Final Report

# EARTHQUAKE ADVISORY SERVICES: A Prototype Development Project

Conducted by the Center for Planning and Development Research
College of Environmental Design
University of California, Berkeley

Funded under a grant from the National Science Foundation
Earthquake Hazards Mitigation Program

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16. Abstract (Limit: 200 words)

Development of the prototype Earthquake Advisory Service (EAS) is reported. The EAS is designed to provide direct technical assistance and written materials to advise people who wish to make informed decisions about earthquake hazard reduction in their residences. It is intended also to be adapted to local conditions by community-based agencies. The EAS prototype involved the testing of early assumptions about program implementation, establishment of a systematic methodology review process, and a review of published information pertinent to the project. It combines the concept of housing advisory services and traditional consulting engineering services with self-help or contracted construction. Operational procedures of the program and the process leading to implementation guidelines are described. Variations and alternatives of the EAS prototype, related issues, and recommendations are presented. The appendices provide background information on housing advisory services and an EAS advisor's field Kit, including instructions for conducting a field visit and a representative recommendation package.

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Madis Pihlak (MCP, 1980) developed and conducted the homeowner questionnaire survey and performed the preliminary analysis of the data. He also assisted during the first round site visits.

Peter Yanev, Structural Engineer and Consultant to the project staff, visited all of the homes and recommended or verified recommended modifications. Mr. Yanev was also instrumental in instituting the grant proposal which follows from his earlier work, Peace of Mind in Earthquake Country (Chronicle Books, San Francisco, 1974).

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Roger Scholl (Technical Director, Earthquake Engineering Research Institute) also participated in the Technical Advisory Committee and supported the direction developed through that process.

Rachel Gulliver Dunne (Member, Los Angeles Building and Safety Commission) served on the Review Panel and consulted with staff on the structural and program development issues. Her assistance was extremely helpful in establishing directions for future work as well as supporting directions taking shape during the project.

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Avery Moore (M.Arch., 1980) coordinated, edited and designed the final version of the homeowner's manual. She produced a concise and consistent document useful to nontechnical readers. The art of translation into plain language is the key to the success of the manual and the essence of her contribution.

Ruth Dunmire-Haimbach (former magazine editor and coauthor of a book about medical doctors) edited and coordinated production of the final report. Working with unwieldy and bulky raw material, she fashioned a readable account of the EAS project.

I. Donald Terner (Associate Professor of Architecture, on leave, and Director of the California Department of Housing and Community Development) developed the project concept and grant proposal, bringing together the structural engineering concerns and the potential of people to participate in their own housing process. Dr. Terner also participated in the Review Panel.

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Dr. Marcy Wang (Assistant Professor of Architecture) also actively participated at Review Panel meetings.

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# Contents

# I. INTRODUCTION

This report describes the development of the prototype Earthquake Advisory Service (EAS). The EAS is designed to provide direct technical assistance and written materials to advise people who wish to make informed decisions about earthquake hazard reduction in their residences. In addition to focusing on actions which can be initiated by homeowners to improve their dwellings' structural performance, the EAS offers information on non-structural issues which can reduce injury and property damage. The EAS prototype is intended to be adapted to local conditions by community-based agencies.

The Earthquake Advisory Service development project was conducted during a period of intensified public concern about earthquake hazards. The earthquakes in the Imperial Valley (October 1979), Livermore (January 1980) and Mammoth Lakes (May 1980) rekindled fears about inadequate protection against earthquake forces. A local government preparedness evaluation, San Francisco's earthquake simulation project in the spring of 1980, renewed concerns about the capabilities of medical and other service institutions to function efficiently after a severe seismic event. Critical reassessments, such as Bruce A. Bolt's warning of the fifty-percent probability of a major Californian earthquake within the next decade*, added to the anxiety. Reaction to these widely publicized events fueled the volume of response to the EAS project announcements.

While generally worried about earthquake hazards, people feel helpless to do much about them. The EAS project--conducted by the Center for Planning and Development Research (CPDR), University of California, Berkeley--addressed this conflict. By concentrating on the area over which citizens have the maximum amount of control, the individual dwelling, the EAS offers practical methods for transforming feelings of helplessness into informed action.

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*The reasoning behind this conclusion was published by seismologist Bruce Bolt and geologist Richard H. Jahns in: "California's Earthquake Hazard: A Reassessment", Public Affairs Report: Bulletin of the Institute of Governmental Studies, 20:4 (August 1979).

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The specific purpose of the EAS project was to design, test, and evaluate a prototype service that would reach and inform residents of seismic hazards, motivating people to voluntarily, effectively and economically undertake home-strengthening modifications. The project presented two major challenges: (1) to tailor the basic housing advisory service model to address earthquake problems, and (2) to devise a preliminary structural analysis procedure for determining and improving the resistance capabilities of residences.

In its broadest interpretation, the project's objective was to minimize life loss and injury in the event of a major earthquake. While the absolute success of this ultimate intention can only be thoroughly evaluated after the strengthened structures experience significant seismic forces, the project rests on the reasonable assumption that critical structural modifications made to improve performance justify the expenditures and effort involved.

## How safe is safe?

The value of projects like the EAS cannot be measured in strictly economic terms. One goal of the project's participants, for example, was to achieve some "peace of mind" about the safety of their families and property in the event of earthquake.

Degree of safety is never a matter of general agreement. Even professionals sometimes fail to accurately perceive risk levels involved in hazards outside the area of their own expertise. Public perceptions of risk often belie statistical data--correlating, instead, with the hazard's "newsworthiness".* Since even innocuous tremors grab headlines, on occasion greater danger levels are attributed to earthquakes than that which might actually exist in a given area.

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*Meier, R. L. "Risk-Taking Within a Living Systems Framework". Institute for Urban and Regional Development, University of California, Berkeley, 1980.

Evaluation of earthquake safety in residences derives from perceptions of: the likelihood and scale of seismic activity; the structure's ability to withstand expected forces and the possible consequences of insufficient resistance; the time spent in the exposed structure; and the level of discomfort, injury and social disruption which an individual is willing to risk.

Policy makers assess the adequacy of risk reduction measures by evaluating factors, among others, such as: (1) experience of similar dwellings in past earthquakes; (2) redundancy (multiplicity of load distribution and carrying mechanisms) of the structure; (3) geological conditions underlying the site; (4) amount of public exposure; and (5) cost benefits involved. Central to the assumptions is the building code premise that life safety is adequately protected but that a certain amount of property damage is tolerable (the precise amount of damage is never pinpointed). Currently, the precept that a single standard is considered suitable is being questioned: presumably, the chosen standard works in the average case and exceptions will be tolerated in extreme cases.

The EAS model attempts to improve upon risk reduction measures, and to assist in the residents' sense of safety by providing modification recommendations tailored to individual dwelling characteristics. Obviously, no degree of structural reinforcement can insure absolute safety, but incremental improvements produce incremental reductions of risk.

<u>Educating the public</u>

A major task of the EAS prototype involved simplifying existing technical information into practical, easy-to-use instructions for homeowners. (A result of this effort, a manual for homeowners, was developed as a product of this project.)

While relatively minor efforts in strengthening wood-frame dwellings may preclude major losses in an earthquake, much of the information to do so remains bound in a technical language of scientific detail. Some experts submit that the public is incapable of rational decision-making, even when armed with all possible technical information. The consensus process often used by developers of earthquake design criteria assumes that without extensive experience the layperson cannot capably carry the responsibility for critical decisions in earthquake hazard mitigation programs. Unfortunately, some professionals build decisions on value assumptions of public priorities, often resulting in a mismatch between public will and the regulations intended to implement public will.

The EAS prototype, and the model upon which it is based, the housing advisory service, assumes that people prefer some control over critical decisions affecting their lives. The fundamental assumption is that regardless of the homeowner's motivation to tackle technical issues, the decision to spend money, time and effort to improve the dwelling's performance--in short, the decision to modify risk--is one which may be assumed by the owner-occupant after receiving information capable of assimilation.

In the EAS model the technician/advisor aids in difficult decision processes by acting as translator, consultant and facilitator of technical information transfer. Modifications are suggested and supported; any expense and implementation is voluntary. The ultimate responsibility for decisions is placed in the hands of the homeowner after receipt of technical briefings.

## The housing advisory service model

Throughout the project implementation, an objective was to seek and assess further refinement of the housing advisory service (HAS) concept as applied to earthquake hazards mitigation. [Background information on the HAS appears in the Appendix.] The EAS, in fact, is an example of a housing advisory service, and as such serves as a useful test of the concept in a specific application.

Housing advisory services provide community-level assistance to owner-builders and self-help rehabilatators. The central concept is that self-help could bring affordable housing to a significant portion of the population, reducing (from 25 to 75 percent) the cost of improvements or additions to the housing stock. Self-help encompasses a broad range of homeowner involvement, from providing all the labor oneself, to acting as one's own general contractor--hiring subcontractors to perform some portion of the work. Homeowners who perform none of the actual physical labor can still realize substantial savings by assuming contracting duties, such as decision-making, bargain-hunting, and the overseeing and coordination of labor.

The transfer of experience in one locale to another requires creative implementation of the basic housing service model. Variables critical to success include the leadership quality of program organizations, housing and general economic trends in the area, motivation factors of the self-helpers, and the availability of alternatives to conventional, market-rate financing and equipment. As the EAS prototype developed in answer to these and other variables, a unique housing advisory service emerged.

This report details that evolution.

## A. MAJOR FINDINGS

Most of this project's findings relate directly to the implementation of an EAS program at the local level. Other findings concern the dissemination of earthquake hazard information, and the mitigation of hazards specifically in residential, wood-frame structures.

(1) The most critical structural-strengthening modifications that were recommended to EAS participants were also the modifications that people were most willing and able to make. These modifications included:

- attachment of the mud sill to the foundation;
- reinforcement of inadequate foundation;
- addition of lateral bracing to the sub-area;
- addition of structural connections and reinforcement of load-bearing columns in porches and in sub-areas; and,
- bracing of water heaters.

(2) Less critical modifications, most of which affected the dwellings' aesthetic or functional characteristics, met with less enthusiasm from project participants. Other factors which discouraged action on these particular recommendations included: fear of creating or discovering additional problems in the process; objection to the financial impact of making the modifications; and doubts about the importance of the modifications under various projected earthquake forces. The recommendations that were less enthusiastically received by EAS participants included:

- removal of improperly secured, unreinforced masonry veneers;
- removal or reinforcement of masonry veneers or unreinforced masonry garden walls;
- partial closing in of broad openings in unreinforced walls, such as the doors of garages and enclosed porches of light-weight construction with little or no shear wall;
- addition of lateral bracing in walls dominated by large windows;
- removal or bracing of unreinforced masonry chimneys.

(3) A substantial number of existing homes would benefit from EAS programs. Many older wood structures share the following defects: inadequate connections between the frame structure and the foundation; inadequate bracing in sub-areas; and inadequate shear-panels in major structural walls. Older homes in particular often have unreinforced masonry chimneys, deterioration of plaster and stucco wall coverings, excessive weight of multiple roof coverings, inadequate connection of columns, and inadequately supported gas appliances.

(4) There is a large potential audience for interactive advisory programs that respond to voluntary action. This finding emerges not only from the strong interest expressed by EAS participants, but from the public's growing awareness of the potential of major seismic events and the hazards of inadequately reinforced structures. The presence of direct technical advice is a critical factor in shifting homeowners from positions of concern but inaction, to positions of informed action.

(5) Generalized information, if properly prepared and distributed, can stimulate voluntary upgrading of residential structures. This conclusion is evidenced by the response to the EAS prototype program; while the program could only provide on-site assistance to 30 participants, over 300 inquiries for help were received. Even without the availability of direct technical aid, voluntary programs could be effective in upgrading a large number of homes, provided the public has access to adequate information.

(6) The EAS program can be economically implemented within existing housing service agencies, using current staff capability. Furthermore, it is evident that a large number of potential host agencies are interested in EAS programs as an extension to existing community services to the public.

## B. RECOMMENDATIONS

The following recommendations are explored in further detail in Section VI.

(1) Local implementation within existing programs. Local government agencies and nonprofit private organizations involved in housing development and/or rehabilitation and conservation of the housing stock should implement the Earthquake Advisory Service within the framework of existing programs.

(2) Government support. Federal agencies, and states in which seismic activity is a major consideration should support local efforts to implement the EAS.

(3) Improve earthquake mitigation data. A comprehensive study should be conducted to expand upon the findings developed through the EAS project's review of experiences in past earthquakes. Information on cases outside the scope of the EAS prototype must be explored.

(4) Improve reporting of experience in seismic events. A standardized procedure for reporting the performance of residential structures in seismic events should be developed and adopted by relevant government agencies and associations involved in seismic safety and earthquake engineering.

(5) Develop incentives. Tax programs could offer incentives for investments in earthquake hazard mitigation. The insurance industry should be encouraged to tailor earthquake insurance to the dwelling's ability to withstand seismic forces.

(6) Extend the EAS model to include other issues. The presence of a technical advisor while making a site visit presents an excellent opportunity for the provision of information on other relevant issues, such as energy conservation and reduction of fire hazards.

## II. THE EARTHQUAKE ADVISORY SERVICE PROTOTYPE

Development of the EAS prototype involved the testing of early assumptions (put forth in the proposal) about program implementation, the establishment of a systematic methodology review process, and a review of published information pertinent to the project. The results of these and other tasks led to the formulation of guidelines by which agencies could set up Earthquake Advisory Services. These guidelines were used, revised and evaluated by CPDR staff in an interactive program with 30 local households.

The EAS prototype combines two major components: (1) the concept of housing advisory services, and (2) the traditional consulting engineer service combined with self-help or contracted construction. Operation of the EAS program can be summarized as follows:

Step 1: After defining the capabilities of the EAS program, outreach efforts are devised. Those desiring to participate contact the advisory service, and the service determines the eligibility of the application. Appointments are then made to visit the homes of qualified applicants.

Step 2: The site visit begins with a discussion of the site's geological features. A comprehensive survey of the exterior and the interior of the building is conducted.

Step 3: While on site the advisor assembles a set of recommendations for structural and nonstructural modifications. These recommendations are explained to the homeowner.

Following is a description of these operation procedures and the process which led to implementation guidelines.

## A. PERSONNEL AND ADVISORS

Because of the broad range of issues, users, problems and institutions affected by the EAS prototype, or potentially affected by its implementation, a broad-spectrum Review Panel was formed [their names and affiliations are listed in Appendix 1]. The Panel convened prior to implementation of the case study portion of the program, and following completion of the case studies and prior to drafting of the final report.

Additional measures were taken to achieve adequate technical review of structural analysis, engineering assumptions, and recommendation guidelines. Qualified faculty and staff members participated in the development of the project's technical aspects. Major assumptions and methodology were also reviewed by noted experts in the field, including Henry Degenkolb, past president of the Earthquake Engineering Research Institute, and Roger Scholl, technical director of EERI.

Early in the project it became apparent that contrary to assumptions, building inspection departments would not be the most appropriate agencies to host Earthquake Advisory Services in California. The 1978 passage of the Jarvis-Gann Initiative (Proposition 13) in California affected the ability of building departments to increase staff size or broaden the scope of services. Recent legislation and court cases concerning agency and municipality liability acted as further deterrents to extended activity. While building department officials in California expressed interest in learning from the project and receiving training for the building inspectors, there was reluctance to become involved in an advisory capacity. However, building inspection departments in other states may appropriately host EAS programs.

