

Overcoming Obstacles to Implementation: Addressing Political, Institutional and Behavioral Problems in Earthquake Hazard Mitigation Policies

by Daniel J. Alesch and William J. Petak

Research Objectives

This project is aimed at bridging the three planes, from basic research, through enabling processes, to engineered systems. At the basic research plane, we have been working to improve our collective understanding about obstacles to implementing mitigation practices, owner decision processes (in connection with other MCEER projects), and public policy processes. At the level of enabling processes, we have been seeking to develop an understanding of how obstacles to greater mitigation can be overcome by improved policy design and processes. At the engineered systems plane, our work is intended to result in practical guidelines for devising policies and programs with appropriate motivation and incentives for implementing policies and programs once adopted.

This phase of the research has been aimed, first, at a thorough, multidisciplinary review of the literature concerning obstacles to implementation. Second, the research has focused on advancing the state of the art by developing means for integrating the insights offered by diverse perspectives on the implementation process from the several social, behavioral, and decision sciences. The research establishes a basis for testing our understanding of these processes in the case of hospital retrofit decisions.

As development continues to concentrate in high risk earthquake areas, the probability increases that disastrous earthquakes will occur. Public officials face the prospect of dealing with earthquake crises that could have been reduced significantly with the application of known technologies. Although earthquakes are an uncontrollable force of nature, unnecessary losses in life and property and social disruptions are generally the result of not having implemented precautions that we know could have mitigated the losses.

The primary research emphasis in earthquake hazard mitigation has been on developing increased knowledge about the earthquake phenomena, increasing understanding of structural performance under earthquake conditions, developing advanced design methods and standards, and improving building codes. Improved knowledge about the

Sponsors

*National Science Foundation,
Earthquake Engineering
Research Centers Program*

Research Team

*William J. Petak, Professor,
School of Policy, Planning,
and Development,
University of Southern
California*

*Daniel J. Alesch, Professor,
Department of Public and
Environmental Affairs,
University of Wisconsin-
Green Bay*

Collaborative Partners

- *The International Institute for Applied Systems Analysis, Vienna, Austria, provided Professor Petak with extended use of its research links and materials during his recent sabbatic leave so that he was able to initiate and develop the literature review.*
- *Representatives from the San Francisco Department of Building and Safety, structural engineers (Degenkolb Engineering, Comartin and Reis, Daniel Shapiro), the Applied Technology Council, California Seismic Safety Commission, and urban planning consultants reviewed the draft document.*
- *Social Science scholars from MAE, PEER, and MCEER reviewed early draft documents.*

physical and technical aspects of the problem has led to the adoption of public policies intended to reduce the probability of loss, but they must be implemented appropriately to actually reduce risk. Today, there remains an inadequate understanding of the barriers, impediments, disincentives, and issues associated with implementing appropriate earthquake hazard mitigation technologies and strategies, much less with overcoming those barriers. This research was undertaken because no complete conceptual model or empirically validated model exists to explain mitigation adoption processes for the rehabilitation of existing structures, either across or within specific stakeholder groups.

Background

Our broadly-based assessment of barriers to policy implementation resulted in a background working paper entitled *Barriers to Successful Implementation of Earthquake Hazard Mitigation Policies*. In it, we address three questions that are central to implementation:

- First, what constitutes appropriate, successful implementation of public policies concerning

earthquake hazard mitigation? That is, how can we determine whether a policy has been implemented appropriately or successfully?

- Second, what are the key variables thought to affect the success of implementation? Which of those variables can be controlled to help ensure successful implementation?
- Third, how can mitigation advocates help to ensure that public policies adopted in an attempt to reduce the probability of losses to life and property from earthquakes are implemented successfully? How can we help ensure that the resources devoted to hazard reduction in pursuit of these policies are used effectively?

