

CHAPTER 5
DEBRIS REMOVAL
David Blois

Introduction

Past experiences in recovery and reconstruction after a major earthquake have provided invaluable examples of the types of situations and problems that could be expected if such a disaster were to strike the Berkeley community. A major earthquake occurring along the Hayward fault zone near Berkeley would certainly result in extensive damage to commercial and residential structures of all types. A meaningful plan for recovery must include a well-organized and comprehensive approach to debris removal, both in terms of immediate recovery and for longer term reconstruction. It is the intent of this paper to evaluate the capabilities of the Berkeley community to respond efficiently in the aftermath of an earthquake and to provide information and recommendations which will hopefully make the recovery process more effective.

Within the past few decades several well documented earthquakes have occurred in California and Alaska. The Alaska "Good Friday" earthquake of March 27, 1964 measured 8.3 on the Richter scale and was one of the largest earthquakes to occur within the 50 states. One hundred fifteen people died and many more were injured. Damage estimates ran to well over \$350,000,000. This included damage to structures of all types including roads, bridges, and port facilities.⁶

In California the San Fernando earthquake of February 2, 1971 measured 6.4 on the Richter scale. A total of 64 people died, 1000 were injured, and over \$500,000,000 in damage resulted. Hospitals and schools bore the brunt of the damage, but highways and public utilities suffered heavily as well, including the Sylmar Power Station and the Van Norman Dam and Reservoir.¹¹

In both earthquakes, the U.S. Army Corps of Engineers played a major role in debris removal operations. The Corps undertook all aspects of the operations including contracting men and equipment, uncovering trapped survivors and bodies, damage assessments, removal of fallen debris, and wrecking of standing structures damaged beyond repair. In San Fernando the Corps demolished and removed over 300 buildings, both public and private. Priority was given to restoration of water and sewer facilities, but the major task in terms of time, money, and labor was the removal of buildings. This required extensive use of heavy equipment such as cranes, bulldozers, and earthmovers. Both the San Fernando and Alaska earthquakes generated enormous amounts of debris which required major efforts to remove to landfill and dump sites.^{6, 11}

General Information

The principal sources of debris may be classified as follows:

1. unreinforced-brick-masonry parapets and bearing walls with wood roofs and floors;
2. inadequately anchored cornices, masonry walls, marquees, signs, precast concrete wall panels, and veneer;
3. glass windows;
4. fallen wires, pole- and platform-mounted transformers, and poles;
5. collapsed and partially-collapsed multi-story buildings; and
6. collapsed and partially-collapsed highway, freeway, and railway bridges.¹⁰

Debris removal operations can be placed into two general categories: (1) those which require immediate action, and (2) those which can be done later. These categories are determined, to some extent, by the system of priorities established under the affected government's emergency operations plan.

In general, the first category would include debris which blocks essential transportation routes and access to key emergency facilities, and debris covering trapped and injured persons. In the case of blocked streets, it may be sufficient to move the debris aside with bulldozers in order to clear a single lane. Streets and freeways blocked by collapsed overpasses will pose a much more serious removal problem, because the concrete or steel members will have to be cut into smaller pieces to facilitate removal, and heavy equipment will be required.¹⁰

The careful removal of debris covering trapped and injured persons is a time consuming and meticulous job requiring cranes, skiploaders, cutting equipment, and considerable manual labor. For example, the collapse of buildings at the Veterans' Hospital in the San Fernando earthquake resulted in the deaths of 47 persons, and 60 people were trapped in the two buildings. The rescue operations were not completed until some 58 hours after the collapse.¹⁰

Debris from the second category may be removed at a later time and trucked to disposal sites using heavy equipment, such as skiploaders and trucks. In the Alaska earthquake, in some cases, debris from residential areas was taken to storage sites where local residents were allowed to sort through it to reclaim any identifiable objects which they deemed worthwhile saving.⁶

A major earthquake will draw heavily on all available equipment and manpower in order to remove debris. Speed and effective response in debris removal operations may save many lives and reduce potential injuries.

Funding for Disaster Relief

Funding for debris removal operations comes from several main governmental sources. The principal legislation regarding funds for disaster relief at the federal level is the Disaster Relief Act of 1970 (Public Law 91-606) and the Federal Civil Defense Act of 1950 (Public Law 81-920, as amended). Under Section 206 of the Disaster Relief Act, the President is empowered to provide emergency funds for disaster relief, including debris removal operations, up to 90 days after an earthquake has occurred. Section 224 of the Act authorizes the federal government to make grants and loans specifically for debris removal to local governments and authorizes federal agencies to perform debris work. It also requires that the affected local government arrange an unconditional authorization for debris removal and, in the case of private property, agree to indemnify the federal government against any claim arising from such removal.^{3, 11}