Discussions with representatives of public and private housing assistance organizations led to the conclusion that those organizations would be the most appropriate EAS host agencies. Their involvement in the housing development and rehabilitation process, staff capabilities, and range of contact with individuals and local community groups are factors which point to a potential for widespread implementation of the EAS prototype through integration into existing housing programs.

Due to the shift in assumptions about host agencies, it was determined that project staff would serve as advisors in the prototype's case studies. Evaluations were made concerning staff capabilities of candidate host agency groups, and actual advisory service activities were built on those assumptions. [The assumed staff capabilities are described in Section III.]

## B. LITERATURE REVIEW

The project began with a comprehensive review of the literature documenting structural damage experienced in past earthquakes. [A bibliography of major sources appears in Appendix 2.] Damage sustained by single-family, wood-frame houses was the focus of the survey. Available records from all strong earthquakes in the United States--from the 1906 San Francisco earthquake to the 1980 Livermore earthquake--were examined.

Included in the review were two important documents in the field of earthquake design criteria for residential structures, ATC-3 and ATC-4 [Appendix 2 provides citations for these reports.] Other recent information was gleaned from participation in relevant conferences: the EERI Second Conference on Earthquake Engineering in Palo Alto, August 1979; and the NBS-NCSBCS Conference, Building Rehabilitation Research and Technology for the 1980's, held in San Francisco, December 1979. Project staff gathered further architectural and engineering data through interviews with individuals involved in structural reinforcement of dwellings.

The primary intent of the survey was to delineate the common features of the subject structures that suffered most of the reported significant damage. The inadequacy of some historical reports made this investigation difficult. For example, the outbreak of fire subsequent to the 1906 San Francisco earthquake, and the dynamiting of structures to create a fire break, distorted the amount of damage caused directly by the tremor. The available photographs are not adequately identified, in many cases, to allow researchers to draw clear conclusions.

More recent earthquakes have been more thoroughly documented, pinpointing specific structural failures. A review of the San Fernando earthquake of 1971 (Sylmar), for example, reveals the failure of split-level houses and two-story structures with inadequate lateral resistance in a major first-floor wall. Reports emphasize that two- and three-story apartment buildings constructed in California during the last three decades often contain a fundamental design defect: the absence of thickness at the meeting of the transverse walls with the longitudinal walls (which, in the Sylmar earthquake, resulted in major shifts in buildings so constructed). In addition, the total collapse of first-floor garage walls frequently occurred during the Sylmar earthquake.

Some generalized but valuable lessons emerged from the literature review. One is that the extent of structural damage may depend more upon the dwelling's underlying geological formations than the structural capability of the dwelling itself. (This suggests a more active role for geologists and geophysical professionals in earthquake engineering analysis and design.) Another recurrent theme in the literature about past earthquakes is the potential for disruption of municipal services and disaster response mechanisms after a major seismic event. Although response to this problem is beyond the scope of the project, the project's educational element can aid awareness of the levels of disaster preparedness.

Other lessons drawn from the literature were outside the EAS project's context but significant enough to warrant attention in future projects that may be based on the EAS prototype. For example, a major consequence of the 1979 Imperial Valley earthquake was the failure of structural underpinnings of mobile homes. The Imperial Valley earthquake also brought to attention the importance of building configuration in determining earthquake safety. The multiplicity of walls, the quality of connections between structural components, wall assembly carrying capacities and other related variables are central to determining structural performance. These and other important topics demand further research.

The literature survey concentrated on direct structural damage, such as failed foundations, structural bearing walls and main-frame elements. However, the earthquake record contains numerous references and summaries of nonstructural damage to various architectural features. These include damage to interior and exterior plaster, broken windows, displaced and over-turned heavy furnishings and mechanical equipment, and damage to masonry veneers and chimneys. Nonstructural damage was surveyed in order to determine the overall effect of a strong earthquake on a residence, to identify major property loss and life-safety hazards, and to educate owners so that they would know what to expect.

Conclusions of the literature review

The following features were judged to be most susceptible to damage from strong ground motion:

- brick or other unit masonry unreinforced foundations;
- lack of positive connections (usually anchor bolts) between the mud sill and the underlying foundations;
- noncontinuous, single-point supports along the foundations, such as peripheral posts without crawl-space bracing;
- insufficient crawl-space bracing;
- insufficiently braced porches, decks, and other protruding or indented architectural features;
- unreinforced unit masonry load-bearing supports such as partial walls, columns, porch supports, etc.;
- excessive openings, such as garage doors and continuous picture windows;
- connections between split-level portions of houses with more complex architectural features;
- unreinforced and reinforced unit masonry chimneys and interior fireplaces;
- unit masonry veneers, particularly veneers which extend more than three to four feet above the foundations of the buildings;
- heavy furnishings and unanchored water heaters, gas heaters and other bulky or heavy equipment; and,
- interior and exterior lath and plaster and stucco finishes, especially when not backed by wood siding.

Of the above, the most destructive and expensive to correct damage was caused by:

- lack of positive connections between the foundations and the wood frame of the house;

- inadequate bracing of the crawl-space;
- inadequate bracing of load-bearing walls;
- tall chimneys falling through the roof or away from side of house; and,
- unrestrained water heaters.

## C. PROJECT SCOPE

The original project proposal suggested 25 to 30 case studies of wood-frame, single-family dwellings located in communities in the vicinity of the University of California, Berkeley. The scope of modifications which would be considered was not delineated in the proposal but has evolved out of the project work. No constraints were placed on socio-economic or other participant characteristics. Despite efforts to recruit rental housing occupants, none came forward during the project.

The architectural, structural, and earthquake-resistant features of single-family residences vary tremendously. Site factors such as slope, availability and cost of construction materials, and age also influence the design of the typical house. To make the project manageable, a series of limitations were placed on the engineering and other features of the houses in order to qualify them for sampling and strengthening under the objectives of the project. The limitations were assumed in order to:

- evaluate the most common types of houses and maximize the effectiveness of the project;
- avoid particularly difficult architectural configurations and the ensuing engineering considerations outside the normal types of construction; and,
- minimize the necessity of complex engineering calculations and maximize the effectiveness of the brief site visits.

The project was limited to pre-World War II dwellings. While the percentage is higher in older cities, an estimated 25 percent of the existing houses in California were built prior to 1940. Almost all of this construction was undertaken without the basic earthquake precautionary measures currently incorporated into modern construction. [Evidence of this fact is presented by the damage statistics of the small (M = 5.6 and 5.7) Santa Rosa, California earthquakes of 1 October 1969, which showed a disproportionate amount of loss in pre-1940 homes as compared to post-1940 homes (Steinbrugge, 1970).]

The following summarizes the primary constraints for qualification for inclusion in the project:

- pre-1940 buildings, excluding more recent additions and modifications;
- unattached buildings;
- wood-frame buildings employing conventional residential construction;
- less than or equal to three stories in height, excluding basement area;
- located on flat ground or gentle slopes--outside the known landslide and soils creep areas of the Berkeley/Oakland hills; and,
- located outside the Alquist-Priolo Special Study Zones along the Hayward fault.

THE CENTER for Planning and Development Research, College of Environmental Design, University of California at Berkeley, is conducting research investigation on new methods that: (a) will minimize potential earthquake hazards of single-family residences and (b) provide clear guidelines on what to do in the event of a disaster.

THE INTENT of this earthquake assistance service is to provide guidelines on how to evaluate the safety of your residence and motivate homeowners and tenants to undertake (if needed) simple structural modifications that will increase their safety and reduce economic losses in the event of an earthquake.

THE CENTER for Planning and Development Research will provide detailed guidelines to help make these modifications on a "do-it-yourself" basis.

PARTICIPANTS will be provided with brief periodic visits by trained research assistants to help explain potential technical questions which may rise from the participant's interpretation of the guidelines.

# EARTHQUAKE ASSISTANCE SERVICE

FOR INFORMATION about this program, please contact the Center for Planning and Development Research, 373 Wurster Hall. 415/642-2896.

FIGURE 1. Publicity flyer and poster.

## D. OUTREACH TECHNIQUES AND RESPONSES

After defining criteria for screening participant dwellings, a plan was developed for communicating with potential participants. A variety of outreach techniques were devised for recruitment and to test the effectiveness of various publicity methods. The release of EAS program announcements was carefully timed, and escalated in scale (from local to regional) so that comparisons could be made based on the volume and type of responses that resulted.

Publicity began with the most local and focused methods and escalated in stages to regional and mass-media outlets. Notices were sent to community association newsletters, campus newspapers, and Berkeley, Oakland and regional newspapers. Radio and television coverage also took place. Posters and flyers were placed in city offices, including building inspection, planning, community development and housing assistance agencies. [For examples of EAS program announcements, see Figures 1 and 2.]

The greatest response came from the most localized or direct methods of contact: community newsletters and word-of-mouth. Local newspaper stories produced the second largest response. The least number of respondents identified regional newspapers and the electronic media as the sources from which they learned of the EAS. Newspaper publicity was perhaps effective because readers select the stories of particular interest, while the nature of radio and television does not so readily allow audience participation in filtering out relevant information.

OFFICE OF PUBLIC INFORMATION

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FOR IMMEDIATE RELEASE

Berkeley--Some simple and inexpensive changes can make a house a lot more safe in an earthquake, according to a research unit at the University of California that is encouraging homeowners to do it themselves.

To demonstrate how this is possible, a group in U.C.'s College of Environmental Design is conducting a pilot how-to service for a limited number of Berkeley and Oakland residents in older homes.

The group will help the homeowners translate technical information into easy-to-use instructions and will also produce a public manual explaining how to strengthen residences to withstand earthquake damage.

The aim is to promote the spread of self-help for seismic safety.

Some relatively simple work could make the difference between major structural collapse and only minor cosmetic damage; according to Peter Yanev, consulting engineer at the U.C. College's Center for Planning and Development Research and author of "Peace of Mind in Earthquake Country."

For as little as $100 to $200 and one or two weekends of work, a self-helper can prevent much of the common quake damage, he said.

This work usually involves attaching the foundation to the lower wood framing portion with expansion bolts and bracing the

-2-

framing with plywood. Also, attaching and bracing water heaters to the floor and adjacent wall.

Other common modifications are strengthening column connections and bracing masonry chimneys.

A typical hazardous feature in pre-1940 homes, Yanev reported, is the lack of connections between the wood sills and the concrete foundation -- a connection required by current California codes.

About a fourth of the homes in California were built before 1940, and the number is much higher in older cities, he noted. Virtually all of this construction was undertaken without the basic earthquake precautionary measures now required.

The technical information to correct seismic hazards has been largely in the hands of earthquake engineering specialists, he said. The Earthquake Advisory Service now in operation at the center is aimed at placing this "vital information" in the hands of the residents.

About half of the 30 homeowners in the demonstration project have been selected. Berkeley and Oakland residents interested in participating in the project, or in receiving the how-to manual on seismic safety, should contact the center at 642-2896.

Funded by the National Science Foundation, the pioneer service consists of inspections by a consulting engineer and research assistants from the center to assess the needs, followed by recommendations on the work to be done and on how to proceed.

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FIGURE 2. EAS publicity release.

## E. ENGINEERING STRATEGY

Based primarily on results of the past damage survey, a preliminary engineering strategy for analysis of the existing structures and an analysis criteria were formulated. It was decided to carry out simple analysis calculations on about ten to 15 buildings (30 to 50 percent of the total sample) in order to establish general trends for the weight of the typical buildings (per square foot of living area), the available lateral force resistance, and the extent of the necessary preliminary strengthening details. Throughout the project, a governing criteria was to evaluate types of details that could be strengthened by the homeowner without major assistance from design professionals.

The results of this preliminary work were presented to the Technical Advisory Committee. At this point, a consensus was reached on the lateral force criteria, the shear stress capacities of various materials of construction and bracing details, and rules of thumb for strengthening details on the basis of experience with past earthquakes and professional judgement to adequately quantify the design variables. This revised criteria was used to recompute and design the necessary strengthening details.

A complete description of the engineering considerations would require an extensive discussion. Instead, only the more important, common details will be summarized in this section.

### Typical weights of sampled buildings

In order to calculate the stresses imposed on a structure by an earthquake, it is necessary to compute the weight of the structure. The total weights of 15 of the sampled houses were computed in order to get a reasonable sample of the typical weight of a house. Of the house type addressed by this study, all had wood crawl-space walls. The maximum lateral shear forces occur at the lowest walls, which for most of these houses are the crawl-space walls. The latter essentially constitutes a low floor. The total weights of the houses varied between 50 and 165 kips. These weights, for a square foot of living area, are between 40 psf and 55 psf.

The stated numbers include the following: roof (sometimes several layers of roofing materials) and roof framing, ceiling and floor framing and finishes (including carpeting), exterior and interior wall framing and finishes (excluding unit masonry veneers), and built-in furnishings. The weight excludes: cripple walls, chimneys and other masonry fixtures (which were assumed to act independently of the structural framing during lateral motion), exterior unit masonry veneers (which were assumed to be unanchored to the framing and would therefore separate and collapse during strong ground motion). Live loads (furnishings, etc.) were excluded from the calculations.

Typical weights of the selected types of houses were necessary for a second reason: to formulate strengthening features, it was necessary to know the average weights of typical houses so that conservative designs could be recommended.

Lateral force coefficient assumptions

During the initial checks for lateral stresses of selected houses, two lateral force coefficients were assumed: 0.15 g. and 0.20 g. The former coefficient essentially meets the requirements of the 1979 Uniform Building Code. The second, higher number represented a stronger earthquake (to account for the proximity of the Hayward fault to the sampled houses, which were always less than five miles away from the fault).

Under both assumptions, calculations for several houses indicated that significant amounts of additional lateral bracing of existing walls would be required both in the cripple stud walls and in the exterior and interior shear walls of houses with horizontal exterior wood sheathing or with exterior stucco (generally over horizontal sheathing). These results were reviewed, taking into consideration the fact that most current code requirements are based on experience with non-wood structures. The significant increases in the lateral force coefficients following the San Fernando earthquake of 1971 were simulated from the poor performance of masonry structures designed to a coefficient of 0.12 g. or less. One the other hand, the experience with wood-frame houses such as those of the present study, is generally good. Failures have usually occurred in the absence of adequate connections or appropriate lateral force resisting systems. Based on past studies, it was decided that a lateral force coefficient of 0.10 g. would be appropriate for checking the seismic resistance of the wood-frame buildings. It was indicated by the Technical Advisory Panel that 0.10 g. would be the approximate value received for wood-frame construction in the next code revision.

The lateral force resistance of the subject buildings was recomputed using the 0.10 g. coefficient. Using that coefficient, the following conclusions were reached:

- Available, properly constructed shear walls of the typical house usually provide sufficient resistance, except in cases where exterior walls (or wall) are dominated by openings.
- Diagonal sheathing, if and when properly nailed, provides sufficient bracing in crawl-space walls.
- Additional plywood bracing of crawl-space cripple walls is necessary unless sufficient diagonal sheathing is present.

Selection of strengthening details

Recommended strengthening details were designed on the basis of material properties, allowable stresses, and engineering analyses that generally follow the recommendations of R. W. Goers [A Methodology for Seismic Design and Construction of Single-Family Dwellings, 1976]. Two of those strengthening details are outlined below.