Our first paper is based on a review of the implementation literature that has developed over the past three decades. A rich body of research on implementation exists within the social and behavioral sciences, but very little of it addresses natural hazards risk reduction. Consequently, we've drawn on a broad base of literature to draw inferences about implementing earthquake hazard mitigation. The 75 page draft report cuts across the

The primary audience for our reports comprises two groups. One group includes architects, engineers, developers, builders, building owners, and organizations whose actions or inactions are the targets of policies intended to get them to reduce risks to themselves and other members of the community from natural hazard events. The second group consists of policy and program designers and public and private program managers with responsibilities in earthquake hazard risk reduction and mitigation.

social and behavioral sciences, drawing on more than three dozen significant studies, and resulting in 37 basic propositions concerning impediments to effective implementation. The propositions are organized around a model we developed that attempts to identify key inter-institutional nexuses in the implementation process.

The Implementation Web

We view organizations as open systems, comprising elements related to one another in ways such that perturbations of one element have ramifications for the others. Organizations exist within environments of varying complexity with which they inexorably interact. Organizational systems, we believe, are inherently unstable, requiring continual resources from the environment to survive and requiring continual adjustment simply to maintain their relative position. Our model enables us to examine multiple organizations embracing all the levels of government within the systems framework.

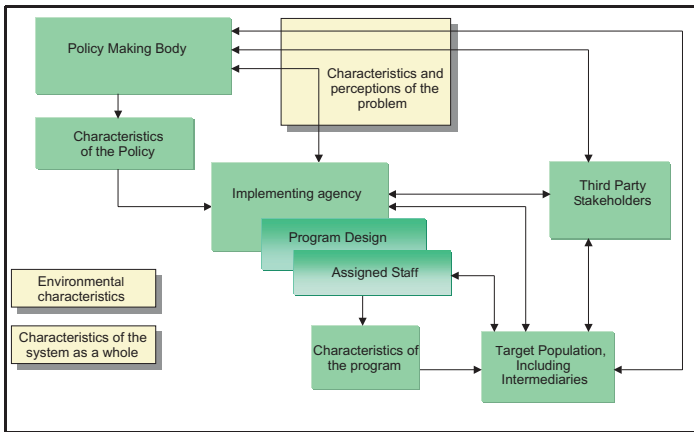
In our work, we examined organizational variables, including policy makers, the program designers, the program implementing agency, staff assigned to implement the program, and the target population. We were unable to find a model in the literature that embraces the contributions of the various social and behavioral science concepts, constructs, and analysis. We chose, therefore, to create a model based on general systems theory to try to embrace the breadth of implementation research. The original model was not

intended as a conceptual breakthrough; it is simply the most convenient, useful way we know to organize this diverse, complex body of research. Our model also contains non-organizational variables that give it substance: the problem giving rise to the policy, the policy itself, the characteristics of the system, and characteristics of the system's environment. Each of these is thought to affect implementation. Finally, the model incorporates dynamic elements. These are characteristics of the system that affect in the model. Four points about the model are particularly important. First, the entire process is dynamic and, typically, iterative; policies are often revisited after having been enacted. Second, policy gets defined and redefined at each step in the implementation process as it is interpreted and reality-checked by the participants in that organizational node. Third, obstacles to implementation can arise at each link in the implementation process. They can also arise at the points at which organizations and processes are joined with one another. Fourth, the nature of the entire process itself may engender obstacles to implementation, particularly if the process is long and complex, involving lots of actors and transactions.

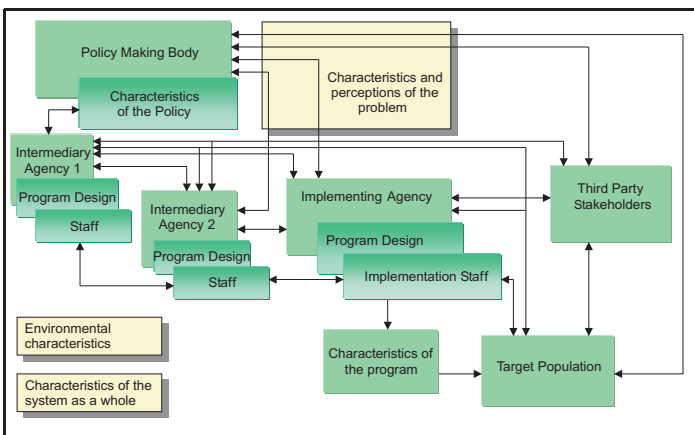
To guide our work, we conceptualized a simple model to embrace the processes that extend from policy adoption through implementation by operating agencies (see figures 1 and 2). We describe this as a complex web of expectations and actions. The model extends to include organizations with implementation roles as well as the characteristics of the implementation

