NSF/CEE-83207

Case Study No. 2

PB84-133917

INNOVATIONS IN EARTHQUAKE AND NATURAL HAZARDS RESEARCH:
UNREINFORCED MASONRY BUILDINGS

Gwendolyn B. Moore
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July 1983

COSMOS
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50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. NSF/CEE-83207	2.	3. Recipient's Accession No. PB84 133917

4. Title and Subtitle
Innovations in Earthquake and Natural Hazards Research: Unreinforced Masonry Buildings

5. Report Date
July 1983

6.

7. Author(s)
G.B. Moore, R.K. Yin

8. Performing Organization Rept. No.
Case Study No. 2

9. Performing Organization Name and Address
COSMOS Corporation
1730 K Street, N.W.
Suite 1302
Washington, DC 20006

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G) CEE8203884

12. Sponsoring Organization Name and Address
Directorate for Engineering (ENG)
National Science Foundation
1800 G Street, N.W.
Washington, DC 20550

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)
Results are presented of research on uninreinforced masonry (URM) buildings. An extensive survey of URM buildings in six regions of the country was undertaken to identify the characteristics of those buildings. A computer model was developed to pretest and predict the responses of walls and diaphragms when subjected to simulated ground motion. Tests were conducted on specimen walls and diaphragms and on existing URM buildings to confirm and refine the methodology. A cost effective means was found for evaluating and retrofitting URM buildings to withstand earthquakes. Use of this innovation occurred as a result of important events during the life of the research project, including: (1) a series of workshops held for officials, engineers, and building owners to acquaint them with the research, and (2) active dissemination of project results.

17. Document Analysis a. Descriptors

Dynamic structural analysis	Tests	Diaphragms (mechanics)
Earthquakes	Technology innovation	Meetings
Earthquake resistant structures	Masonry	Walls
Buildings	Computers	Technology
	Surveys	

b. Identifiers/Open-Ended Terms
Ground motion

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c. COSATI Field/Group

Availability Statement	19. Security Class (This Report)	21. No. of Pages
NTIS	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

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Related Reports

Moore, Gwendolyn B., and Robert K. Yin, "Innovations in Earthquake and Natural Hazards Research: Local Government Liability," COSMOS Corporation, Washington, D.C., April 1983.

ISBN No. 0-942570-03-0

This material is based upon work supported by the National Science Foundation under Grant No. CEE-8203884. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the Foundation.

Preface

The present case study is part of a project investigating the process by which earthquake and other natural hazards innovations are utilized, the goal of which is to improve the usefulness of these innovations to policymakers, state and local officials, service providers, and citizens.

The case study is one of a series of nine--six will be widely disseminated, and three will be available to researchers upon request. In addition, a summary volume will discuss: the theoretical underpinnings of the project and its design and case selection procedures; report the analyses across all nine cases; and develop specific policy recommendations--aimed at research investigators and R&D funding agencies--to promote the utilization of future research.

We would like to thank the principals of the ABK Joint Venture--Robert D. Ewing, Albin W. Johnson, and John C. Kariotis--for their cooperation in conducting this case study. These three individuals and officials from the Los Angeles Department of Building & Safety--Earl Schwartz and Art Devine--reviewed and provided useful comments on the draft of this case. Finally, we appreciate the continuing support and assistance of William A. Anderson, our NSF project officer. This assistance notwithstanding, we alone are responsible for errors or omissions.

G.B.M.
R.K.Y.

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Summary

The study of innovation can take many forms. One traditional dichotomy has been between knowledge production and knowledge use. The former includes such topics as creativity and invention, research and development (R&D) management, and commercialization processes; and the latter includes such topics as dissemination, diffusion, and utilization. Regardless of a study's focus, however, the objective is to improve society by understanding how new ideas are generated, produced, and used.

Innovations in Earthquake and Natural Hazards Research

The present case study focuses on knowledge use. The study analyzes how an innovation in earthquake and natural hazards research was used for practical and policy purposes, why utilization occurred, and what potential policy implications can be drawn. The case is the second of nine, all aimed at developing recommendations for improving research utilization in the future. (Six will be widely disseminated as final reports; three will be made available to researchers upon request.)

Research on earthquake and natural hazards offers a unique opportunity to study the utilization of innovations, because both social science and physical science innovations are relevant. For example, the first case in this series involved a social science innovation--the identification of local government liabilities in relation to losses due to earthquakes. This second case study is of a physical science innovation--a new and cost-effective process for evaluating and retrofitting unreinforced masonry buildings. Thus, the variety of innovations not only offers an opportunities to develop explanations for utilization, but also provides a chance to compare the utilization of social science and physical science innovations. This comparison has not, to our knowledge, been directly made in previous studies.

One of the tentative, overall findings from the first two cases and others now underway is that the traditional dichotomy between the knowledge production and knowledge utilization processes may have been misguided. Fruitful utilization seems to occur when the two processes are intertwined. In fact, in this case, significant utilization occurred even before the research project had been completed. Thus, future research and policy actions may have to account for such complex and nonlinear outcomes.

The Innovation

The innovation in the current case study was a cost-effective means to evaluate and retrofit unreinforced masonry (URM) buildings to withstand earthquakes. URM buildings are among the architecturally distinguished buildings in the country--including the Faneuil Hall Marketplace in Boston and the famous Bradbury Building in Los Angeles. However, URM buildings--built in the first third of the century before seismic criteria were included in most building codes--pose a serious threat to life when subjected to moderate or strong ground motions. In fact, much of the damage from both the 1971 San Fernando and the 1983 Coalinga (California) earthquakes was due to collapses of URM buildings.