- Shear resistance of crawl space. On the basis of computations and review by the Technical Advisory Panel, it was determined that a minimum of six feet of additional plywood bracing would be required in each direction in each corner of the house (a total of eight panels), with a capacity of about 700 plf. The length of the bracing should be increased so as to equal at least twice the height of the crawl space.
- Foundation anchor bolts. For single-story houses, the current requirements in California are sufficient--1/2-inch diameter bolts, six feet on center. For heavier, two-story houses, 3/4-inch diameter bolts; and for heavy three-story houses, four-foot centers are required.

A "walk through" survey of each house was conducted in order to collect the necessary data for subsequent engineering calculations and strengthening recommendations. The methodology for a typical "walk through" is described in the following section.

## F. SITE VISITS

### Applicant screening

When a potential participant telephoned in response to EAS program announcements, CPDR office staff recorded name, address, age of house, and contact information (telephone numbers at home and work). Research staff then screened the application according to project criteria: age and size of dwelling, construction materials, location with respect to the seismic study zone, and slope at the site.

In the order in which calls were received, the first 15 participants were chosen as they became eligible. To obtain a broader sample, the second 15 case studies were selected from residents of Oakland. However, analysis revealed a close similarity of characteristics, regardless of Oakland or Berkeley residence, and participants were therefore treated in the data as a single set.

Selected applicants were contacted by telephone and appointments were made for a site visit. Most of the visits were scheduled for early evening or on weekends, to accommodate applicants who work or have other obligations during the regular work week.

### Site visit procedures

The entire research team conducted the first case study to establish and verify methodology. This had been prearranged with the participant who was prepared for the large number of people who visited her home. In other site visits, the research team consisted of two, or in some cases, three staff members. The engineering consultant, Peter Yanev, attended initial site visits with all members of the research team. In other cases he visited the home at a different time which he arranged directly with the participants.

Site visits began with a discussion including as many members of the household as were interested in the subject. Maps obtained from the U.S. Geological Service, local seismic safety elements, and other engineering studies served as a base for discussing the general characteristics of the dwelling's location with respect to seismic hazards. This discussion included: (1) the location of known faults and ground ruptures and fault traces; (2) location of dams which could be subject to rupture in the event of a seismic episode, and potential flood areas; (3) geology of soil in the vicinity, and (4) the potential of tsunami, seiches and landslides. The discussion provided participants with an understanding of the relationship of their home to general seismic hazards apart from the specific structural features of the dwelling. It also enabled homeowners to assess the safety of their dwelling's location relative to other residential locations in the area.

During the first site visit a questionnaire--developed to survey case study participants, their structures, and their previous experience with earthquake hazards--was administered. [Those who requested, but could not be given, direct technical assistance also completed questionnaires; these forms were mailed with letters stating that completion of the questionnaire was a prerequisite to receipt of the homeowner's manual. Results of this survey appear in Section II, page 41.]

Before beginning the survey of the property and the structure, participants were urged to pose questions relevant to the project and its available services. The project's purpose and scope were fully explained and its dependence upon participant contribution was stressed. An assessment of the participants' ability to make repairs, through their own labor or that of hired workers, was made.

Typical "walk through" of a sampled house

The "walk through" of a house generally required between one-and-one-half to three hours. It was accomplished by two or three staff members under the supervision of the project principals or the consulting engineer. The "walk through" can be divided into three major areas, each concentrated on the following: geotechnical aspects; structural details; and nonstructural details.

Geotechnical aspects. The geotechnical investigation was necessary in order to eliminate sites which did not meet the criteria of acceptance and to determine the approximate intensity of expected ground motion, given a large magnitude earthquake on a nearby active fault (the Hayward fault in all cases). Fifteen to 30 minutes were spent reviewing the available geotechnical data, which was collected from publicly available information, such as the Seismic Safety Elements for the Cities of Oakland and Berkeley, and published maps by the U.S. Geological Survey, the California Division of Mines and Geology. For each building, the following were reviewed as available:

- geologic maps
- fault maps
- isoseismal (intensity) maps
- underground channel maps
- landslide and other ground instability maps
- reservoir failure flood maps

Structural details. The second step in the building "walk through" involved assessment of architectural and structural characteristics. Both the interior and the exterior of the buildings were evaluated. Sufficient data was collected in order to carry out a simplified analysis of the lateral force resisting system of the building.

House exteriors were investigated in order to determine the following:

- General extent of shear walls and windows and other openings.
- Chimneys and their possible failure mechanisms and paths. (The quality of mortar of exterior masonry chimneys was determined by removing a small portion in a sampling of areas. Advisors had to be careful to avoid being fooled by recent cosmetic treatment

of the joints which did not reflect the general quality of the mortar in the chimney. The potential for attaching the chimney to the house structural members was assessed. Portions of the chimney protruding above the house were examined for the potential to be replaced by metal flues or to be braced by addition of metal straps, rods, or other braces. When chimneys were supported in the sub-area, inspections were made of the adequacy of the foundation and that portion of the chimney visible in the sub-area. In many cases, settling created a gap between portions of the masonry chimney.)

- Porches and their supports. (Hazardous conditions exist particularly where columns supporting porch roofs are inadequately fastened to the roof structure. It is often difficult to determine the adequacy of connections without actually dismantling portions of the structure. If connections were deemed inadequate, metal fasteners were suggested.)
- Additions, particularly enclosed all-glass porches.
- Other heavy ornamentation and architectural features which might be hazardous.
- Exterior masonry veneers.
- Hazardous trees and other vegetation.
- Multi-layered old roofs.
- Condition and type of siding. (Of particular concern: improperly fastened wall coverings or wall coverings which in other ways did not possess the structural integrity intended in the original design. Cracked stucco, inadequately nailed wood siding, deteriorated or split wood widing, and other indications of deterioration were identified.)
- Types of existing seismic resisting elements.

The next step, investigation of house interiors, focused on the following features:

- General adequacy of the interior walls and how they might aid exterior walls in resisting the seismic loads.

- General condition of the interior finishes, specifically the extent of cracking to old plaster.
- Condition of interior chimneys, particularly in the attic where they might suffer a bending failure.
- Dangerous interior features such as unbraced heavy bookshelves and unbolted kitchen cabinets.
- Water heaters and furnances which were not braced or bolted; piping, supplying gas to the appliances, should also be strapped or in another manner fastened to the structure.
- The safer areas of the house.

Sub-area. The sub-area or crawl space (the area between the ground and the first story of houses built on wooden joists) was carefully inspected to determine the condition of the foundation, cripple walls, and the connections between the first floor and the structural members supporting it. Probably the most important thing to determine in the sub-area is whether the mud sill is attached to the foundation. This normally was determined by inspecting for the presence of foundation bolts which project through the top of the mud sill. If not present, careful inspection determined use of other methods of fastening. In the absence of fastening, recommendations were made according to the manual's directions for proper securement of the mud sill to the foundation.

Connections. The adequacy of connections between various members of the structure is widely viewed as the most critical element determining the wood-frame structure's ability to resist earthquake force. Where necessary the addition of metal connectors were advised to improve the quality of such connections.

The condition of all wood members was examined. Wood rot and insect infestation and damage were identified and damaged or infested members recommended for replacement.

Lateral support

Bracing. The adequacy of bracing of sub-areas was determined. In the case study houses it was commonly found that the joists rested on cripple walls, not directly on the foundation; some lateral support on cripple walls was recommended.

Sheathing. Diagonal sheathing is desirable, but it was not assumed that it had been properly nailed. Inspections, involving removal of portions of exterior cladding, were made to determine the adequacy of the nailing. Where diagonal sheathing was not present, the addition of lateral bracing was suggested. (As shown in the homeowner's manual, this is done by adding plywood at the corners of the structure or other strategic locations. If the surface to which the plywood will be nailed is not in a single plane, then blocking is necessary to provide a single plane for nailing of the added bracing.)

It is a common condition in older homes that sill plates are wider than the studs which they support. In this case, blocking in the same dimension as the studs can be nailed on the sill between the studs, or the studs can be furred out to the same plane as the sill plates. It was explained to participants that sheathing added to provide lateral bracing must be nailed entirely around its perimeter and in the field to intermediate structural members in order to achieve the desired strength.

Column connections. Where beams were supported on columns in the sub-area, inspection was made to determine the adequacy of connections at the top and bottom of the column. Where adequate connections did not exist, it was recommended that metal fasteners, nailing, or straps be added.

In summary, the final step of the "walk through" involved the building's foundation, which was examined for indications of major settling or structural cracking which may have resulted from previous seismic activity or significant ground movement. The following were evaluated:

- Extent of bolting.
- Crawl-space bracing.
- Other bracing of posts and taller columns.
- General conditions of the concrete foundations. (This was determined by checking for spawling or indications of poor-quality cement. If the foundation was not constructed of concrete but rather of unit masonry, mortar was inspected for its condition. Recommendations were made for the partial replacement of non-concrete foundations.)
- Type of bolting required and spacing of bolts; use of steel plates when bolting would be difficult.

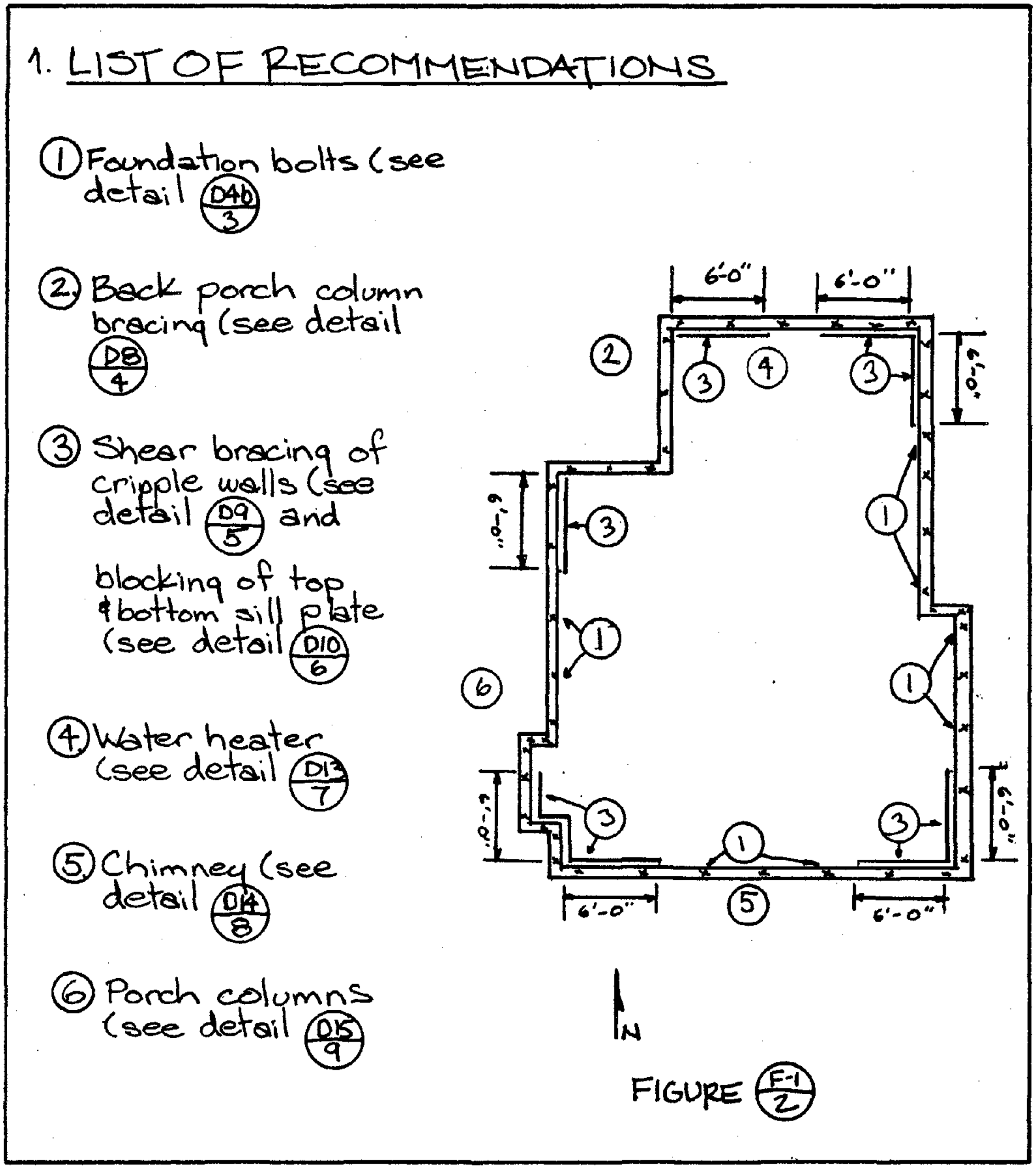


FIGURE 3. Typical list of recommendations. EAS participants received floor plans of their houses, indicating the location of modification recommendations. Attachment sheets detailed the modification work that was required.

## G. SELECTION OF RECOMMENDATIONS

Upon completion of the house inspection, the research team assembled a set of recommendations concerning the deficiencies found in the house. The prepared material included a diagrammatic plan of the house with references indicating the location of each recommendation. [See Figure 3 for an example.] The floor plan noted the location of major longitudinal and transverse walls, and the configuration of the foundation indicated the location of all posts and columns as well as poured and pier foundations. The presence of standing water or other indications of a high water table, which may indicate unstable soil conditions, was noted.

Before the recommendations package was given to the homeowners, they were asked to sign a waiver of liability form [see Appendix 4].

Participants were encouraged to call the EAS if they needed further clarification or other assistance. Where necessary, project staff revisited the home to clarify information not adequately obtained during the initial site visit. In some cases participants requested that staff also return when hired construction workers who would be making the modifications were present. At that time staff explained what was required.

The major structural alterations suggested to the project's 30 participants are summarized in Figure 4.

| STRUCTURAL IMPROVEMENTS NEEDED | PARTICIPANTS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Replace brick foundation with concrete walls and footing | ● | | | | | | | | | | | | | | | ● | | | | | | | | | ● | | | | | |
| Insert expansion bolts in existing concrete foundation | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Install metal plates in areas where foundation is inaccessible from crawl-space | | | ● | ● | ● | | | | ● | | | ● | | | ● | | | | | | | | ● | | | | ● | | | |
| Brace post/beam connections in basement and crawl-space | | ● | | | ● | ● | ● | | ● | | | | ● | ● | | ● | | ● | ● | | ● | ● | | ● | ● | | ● | | | |
| Brace cripple walls with structural grade plywood | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● |
| Nail exterior diagonal sheathing | ● | ● | | | | | | | | | | | | | | ● | | | | | | | ● | | | | | | | |
| Brace water heater | ● | ● | | ● | ● | | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Brace interior and/or exterior chimney | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | ● | | | ● | | ● | ● | | ● | |
| Brace porch column connections | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | ● | ● | ● | ● | | | | | ● | | | ● | ● | | | | ● | |
| Brace narrow shear panels with hold-downs | | | | ● | | | | | | | | | | | | | ● | | | | | | | | | | | | | |
| Obtain additional engineering analysis | | | | | ● | | ● | | | | ● | | | ● | | ● | ● | | | | | | | | | | | | | |

FIGURE 4. Major recommendations given the 30 EAS project participants.