Links to Current Research

- *Our efforts to seek greater understanding of how to ensure increased application of methods for earthquake hazard risk reduction by public and private organizations cuts across the program focuses in lifelines, hospitals, and response and recovery, including community sustainability and community resilience.*
- *Hospital retrofit cases are being used as a test bed for furthering our knowledge and for developing practical guides to improving mitigation practice, coordinating our work closely with that of von Winterfeldt, Tierney, and others. Since the MCEER agenda is aimed at the application of new technologies to the reduction of risk, implementation necessarily cuts across all programs and is relevant to each.*



■ **Figure 1.** Implementation Within a Single Jurisdiction



■ **Figure 2.** Implementation in a Multi-Level Governmental Setting

process itself. Our focus is on sets of organizations and the systemic setting within which they play their implementation roles. We call these different sets of organizations primary target organizations, market intermediaries, front line implementors, indirect implementors, nongovernmental policymaking participants, and public policymaking organizations.

Primary Actors in the Implementation Process

We define **Primary Target Organizations** as architects, engineers, de-

velopers, builders, building owners, and organizations whose actions or inactions are the targets of policies intended to get them to reduce risks to themselves and other members of the community from natural hazard events. **Market Intermediary Organizations** are defined as private organizations and public agencies that provide mortgage monies, mortgage insurance, or insurance against losses from natural hazard events including, especially, those whose policies and practices affect the behavior of **Primary Target Organizations**.

We have defined **Front Line Implementing Organizations** as agencies, typically public agencies, such as building and safety and code enforcement agencies, that are charged with program implementation. That is, they are organizations that are expected to allocate resources, including time and personnel, to bring about the desired effects in the target organizations. We include the individuals within those organizations assigned to take action. **Indirect Implementing Organizations**, on the other hand, are those organizations charged with designing implementation programs which mandate others, like local departments of building and safety, to take action, inflict sanctions for not taking action, or provide incentives to take action. Typically, these are viewed as federal or state agencies responsible for ensuring that municipalities administer mitigation programs.

Nongovernmental Policymaking Participants are an important element in the implementation web. They comprise private organizations that participate in policy development, such as professional associations (SEAOC, BSSC), and private interest

groups that seek to influence policy (ICBO, trade organizations). Some participants are fully engaged in public policy formation to the extent that they are almost indistinguishable from authorized public policymakers in their sphere of influence.

Policy Making Organizations are defined for our purposes as public legislative, executive (or occasionally judicial) entities that adopt and authoritatively state a policy intended to reduce risk to life and property from natural hazard events

What Constitutes Successful Policy Implementation?

At the simplest level, "implementation represents the faithful fulfillment of policy intentions by public servants" (Calista, 1994, p. 117). Newcomers to business and government often assume that a policy, once adopted, will be implemented in accord with the policy makers' intent. An increasingly rich body of research confirms what old hands know - that is just not the case. Practitioners and scholars have come to understand that policy adoption is simply one milestone in a continuing process of addressing an issue. Researchers have concluded, however, that implementation is a critical part of policy making process. Policy is adopted and adapted and drifts, morphs, and mutates through the implementation process. The extent of drift and mutation depends on a myriad of variables, only some of which can be controlled by policy makers. Calista's assessment of the field of study is that it has

evolved from one of viewing implementation as simply the process of carrying out policy directives to where implementation "is now integral to the field of policy intervention, including recognizing its influence on policy formulation" (Calista, 1994, p. 117). Evidence continues to mount demonstrating that, often, policies are not implemented in accord with the policy makers' intent. Indeed, it may be that successful implementation is the exception rather than the rule. Calista reports that the most prevalent finding in implementation research is that outcomes are either disappointing or unwitting (Calista, 1994, citing Derthick, 1990). Others suggest that policy implementation is "the continuation of politics with other means" (Majone and Wildavsky, 1978).