The dual concerns of potentially huge losses from URM building collapse and the excessive cost required to retrofit them, led to the initiation of a research project to develop cost-effective retrofit methods. The research--still in progress at the time of this case study--is producing a methodology for evaluating and retrofitting URM buildings. The research has involved both analytical and experimental investigations, using computer and physical models to simulate earthquake motions. Initially, an extensive survey of URM buildings in six regions of the country helped to identify the characteristics of buildings to be the subject of further analysis. Later, a computer model was developed to pretest and predict the responses of walls and diaphragms (i.e., floors and roofs) when subjected to simulated ground motion. Finally, tests were conducted on specimen walls and diaphragms, and on existing URM buildings, to confirm and refine the methodology.

The research was conducted by a joint venture, "ABK, A Joint Venture," organized by three Los Angeles-area engineering firms--Agbabian Associates, S.B. Barnes and Associates, and Kariotis, Kesler & Allys.

Uses of the Research and Explanations for Use

The findings--in the form of design and engineering specifications--have been used by local officials to develop ordinances, and by engineers to evaluate and retrofit buildings. The case study presents vignettes of individual utilization experiences, and also assesses the extent of utilization. In general, the innovation already has been used widely, even given the fact that the ABK research has not been completed.

Utilization occurred, as revealed by the case study, as a result of important events during the life of the research project. These events included: 1) a NSF-sponsored conference of engineers where research priorities were identified; 2) the membership of both researchers and users in a professional association, the Structural Engineers Association of Southern California (SEASC), that facilitated communication between the two groups; 3) a series of workshops held for officials, engineers, and building owners to acquaint them with the research, and 4) active dissemination of project results, as they became available, throughout the life of the project.

Overall, the case study concludes that the prior identification of a problem as well as the effects of a continuously active network of knowledge producers and users can account for the utilization experiences of the ABK innovation.

Policy Implications

Although the case study presents the experiences of but a single innovation, the policy implications are discussed to establish a within-case rationale for the findings. Along these lines, future policies likely to favor utilization are those deriving both from a <u>problem-solving</u> and a <u>social interaction</u> perspective, in contrast to those deriving from a research, development, and diffusion perspective. Should this finding, which is consistent with that of the first case study of this series,* be replicated in the subsequent case studies, the aggregate results will provide strong support for guiding individual research investigators as well as the R&D policies of such agencies as the National Science Foundation, the National Institutes of Health, and other federal and private research-funding organizations.

* Moore, Gwendolyn B., and Robert K. Yin, "Innovations in Earthquake and Natural Hazards Research: Local Government Liability," COSMOS Corporation, Washington, D.C., April 1983.

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THE ABK JOINT VENTURE RESEARCH PROJECT: METHODOLOGY FOR MITIGATION OF SEISMIC HAZARDS IN EXISTING UNREINFORCED MASONRY BUILDINGS

I. INTRODUCTION

Unreinforced masonry buildings are among the older, more architecturally prized buildings in cities across the country. However, in the event of an earthquake, these buildings pose a serious threat, due to their possible collapse and the resulting loss of life. In fact, structural engineers believe that such buildings constitute 80 to 90 percent of the total threat to life when an urban area is shaken by moderate to strong ground motions (Ewing, Johnson, and Kariotis, 1982, p. 2).

To deal with this hazard, three firms in the Los Angeles area formed a joint venture--named "ABK, A Joint Venture"--to develop practical and reliable methods for evaluating the performance of unreinforced masonry buildings when subject to seismic shaking, and to identify cost-effective ways to strengthen them structurally. ABK's overall objective has been to reduce the risk of injuries or death that may result from the effects of earthquakes, and much of its work has already been put to use. The innovative component of the research was to define a standard that met the basic need for assuring life safety, but that still fell short of the stringent standards (and concomitant high costs) in effect for newly constructed buildings.[1]

The purpose of the present case study is to document and explain the observed uses of the ABK research, and to discuss the implications of these findings for future strategies to promote the utilization of earthquake and natural hazards research. (The individuals interviewed as part of this case study are listed in Appendix I.) The case study:

- discusses the problems associated with unreinforced masonry and the origin of the ABK research project,
- outlines the research effort,
- describes the uses to which the research has been put, and
- explains why utilization occured.

The case study is one of nine. Each examines the utilization experience of a different earquake and natural hazards research project. The findings relating to the ABK case are reported here; conclusions from all nine cases are reported in a summary volume.

The Unreinforced Masonry Problem

Unreinforced masonry construction is pervasive throughout the United States. In the City of Los Angeles alone, there are approximately 8,000 commercial, industrial, apartment, hotel, and public buildings constructed of unreinforced masonry (URM). These buildings were constructed before earthquake standards were included in the Building Code.[2] Some of these URM buildings are highly valued historic structures, such as the famous Bradbury Building located in downtown Los Angeles. Other cities have the similarly-prized URM structures, such as Faneuil Hall Marketplace in Boston, and many pre-1886 residences in Charleston, S.C.

Los Angeles officials have estimated that, without structural improvements, URM buildings could cause up to 8,500 deaths and 34,000 injuries in the event of a major earthquake.[3] The San Fernando Valley earthquake in 1971 was a tragic demonstration of the vulnerability of these buildings. Further unfortunate evidence of the URM problem was witnessed on May 2, 1983, when an earthquake hit Coalinga, California. The earthquake's damage was concentrated in the downtown area, where, in "...a 12-block cluster of older, unreinforced brick buildings...141 structures were destroyed. The quake sheared off the facade of many businesses, giving them the look of gigantic dollhouses with exposed interiors. Other buildings were reduced to dusty heaps of rubble" (Newsweek, 1983, p. 39).

ABK's research was intended to address this concern. The results of the research have supported the development ordinances in at least two cities in California--Los Angeles and Santa Ana--that require building owners to make structural modifications to make their buildings better able to withstand seismic shaking, thus reducing the danger of collapse and loss of life.