Federal funds for disaster relief are administrated primarily by the Office of Emergency Preparedness. At the state level these funds are then administered by the Office of Emergency Services, for California, which allocates them to the affected local governments. The Army Corps of Engineers is primarily responsible for undertaking the actual debris removal operations as specified in sections 203 and 224 of the Disaster Relief Act.¹¹

In past earthquakes clean-up operations often required more than 90 days, with the result that some people felt that they did not receive sufficient aid. In the San Fernando earthquake, misunderstanding or ignorance of the law led some homeowners and private businessmen to undertake clean-up operations on their own properties under the assumption that the federal government would reimburse them, when in fact no such provision exists. A general dissatisfaction with the bureaucratic process for obtaining district relief funds was also expressed by many affected citizens.¹¹

The Berkeley Community

The principal Berkeley city agencies responsible for debris removal in the event of an earthquake are the Public Works Department, Civil Defense Department, and the Environmental Health and Safety Department. Of these, the Public Works Department would supply a large part of the manpower and equipment through the Department of Streets and Sanitation, as well as damage assessment teams from the Engineering Department. The city operates a corporation yard at 1325 Allston Way where the majority of the city's heavy vehicles are kept and maintained.

The Berkeley Emergency Operations Plan calls for an emergency operations center (EOC) to be established in the communications center in the Hall of Justice under the direction of the City Manager. Branch operations centers are also to be established including one, EOC-1, at the corporation yard.⁴

EOC-1 will be staffed by those who perform their daily duties there. Under the city plan the chief of Streets and Sanitation would be responsible for supervising and coordinating debris removal operations. He is responsible to the Director of Public Works and the City Manager, but it is expected that in an emergency situation many operational decisions will be made by him alone such as equipment mobilization, assignment of personnel, and contracting local help.^{1, 4}

Equipment at the corporation yard consists mainly of garbage trucks, street cleaning vehicles, passenger cars, and a skiploader. The city also owns and operates a bulldozer at the Berkeley Sanitary Landfill site, and owns some equipment which it can use for cutting steel of concrete members. The city itself does not own any cranes, derricks, or heavy earthmoving equipment other than the bulldozer at the Landfill site.¹ It is expected that local private firms will be able to supply such heavy equipment in the event of an emergency. Each department that will be actively engaged in disaster relief has a list with the names and numbers of local private firms that would supply equipment, manpower, and technical aid, according to the various needs of the departments.⁸

The main function of the Streets and Sanitation Department in the EOP is to clear essential transportation routes and to ensure access to key emergency facilities which are outlined in the plan. This includes clearing evacuation routes of fallen debris and removing diverters from around Alta Bates Hospital. The Department is also responsible for aiding the recovery of essential utility services, especially with regard to sewage facilities.^{1, 8}

In the event of a disaster, jurisdictional and operational boundaries would not be absolute and a certain amount of overlap within departments is expected. Since the Public Works Department represents a substantial portion of the city's total manpower, it is likely that some of its people will be employed in other types of operations in coordination with other city agencies. This would probably include search and rescue operations where debris will have to be removed from collapsed structures to free trapped and injured persons, damage assessment, transportation of injured persons, and general information gathering.

Throughout the recovery process the city's disaster relief organizations will most likely be working with various agencies at the county, state, and federal level, as well as volunteer workers from local areas. This would apply to most aspects of debris removal from rescue operations and damage assessment to short and long-term removal of debris and hazardous structures. Careful coordination of activities between agencies and organizational levels will be essential to avoid wasted effort or overlooking any important aspects of recovery operations.

Some aspects of debris removal may be beyond the scope of the city's capabilities to deal with effectively. This would include long-term debris removal operations requiring extensive use of heavy equipment and removal and containment of special hazards such as spilled chemicals,

chemical fires, and radioactive wastes. No specific plan has been adopted by the city for dealing with such special hazards and responsibility for them will be relegated to the U.S. Army Corps of Engineers and specially trained technical teams.^{1, 8} The Corps will probably assume control for long-term debris removal operations as it did in the Alaska and San Fernando earthquakes.

University of California Campus

Although the University of California campus is part of the Berkeley community, it is considered the property of the State of California, and as such, is subject to different jurisdictional and administrative guidelines. However, since it is assumed that jurisdictional boundaries will not be strictly adhered to in the immediate aftermath of an earthquake, emergency operations will presumably extend to the University of California campus if there was need for them.

