectural profession, and facilitate the introduction of seismic considerations into design studio work. In future recruitment of faculty members for teaching roles in building technology, structures, and construction, candidates' qualifications should include a realistic grasp of seismic design and its importance in California architectural practice.

Promoting Participation in Continuing Education

Continuing education is widely used in many professional fields to keep up with state-of-the-art practice. When practice is changing rapidly, continuing education is a key way to maintain competence and learn specific new methods and procedures. Well-designed and well-attended continuing education programs in architecture could help practicing architects become much better informed on seismic design issues. The CCAIA's Professional Liability Project Steering Committee commented as follows in introducing its report on continuing education for architects:

> ...the architect in practice must continue his/her education to meet public and client expectations of proficiency in rapid legal and technical changes affecting the design and construction industry.

CCAIA and its chapters should sponsor continuing education programs for architects, and the curricula should include seismic design as a major topic of instruction. CCAIA, SEAOC, and the Earthquake Engineering Research Institute (EERI) should collaborate in developing seminars on seismic design involving architects and structural engineers. Such programs can improve architect-engineer interaction in design work and strengthen architects' understanding of the seismic concerns of structural engineers.

State-mandated participation in continuing education is often required for relicensing in a number of fields—e.g., health care, accounting, real estate and law. In California and most other states, however, continuing education for architects has been voluntary, and participation not especially strong.

CCAIA's Professional Liability Committee has recommended that the CCAIA Board of Directors consider a policy of mandatory continuing education for architects, primarily to improve the standards of professional practice, and to reduce liability, litigation and insurance premiums. Our committee also supports the concept of mandatory continuing education for architects. To implement such a policy, eligibility for relicensing can be conditioned on participation in continuing education programs, which should include instruction in seismic-design practice and on the need for close architect-engineer collaboration.

The insurance industry should be encouraged to expand the use of incentives for active participation in continuing education, testing, and peer review programs (see also above, "Peer Review of Architectural Firms"). The Seismic Safety Commission should encourage the insurance industry to include seismically related questions in any examinations used to qualify California architects for premium credits or other incentives.

Post-Earthquake Roles of Architects

There are several significant roles architects could play after damaging earthquakes. These roles generally are beyond the training and experience most architects now have, but with appropriate advance preparation they could participate actively. Thus architects could help evaluate the safety of damaged structures, and assist recovery and reconstruction efforts. By involving themselves in these roles, architects can also improve their professional knowledge of seismic safety and building vulnerability.

Accordingly, CCAIA and CBAE, working with OES, should be encouraged to continue development of appropriate training programs on the rapid screening and evaluation of damaged buildings, and to promote participation by California architects and other construction professionals. The ultimate goal should be a substantial cadre of architects willing, able and qualified to join earthquake-damage assessment teams in responding to future earthquake disasters.

Rapid Screening and Evaluation of Damaged Buildings

Moderate or large earthquakes in urban areas may place heavy demands on the design and construction professions. Damaged buildings must be identified and screened to guide decisions on the safety of continued occupancy and the need to post some structures as unsafe. The demand for rapid screening and the urgent need for shelter may require help from a broad segment of the design and construction professions.

Previous earthquake experience, good advance training, or both, are essential for proficiency in post-earthquake screening and evaluation. Currently the engineering community participates in such a training program with the Office of Emergency Services (OES), through the Structural Engineers Association of California (SEAOC) and the American Society of Civil Engineers (ASCE). In 1991 CCAIA bacame a participant in OES volunteer damage assessment programs, training courses for architects have been held, and architects are now included in the OES plan for post-earthquake evaluations. This participation is highly commendable, and should continue as rapidly as possible.

Thus architects can also acquire the skills needed for effective post-earthquake screening and evaluation. With adequate training, they can make significant contributions to earthquake-disaster response. Participation in training and post-earthquake site visits are excellent ways to increase architects' seismic knowledge, which will also assist them in their regular practice.

Assistance with Recovery and Reconstruction

Following a significant earthquake, damage assessment and environmental impact analysis by teams of architects, planners, engineers, and geotechnical experts can facilitate recovery and reconstruction planning. As team members, architects can help assess a community's architectural and historical resources, and advise on alternative strategies for recovery and reconstruction.