The Origin of the Research Project

A number of parallel events set the stage for ABK's research. The San Fernando Valley earthquake in 1971 caused the failure of numerous URM buildings. This event prompted Los Angeles officials to find feasible ways to strengthen unreinforced masonry, rather than facing two unpleaseant choices: either demolishing the buildings, or forcing owners to spend over 100 percent of their buildings' replacement costs to meet the seismic standards applicable to new buildings. Thus, the Los Angeles officials surveyed the URM buildings in the city and identified, as noted in the preceding section, nearly 8,000 such buildings.[4]

Officials at the National Science Foundation (NSF) who had learned of the URM losses in the 1971 earthquake also began to focus on the URM problem. Although the vulnerability of URM buildings had been recognized among engineering professionals, NSF found that little research had been done to understand the response of URM buildings to seismic shaking. One surprising fact further stimulated interest in the URM problem: some URM buildings had withstood earthquakes--as in Charleston's experience--although the buildings, theoretically, should have failed.[5] This fact led engineers to believe that the variability of materials used in URM buildings contained important lessons about how they might be altered to resist seismic shaking. Nevertheless, no systematic testing of URM buildings had been conducted, and no guidelines for making the buildings more earthquake-resistant existed.

In an effort to stimulate discussion of the URM problem and identify the needed research, NSF sponsored a workshop that was conducted by Dr. Robert D. Hanson of the University of Michigan. The workshop, entitled "Repair, Strengthening, and Rehabilitation of Buildings: Recommendations for Needed Research," was held on June 9-10, 1977, in San Francisco. Invited to attend were approximately 25 individuals working on the topic of building repair and retrofit. At the meeting, specific problems of URM buildings were discussed.[6]

Attending this meeting were a number of individuals later affiliated with ABK, including S.B. Barnes, John Kariotis, Clarkson Pinkham, and Ben Schmid (all of whom were structural engineers), and Earle Schwartz from the Department of Building and Safety of the City of Los Angeles. Specifically highlighted by the group was the "immediate need" to evaluate possible methods of strengthening lime mortar buildings (a subset of URM buildings).

In addition to this workshop, the NSF placed a priority on research that would lead to solutions to the URM problem. This was in part due to the number of URM buildings and the magnitude of potential losses--not only in Los Angeles, but in all seismic zones of the country. Thus, in early 1977, the general topic of earthquake engineering and hazard mitigation was included as a topic in the program solicitation under the "Small Business Innovation Applied to National Needs" program.[7]

Under that solicitation, three engineering firms--Agbabian Associates, S.B. Barnes and Associates, and Kariotis, Kesler & Allys (subsequently Kariotis & Associates)--applied separately for and received independent awards to develop a methodology for mitigating URM hazards. Overall, the "methodology" consisted of several components, each becoming the focus of one of the three firms. The research project, the activities of the three firms, and the work of their eventual joint venture, are described in the following section.

NOTES TO SECTION I

1. The standards for construction of new buildings are intended to prevent loss of life and property damage. Ordinances based on the ABK research aim only to prevent loss of life, and are thus less stringent than standards for new construction.

2. Earthquake standards were first incorporated into Los Angeles building codes in 1934. Other areas of the country began to establish earthquake standards in 1940. For a full description of URM construction throughout the United States, see "Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings: Categorization of Buildings," ABK-TR-01, ABK, A Joint Venture, El Segundo, Calif., December 1981.

3. Based on U.S. Geological Survey statistics.

4. The city-wide survey was done during 1977 and 1978, identifying 7,876 pre-1934 URM buildings in Los Angeles.

5. In 1886, Charleston suffered a major earthquake of an estimated 9 or 10 on the Mercalli scale (the scale range is 1-12). According to commonly-accepted engineering principles, all of Charleston's URM buildings should have collapsed in an earthquake of that intensity, but 75 percent of them remain today.

6. Information about this meeting was obtained through a telephone interview on February 17, 1983, with Dr. Robert D. Hanson, Department of Civil Engineering, University of Michigan.

7. The name of the program was subsequently changed to the Small Business Innovation Research (SBIR) program. This program is discussed in more detail in the Section II.

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II. THE RESEARCH PROJECT

The research project to develop practical and reliable methods for evaluating and structurally modifying unreinforced masonry (URM) buildings began in October 1977, when three engineering firms received awards from the National Science Foundation (NSF). After the initial six-month awards, the three firms--Agbabian Associates, S.B. Barnes and Associates, and Kariotis, Kesler & Allys--formed "ABK, A Joint Venture" to continue the research.

Prior to 1977, when they began collaborating, each of the firms had independently pursued specialized types of engineering work. Agbabian Associates specialized in applied research projects; the seismic evaluation of dams, powerplants, and nuclear facilities; analysis and design of structural and mechanical systems subjected to conventional and nuclear weapon effects; and high-technology testing and analysis. Both S.B. Barnes and Associates and Kariotis, Kesler & Allys had been active in the design, construction, and reconstruction of a variety of types of buildings--residential, commercial, and industrial. Staff of all three firms were also members of the Structural Engineers Association of Southern California (SEASC). SEASC is an active professional organization devoted to "establish the highest professional standards, to advance the science of structural engineering and to provide the public with safe and economical buildings" (SEASC, no date).

Individual Awards

The three NSF awards were initially made to the three firms in October 1977. From NSF's perspective, these awards were Phase I of a three-phase, small business program, moving from feasibility testing to full commercialization of innovations.[1]

Basically, all three efforts were intended to determine the studies and testing needed to arrive at a methodology for mitigating seismic hazards in URM buildings, by developing structural and economic criteria for the required retrofitting of those buildings. From the Phase I work, the principals concluded that developing such a methodology was feasible, and thus paved the way for Phase II work.

Each firm received a $25,000 "Phase I" award under this program and investigated a portion of the general topic. Although the awards were independent, the three firms closely coordinated their work, with meetings weekly throughout the six-month Phase I period (Adham and Ewing, 1978, p. 1-3). Figure 1 illustrates the portion of the work done by each firm. (Figure 1 also shows proposed research by a fourth structural engineer, Ben L. Schmid. His contribution was to have been to determine the physical properties of URM construction to provide data for modeling, analyzing, and evaluating the response behavior of URM buildings. However, this proposed research was not supported by NSF, and this fourth element of the overall methodology was dropped.)