## H. FINAL CONTACT WITH PARTICIPANTS

During the first two weeks of September, the 30 EAS participants were contacted and asked to give general evaluations of the program. The participants were also contacted via telephone 45 days after the recommended improvements packages were handed to them by the project staff.

The participants expressed enthusiasm and appreciation for the project. All had received draft copies of the homeowner's manual, but had no specific comments or further suggestions.

As indicated in Figure 5, of the program's 30 participants, 12 had begun performing the suggested modifications as of early September. Of these 12, one participant had completed all the modification recommendations and five participants had completed one recommendation.

It is important to note that eight of the first 15 participants had started on the recommendations by early September, as contrasted with only four of the second 15 participants. One reason is that the first 15 participants had received their recommendation packages at least one full month before the remaining 15 participants and therefore had more time to begin modifications. The first 15 participants also had the added motivation of being closely involved in the EAS program during a period of seismic activity (notably, during the Livermore tremors, the effects of which were strongly felt in the East Bay area). Generally, people grow more concerned about earthquake hazards immediately after seismic events. During the EAS development project there was a close correlation between seismic activity and activity undertaken by participants to reduce the consequences of earthquakes. Site visits and phone calls to the second group of participants occurred during the summer--a time of relative seismic inactivity locally.

By early September, with only one exception, all of the participants who had begun modification work had employed subcontractors to perform the labor. Bolting of the sill plate to the foundation wall, and bracing of the cripple walls with plywood sheets were the most common recommendations requiring use of hired labor.

Most participants expressed doubts about the economic, technical or aesthetic feasibility of bracing the chimney. Similar doubts were expressed when reinforcing porch columns could only be achieved by removing elaborate trim work either at the base or capital of the column.

As part of the recommendation package, participants received a list of construction firms known to be familiar with earthquake mitigation work. Two participants, however, expressed concern over the abilities and experience of the firms they had hired. While these two cases may be atypical of the general capabilities of contractors, some construction firms may need training before undertaking the structural improvements recommended by the EAS project.

Most of the participants expressed preference towards hiring help in performing the work needed. They attributed this preference to (1) limited available time to do the physical labor; (2) the crawl space being too constricted for easy access, and (3) unfamiliarity with materials and tools needed to perform the work.

Of the 18 participants who had not done any of the recommendations, two were in the process of obtaining estimates. Others were positive about doing the recommendations in the near future, but stated that other repairs (such as installing a new roof) currently took precedence over earthquake mitigation improvements.

| Participants | Number of Recommendations | Kind of Recommendations * | Recommendations Performed | Kind of Recommendations Performed | Method | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | Own Labor | Labor Contracted | |
| 1 | 5 | a,e,f,g,h | | | | | |
| 2 | 7 | b,d,e,f,g,h,e | | | | | Next Spring. |
| 3 | 6 | b,c,e,h,i,j | | | | | Don't know when. |
| 4 | 6 | b,c,e,g,h,i | ✓ | b,c,e,g | | ✓ | |
| 5 | 8 | b,c,d,e,g,h,i, k | ✓ | b,i | ✓ | ✓ | Bolting by contractor; rest themselves. |
| 6 | 5 | b,d,e,h,i | ✓ | b | | ✓ | Will not do chimney. |
| 7 | 7 | b,d,e,g,h,i,k | ✓ | b | ✓ | | Will do work themselves. |
| 8 | 5 | b,e,g,h,i | ✓ | b,e | | ✓ | |
| 9 | 6 | b,c,d,e,g,h | ✓ | b,c,d,e,g | | ✓ | |
| 10 | 5 | b,e,g,h,i | | | | | Next summer. |
| 11 | 6 | b,e,g,h,i,k | | | | | Roofing will be first this year. |
| 12 | 3 | b,c,e | ✓ | b,c,e | | ✓ | |
| 13 | 6 | b,d,e,g,h,i | ✓ | b | | ✓ | |
| 14 | 7 | b,d,e,g,h,i,k | | | | | Have to do roof first. |
| 15 | 4 | c,g,h,i | | | | | |
| 16 | 7 | a,d,f,g,h,i,k | | | | | In the process of getting estimates. |
| 17 | 6 | b,e,g,h,j,k | | | | | |
| 18 | 5 | b,d,e,g,h | ✓ | b,d,e | ✓ | ✓ | Bolting by contractor. |
| 19 | 5 | b,d,g,h,e | | | | | |
| 20 | 3 | b,e,g | | | | | |
| 21 | 6 | b,d,e,g,h,i | | | | | In the process of getting estimates. |
| 22 | 4 | b,d,e,g | | | | | |
| 23 | 4 | b,c,f,g | | | | | |
| 24 | 6 | b,d,e,g,h,i | ✓ | b | | ✓ | |
| 25 | 6 | a,b,d,e,g,i | ✓ | a,b,d,e,g,i | | ✓ | |
| 26 | 4 | b,e,g,h | | | | | |
| 27 | 6 | b,c,d,e,g,h | | | | | Too many other things; will do it in the future. |
| 28 | 3 | b,e,g | | | | | |
| 29 | 5 | b,e,g,h,i | ✓ | b | | ✓ | |
| 30 | 3 | b,e,g | | | | | |

*
a, replace brick foundation
b, install expansion bolts
c, install metal plates
d, brace post/beam connections
e, brace cripple walls
f, nail exterior sheathing
g, brace water heater
h, brace chimney
i, brace porch columns
j, install hold-downs to brace narrow shear panels
k, additional engineering analysis needed

FIGURE 5. The above chart outlines the progress on structural modifications that had been made by EAS participants as of September, 1980.

## I. MATERIALS AND FORMS

A complete set of materials was developed to aid local agencies in implementing Earthquake Advisory Services. The materials include a manual for construction specialist and homeowner participants, a field kit for EAS advisors, participant recruitment flyers and posters, news releases and a questionnaire to survey EAS participants. Local jurisdictions may modify and supplement the materials to provide information relating to local seismic hazards, building permit requirements, inspections, loan programs, materials, tool rental, and other forms of local assistance. The following briefly describes the two basic EAS aids.

The manual. Titled Earthquake Hazards and Wood Frame Dwellings, the manual is intended for use by homeowners with minimal knowledge of construction. It describes the nature and origin of seismic activity; basic geological considerations; structural problems experienced in past earthquakes; remedial work which can be conducted after identification of defects; and general suggestions for earthquake preparedness. This manual is illustrated with drawings for such tasks as foundation repair and the bracing of water heaters. A glossary of terms relating to seismology as well as building construction is provided. The manual can be amplified with lists relevant to the local context: sources of materials, tools, technical and construction assistance, permit requirements and procedures, and agencies providing earthquake services.

The EAS Advisor's Field Kit. A set of single-page handouts contain recommendations to remedy the common structural defects identified during the study project. [In preparing the recommendations there was an effort to simplify the skills necessary for categorizing the building defects and selecting appropriate modifications. Therefore, the modification recommendations do not cover certain difficult situations, for which consultants may be required.] The kit includes guidelines for conducting site visits, and a representative recommendation package to be provided homeowners. [See Appendix 4 for an example of the Field Kit.]

## J. PARTICIPANT PROFILE

A six-page questionnaire was designed to survey EAS program participants, their structures and their "seismic awareness". Of the more than 300 people who had requested direct technical assistance but could not be included in the case studies, 113 Bay Area homeowners completed the questionnaires as a prerequisite to receiving the homeowner's manual. The results of the mailed-in survey are summarized in Figure 6. The 30 case study participants, who also answered the questionnaire, are excluded from the tabulations. However, no significant differences existed between answers given by the case studies and those by respondents to the mailed survey.

As Figure 6 shows, the survey's respondents are educationally and professionally atypical of the general population. One explanation points to the prototype's outreach methods: the type of advertising and where it was advertised. A majority of respondents learned of the EAS program through newspaper articles, and regular newspaper readers often comprise a highly educated minority within the larger population. Many university-employed persons found out about the program through campus newsletters, thus accounting for the large percentage of professors who responded. The prototype's outreach methods were not deliberately designed to attract the portion of the population that it did; the result, however, emphasizes that EAS host agencies must carefully devise outreach programs to reach the targeted population.

## QUESTIONNAIRE RESULTS

OUTREACH METHOD (how respondents found out about the EAS program):

| Friend | Press | Radio | T.V. | Planning Dept. Leaflet | Neighborhood Assoc. News | UCB Bulletins | No answer |
|---|---|---|---|---|---|---|---|
| 5% | 45% | 0.8% | 0% | 2% | 20% | 15% | 9% |

### DEMOGRAPHIC PROFILE:

**Residence location**
- Berkeley.......85%
- Oakland........ 6%
- San Francisco.. 3%
- Other East Bay area.......... 6%

**Respondent's age**
- Under 40.......43%
- 40-60..........34%
- Over 60........15%

**Group Composition**
- Family.........50%
- Couple or single........32%
- No answer......18%

**Education**
- BA.............18%
- MA.............37%
- Above MA.......43%
- No answer...... 2%

**Employment**
- Clerical....... 5%
- Teacher.......4.5%
- Self-employed professional..24%
- Professor......22%
- Social work.... 5%
- Administrator..15%

### HAZARDS AWARENESS:

**Respondents experiencing geological or other natural disasters**
Yes.....35% No.....61% Unknown.....4%

**Awareness of fault systems**
- Calaveras/Hayward/San Andreas...................53%
- Hayward/San Andreas............................40%
- San Andreas.................................... 6%

**Awareness of earthquake related hazards**
- Ground shaking/ground failure/tsunami/seiches... 8%
- Ground shaking/ground failure/tsunami...........40%
- Ground shaking/ground failure..................29%
- Ground shaking.................................10%
- No knowledge...................................11%

**Awareness of information about seismic hazard mitigation**
- Yes and read it...........40%
- Yes but haven't read it..23.7%
- No knowledge..34%
- No answer....2.3%

**How often respondents think about earthquakes**
- Quite often.........13%
- While at home.......17%
- While at work....... 9%
- While driving across the bay.....11%
- While at public gatherings......... 9%
- When reading about it...........26%
- Never...............10%
- No answer...........26%

**When respondents think next great earthquake will occur**
- Less than 5 years...14%
- 5-10 years..........28%
- 20 years...........17%
- More than 20 years..11%
- No answer...........23%

### PROFILE OF STRUCTURES:

**Age of dwelling**
- Over 50........74%
- 25-50..........21%
- Under 25....... 3%
- Unknown........ 2%

**Size (sq. ft.)**
- Over 2000......47%
- 1500-2000......32%
- Under 1500.....19%
- Unknown........ 2%

**Construction**
- Woodframe.....100%

**Number of floors**
- One.................23%
- Two.................57%
- Three...............16%

**Foundation**
- Brick..............11%
- Concrete...........87%
- Unknown............ 2%

**Exterior finish**
- Stucco................61%
- Wood siding...........18%
- Cedar shingles........16%
- Masonry veneer.......1.5%

**Roof**
- Asphalt shingles......53%
- Tar & gravel..........20%
- Clay tile............ 9%
- Slate................. 2%
- Wood shingle.......... 7%
- Other................. 2%
- Unknown............... 7%

FIGURE 6. Major results of the participant survey.

# III. IMPLEMENTING AN EARTHQUAKE ADVISORY SERVICE

The Earthquake Advisory Service prototype described in this report can be applied without major modification in most areas where wood-frame, older (pre-1940) buildings predominate. The proposed model assumes implementation through an existing, local nonprofit, private housing assistance or development program, or through a local government agency involved in assisting the acquisition or rehabilitation of existing dwellings. Such programs typically operate around loans and grants available through the federal government (primarily from the Department of Housing and Urban Development and through the Farmers' Home Administration). Some community groups funded by the Community Services Agency, state funding or other sources may also serve as host agencies. In some jurisdictions, building code enforcement agencies may choose to provide EAS programs.

Technical and financial support from various governmental levels can significantly assist in the program's implementation. However, the service can be implemented immediately, within the framework of many existing local housing programs, with little additional expense or effort. Potential EAS host agencies that operate only during regular office hours, however, must seriously consider making site visits and consultations with clients after normal working hours and on weekends. Failure to do so could inhibit the EAS program's effectiveness.

Applications in different localities within specific agency operations and in response to local conditions of structures, population characteristics, and geological and seismological characteristics will dictate modifications of the mode and adaptation to the local context.

This section expands upon major implementation details that were outlined in Section II's prototype description.

## A. PUBLICITY PROGRAM

The agencies most likely to implement EAS programs typically have existing channels of information dissemination and know how to best reach their own target population.

Publicity programs should advise potential participants of general eligibility requirements if any, costs of service if any, extent of services, and methods for contacting the host agency to request assistance. Whatever the method of publicizing the Earthquake Advisory Service, care should be taken not to raise expectations beyond the ability of the agency to respond to the demands created by publicity. A cautious initial publicity effort is advised to avoid overloading project staff.

B. PERSONNEL

The EAS prototype assumes the availability of a construction specialist who can implement the program in the field. The potential EAS host agencies described above often employ construction specialists, and those individuals already in the employ of host agencies have the added advantage of experience with the host agencies' clientel. Agencies not already employing such a person, however, should encounter no difficulty recruiting competent personnel. There are generally many qualified individuals in a given locale available to perform construction specialist functions.

Construction specialists typically have extensive background in residential construction as contractors, builders or trades-people. They can assess building characteristics, identify the various components of the building, and recognize irregularities or digressions from standard practices. They are able to assess the work necessary to upgrade a structure, either in terms of performance with respect to code or to improve its aesthetic or functional qualities. They must be capable of conducting competent materials takeoffs and preparing cost estimates for completion of required work. They usually have little or no training in structural analysis or design, but are capable of performing mathematical computations. Construction specialists typically are familiar with major local institutions involved in construction, and, frequently, housing development programs--particularly the development of government-assisted housing. They are familiar with local regulatory agencies.

The EAS host agency may wish to provide back-up technical support to the earthquake advisors. Technical support mechanisms could include the retention of an engineer or architect on a fixed-fee or cost-plus basis. While such services increase the cost of the Earthquake Advisory Service, the availability of professional advice on difficult cases may justify the added expense.

## C. FINANCIAL CONSIDERATIONS

Project funding. Many agencies may be able to include Earthquake Advisory Services with existing services at no additional charge. If so, the funding problem resolves itself. Agencies wishing to recover the costs of services can directly charge clients, or seek a subsidy or other support from local, state or federal agencies. Costs could also be recovered as part of the fee included in the housing agency's packaging costs. Experience in developing the EAS prototype indicates that the handling of each client case requires approximately two to three field-staff hours and one-half to one office-staff hour. However, if the program is incorporated into other regularly provided services, the time involved need not be as large. Earthquake hazards inspections can become a routine part of total house inspections and probably will not contribute more than an hour of additional time.

Financial support for participants. Sponsoring agencies might consider providing financial assistance for the costs of materials, equipment and even labor involved in making modifications recommended under an EAS program. Based on experience with the EAS prototype, such costs may range from $200 to $1000 per case.

Nonprofit EAS programs can financially help participants in less direct ways. The agency could help homeowners economize by running their own tool rental service and loan library. The agency could even purchase and resell foundation bolts and other hardware items at a bulk purchase discount and pass along the savings to self-helpers.

If modifications can be included in a program which provides subsidized loans or grants to homeowners, efforts should be made to seek such support. Local or state government could establish a revolving fund to encourage the conduct of recommendations made by the EAS programs. There are other potential schemes (such as community development block grant funds) for developing financial support for earthquake mitigation programs that each locale should explore.