Planning for communities devastated by nonearthquake disasters—e.g., Wichita Falls, Texas (tornado); Lynn, Massachusetts (major fire); West Virginia (floods)—has demonstrated how architects affiliated with the American Institute of Architects (AIA), along with other professionals, can provide valuable support to help beleaguered communities develop reconstruction ideas.

Multidisciplinary teams supported by AIA's Regional/Urban Design Assistance Team program—brought together for short problem-solving charrettes—identify community assets, resources and limitations, stimulate local thinking, and help community leaders focus on promising directions for physical and economic recovery. Similar programs sponsored by CCAIA were organized after the Coalinga, Whittier, and Loma Prieta earthquakes.

Such disaster response teams do not need to draft precise solutions or plans, but can suggest design themes and generic solutions illustrating concepts for future reconstruction. These in turn can stimulate community action in formulating local reconstruction plans. Perhaps the most important result of such endeavors is the positive psychological impact of looking beyond the immediate destruction toward the future of a rebuilt city.

CCAIA and CBAE should promote measures to strengthen California architects' ability to respond quickly and effectively in helping provide emergency planning and technical assistance. To this end, state and local chapters of the AIA should join with the National AIA Urban Design and Planning Committee, Regional Urban Design Assistance Teams, in developing architects' capacity for early response to major disasters, including earthquakes.

Earthquake Site Visits—Learning from Earthquakes

Site visits immediately after damaging earthquakes are probably the best way to enhance architects' awareness of the effects of seismic forces on various kinds of structures and designs. Site visits and post-earthquake investigations can teach design professionals a great deal about the kinds of structures that are vulnerable to failure, as well as those that perform well in earthquakes.

Acting both individually and through EERI, SEAOC, and other organizations, many structural engineers—particularly those having a special interest in earthquake engineering—have learned a great deal from site visits made to examine earthquake damage. Interested architects could likewise benefit from involvement in such post-disaster investigations.

Accordingly, concerted efforts are needed to get more architects to make site visits immediately after damaging earthquakes, and to attend subsequent debriefings. CCAIA and CBAE should seek EERI's advice in developing a site-visit program based on the highly successful "Learning from Earthquakes" program, or alternatively, CCAIA members should participate directly in EERI's program. CCAIA should work actively to further such efforts, and should recommend that local AIA chapters use membership meetings and chapter media to inform members on the value of post-earthquake site investigations and debriefings.

By promoting earthquake site visits and disseminating post-earthquake information, CCAIA and the CBAE can reach a considerable percentage of the 18,000 practicing architects in California. After major earthquakes, the professional organizations and the licensing boards should plan for and sponsor special debriefing workshops for design professionals. Perhaps these could be presented jointly with EERI.

For wide dissemination of lessons learned from earthquakes, the Seismic Safety Commission should work with CCAIA, CBAE, EERI, SEAOC and ASCE to sponsor and promote the preparation of a book on earthquake damage for use by owners, architects, engineers and other construction professionals. It should contain photographs, graphics and text illustrating and explaining the causes of typical failures, and recommending ways to avoid them.

Summary of Recommendations

Introduction

Implementation of these recommendations will significantly strengthen the effectiveness of architects in earthquake hazard mitigation, and contribute to good seismic design of buildings that are able to perform satisfactorily in earthquakes. We urge CCAIA, CBAE, SEAOC and other appropriatre organizations to support these recommenfdations and help carry them out. The Commission will periodically monitor progress, taking further action as needed.

Strengthening Architects' Leadership Roles

1. The California Council of the American Institute of Architects (CCAIA) should promote architects' earthquake awareness and knowledge of seismic safety needs, in order to strengthen the profession's community and education leadership capabilities.

Preparing and Using the References and Resources

2. CCAIA and the Board of Architectural Examiners (CBAE), along with the Structural Engineers Association of California (SEAOC) and the Board of Registration for Professional Engineers and Land Surveyors, should promote use by architects and structural engineers of the guidelines, references, performance evaluations and other documents recommended in this report.