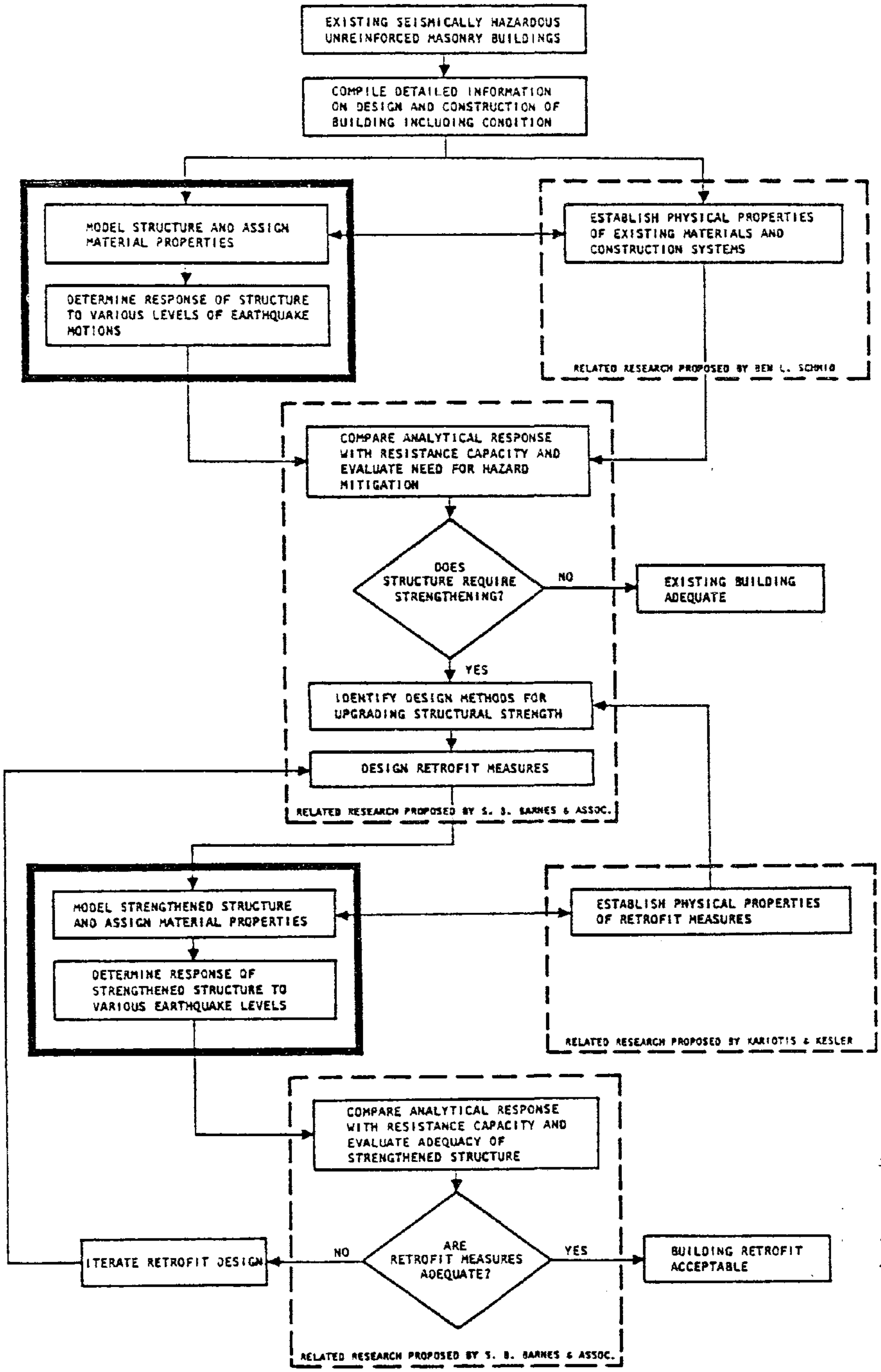
In Phase I, Agbabian Associates evaluated methods for selecting earthquake ground-motion, and developed an experimental and analytical program for studying the behavior of critical components of URM buildings. Agbabian found that, due to certain physical characteristics, URM buildings do not respond to seismic shaking in the same way as new masonry construction. The results of this Phase I work are reported in "Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings: Phase I," by S.A. Adham and R.D. Ewing, El Segundo, Calif., 1978.

S.B. Barnes and Associates investigated methods for determining whether a URM building is hazardous to life safety, and if it is, how to strengthen it so that it is no longer a life hazard. In Phase I, Barnes outlined of a method to determine the need for seismic retrofit with related retrofit procedures. (The outline is shown in Figure 2.) The results of this Phase I work are reported in "Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings: Phase I," by S.B. Barnes, A.W. Johnson, and C.W. Pinkham, Los Angeles, Calif., March 1978.