## D. MAKING RECOMMENDATIONS TO PARTICIPANTS

In cases where the inspector doubts the adequacy of certain elements of the house, or where problems are not within clear guidelines established in the manual, an engineer or architect should be called to help resolve the questions. Even with professional advice, the correct course of action in some situations may be difficult to determine. In many cases the homeowners' preferences and the aesthetic and functional impact of modifications on the house will govern over structural factors.

Upon completion of the house inspection the advisor should assemble a set of recommendations concerning the deficiencies found. A cover sheet should be prepared, containing a diagrammatic plan of the house, with a reference indicating the location of each recommendation. A list of other materials provided the homeowner should be noted. All recommendations should be made in writing and a copy of the cover sheet, index, waiver form, and diagram locating recommendations should be retained for the advisory service's records. In addition to limiting the advisory service's liability, this procedure provides advisors in the office with background information in case the homeowner contacts the agency later for further advice.

Participants must be clearly informed of the importance of obtaing building permits and reviewing building code performance standards before performing structural modifications. It must be stressed that strengthening procedures recommended do not necessarily bring the dwelling "up to code" since electrical, plumbing, and other structural code considerations--while discussed with the homeowners--do not constitute a major part of the EAS project.

If the advisory service conducts follow-up visits for continued technical assistance, that information should be provided. Advisors should make certain that homeowners have opportunities to clarify any points of confusion before concluding the visit.

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# IV. THE EAS PROTOTYPE: VARIATIONS AND ALTERNATIVES

The diversity of the population demands a diversity of mechanisms through which to best serve it. Depending upon the host agency's mission, funding, clientele, location and other factors, some of the options described briefly below may be considered. Many of the possibilities can be additions to rather than substitutes for the prototype.

(1) Indirect technical assistance, the provision of generalized recommendations through written and visual information or other presentations, involves no person-to-person contact. Programs could distribute information free, or at cost to encourage the use of the information developed under the EAS project. There are many people for whom indirect technical assistance is quite adequate, if not preferred.

Radio, TV, video tape, and movie or slide presentations could be developed based on the work to date. The Lawrence Hall of Science and the CPDR, University of California, Berkeley, are exploring options to develop training sessions for community leaders based on the EAS prototype and the information developed for it. Community groups--neighborhood associations--can utilize such materials, training sessions, or media for direct or indirect technical assistance.

(2) Private sector mechanisms. Many private sector institutions--including components of the building industry, the financial community, and the insurance industry--could play an active role in facilitating residential earthquake hazard mitigation. Small firms offering structural improvement services could provide Earthquake Advisory Services based on the CPDR prototype.

Some EAS host agencies might retain a consulting engineer to provide direct service to their clients. Some architects and engineers offer this type of service on an hourly-rate basis, and local agencies may wish to hire such an individual on salary in order to partially reduce the cost of such services. This is a viable alternative for homeowners or agencies who can afford such services.

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(3) Government involvement. The use of federal resources for a limited population often draws heated debate. However, disaster relief legislation and programs transfer the liability for disaster to the general population. The entire populace therefore benefits from reduction in property and life loss in the event of a major earthquake. The housing advisory service model on which the Earthquake Advisory Service is based represents only one of many effective mechanisms available to government. Following are some alternatives which could be considered.

- Assistance to the private sector. Local governments may offer financial assistance for the upgrading of buildings, with participation in an EAS program as a condition for receiving loans or grants. These funds could be a fixed amount for a specified purpose in which the homeowner self-certifies and self-qualifies or, at the other end of the spectrum, could be provided under strict guidelines. The availability of loans at reduced interest rates could greatly encourage those with financial limitations to make the necessary modifications. Building code enforcement programs have successfully used this type of program.

  Technical assistance could include the availability of a government-supported contractor who directly provides assistance either to homeowners or to host agencies. (Examples of such programs include agricultural extension services, and housing and energy advisory services.) Providing both indirect and direct technical assistance, the technical assistance contractor could prepare materials, conduct training sessions, troubleshoot within given agencies, and facilitate information transfer from the local level to appropriate state and federal agencies.

  Government could also provide technical assistance and training to private firms and individuals in the construction or construction design fields. (Over the past three years the California Energy Commission has provided such assistance to help the private sector understand the intent, nature and use of the Commission's regulations.) Conferences and published materials can aid in transferring the information gained in the Earthquake Advisory Service to the private sector.

- Underwrite implementation costs. State or federal government agencies could encourage the establishment of Earthquake Advisory Services by underwriting local programs during the critical start-up phase. Such a program would focus on the training of personnel, the preparation of materials for the establishment of an ongoing program, and the provision of technical aid during the early stages.

  The government should consider funding a portion or all of the costs of ongoing operation of EAS programs. Such support becomes particularly effective when focused on target urban populations with high levels of need. (Such support is currently provided in California for housing advisory services on a pilot basis, and has already been used extensively in energy conservation services.)

- Mandatory regulations. Some jurisdictions have taken steps to require retrofit of structural improvements to existing buildings. These measures, however, frequently meet with resistance by community members. In a time of increasing criticism of government intervention and growing regulatory powers, programs based on voluntary action in response to government-assisted information should be identified and implemented. The proposed EAS program does not require massive funding or government support.

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## V. RELATED ISSUES

Several concerns related to earthquake hazard mitigation were identified during the EAS prototype development, but were outside the scope of the project. A few of these concerns, which could be addressed in the implementation of Earthquake Advisory Services, are identified here.

(1) Rental property. Although the EAS prototype project advertised services for tenants, no tenants applied. Perhaps they were discouraged from doing so because they did not believe that landlords would willingly bear modification costs or allow tenants to make changes to the structure. Tenants also justifiably hesitate to invest their own money, time and effort in dwellings that they may occupy for a brief time. If the dwelling seems unsafe, they may choose simply to move. However, Earthquake Advisory Services could provide tenants and landlords with building assessments and encourage voluntary modifications by the landlord, or cooperatively by the landlord and tenant.

(2) Special study zones. While the prototype excluded homes within the Alquist-Priolo Special Study Zone along the active Hayward fault, residences near known faults require special consideration and deserve attention.

(3) Masonry construction. The small amount of masonry residential construction in the San Francisco Bay Area, and in California in general, led to the elimination of masonry structures from the case study sample. This criteria proved unnecessary since no applications came from occupants of such dwellings. Further research projects could apply the EAS approach to masonry construction common in portions of the country which are subject to frequent seismic forces.

(4) Geological problems. Acknowledging the enormous influence of underlying geology on the functioning of dwellings, the EAS project attempted to make participants aware of geological considerations in assessing site hazards. However, geological considerations are not adequately integrated into the work of structural analysis and design engineering; the

two fields tend to remain separate and in isolation from one another. Future projects should explore the potential for integrating structural and geological considerations for dwellings and other structures.

(5) Liability. Liability questions often impede innovation of many worthwhile programs. It is an area that requires investigation. Although the NSF-funded, Association of Bay Area Governments' reports are useful, they require updating in light of recent court cases involving liability and responsibility to act.

(6) Mobile homes. The results of recent earthquakes have brought to attention deficiencies in the support structures for mobile homes. Although efforts have been made to install foundation tie-downs, programs to mandate or even guide such efforts at the California state level have been rejected by mobile home park owners as well as mobile homeowner's associations. The EAS approach of self-help techniques could considerably reduce the cost of such programs.

# VI. RECOMMENDATIONS

The Earthquake Advisory Service model is an effective one for the diffusion of knowledge, the raising of public awareness, and the mitigation of earthquake hazards considered too risky to endure. There are areas that, if further researched, resolved, and incorporated into the program, could greatly enhance its success. A few of those more critical areas are identified below.

(1) Local implementation within housing advisory services.

Often, government-supported housing programs have met the needs of narrowly circumscribed portions of the population. Many people find themselves ineligible for participation, or find the program unresponsive to individual needs. The housing advisory service concept attempts to correct this deficiency by providing advice and response tailored to the context of the client. Housing advisory services can play a significant role in connecting homeowners and tenants with resources which can best help them achieve goals within their own means and capabilities. It was this concept which originally gave rise to the development of the EAS program.

During the CPDR project, problems beyond the scope of the EAS program were expressed by the participants or identified by project staff. These concerns stressed the need for an integrated, comprehensive approach to housing advisory services. Earthquake Advisory Services should, to the maximum extent feasible, be incorporated into broad-focus housing advisory service programs. Where such programs do not exist, EAS programs should be implemented in such a way as to not preclude the future establishment of broadened activities.

Among the specific implementation recommendations, perhaps the most crucial is that EAS services must be extended to evenings and weekend hours to accommodate the many people who have other obligations during the regular work week.

(2) Government support.

Federal agencies (i.e., the Department of Housing and Urban Development, National Science Foundation, the Federal Housing Administration, the Federal Home Loan Bank Board, and the Community Services Administration) should consider funding demonstration EAS programs as well as other forms of support for local implementation of the prototype program. States in which seismic activity is a major concern should also support local efforts to implement the Earthquake Advisory Service in conjunction with ongoing housing programs.

(3) Improve earthquake mitigation data.

A comprehensive study should be conducted to improve upon the findings developed through the EAS project's review of experience of past earthquakes. Information on cases outside the scope of the EAS prototype (i.e., multi-family residences, masonry construction) must be explored.

Much of the data used to develop this project's structural analysis framework was assembled from obscure, difficult to obtain or antiquated sources. These include reports which had limited distribution, those developed without coordination with other data gathering activities, old studies which are relatively unknown but whose data output and conclusions form part of the tacit assumptions of earthquake engineering analysis, and data on structural assembly performance which is limited with respect to floor and wall assemblies and difficult to interpret due to possible differences between the test walls and the actual walls encountered in the field today. Other reports consulted were found to contain recommendations for new construction only and were not applicable to existing building stock.

These data problems should be addressed at a level of effort and at a pace commensurate with the value of such data and the state-of-the-art. In contrast to efforts devoted to engineering of large structures, structural engineering of dwellings has been virtually neglected. This is questionable, due to the large percentage of time people spend at home and the consequent level of exposure. The testing of wall assemblies, for example, could contribute considerably to the quality of residential earthquake engineering.

Present knowledge about wood-frame structural performance in earthquakes is lacking in specific detail for sound planning. This defect is currently treated by the use of safety factors, redundancy, margins of error, and other repetitive and costly measures. If, as is generally agreed, many structures are considerably over-built, the implementation of reduced or more realistic design standards could result in substantial dollar savings.

(4) Develop improved reporting of experience in seismic events.

A standardized reporting procedure for major future seismic events should be developed. The ad-hoc nature of existing reports, developed independently and with no consistent reporting techniques or presentation guidelines, creates difficulties in comparing the experiences of structures in earthquakes. An earthquake reporting procedure should be formulated by groups experienced both in the preparation and use of such reports.

Structural characteristics of buildings which were well documented after recent earthquakes should be reexamined in relation to current design practice and standards for evaluating probable performance of similar structures. Previous experience can aid in validating present assumptions. A more complete analysis should be compiled of the relative probabilities of property damage and life safety hazards involved in various structural defects. This data can be used in modeling large-scale predictive analyses of the effects of future earthquakes. In addition, relevant agencies should be notified of the implementation of EAS programs. Detailed records of the modifications should be developed, providing a base for comparing the experience of the improved houses with the general population of similar buildings. Researchers could then evaluate the effectiveness of various measures recommended under the EAS program.

(5) Develop incentives.

- Tax incentives: Local, state and federal tax programs (including both income and property) should consider incentives for investments in earthquake hazard mitigation. Such incentives have been employed in California with respect to energy conservation and historic preservation and should be explored for application in the field of earthquake hazard mitigation.

- Insurance incentives: Some authorities, suggesting that earthquake hazard mitigation through structural modification is not cost-effective, advocate the purchase of insurance in lieu of modifications. However, while the purchase of insurance minimizes "out of pocket" losses, they cannot defray social disruption or personal tragedy which accompanies structural and personal property damage. Earthquake insurance should be considered in addition to making necessary structural modifications.

  Other options exist. Reduced premium rates for earthquake insurance on modified structures (or generally for fire or homeowner insurance) could stimulate increased use of voluntary modification programs to improve structural performance. Insurance companies could withhold insurance or charge higher premiums for homes which have not undergone necessary modifications. Such measures would require drastic changes in the manner in which homeowner insurance is written. Common practice does not always include a visit to the home by underwriters, and a determination of the required work would have to be made and certified. Perhaps an EAS agency or a construction specialist could undertake that role. Because of the insurance industry's tremendous potential to encourage structural modifications to improve earthquake resistance, more possibilities should be explored in the insurance area.

(6) <u>Extend the EAS model to include other issues.</u>

The housing advisory service model has tremendous potential not only in the area of earthquake hazards mitigation, but in energy and other resource conservation, weatherization, housing production cost reduction, and public involvement and education in a variety of other housing activities. An especially relevant and topical application would be the delivery of technical assistance in the appropriate means of retrofitting energy conservation and passive solar devices. Current activities in the residential retrofit area have failed to utilize the potential of self-help and owner-built activities, and the result is a lack of homeowner involvement in the rehabilitation activity. The exclusion of the occupant in the process seriously inhibits the rapid diffusion of techniques and technologies.

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## VII. CONCLUSION

As this report goes to press, a major earthquake hit California's north coast. The November 9, 1980 earthquake, originating near the City of Eureka at 2:27 am, registered 7.0 on the Richter scale at the Berkeley seismic station. A major highway bridge collapsed and houses moved off their foundations. Responding to questions about the Eureka earthquake, Robert Wallace, chief scientist for the U.S. Geological Survey's Office of Earthquake Studies, told reporters: "There have been more quakes in the high fives and sixes in the past year and a half than there have been in a decade or so. A fairly long period of quiescence has come to an end in California."

The Eureka earthquake reemphasized that: (1) California is evidently in a cycle of renewed seismic activity, and (2) steps must be taken to reduce urban vulnerability to seismic activity.

The strengthening of public structures, like the highway bridge near Eureka, are to be addressed through approaches that were beyond the discussions of this report. But the private sector's own dwellings can be effectively approached through Earthquake Advisory Services programs. It is reasonable to assume that some of the estimated $2 million damage from the Eureka earthquake could have been reduced if the damaged homes had been securely attached to their foundations. The EAS program encourages these modifications and other remedial work on dwellings by providing: (1) information that has been translated from technical or scientific language, and (2) support through which people can utilize self-help methods to voluntarily strengthen their homes.

The EAS prototype demonstrates a method for earthquake hazard mitigation programs based on self-help. The information and local interest generated by the project is an additional, valuable result. More work needs to be done on large-scale implementation. As Bolt and Jahns stressed in their 1979 earthquake reassessment report, "Increasing efforts should be made to involve and activate the private sector more effectively [in comprehensive hazard mitigation programs]." If creatively applied, EAS programs could be a significant step towards addressing earthquake mitigation activity.