Professional Interaction in Seismic Design

3. CCAIA and SEAOC should identify opportunities to strengthen processes of professional interaction.

4. CCAIA and SEAOC should identify key seismic design issues of common interest and concern.

Seismic Goals and Expectations

5. Architects and structural engineers should collaborate in preparing guidelines on how to draw up seismic goals and expectations statements for use in their practice.

6. CCAIA and SEAOC should encourage architects and structural engineers to adopt the practice of preparing seismic goals and expectations statements for all significant projects.

7. Seismic goals and expectations statements should be prepared for all significant building projects in California. We recommend that each statement's contents be agreed to by the principal parties—the design team, the owner and the contractor—and each statement be incorporated into the building program documents of each project.

Seismic Performance Guidelines and Evaluation Reports

8. In the early stages of significant California building projects, architects and engineers should be encouraged to collaborate in preparing seismic performance guidelines for the alternative designs actively being considered. Owners should be prepared to pay the fees necessary to support the services required.

9. Using the performance guidelines, a seismic performance evaluation should be prepared for use in discussing building type, configuration, and structural, nonstructural and mechanical systems with the owner/builder.

Scope-of-Work Guidelines and Agreements

10. CCAIA and SEAOC should arrange for and coordinate the preparation of scope-of-work guidelines.

11. CCAIA and SEAOC should actively promote the use of seismic scope-of-work guidelines by practicing professionals in preparing agreements for appropriate projects, clearly spelling out task assignments. It is recommended that,

where appropriate, scope-of-work agreements be included in building contracts.

12. Architects and engineers should encourage owners to include monitoring and construction observation in the scope-of-work of all projects. In negotiations with owners/builders, design teams are urged to request the budgeting of sufficient funds to pay for necessary services, including on-site observation during construction.

Peer Review of Architectural Firms

13. In the interest of improving practice, and thereby reducing potential liabilities and lowering insurance premiums, architecture and structural engineering firms should be encouraged to submit to peer review.

14. CCAIA and SEAOC should encourage the insurance industry to make wider use of premium incentives based on peer reviews.

15. The Seismic Safety Commission should work jointly with CCAIA and the Consulting Engineers Association of California (CEAC) in promoting the inclusion of seismic design considerations in peer review evaluations.

Testing and Licensing Architects

16. The California Board of Architectural Examiners (CBAE) should continue to take all reasonable steps needed to promote high levels of seismic awareness and competence on the part of those who successfully complete the architectural licensing process.

Realizing the Potentials of Architectural Education

Strengthening Educational Programs

17. All schools of architecture that prepare students for practice in California should provide and require instruction in the basic principals of seismic design, and where feasible this should be offered in collaboration with schools of engineering.

Improving Faculty Awareness

18. The California Council of Architectural Educators should provide symposia and seminars to familiarize architectural school faculty members with seismic design, emphasizing its importance to the architectural profession and facilitating the introduction of seismic considerations into design studio work.

19. New faculty members recruited for teaching roles in architecture/ building technology should have an understanding of seismic design and its importance for architectural practice in California.

Promoting Participation in Continuing Education

20. To improve standards, reduce liability and lower insurance premiums, architects are encouraged to support continuing education, including instruction in seismic design.

21. CCAIA should encourage continuing education programs, and through the local chapters provide opportunities for architects to participate in voluntary continuing education.

22. The Commission should encourage the insurance industry to expand the use of premium credits as incentives for active participation in continuing education, testing, and peer review programs. Evaluations used to qualify California architects for premium credits should consider knowledge of seismic design.

23. CCAIA and SEAOC are urged to collaborate in developing joint seminars on seismic design, involving architects and structural engineers.

Post-Earthquake Roles of Architects

Rapid Screening and Evaluation of Damaged Buildings

24. CCAIA and CBAE should participate strongly in Office of Emergency Services (OES) planning for the rapid evaluation of damaged buildings, and encourage the participation of interested architects, as well as other construction professionals. Training programs should be organized in conjunction with other technical groups involved in the OES plan.