Kariotis, Kesler & Allys, in their Phase I work, categorized the types of existing URM construction in various seismic zones in the United States, classified current structural alteration methods, and investigated material properties and the response of different classes of structures to ground motion. Kariotis found common characteristics of URM buildings in

Figure 1

METHODOLOGY FOR MITIGATION OF SEISMIC HAZARDS IN EXISTING UNREINFORCED MASONRY BUILDINGS

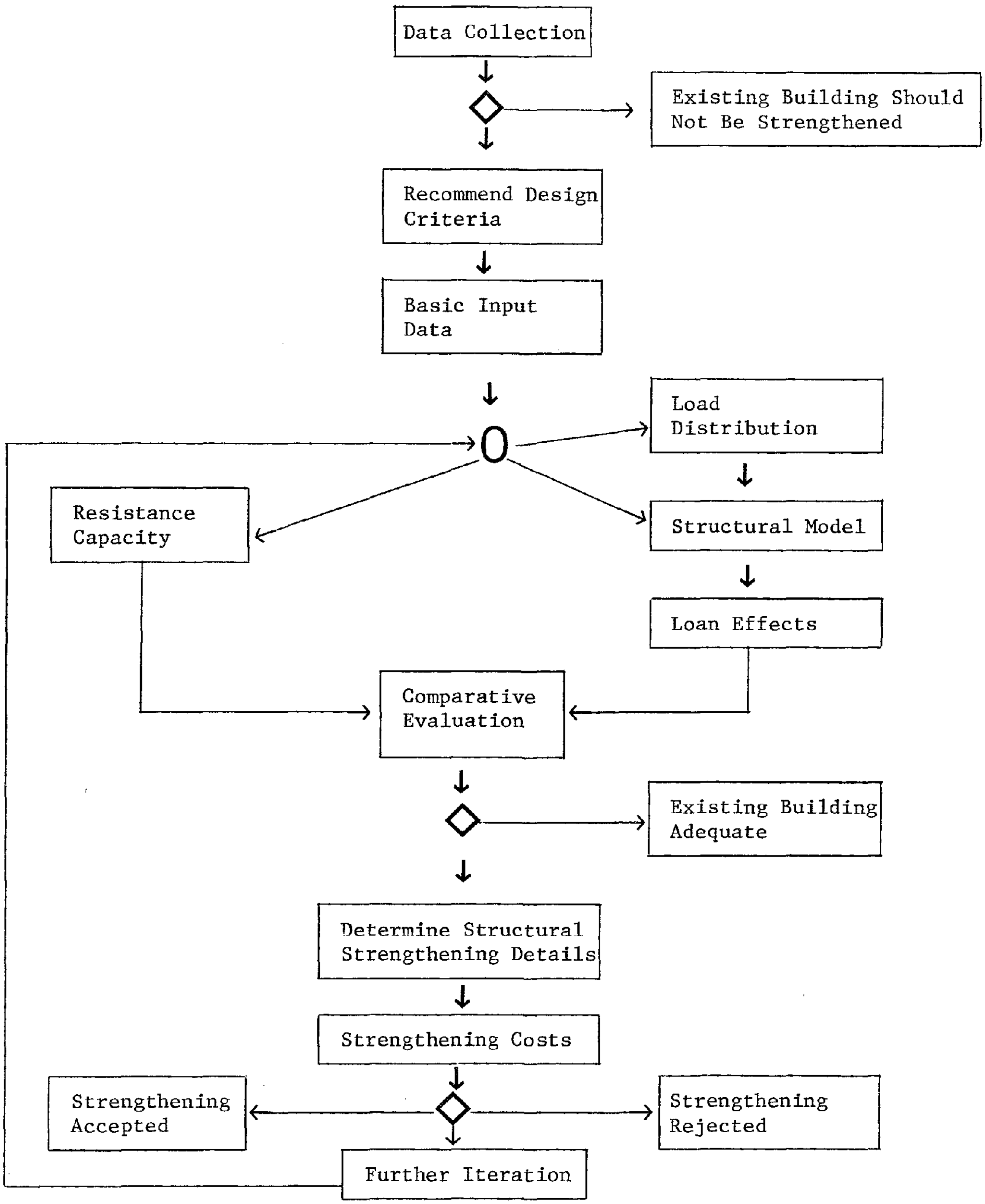


Note: Boxes in heavy lines connotes work by Agbabian Associates.

Source: Agbabian Associates, "Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings--Response of Existing Systems to Earthquake Motions," proposal to NSF, April 1977, p.5.

Figure 2

FLOW CHART FOR DETERMINING NEED FOR SEISMIC RETROFIT AND RETROFIT PROCEDURES



Source: S.B. Barnes and Associates, "Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings: Phase I," March 1978, p. 1-2.

all seismic zones, and concluded that previously-used methods for evaluating seismic properties of new materials did not apply to URM buildings. The results of this Phase I work are reported in "Mitigation of Seismic Hazards in Existing Unreinforced Masonry Wall Buildings: Performance of Undesigned and Modified elements and Evaluation of Modification Methods," by Kariotis, Kesler & Allys, Pasadena, Calif., March 1978.

ABK and Phase II

In April 1978, the three firms formed "ABK, A Joint Venture," to perform research pursuant to a "Phase II" contract from NSF. The joint venture enabled the principals from the Phase I work to collaborate, within the same organizational framework, as ABK was directed by an executive committee consisting of the principal investigators of the Phase I projects. One of the original investigators, Robert D. Ewing of Agbabian Associates, was designated as the chairman of the executive committee, and has been administratively responsible for the joint venture. The ABK organization chart is shown in Figure 3.