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# VIII. APPENDICES





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## APPENDIX 3: Housing Advisory Services—Background

In 1968 Congress passed the Housing and Urban Development Act requiring HUD to report to Congress on self-help housing in the United States. The Organization for Social and Technical Innovation, Inc. (OSTI) of Cambridge, Massachusetts, and San Francisco, California, conducted a study and prepared a report titled Self-Help Housing in the U.S.A. HUD asked OSTI to continue the work begun in their study and to recommend programs which might increase the utilization of self-help in the accomplishment of national housing goals. This project, completed in June, 1970, resulted in a number of recommendations including strong encouragement for the establishment of what was called the Housing Advisory Service (HAS). The HAS would operate at a community level providing assistance to owner builders and self-help rehabilitators, as well as tenant maintenance and management programs to assist people in overcoming barriers to self-help housing activities. The research team believed that self-help housing could bring affordable housing to a much larger portion of the American population.

In 1968 owner-builders constructed 160,000 single-family dwellings--approximately 18 percent of all single-family dwellings built that year. Historically the percentage of owner-built housing had been higher and appeared to level off during the 1960s. [More recent data indicates that the 16 to 20 percent of all single-family dwellings range has continued. In 1978, according to the Bureau of Census, 274,000 single-family dwellings were owner-built.[1] Additionally, self-help rehabilitation was believed to comprise the major portion of home repair and home remodeling activity. A more recent estimate places the percentage of such activity at between 65 and 75 percent of all home renovations.[2]]

The tremendous amount of owner-built and self-help building activity in the absence of government assistance suggested to the OSTI research team

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[1]Bureau of the Census, Department of Housing and Urban Development. Characteristics of New Housing. Construction Reports, Series C-13, 1968-1978.

[2]Organization for Social and Technical Innovation, Inc. Self-Help Housing in the U.S.A. Cambridge, Massachusetts, June 1969.



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that there was potential for a vast increase of self-help use if the government removed barriers and provided supports. The HAS was intended as a general housing assistance program which would respond to people's identified needs for assistance. Traditional programs of housing assistance are categorical and narrowly defined, tending to operate in isolation from one another. Potential participants who do not meet eligibility requirements grow discouraged and do not generally receive referrals to other agencies. Additionally, government support for assisted housing is small in proportion to the need because of strategies which focus primarily on massive subsidies. The HAS, in contrast, could operate on a cost-reimbursable basis.

In research conducted in 1968 in New England, and in the southeast in 1969, William C. Grindley found self-helpers/owner-builders reporting savings ranging from 25 to 70 percent of the cost of comparable, contractor-built housing.[1] While at the time the OSTI staff did not believe such savings were possible, recent experience has confirmed that owner-builders frequently do achieve such savings.

The HAS approach, as demonstrated in New York in the U-HAB program, can provide those without sufficient resources to meet down-payment requirements for homeownership with an opportunity to earn the equity through participation in the housing development.

In California in 1978, the Legislature established the California Housing Advisory Service in the State Department of Housing and Community Development. That program provided grants ranging from approximately $5000 up to $30,000 to local housing assistance organizations providing assistance to owner-builders and self-help rehabilitators. While the program is still relatively new, initial results indicate tremendous accomplishments and encourage further consideration of the HAS model.

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[1]Organization for Social and Technical Innovation, Inc. Self-Help Housing in the U.S.A. Report #8, Cambridge, Massachusetts, 1970.

## APPENDIX 4: EAS Advisor's Field Kit

The material assembled here represents a collection of items to be used by EAS field personnel during site visits. It includes:

(1) instructions for conducting the field visit, and
(2) a representative recommendation package to be provided to the participating homeowner.

The sample recommendation package provides:

(1) a cover sheet outlining the EAS project's intent, and recording the participant's name and address;
(2) a liability release form;
(3) a floor plan of a house, indicating areas that require modification; and
(4) attachment sheets detailing the modification work that is required.

Excluded from the recommendation package here are additional sheets which EAS host agencies will generate to provide information about local resources. These aids should list tool rental outlets, suppliers that stock materials and hardware commonly used in earthquake mitigation work, local firms specializing in construction modifications for structural reinforcement against seismic hazards, and other relevant forms of local assistance. Other information provided could relate to the area's specific seismic hazards, local building permit requirements, inspections, and sources of loan or grant programs.

While not provided here, the EAS advisor's kit would also include a full set of attachment sheets detailing common modification work [the EAS prototype project staff produced 25 of these basic guides]. The advisor would also have a copy of the homeowner's manual [Earthquake Hazards and Wood Frame Houses], and a set of appropriate maps from the U.S. Geological Survey Office and the local seismic safety elements. [For the Cities of Berkeley and Oakland, project staff referred to three basic maps providing the following types of information: location of reservoirs, above-ground and underground streams, possible areas of flooding, landslide areas, location of the Alquist-Priolo Special Studies Zone, recent fault line movement (field evidence), and the underlying geology.]

## SITE VISIT PROCEDURES: GUIDELINES FOR THE EAS ADVISOR

Site inspections, which require between one-and-one-half to three hours, can be divided into three major areas: geotechnical aspects, structural details, and nonstructural details.

### Meeting the participants

Site visits begin with a discussion including as many members of the household as are interested in the subject. A discussion of the general characteristics of the dwelling's location with respect to seismic hazards should include:

(1) the location of known faults and ground ruptures and fault traces;

(2) location of dams which could be subject to rupture in the event of a seismic episode, and potential flood areas;

(3) geology of soil in the vicinity; and,

(4) the potential of tsunami, seiches and landslide zones.

This "briefing" provides participants with an understanding of the relationship of their home to general seismic hazards apart from the specific structural features of the dwelling. Additionally, it enables homeowners to assess the safety of their dwelling's location relative to other residential locations in the area.

Before beginning the survey of the property and the structure, participants should be urged to pose questions relevant to the project and its available services. The project's purpose and scope should be fully explained, and its dependence upon participant initiative should be stressed. An assessment of the participants' ability to make repairs, through their own labor or that of hired workers, should be made.

### Geotechnical investigation

An evaluation of the geotechnical aspects of the site is necessary in order to determine the approximate intensity of expected ground motion, given a large-magnitude earthquake on a nearby fault. Fifteen to 30 minutes might be spent reviewing the available geotechnical data, which can be collected from publicly available information such as local seismic safety elements, maps by the U.S. Geological Survey, and other engineering studies. For each building the following types of maps can be reviewed: geologic; fault; isoseismal; tsunami; underground channels; landslide and other ground instabilities; and reservoir failure flood maps.

Structural details

The second step in the site inspection involves assessing architectural and structural characteristics. Evaluate both the interior and the exterior of the buildings.

The exteriors of the houses are investigated to determine the following:

- General extent of shear walls and windows and other openings.
- Chimneys and their possible failure mechanisms and paths. (The quality of mortar of exterior masonry chimneys can be determined by removing a small portion in a sampling of areas. Avoid being fooled by recent cosmetic treatment of the joints which do not reflect the general quality of the mortar in the chimney. Assess the potential for attaching the chimney to the house structural members. Examine portions of the chimney protruding above the house for the potential to be replaced by metal flues or to be braced by addition of metal straps, rods, or other braces. When chimneys are supported in the sub-area, inspections should be made of the adequacy of the foundation and that portion of the chimney visible in the sub-area. In many cases, settling creates a gap between portions of the masonry chimney.)
- Porches and their supports. (Hazardous conditions exist particularly where columns supporting porch roofs are inadequately fastened to the roof structure. It is often difficult to determine the adequacy of connections without actually dismantling portions of the structure. Metal fasteners should be suggested if connections are deemed inadequate.)

- Additions, particularly enclosed all-glass porches.
- Other heavy ornamentation and architectural features which might be hazardous.
- Exterior masonry veneers.
- Hazardous trees and other vegetation.
- Multi-layered old roofs.
- Condition and type of siding. (Of particular concern: improperly fastened wall coverings or wall coverings which in other ways do not possess the structural integrity intended in the original design. Cracked stucco, inadequately nailed wood siding, deteriorated or split wood siding, and other indications of deterioration should be identified.)
- Types of existing seismic resisting elements.

The next step, investigation of house interiors, focuses on the following features:

- General adequacy of the interior walls and how they might aid exterior walls in resisting the seismic loads.
- General condition of the interior finishes, specifically the extent of cracking to old plaster.
- Condition of interior chimneys, particularly in the attic where they might suffer a bending failure.
- Dangerous interior features such as unbraced heavy bookshelves and unbolted kitchen cabinets.
- Water heaters or furnances which were not braced or bolted; piping, supplying gas to the appliances, should be strapped or in another manner fastened to the structure.

Sub-area. Carefully inspect the sub-area or crawl space (the area between the ground and the first story of houses on wooden joists) to determine the condition of the foundation, cripple walls, and the connections between the first floor and the structural members supporting it. Probably the most important thing to determine in the sub-area is whether the mud sill is attached to the foundation. This normally is determined by inspecting for the presence of foundation bolts which project through the top of the mud sill. If not present, careful inspection determines use of other methods of fastening. In the absence of fastening, recommendations should be made according to the manual's directions for proper securement of the mud sill to the foundation.

Connections. The adequacy of connections between various members of the structure is widely viewed as the most critical element determining the wood-frame structure's ability to resist earthquake force. Where necessary the addition of metal connectors are advised to improve the quality of such connections.

Examine the condition of all wood members. Wood rot and insect infestation and damage should be identified and damaged or infested members recommended for replacement.

Lateral support

Bracing. Determine the adequacy of bracing of sub-areas. It is commonly found that joists rest on cripple walls, not directly on the foundation. Some lateral support on cripple walls should be recommended.

Sheathing. Diagonal sheathing is desirable, but it should not be assumed that it has been properly nailed. Inspections, involving removal of portions of exterior cladding, should be made to determine the adequacy of the nailing. Where diagonal sheathing is not present, the addition of lateral bracing should be suggested. (As shown in the homeowner's manual, this is done by adding plywood at the corners of the structure or other strategic locations. If the surface to which the plywood will be nailed is not in single plane, then blocking is necessary to provide a single plane for nailing of the added bracing.)

It is a common condition in older homes that sill plates are wider than the studs which they support. In this case, blocking in the same dimension as the studs can be nailed on the sill between the studs or, alternatively, the studs can be furred out to the same plane as the sill plates.

It should be explained to participants that sheathing added to provide lateral bracing must be nailed entirely around its perimeter and within the field to intermediate structural members in order to achieve the desired strength.

Column connections. Where beams are supported on columns in the sub-area, inspections determine the adequacy of connections at the top and bottom of the column. Where adequate connections do not exist, metal fasteners, nailing or straps should be added.

In summary, the final step of the site inspection involves the building's foundation, which should be examined for indications of major settling or structural cracking which may have resulted from previous seismic activity or significant ground movement. The following should be evaluated:

- Extent of bolting.
- Crawl-space bracing.
- Other bracing of posts and taller columns.
- General conditions of the concrete foundations. (Determine this by checking for spawling or indications of poor-quality cement. If the foundation is not constructed of concrete but rather of unit masonry inspect the condition of the mortar. It may be necessary to recommend partial replacement of non-concrete foundations.)
- Type of bolting required and spacing of bolts; use of steel plates when bolting would be difficult.

Selection of recommendations

An important component of the recommendation process involves determining when professional engineering help is required to carry out the necessary strengthening work. In cases where you doubt the adequacy of certain elements of the house, or where problems are not within clear guidelines established in the manual, an engineer or architect should be called to help resolve the questions. Even with professional advice, the correct course of action in some situations may be difficult to determine. Often the homeowner's preferences, finances, and the aesthetic and functional impact of modifications on the house will govern over structural factors.

Upon completing the house inspection, assemble a set of recommendations concerning the deficiencies found in the house. The prepared material should include a diagrammatic plan of the house with references indicating the location of each recommendation. The floor plan should note the location of major longitudinal and transverse walls, configuration of the foundation indicating the location of all posts and columns as well as poured and pier foundations. The presence of standing water or other indications of a high water table, which may indicate unstable soil conditions, should be noted.

A list of other materials provided the homeowner should be noted. All recommendations should be made in writing. A copy of the cover sheet, index, waiver form, and diagram locating recommendations should be retained for the advisory service's records. In addition to limiting the service's liability, this procedure provides advisors in the office with background information in case the homeowner contacts the agency later for further advice.

Before giving the recommendations package to the homeowners, participants should be asked to sign a waiver of liability form. Participants must be clearly informed of the importance of obtaining building permits and reviewing building code performance standards. It must be stressed that strengthening procedures recommended do not necessarily bring the dwelling "up to code" since electrical, plumbing, and other code considerations--while discussed with homeowners--are not a focus of the project.

Inform the homeowner if the advisory service conducts follow-up visits for continued technical assistance. Make certain that homeowners have opportunities to clarify any points of confusion before concluding the visit.

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232 WURSTER HALL
BERKELEY, CALIFORNIA 94720

TEL: (415) 642-2896
642-7911

# SAMPLE

FROM: Earthquake Assistance Services

TO : A. Smith
10 Eucalyptus Blvd.
Berkeley 94703

IT IS THE INTENT OF THE FOLLOWING RECOMMENDATIONS TO PROVIDE IMPROVED BUILDING SAFETY IN THE EVENT OF AN EARTHQUAKE. THE RECOMMENDATIONS DO NOT NECESSARILY BRING THE HOUSE INTO PARTIAL OR COMPLETE COMPLIANCE WITH PAST OR CURRENT BUILDING CODES.

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(Earthquake Advisory Service Program Participant)

The undersigned Participating Homeowner and/or Tenant has received a copy of, has read and understands the recommendations of the Earthquake Advisory Service for the A. Smith residence at 10 Eucalyptus Blvd., Berkeley, dated 18 July 1980. These recommendations ~~is~~ are not intended to constitute a contract and the undersigned participant understands that the program may be altered or modified without prior notice.

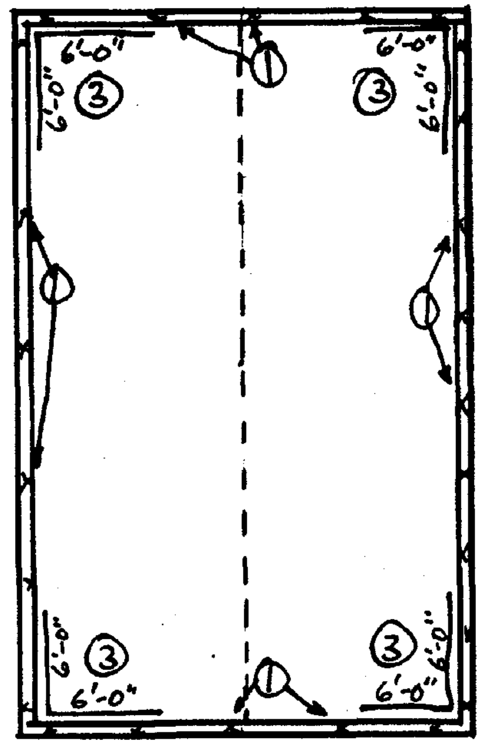
The Participant, in consideration of the Earthquake Advisory Assistance Program of the University of California, hereby indemnifies and holds harmless and releases and forever discharges The Regents of the University of California, and all their agents, officers, assistants and employees, either in their individual capacities or by reason of their relationship to the University of California, from any and all claims and demands whatsoever which the undersigned, or the undersigned's heirs, representatives, executors, administrators, or any other persons acting on behalf of the undersigned, or any other affected persons, have or may have against The Regents of the University of California or said agents, officers, assistants and employees by reason of any injury or damages to persons or property or any other consequences arising or resulting directly or indirectly from the undersigned's participation in the aforementioned Program, including, but not limited to, the failure or inadequacy of any measures or property modifications undertaken as a result of said Program.