The University of California has adopted an Emergency Operations Plan of its own to be implemented in the event of an earthquake. The University possesses limited resources to deal with debris removal. It has no heavy equipment, therefore it will have to rely on outside help in removing large amounts of debris. The Office of Facilities Management, headquartered at 2000 Carleton Street, employs a large portion of the non-academic staff on campus and could use its people in search and rescue operations, damage assessment, hazard marking, and debris removal to a limited extent. Under the Environmental Health and Safety Department on campus the Chemical Irritant Removal Team would deal with hazardous chemical spills, chemical fires, gas leaks, and any radioactive hazards which may develop.⁹

For long-term and heavy debris removal operations the University of California will rely on help from the Berkeley city agencies as well as State and Federal agencies. Through the Office of Facilities Management Projects Coordinator, local firms could be contracted for equipment and manpower. The University of California has prepared blanket contracts with local construction and engineering firms which would be employed in an emergency situation. Initial damage assessments would be undertaken by the University of California engineering staff assigned to the O.F.M., but extensive evaluations would be made by private engineering firms.⁹

Disposal of Debris

It is generally assumed that most of the debris resulting from an earthquake will eventually be hauled to the Berkeley Sanitary Landfill Site from holding areas within the city, or in some cases, will be sold or given to private firms in need of fill. The Landfill site is currently used for routine municipal garbage dumping. It is not considered a suitable site for storage of liquids or hazardous materials and so far no large amounts of heavy debris have been dumped there. Although no exact termination date for dumping at the Landfill site has been set,

it is expected that filling will stop sometime within the next five to ten years.⁵ Land easements and rights-of-ways for areas to be used as temporary dumping sites by the Corps of Engineers or other outside agencies must be authorized by the responsible city department.² Apparently, little thought has been given to this matter, as there is no specific planning regarding temporary sites in the current Berkeley E.O.P.⁸

It is not clear exactly how the city will deal with the containment and storage of hazardous chemicals. There are provisions for the Corps of Engineers to create "special chemical dumps" under federal legislation but presumably these would not be within the city limits. Some planning to hire local firms to remove stored chemicals has apparently been done by the city.⁸

Analysis and Recommendations

A major earthquake will place great demands on the Berkeley community's resources for coping with the emergency period afterwards. Debris removal operations will require large amounts of equipment, manpower and a well organized and coordinated effort. The actual resources needed and the specific kinds of operations required will be determined to some extent by the characteristics of the community and by the earthquake itself; time of day, severity, and location of epicenter. Emergency response planning should emphasize reliance on the resources immediately available to the Berkeley community, as much as possible, to contend with the general problems of debris removal and those more specific to the Berkeley area.

The need for large amounts of equipment and manpower and the volume of work that will need to be done may present a major problem. Although the Public Works Department is primarily responsible for clearing transportation routes and restoring utility services in a disaster, it will almost certainly be required to aid in rescue operations involving debris clearing. If damage is widespread it will necessitate dispersing men and equipment over a large area, placing a further demand on equipment reserves.

Since the city owns little heavy equipment such as cranes and earthmovers, it will be required to call on local private firms for assistance. It is essential that an adequate plan for hiring and utilizing local firms for equipment and manpower be adopted. The firms that agree to participate must be made aware of all the relevant aspects of such a plan. They should be aware of the nature of the possible disaster and make provisions to be available or easily reached at all times. Firms may be assigned on a rotating basis for this purpose. The responsible city agencies should have a precise idea of the resources they have at their disposal under the plan and insure that it will be adequate to meet the worst situations. Lists of participating firms should be updated regularly to ensure that equipment reserve will be adequate at all times. Predetermined, written agreements between the city and participating firms should be

adopted to cover emergency situations. These agreements should also be updated yearly to allow for changes in personnel and businesses.

Coordinating debris removal with other disaster relief operations and agencies from other levels of government will be a major effort. Although it is not possible to predict exactly how much and what kinds of coordination will be required between the city agencies involved in on-the-spot disaster relief operations, planning in this area may avoid much confusion and wasted effort.

Test drills, based on a hypothetical earthquake damage scenario, can be helpful in revealing weak points in current emergency response plans and may show what aspects of debris removal operations will be the most difficult from the coordination standpoint. Since the city will rely heavily on private firms for debris removal, it is important that the participating companies be considered in overall disaster relief coordination planning, and they should be included in test exercises. For long-term debris removal careful consideration should be given to coordination of operations between city agencies, such as Public Works, and agencies at other governmental levels, especially the Corps of Engineers.

Another aspect of coordination that should receive some attention is how to deal with volunteer workers. The logistics of handling a mass of volunteer workers converging into an emergency operations center can be a problem. Planning should be undertaken as to who will organize volunteers, ascertain what skills they have, direct them to needed areas, and so forth. The Public Works Department should develop its own plan for coping with and efficiently using volunteers to facilitate debris removal operations.

Coordination between city agencies and the University of California should also be considered, and a plan for a joint resource pool for debris removal should be adopted. The University of California must also ensure that its own plans for long-term debris removal operations are adequate and workable, especially with regard to hiring private firms for removal work.