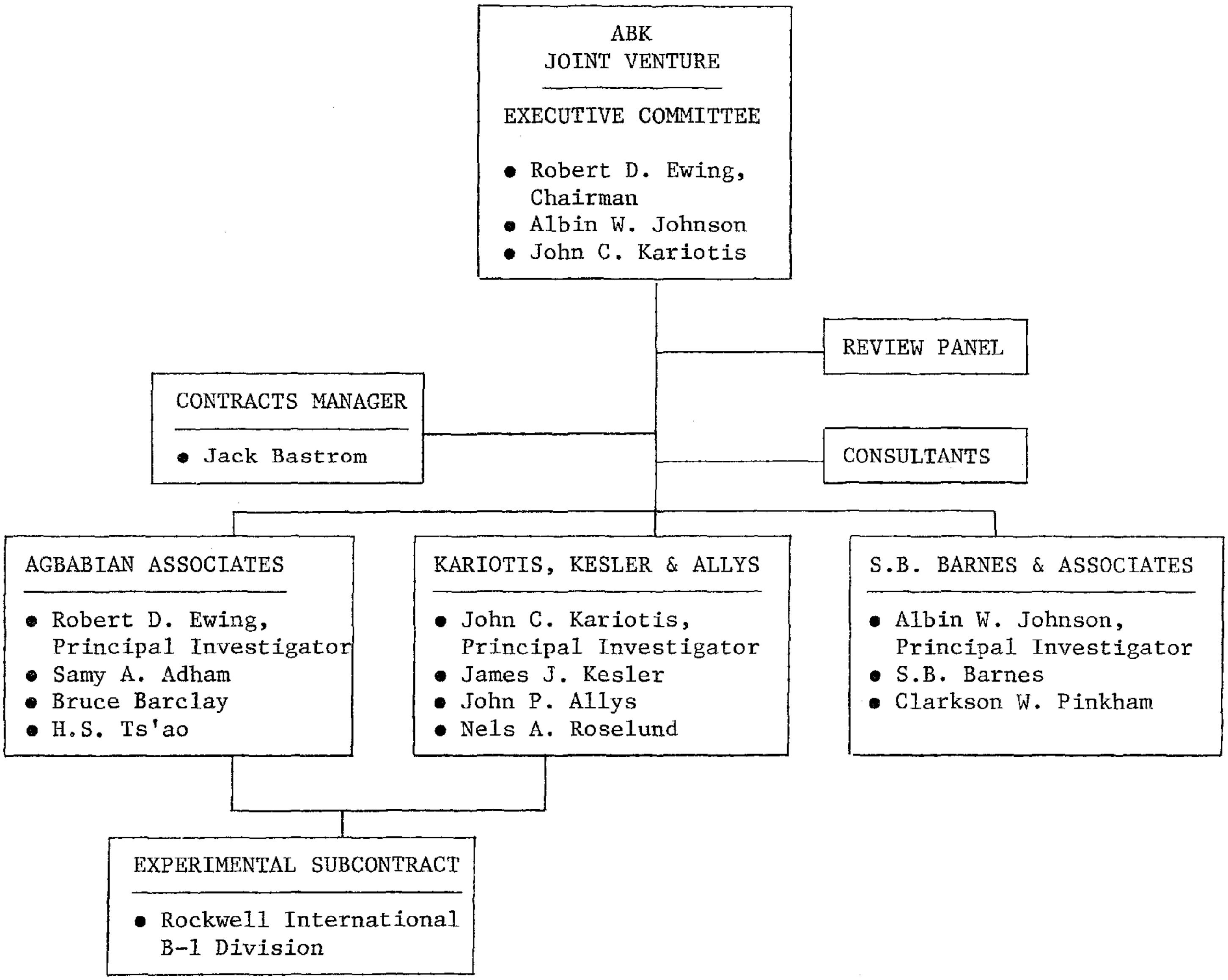
To this day, the sole activity of ABK has been to work on earthquake-hazard mitigation in URM buildings. ABK's sole support has been from NSF, which made one award to the joint venture in October 1978, and a second award in February 1981. The full array of awards, covering both phases of the research effort, is shown in Table 1.

The ABK research has been divided into three sets of tasks, with one or more of the members of the joint venture having primary responsibility for each task. The three tasks are:

> 1) to evaluate the existing data on building standards, including categorizing existing URM buildings, reviewing the history of seismic damages to URM buildings, evaluating prior testing and analysis, and examining retrofitting efforts by the engineering profession to mitigate seismic hazards;
>
> 2) to devise and carry out a testing program...[for] several structural components, including a variety of diaphragms, walls both in-plane and out-of-plane, and anchorages; and

Figure 3

ABK ORGANIZATION CHART



Source: ABK, Phase II Proposal, April 1978, p. 4-3.

Table 1

NATIONAL SCIENCE FOUNDATION SUPPORT
OF THE THREE FIRMS AND THE ABK JOINT VENTURE

Phase I Awards		
October 1977	Agbabian Associates	$ 25,000.
October 1977	S.B. Barnes and Associates	25,000.
October 1977	Kariotis, Kesler & Allys	24,391.
Phase II Awards		
October 1978	ABK, A Joint Venture	924,748.
February 1981	ABK, A Joint Venture	422,377.

> 3) to develop simplified analysis methods to determine failure modes that may be life threatening, a process which is the culmination of the preceding two sets of tasks and leads directly to the development of the final methodology (ABK, 1980, p. 1-1).

These tasks included both analytical and experimental investigations, using computer and physical models subjected to simulated earthquake ground motions. An initial step in the research was an extensive survey of URM buildings in six regions of the country, each representing different seismic characteristics. The cities that were surveyed within these regions were those with a substantial number and diversity of URM buildings. An extensive photographic record was made of many of the buildings. A categorization of URM buildings, developed from this survey, helped to identify the characteristics of buildings to be the subject of further analysis.

In addition, an analytic computer model was developed. The model was used to pretest and predict the responses of walls and diaphragms (i.e., floors and roofs) when subjected to similated ground motion, and to identify the forces required at the top and base of the URM walls to simulate the desired range of ground motions. Specimen diaphragms and URM walls were shaken by hydraulic "hammers," programmed (by the analytic model) to produce the displacement of selected, scaled earthquake motions. The model proved to be a good representation of the actual response of walls and diaphragms.

Further testing of actual, existing URM buildings was being conducted on URM buildings in Los Angeles at the time of this case study. The results of these full-scale tests will be helpful in providing "real-life" confirmation of the results of the wall and diaphragm tests.

The results of these activities will be reported in eight anticipated project reports, four of which had been completed by the time of this case study. All eight reports are listed in Table 2. In addition, the research has already been presented and published through numerous professional channels. Nearly 30 such publications and presentations are listed in Appendix II.