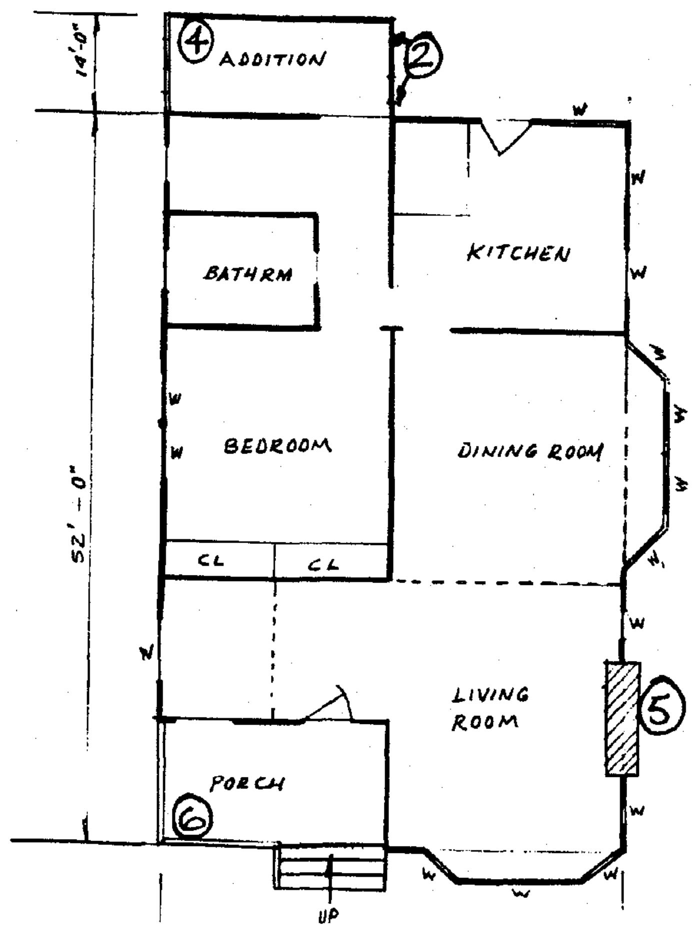
Dated____________________day of ______________, 19___.

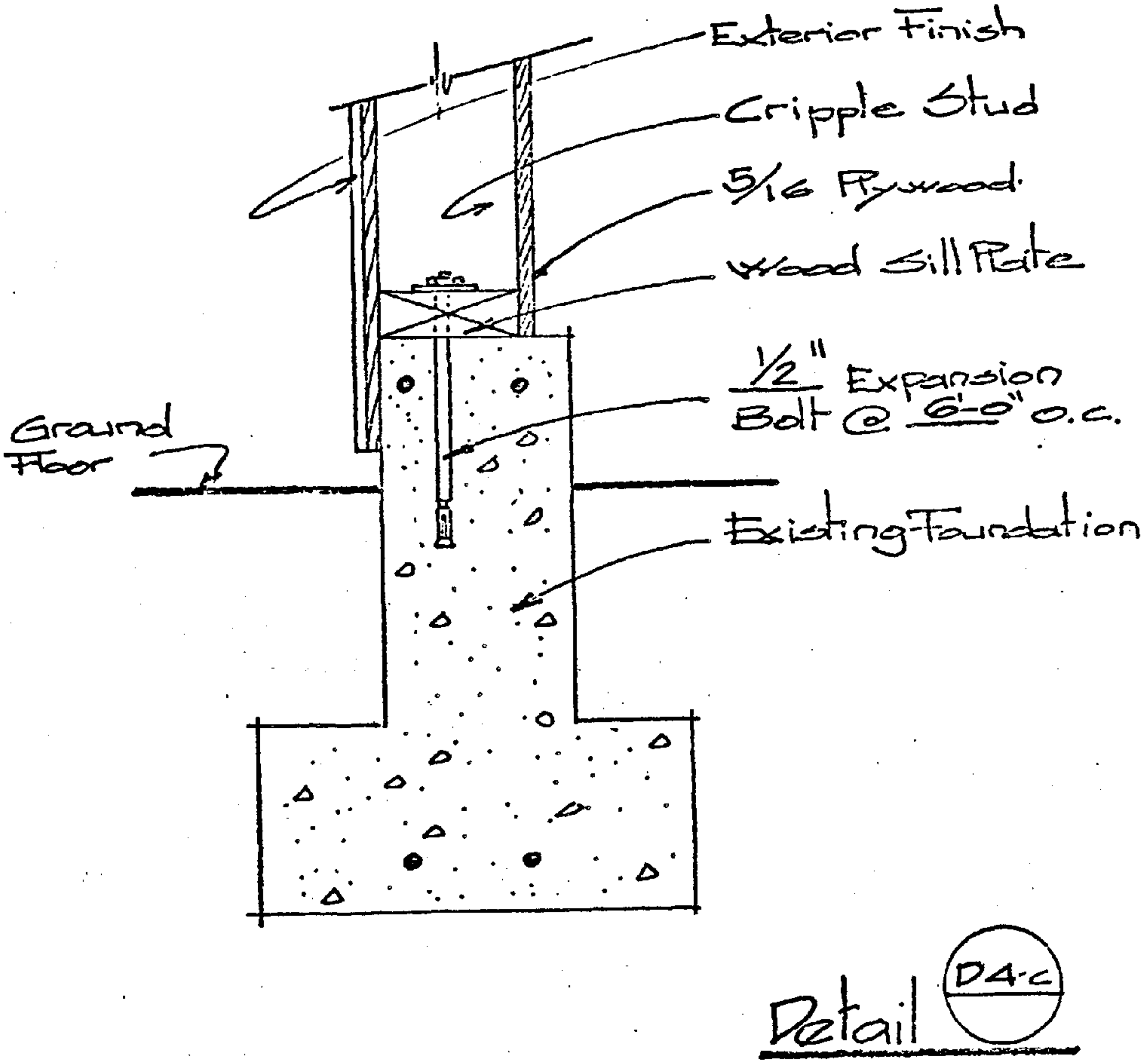
____________________ ____________________

Witness Participating Homeowner(s)

1. Foundation bolts see detail D4-C
2. Post/beam connections see detail D8
3. Cripple wall bracing see detail D9 and block detail D10
4. Water heater see detail D13
5. Chimney see detail D14
6. Porch columns see detail D15



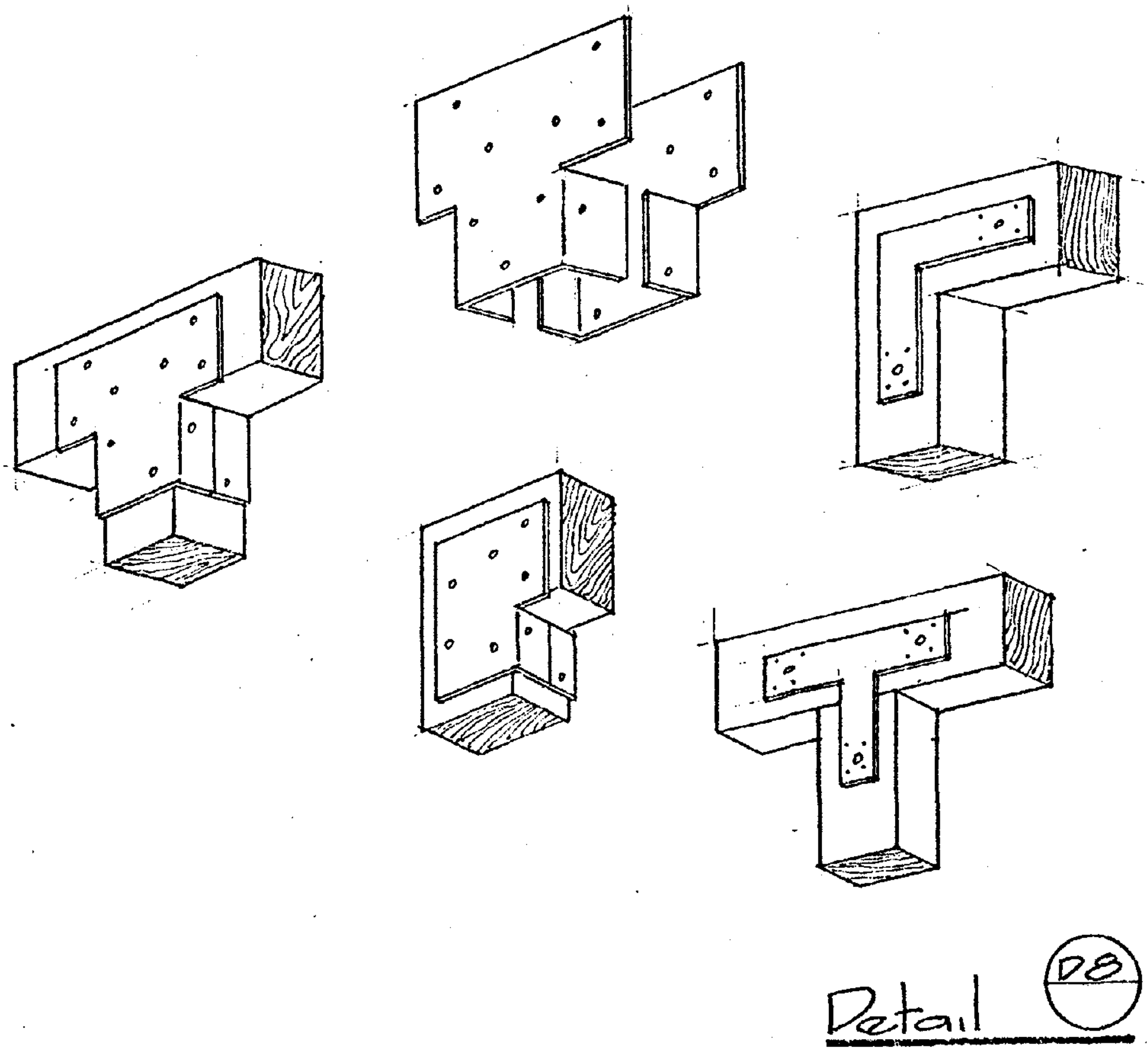






Foundation Repair

Concrete

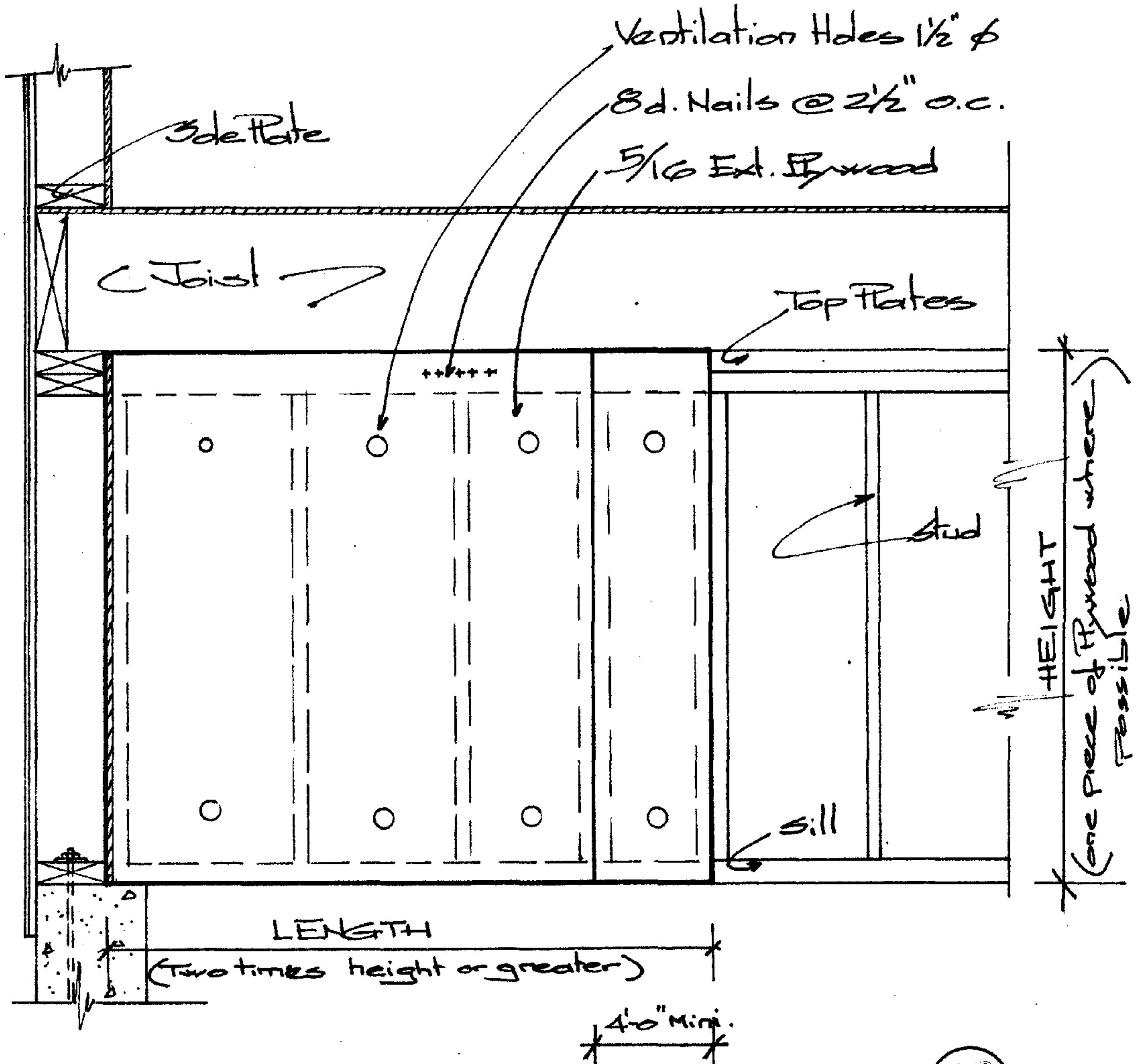
Drill 1/2 inch diameter holes through the top of the sill plate and 7 inches into the concrete foundation wall for the insertion of 1/2 -inch foundation expansion bolts. Holes should be no more than 12 inches from the ends of each piece of the wood sill plate. Additional bolts should be placed at 6'-0" feet on centers.