We have concluded that successful implementation is not the same as solving the problem. It is entirely possible that a program could be implemented exactly as intended and that the program is ineffective because the problem transformed during the implementation period or because the program was flawed conceptually. If a local government provides incentives for action by private actors, some will choose to participate and others will not. It is possible that an overwhelming majority act in such a way as to convince even the most jaded skeptic that the policy has been implemented. Suppose, however, that only 10 percent of those targeted by the policy and eligible to participate actually volunteer to participate in the program or implement the policy. Is policy implementation successful? Presumably not, because such a small proportion of the target was reached. Careful di-

“A rich body of research on implementation exists within the social and behavioral sciences, but very little of it addresses natural hazards risk reduction.”

agnosis of the implementation process might focus attention on a specific aspect of the program designed to implement the policy, such as providing greater incentive or engaging in more effective campaigns to make members of the target audience more aware of the program. If each of the organizations in the implementation net does precisely what is called for in an agency’s program plan, but, still, the private citizens or organizations targeted for action fail to take the steps that bring about clear intent of the public policy, is implementation successful or has it failed?

We concluded, too, that successful implementation is a matter of degree. Consider the fanning out of responsibility for implementation. A federal agency looks to fifty states, each of which looks to a hundred or more municipalities, each of which looks to several employees, each of whom tries to affect the behavior of a dozen or more individuals or firms. What proportion of the several hundred thousand potential "implementations" in this example has to "take" for implementation to be judged successful? Successful implementation is clearly, then, a relative concept. We have to think of it in terms of the extent to which it has occurred rather than whether it has occurred. Success, in the case of implementation, is not a matter of absolutes.

Criteria for Evaluating Implementation

We have identified six criteria for evaluating the extent to which implementation has been successful:

- Did the policy have the nominally intended effect on the intended target population?
- To what extent were there unintended side effects and were those side effects adverse?
- To what extent did the various elements of the implementation network comply with policy directives?
- What proportion of the target was reached?
- Did implementation take place within a reasonable time frame? That is, if one expected implementation of a retrofit to be completed within five years and it has been fifteen and the job is not yet completed, how effective has the implementation been?
- Were the costs of implementation acceptable and reasonable?

Barriers to Implementation

We developed 37 propositions concerning obstacles to implementation, including obstacles throughout the policy development and implementation process. For Year 4, we focused our attention on examining reasons private organizations might not implement risk reduction measures. We summarized those impediments into four barriers.

Barrier 1. The organization does not perceive itself at risk.

The first barrier to successful implementation of earthquake risk reduction is that the organization facing the risk does not perceive itself at risk. Most practitioners in the earthquake hazard field may find it difficult to comprehend there are organizations that are not

fully aware of their exposure and vulnerability, many are not, even in seismically active areas. In such cases, appropriate means for overcoming the ignorance barrier by efforts to communicate the hazard along with improving the target organization's perceptions of exposure, vulnerability, and probable effects.

Barrier 2. The organization may perceive itself to be at risk, but does not perceive that it can do something to reduce the risk.

Organizations may see themselves as having both exposure and vulnerability, but not know what to do to reduce the probability of loss when the event occurs. This condition can exist when there is a small inventory of acceptable risk reducing actions or when no means have yet been devised to mitigate the potential loss. The organizational decision makers may have a fatalistic mind set that dictates against attempts at risk reduction. Or, the problem may be viewed as intractable by organizational decision makers.

Barrier 3. The organization sees the risk and possible actions, but doesn't see taking risk-reducing actions as in being in its best interest.