The eventual product of this research will be a complete methodology for assessing and retrofitting URM buildings. As such, the product is a "process"--i.e., a way of testing, analyzing, and bringing URM buildings up to a minimal structural standard. The innovative contribution has been to focus on the protection of life safety, and not necessarily to avoid damage to the building. Only with such a focus has it been possible to develop retrofitting techniques not requiring an expenditure exceeding the value of the building.

Table 2

PROJECT REPORTS OF THE ABK JOINT VENTURE

Categorization of Buildings, Topical Report 01, December 1981

Seismic Input, Topical Report 02, December 1981

Diaphragm Testing, Topical Report 03, December 1981

Wall Testing, Out-of-Plane, Topical Report 04, December 1981

Interpretation of Diaphragm Tests, forthcoming

Interpretation of Wall Tests, Out-of-Plane, forthcoming

Anchorage Requirements, forthcoming

The Methodology, forthcoming

NOTES TO SECTION II

1. This three-phase program, originally called "Small Business Innovation Applied to National Needs" and later renamed the "Small Business Innovation Research" (SBIR) program, provides funding for small businesses to pursue innovative ideas. Phase I funds are provided for testing the feasibility of a concept, with Phase II funding available if the objectives of Phase I were met. Phase III does not involve federal funds (except in the event of a procurement contract), but relies on capital from private sources to commercialize the R&D results of the small business. Applicants for Phase II funds are given priority when they have a commitment for this "follow-on" funding from a private source. The overarching objective of the SBIR program is to stimulate the commercialization of small-business innovations.

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III. THE USES OF THE ABK RESEARCH

The knowledge generated by the ABK project already has been put to use in a number of ways, although the project was still in progress at the time of this case study.

This section discusses the potential uses of the ABK research, contains illustrative examples of actual use, and provides information about the broader extent to which the research has actually been used.

Potential Uses and Users

Our previous research on the utilization process has suggested three categories for describing the uses of R&D: decisionmaking, practice, and enlightenment.[1] Of these, both the decisionmaking and practice categories are relevant, as the ABK research can be used by state and local officials, engineers, and code-writing bodies (e.g., the International Conference of Building Officials). The range of potential uses and users of the ABK research is shown in Table 3.

Decisionmaking. For decisionmaking, the ABK project was designed to provide specifications and criteria for modifying state statutes and local ordinances relating to the retrofitting of URM buildings. Thus, the project intended to assist state and local officials: 1) in assessing the efficacy of proposed statutes or ordinances intended to address the URM, and 2) in designing statutes or ordinances to establish retrofitting standards. Evidence of this type of decisionmaking use would be the actual consideration, modification, design, or adoption of statutes or ordinances.

Practice. For practice, the ABK research was designed to be used by engineering professionals, to identify methods and procedures for testing, evaluating, and strengthening URM buildings. Thus, the project was intended to improve engineering practice in two ways: 1) to evaluate, test, and retrofit URM buildings, and 2) to develop new engineering codes for retrofitting URM buildings.

With regard to evaluation, testing, and retrofitting, the ABK research can provide specific formulas and techniques to be employed by

Table 3

POTENTIAL USES OF THE ABK RESEARCH

TYPE OF USE	PRIMARY USERS
Decisionmaking	
To identify, evaluate, and consider options to the URM problem.	Local Officials State Officials
To develop and adopt statutes and ordinances requiring retrofitting of URM buildings.	Local Officials State Officials
Practice	
To evaluate and test URM buildings.	Structural engineers
To retrofit URM buildings.	Structural engineers
To develop new standards for retrofitting URM buildings.	Code-writing bodies in the engineering field

engineers. For example, an engineer might use the anchorage techniques developed by the ABK project to strengthen a URM building. Although techniques developed by ABK are not the only ones that can be used, engineers associated with the project and others suggest that the ABK techniques are the most cost-effective ways currently available.

With regard to code and standards development, the reader is reminded that the practice of engineering is guided by a series of codes and standards.[2] The results of the ABK project could be incorporated into codes to guide URM testing and rehabilitation.

Examples of Use

With these potential uses in mind, we identified several uses of the ABK research that have already occurred. Vignette No. 1 describes how the ABK research was used by the City of Los Angeles in developing a URM ordinance, and Vignette No. 2 describes a similar ordinance adopted by the City of Santa Ana, California. Vignettes No. 3 through 5 describe how engineers actually retrofitted URM buildings.

Extent of Use

A further question, beyond these specific uses, is the actual extent, or prevalence, of use of the ABK research. However, such a broader pattern was difficult to determine for a number of reasons.

First, at the time of this case study, the ABK research project was still ongoing. It is not for some period of time after completion of a project--from months to years--that full utilization outcomes are likely to be realized. Thus, because ABK is ongoing, its utilization cannot be expected to be very extensive.

The second reason why it is difficult to determine the extent of use of the ABK research is that actual engineering efforts--i.e., retrofitting of URM buildings--are unlikely to occur in the absence of an ordinance requiring the retrofit of URM buildings. This second reason also makes the extent of use unusually difficult to interpret.

Vignette No. 1: Developing a Los Angeles Ordinance[3]

In January 1981, the City Council of Los Angeles passed an ordinance dealing with earthquake hazard reduction in existing URM buildings by adding Division 68 of Article 1 of Chapter IX of the Los Angeles Municipal Code. The ordinance established minimum standards for structural seismic resistance, for buildings with unreinforced masonry walls constructed prior to October 6, 1933, when the Municipal Code first required earthquake-resistant construction. The ordinance specifies priorities and a time schedule for mandatory compliance.

Initial drafting of the ordinance was begun in 1976 by the Department of Building and Safety, and in 1977 it was submitted to the City Council for consideration. At that time, the draft ordinance closely resembled the one for the seismic design of new buildings. The City Council established a special citizens' study committee to investigate and review the financial, economic, and engineering aspects of the proposed ordinance, and also asked that the environmental impact of the proposed ordinance be assessed.