Foundation Repair

Post/Beam Connections

Place brackets, bracing, or T-straps at top of post securing into beams

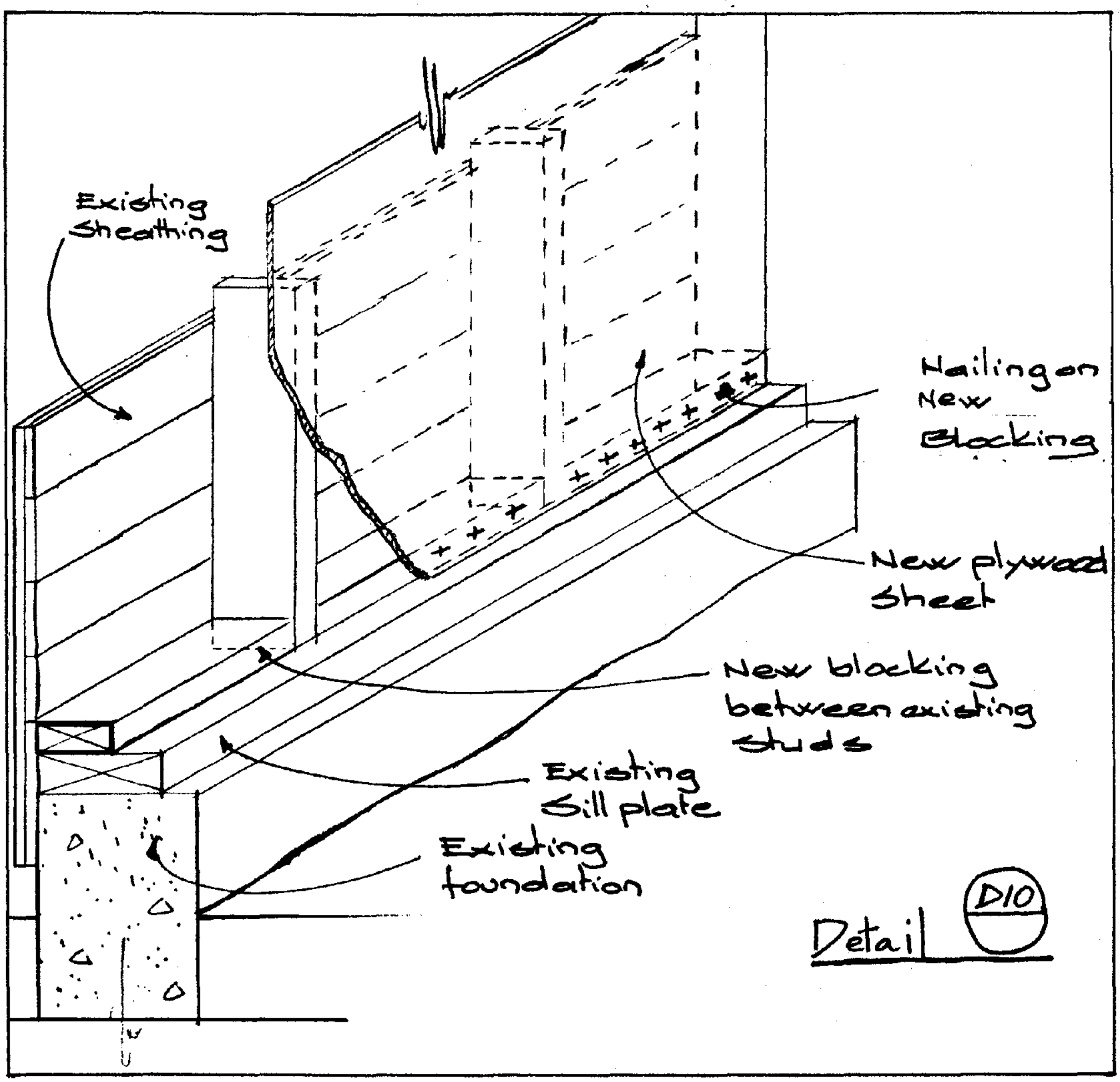



Crawl Spaces Walls

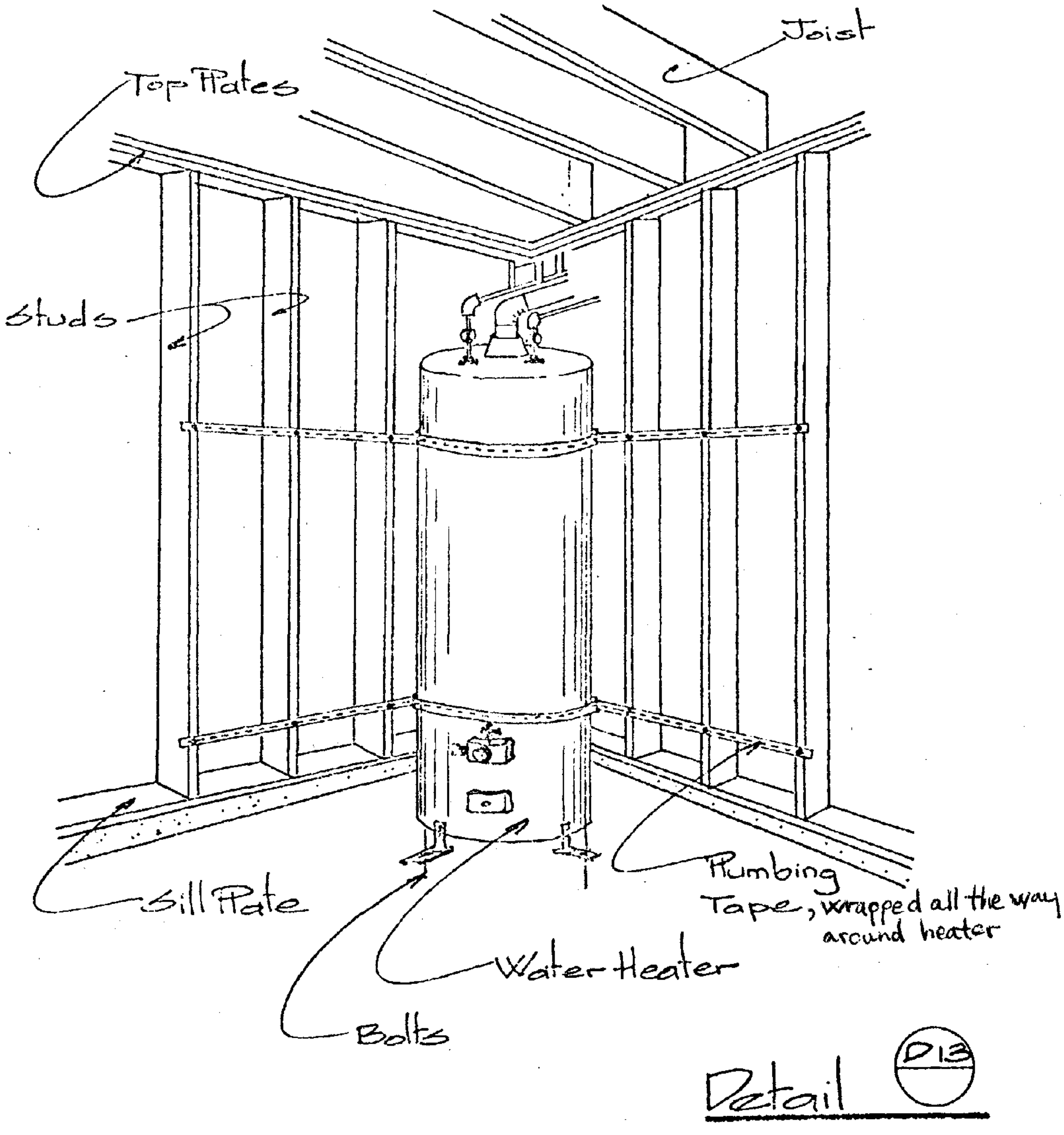
Cripple Wall Bracing

Detail D9

Nail 5/16 inch thick exterior structural grade (I orII) plywood sheets at the corners of walls covering a minimum distance of no less than twice the height. Studs or plates should be blocked to permit the nailing of the plywood sheet every 2 1/2 inches along the perimeter of the sheet. See detail D10 Preserve needed ventilation to crawl spaces equal to 1 1/2 sq.ft. per 25 linear feet.

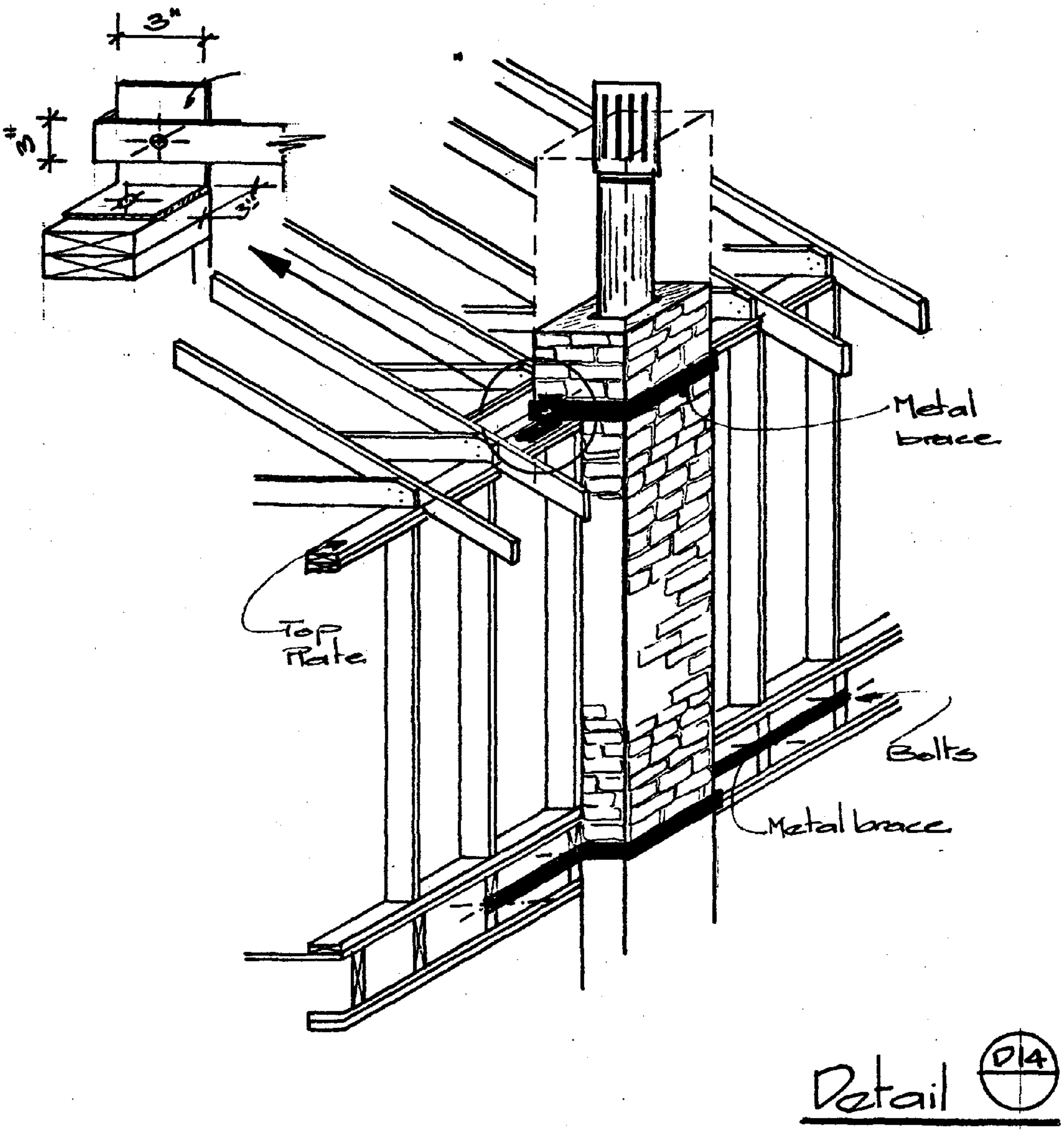



When cripple studs are narrower than the sill plate, you can nail blocking (pieces of wood) between studs (on top of the sill plate) to provide a flush surface to support plywood bracing.




## Water Heater

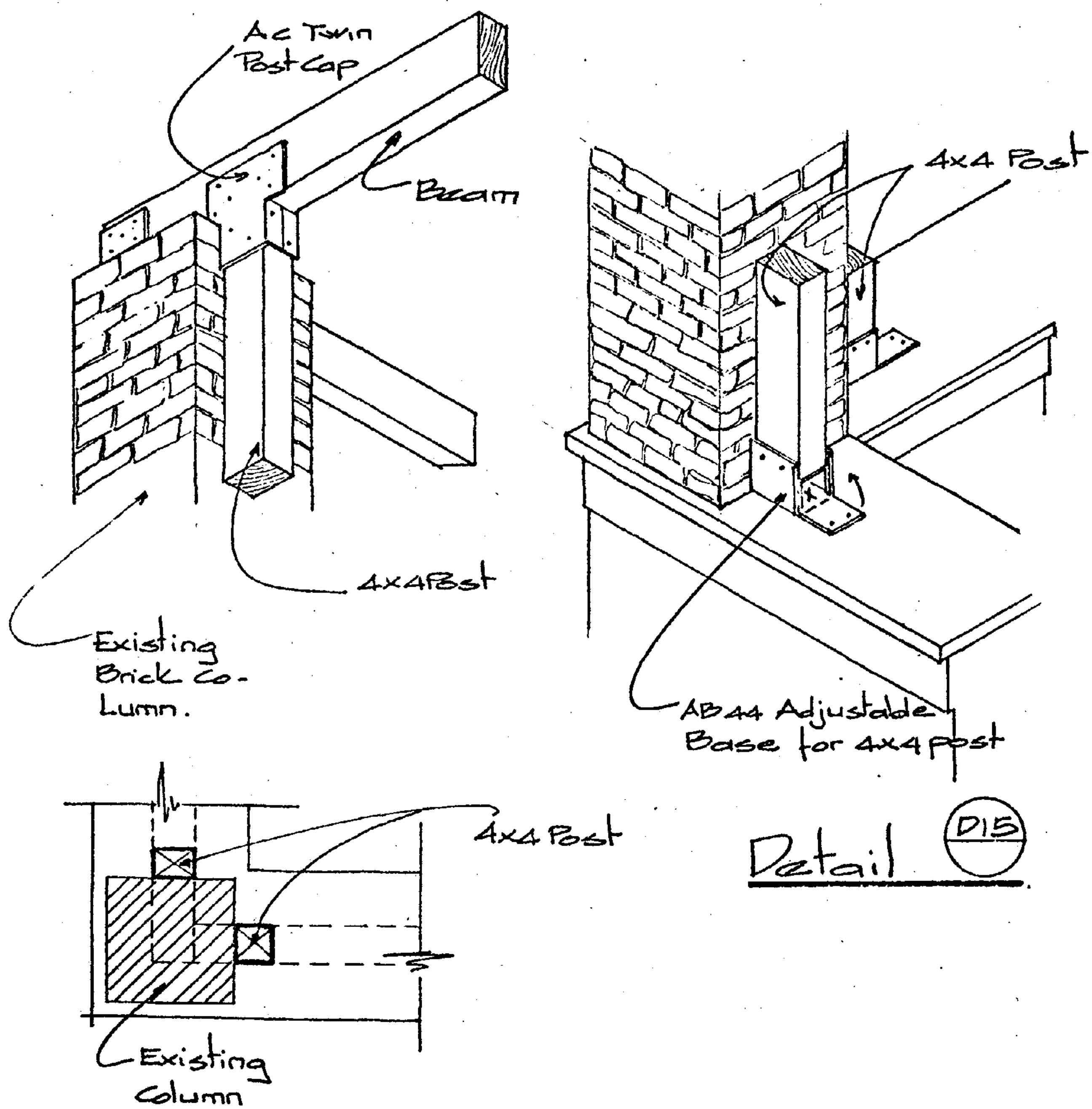
Water heaters should be secured to the floor by bolting them down or strapped in place by the use of plumbing tape.




Roof Area

Chimney

The brick chimney must be braced or reduced in height to prevent toppling.




Porch Column Connection

Porch columns should be secured to the beam(s) by placing a T-strap or other approved bracing at the top and bottom.