This barrier is not at all unlikely. Decision makers must weigh the sure costs of risk reduction against the possible benefits and, then, compare those costs and returns against those of other possible investments. Earthquake hazard miti-

gation does not always win those comparisons. Second, any risk reduction measures must be congruent with organizational culture, goals, and priorities; if they are not, then the investment is directed toward other goals. Similarly, the proposed mitigations must be congruent with organizational motivation.

Barrier 4. The individual organization may be aware of the problem and risk reduction measures and be eager to reduce its risks, but find that it is impossible to take action at this time.

Any of several reasons can keep an organization from acting when it knows the risk, understands there are ways to reduce risk, and is willing to move ahead. There may not be space on the organizational agenda right now. The organization may not have the capacity at present in terms of financial strength or available skills. Or, it may be that the organizational environment presents sufficient ambiguity to cause the organization to defer action.

Overcoming Barriers to Implementation

In Year 4, we also worked to develop a document useful to the decision making community and to integrate our work with other MCEER tasks. Our second working draft, entitled *Overcoming Barriers To Implementing Earthquake Hazard Mitigations: A Practical Guide*, is an attempt to develop practical means for overcoming

“We have concluded that successful implementation is not the same as solving the problem.”

barriers that occur throughout the implementation network. The guidelines on which the draft is based are summarized below.

Guideline 1: If a basic obstacle to taking precautions is an inaccurate assessment of risks by the target organization, then the hazards professional, if he or she expects to have any impact, must provide the organization with a clear, compelling statement of the risks to the organization.

Guideline 2: Risk reduction measures are more likely when the **Primary Target Organizations** see a clear link between the potential hazardous event and adverse effects on them and their businesses. Prudent hazard mitigators work to make the linkage clear to those organizations.

Guideline 3: The probability of successful implementation of a policy (in either a multi-organizational setting or in a single organization) increases when both those involved in policy making and implementation have a similar perception of the problem. It is sensible, then, to help ensure similar perceptions by active communication among the two parties.

Guideline 4: Problems often shift out from under solutions, rendering policies obsolete, ineffective, or dysfunctional. Prudent implementors work to ensure that policies are modified as necessary to ensure they are both effective and appropriate, so that efforts at implementing the policy will not diminish.

Guideline 5: For an organization to take steps to reduce its exposure or vulnerability to earthquakes, key decision makers in the organization must believe that practical steps exist to reduce the risks associated with the event or condition and that those steps are congruent with

the problem. To increase the probability of implementation, design professionals and public officials must ensure that decision makers see the link between the risk and the solution.

Guideline 6: The prudent implementor does not assume that the **Primary Target Organization** understands the availability of a range of solutions and the possibility of modifying solutions to match the specific needs of the individual organization.

Guideline 7: The more a problem is viewed intractable, the less likely it is that implementation will be successful. Hazard mitigators must work to reduce ignorance about the phenomenon, reduce diversity in specific target populations, work with reasonably sized target populations, and become more skilled in understanding means for changing perceptions and behavior in the target population.

Guideline 8: Successful implementation of new policies and approaches is more likely to occur promptly in organizations that are traditionally amenable to change or have a culture that embraces innovation.

Guideline 9: The probability of successful implementation increases to the extent that actors in the implementation process perceive congruence between means and ends; that is, they will work harder to ensure implementation if they perceive that the policy and the programs designed to implement the policy are appropriate, given their perception of the problem.

Guideline 10: The probability of successful implementation in either a multi-organizational setting or in a single organization increases to

the extent that various actors in the organization have similar goals with respect to risk reduction and buy into the means selected for risk reduction.

Guideline 11: Risk reduction measures are more likely to be faithfully implemented when the organizational leadership's support is unambiguous, the order is widely publicized, the people charged with implementation have everything needed to implement the measures, and those charged with implementation have no doubt of the authority of the leadership to issue the decision.