Assistance With Recovery and

Reconstruction

25. CCAIA and CBAE should be encouraged to promote measures to strengthen California architects' ability to provide emergency technical assistance.

26. Local chapters and councils of the AIA should be encouraged to join with the National AIA Urban Design and Planning Committee, Regional Urban Design Assistance Teams, in developing architects' capacity to provide emergency technical assistance after earthquakes, as well as other major disasters.

Earthquake Site Visits—Learning from Earthquakes

27. CCAIA and CBAE should seek EERI's advice in developing plans for architects' earthquake site-visits, based on EERI's highly successful "Learning from Earthquakes" program or, alternatively, should participate directly in the EERI program. Concerted efforts should be made to encourage architects' participation in post-earthquake site visits and debriefings.

28. CCAIA and CBAE should be encouraged to make plans for and sponsor special post-earthquake debriefing workshops for architects, perhaps presented jointly with EERI.

29. The Seismic Safety Commission will work with CCAIA, CBAE, EERI and SEAOC to promote the preparation of a book on earthquake damage for use by architects. The book should use photographs, graphics and text to illustrate and explain the causes of typical structural and nonstructural failures, and acquaint architects with effective ways to minimize such failures.

Appendix A—Acronyms

ACEC	American Consulting Engineer's Council
AIA	American Institute of Architecture
AICP	American Institute of Certified Planners
ASCE	American Society of Civil Engineers
CBAE	California Board of Architectural Examiners
CCAIA	California Council, American Institute of Architects
CE	Civil Engineer
CEAC	Consulting Engineers Association of California
DPIC	Design Professionals Insurance Company
EERI	Earthquake Engineering Research Institute
FAIA	Fellow, American Institute of Architects
MEP	Mechanical, Electrial, Plumbing
NCARB	National Council of Architectural Registration Boards
OES	Office of Emergency Services
RUDAT	Regional Urban Design Assistance Teams
SE	Structural Engineer
SEAOC	Structural Engineers Association of California

Appendix B—Notes on Terminology

A number of terms used in the body of this report have specific meanings. These are briefy discussed below.

Deformation compatibility: A measure of a building's ability to deform during earthquakes and accommodate deformations without the battering and premature failure of building elements.

Diaphragm: A horizontal, or nearly horizontal, system acting to transfer lateral forces to walls, frames, or other resisting elements. The term "diaphragm" includes horizontal bracing systems.

Drift (story drift): The displacement of one level relative to the level above or below.

Ductility: The ability of a material or combination of materials to withstand repeated bending and major deformation without fracture or failure.

Geotech: A geotechnical engineer.

Inelastic demand: A building's response to earthquakes that accounts for behavior beyond the first onset of damage.

Infill: An unreinforced wall that fills in parts of a structure's frame of beams and columns. The interaction of infill walls with frames can have a significant impact on the overall seismic response of structures. Infill walls may also fail during earthquake shaking.

Liquefaction: The transformation of a granular material from a solid state into a liquefied state due to increased pore-water pressure.

Offset: A discontinuity in a building's lateral force path, such as an element that does not align with the supporting element below.

Pounding: The bumping, battering, or hammering that occurs when two adjacent inadequately separated structures strike each other during an earthquake.

Re-entrant corner: Interior corners where wings of irregular buildings adjoin. Stresses concentrate at re-entrant corners during earthquakes.

Richter scale: The most widely used measure for the magnitude of an earthquake.

Seiche: Oscillation of the surface of water in an enclosed or semi-enclosed basin (lake, bay, or harbor) which can be caused by earthquake shaking.

Setback: A horizontal offset, such as in the plane of an exterior wall.

Settlement: The sinking or lowering of the gound surface; slope failure.

Soft story: A relatively flexible story in a building often at the ground floor where there are fewer columns, braces, or walls to resist earthquake forces.

Subsidence: The sinking or lowering of the ground.

Tsunami: A sea wave produced by large displacements of the ocean bottom, often the result of earthquakes or volcanic activity; also known as a seismic sea wave.

Yield stress: The stress at which a building element will become damaged and no longer return to its original shape.