If possible, a "seismic hazard probability" map should be developed for Berkeley. Ideally, such a map would outline areas within Berkeley according to the major types of structures present, their construction, and age. By determining which areas are likely to suffer the most damage and what types of debris can be expected from these areas, debris removal may be greatly facilitated, especially with regard to search and rescue operations for trapped victims. By extending such seismic zoning to individual structures in business areas and the University of California campus, rescue and debris removal work may be made even more effective. If a cost estimate for cleanup operations can be developed along with the seismic zoning map, long-term debris removal operations can be better planned and organized.

In any emergency operations plan there must be some flexibility to allow for unforeseen and novel situations that may arise after a disaster has occurred. However, some subjects may benefit from more attention and specific planning, from the viewpoint of debris removal, than they have apparently received in Berkeley's current E.O.P. This includes chemical fires and hazardous chemical releases, radioactive hazards that may develop from the University of California's reactor, coping with a BART disaster, dealing with collapsed hillside structures, and planning for dumping and storage sites for debris and hazardous substances. Studies addressing each of these problems should be undertaken to determine to what extent these subjects will pose hazards in the event of an earthquake, how difficult it will be to deal with them, and what type of resources will be required to carry out removal of debris for them.

A list of firms, both public and private, that use or store hazardous chemicals and substances and a location map of these firms may be helpful. Any local, private firms with experience in dealing with transportation and removal of hazardous substances should be included on the Public Works emergency call list.

Debris removal operations for hillside structures may prove especially difficult. Since the Hayward fault zone runs directly through Berkeley's eastern hills, damage from an earthquake will probably be acute there. Access to damaged houses and buildings may be greatly hindered by landslides which may block streets, most of which are narrow to begin with. The narrowness of many of Berkeley's streets may prove to be a major obstacle in overall debris removal operation as well.

With regard to dumping sites, the city should have a clear idea of its options. Although the Berkeley Sanitary Landfill Site is regarded as the main dumping area for Berkeley, it may not be practical to move large amounts of debris there at first, due to its location. Planning should be undertaken to determine which areas in Berkeley will provide suitable holding areas for debris before it can be moved to more permanent sites. The storage of chemicals and other hazardous substances should be given serious consideration and plans to minimize the threats to health and safety that they may present should be adopted if it becomes necessary to store them temporarily within the city.

Choice of both permanent and temporary dump sites should not be made at the expense of incurring long-term environmental damage. Dumping debris along the San Francisco Bay shoreline, other than at existing fill sites, should be avoided. Storing hazardous substances where they may leach out into the Bay through the water table should be avoided at all costs. Some thought should be given to recycling debris where practical to be used as fill in needed areas or for other purposes.

Conclusions

Experience has shown that at the onset of disaster the immediate on-the-spot response must come primarily from local government. In most areas it is the only organization with a range of capabilities, public safety, public works, social services, and administrative, already on the scene and functioning. The ability of a local government to respond after a major earthquake will depend to a large extent on sound pre-disaster planning. For debris removal and related matters this means a realistic assessment of the City's capability to deal with large scale and diverse operation requirements, a well organized and coordinated emergency relief operations plan emphasizing community self-reliance, and adequate planning to coordinate city agencies with state and federal agencies for long-term operations. Adopting an attitude of community self-reliance in planning for these and other aspects of debris removal may result in fewer fatalities and a more efficient and speedy recovery from a major earthquake disaster.

REFERENCES CITED

1. Alcorn, Edward, Chief of Streets and Sanitation, City of Berkeley, 1979, oral communication.
2. Anderson, Roy, Emergency Operations Planner, Army Corps of Engineers, San Francisco Office, 1979, oral communication.
3. California, Special Subcommittee of the Joint Committee on Seismic Safety California Legislature, 1972, The San Fernando Earthquake of February 9, 1971 and Public Policy.
4. City of Berkeley, City Manager's Office, April 6, 1977, Disaster Relief Plan.
5. Fahrner, M., Operations Manager, Berkeley Sanitary Landfill Site, Berkeley, 1979, oral communication.
6. National Research Council, 1970, The Great Alaska Earthquake of 1964, National Academy of Sciences, Washington, D.C.
7. Office of Emergency Planning, September 1967, Report of Earthquake Seminar June 13-14, 1967.
8. Porter, Vic, Chief of Civil Defense Department, City of Berkeley, 1979, oral communication.
9. Reinhold, Arnold, Projects Coordinator, Office of Facilities Management, University of California, Berkeley, 1979, oral communication.
10. U.S. Geological Survey, 1976, A Study of Earthquake Losses in the Salt Lake City, Utah Area, Open File Report 76-89.
11. U.S. Senate, 1971, Governmental Response to the California Earthquake Disaster of February 1971: Hearings before the Committee on Public Works: 92nd Congress, 1st session, no. 92-H22, June 10, 11, and 12, 1971.