Guideline 12: Unless the interests of the various stakeholders, especially those of the **Primary Target Organizations**, are accommodated at some minimally acceptable level, it is likely that mitigation policies and programs will face guerilla action, be subject to subsequent watering down, and face court challenges.

Guideline 13: "Hazard mitigation is not a technical exercise; it is inherently and often intensely political because mitigation usually involves placing cost burdens on some stakeholders, and may involve a redistribution of resources. Hazard mitigators must, therefore, develop political as well as technical solutions" (Alesch and Petak, 1986).

Guideline 14: Policies are more likely to be implemented successfully when they are entrusted for implementation to organizations that embrace the same goals and values as those implicit or explicit in the policy.

Guideline 15: Organizations will work toward achieving successful implementation to the extent that they believe they can implement the policy, that implementing the policy will achieve desired program

objectives, and that achieving the program objectives is consistent with and supportive of the organization's primary objectives.

Guideline 16: Private organizations are more likely to implement risk reduction practices when they see that the risk poses a clear and present danger to their enterprise. Coupling risk reduction with routine business concerns, such as property and casualty insurance and related risk management concerns, helps bring it to the attention of the organizational decision makers.

Guideline 17: Public policies intended to induce private parties to reduce natural hazard risks to the organization and to the public at large are more likely to be implemented when the financial concerns of the private parties are acknowledged explicitly in the policy and provisions are made to alleviate financial burdens associated with implementation.

Guideline 18: Other things being equal, successful implementation depends on entrusting implementation to organizations with sufficient capacity to administer the program. If local government agencies are called upon to implement risk reduction programs, they should be provided with the resources necessary to do the job.

Guideline 19: Implementation proceeds more effectively when "the leaders of the implementing agencies possess substantial managerial and political skill and are committed to statutory objectives (Sabatier and Mazmanian, 1979).

Guideline 20: Smaller organizations may need technical assistance, in the form of consultants or self-help instructional materials, to augment their staffs so they are capable

“Case studies involving seismic retrofit of hospitals are planned to evaluate and extend the propositions concerning barriers to implementation and a means to overcome them.”

of making prudent choices concerning risk reduction for buildings and structures.

Guideline 21: In complex organizational environments characterized by instability and change, it may be useful to test implement public risk reduction programs aimed at private organizations in pilot projects in a variety of settings. This will help avoid implementation pitfalls that could come from immediate, widespread implementation.

Guideline 22: If the purpose of a public program is to induce private organizations to implement risk reduction policies and practices, governmental organizations should work to make it easy for the private organizations to understand the requirements and to facilitate implementation by the private organizations.

Conclusions and Further Research

In February 2001, we distributed both drafts to a select group of fourteen practicing structural engineers, public officials, and members of the earthquake hazard community who agreed to read both documents and to participate in a one day session in San Francisco to critique our work and our products. The session, held in March, was extremely successful. Because the reviewers were practitioners, the focus was primarily on the second working draft. The participants pointed out what was useful and what was not, helped us clarify our target audience, and provided guidance on how we could make the draft more useful. At this writing, we are working to

integrate their critique into the document.

We have also distributed our first draft — the synthesis of the prior research on implementation — to a half dozen scholars drawn from the social and behavioral sciences. Each of these scholars is associated with one of the three engineering research centers (MCEER, MAE, or PEER) and is actively engaged in earthquake hazard research. The group of scholars collectively decided it would be appropriate to meet in a central location to review their work. The group will have assembled by the time this report is published and will have provided a substantive critique of our draft report. Along with the critiques by the practitioners, this review will guide our development of final documents.

Several tasks dominate our current research activities. The first is completing our review of the state of the art in understanding obstacles to implementation and means for overcoming them. We have essentially completed our assessment of policy, intergovernmental, interorganizational, political, and process variables. We still have work to complete on obstacles to implementation associated with organizational behavior and decision making. Second, we will revise our drafts based on critique from the scholars and practitioners who have reviewed our work. Third, we will begin case studies involving seismic retrofits of hospitals as a means for evaluating and extending our set of propositions concerning barriers to implementation and means for overcoming them. Fourth, we will continue the development of our conceptual model

concerning the implementation process. Development of the conceptual models has been guided by the existing research literature, but refining and specifying the model is dependent on the data elicited in our stakeholder studies.

Beyond this year, we hope to expand our hospital retrofit case studies. Second, we will continue our current efforts to integrate our work with other MCEER researchers,

Detlof von Winterfelt (University Southern California) and Kathleen Tierney (Disaster Research Center, University of Delaware). Third, we will complete the development of our conceptual model of the implementation process. Finally, we expect to complete two monographs for publication by MCEER focusing on means for overcoming barriers to implementation both in the public and private sectors.

References

- Alesch, Daniel J., (1998), "Adopting And Implementing Performance-Based Seismic Design Standards," paper prepared for the Earthquake Engineering Research Institute, Oakland, CA.
- Alesch, D.J., and Petak, W.J., (1986), *The Politics and Economics of Earthquake Hazard Mitigation*, Natural Hazard Research and Application Center, University of Colorado, Boulder, CO.
- Bardach, Eugene, (1977), *The Implementation Game: What Happens After a Bill Becomes Law*, Cambridge, Mass.: The MIT Press.
- Calista, Donald, (1994), "Policy Implementation," *Encyclopedia of Policy Studies* (ed. Stuart Nagel), Marcel Dekker, New York, NY., pp 117-155.
- Calista, Donald, (1986), *Linking Policy Intention and Policy Implementation: The Role of the Organization in the Integration of Human Resources, Administration and Society*, Vol. 18, pp. 263-286.
- Drabeck, Thomas E., Mushkatel, Alvin H. and Kilijanek, Thomas S., (1983), *Earthquake Mitigation Policy: The Experience of Two States*, University of Colorado, Boulder, Institute of Behavioral Science, Monograph 37.
- Earthquake Engineering Research Institute, (1988), *Incentives and Impediments to Improving the Seismic Performance of Buildings*, Oakland, CA.
- Godschalk, David R., Beatley, Timothy, Berke, Philip, Brower, David J., Kaiser, Edward J., Bohl, Charles C., and Goebel, R. Matthew, (1999), *Natural Hazard Mitigation: Recasting Disaster Policy and Planning*, Island Press, Washington, D. C.
- Lipsky, M., (1971), "Street Level Bureaucracy and the Analysis of Urban Reform," *Urban Affairs Quarterly*, Vol. 6, pp. 391-409.
- Mazmanian, D. A. and Sabatier, P.A., (1989), *Effective Policy Implementation*, Lexington Books, Lexington, MA.
- Majone, G. and Wildavsky, A., (1978), "Implementation as Evolution," *Policy Studies Annual Review*, Vol. 2. H. E. Freeman (ed.), Sage, Beverly Hills. CA
- May, Peter J. and Williams, Walter, (1986), *Disaster Policy Implementation: Managing Programs Under Shared Governance*, Plenum Press, New York.

References (Con't)

- Pressman and Wildavsky, (1984), 3rd edition, *Implementation*, University of California Press, Berkeley, California
- Sabatier, P. and Mazmanian, D., (1979), "The Conditions of Effective Implementation; a Guide to Accomplishing Policy Objectives," *Policy Analysis*, No. 5, pp. 481-504.
- Sabatier, P. and Mazmanian, D., (1981), "The Implementation of Public Policy: A Framework of Analysis," in *Effective Policy Implementation*, (eds. D. A. Mazmanian and P. A. Sabatier), Heath, Lexington, MA.
- Sabatier, P. A., (1986), "Top-Down and Bottom-Up Approaches to Implementation Research: A Critical Analysis and Suggested Synthesis," *Journal of Public Policy*, Vol. 6, pp. 21-48.
- Taylor, Craig, Mittler, Elliot, and Lund, LeVal, (1998), *Overcoming Barriers: Lifeline Seismic Improvement Programs*, Monograph No. 13, American Society of Civil Engineers, Reston, VA.