The contents of the ordinance that was finally approved by the City Council were taken from the special citizens' study committee, although it was based in part on the results of the ABK research. In general, the ABK research, according to Earl Schwartz of the Los Angeles Department of Building & Safety, allowed a "different way of analyzing [URM] structures," and "changed our philosophy" about URM buildings. Specifically, the ABK research is reflected in Division 68 by specifying minimum height-to-thickness ratios for URM walls, certain allowable values for existing materials, and certain allowable values for new materials used in conjunction with existing construction.

The ABK research has continued to produce test results that validate and refine the design criteria in Division 68. Some of these test results will allow for the relaxation of design standards (e.g., by reducing the allowable height-to-thickness ratios of URM walls). In other cases, the tests indicated the need to make the code more restrictive (e.g., by reducing the allowable value for straight diaphragm sheathing from 150 lbs. per square foot to 100 lbs. per square foot). These changes will be reflected in a revision of the Division, effective July 1983.

Recall that the ABK research focused on the evaluation and retrofitting of existing URM buildings--i.e., buildings constructed prior to the time when earthquake standards were included in the local ordinances guiding construction of new buildings. To retrofit such buildings to withstand seismic shaking is an expensive decision. It is estimated, based on the standards established by the Los Angeles URM ordinance (Division 68), that the cost of retrofitting an industrial building would be $2 to $4 per square foot, $4 to $8 per square foot for retail buildings, and $6 to $12 per square foot for apartment buildings.[8] Thus, unless unusually concerned about earthquake losses, it is unlikely that a building owner (whether an individual, a corporation, or a government entity) would initiate retrofitting unless required to do so. Consequently, in the absence of an ordinance, owners would not engage engineers to retrofit those buildings, and hence the ABK research would not have an "opportunity" to be used.

In addition, the absence of a URM ordinance can also prevent the use of innovative techniques for testing and retrofitting. For example, construction on buildings requires a permit, which is issued consonant with the approval of construction plans. If an engineer were proposing to retrofit a building in an innovative way, it is possible that a permit would not be issued because permit approval is usually based on known and existing methods and standards. This permit process, therefore, can constrain the introduction and use of new engineering methods and techniques.

Further, the code-writing and ordinance-drafting process can take many years. As noted, the use of the ABK research is highly dependent on engineering codes and local ordinances. Protracted periods of time are routinely expected before new engineering knowledge is used in either the code-writing or the ordinance-development process. For example, the drafting and passage of the Los Angeles URM ordinance took over five years. Long periods also elapse before new engineering knowledge is assimilated and incorporated into engineering codes. (The International Conference of Building Officials estimates that the average time for considering a proposed code revision and incorporating it into the UBC is two years.)

Vignette No. 2: Adopting a Santa Ana Ordinance[4]

The City of Santa Ana adopted an ordinance that establishes minimum standards for the structural seismic resistance of URM buildings. The ordinance, Article XI of the Santa Ana Municipal Code, was originally adopted on February 19, 1981, and was revised on September 8, 1981.

The Santa Ana ordinance is essentially identical to the Los Angeles ordinance. Two engineers who were instrumental in the drafting and adoption of the Santa Ana ordinance, John Coil and Robert Lawson, were members of SEASC, and were thus aware of both the ABK research and the Los Angeles ordinance-development process.

Bob Tyler of the Santa Ana Department of Planning and Development Services knew about the ABK involvement in testing of URM buildings, and how that research had shaped the Los Angeles ordinance. Further, Tyler reported that Santa Ana was "keeping in step" with Los Angeles as they modified their ordinance, based on the flow of results from the ABK research. Santa Ana officials estimate that 200 URM buildings are covered by Article XI.

Vignette No. 3: Building Renovation Under Division 68[5]

A Los Angeles structural engineering firms was engaged to evaluate and renovate a 3-story apartment building on Adams Street in Los Angeles. The renovation, initiated about one year ago and almost complete at the time of this case study, was done in response to a Division 68 compliance order.

Work done to the building, which was described by the engineer as otherwise "in good shape," consisted of adding a continuous steel angle around the building, and bolting it through the masonry walls to the floors and at the roof level. Two aspects of Division 68 made the renovation easier and more cost-effective, according to the engineer. First was the provision having to do with existing materials, that allows "reduction in [design earthquake] forces by 30 percent if a building has cross-walls less than 40 feet apart, " as the Adams Street building did. Second was the provision allowing the use of existing materials in conjunction with new materials for shear, thus requiring fewer new materials to be used during renovation.

And finally, even within the jurisdictions having URM ordinances, only a limited number of engineers would be expected to be knowledgeable about the ABK research. In California, for example, the design of structures requires knowledge of seismic and earthquake forces, and only structural engineers are allowed to design schools, hospitals, or structures to exceed 60 feet in height. These engineers are formally certified by the State of California but are not similarly recognized in most other states. To qualify as a structural engineer in California, applicants must take both the civil and structural engineering certification tests. Therefore, as in any professional group, the structural engineers who undertake URM retrofitting projects are a subset of all engineers.

These reasons, therefore, limited any assessment of the extent of use of the ABK research, and limited the pool of potential users to engineers: 1) who undertake URM projects, and 2) who practice in seismically hazardous areas that have URM ordinances.

These limitations notwithstanding, two separate efforts were made to determine how extensively the ABK research was being used. First, phone calls were made to structural engineers who were members of the Structural Engineers Association of Southern California (SEASC), and to engineers known to have actually evaluated or retrofitted URM buildings; and second, the scope of the anticipated impact of Division 68 on retrofitting URM buildings was identified.

Calls to Structural Engineers. Potential respondents to a telephone survey were identified from the SEASC membership list. By using a random numbers table, 51 members and their associated firms were selected. Of these, 14 were eliminated because they were located outside the Los Angeles area (ranging from Pennsylvania to New Zealand), and another 16 were eliminated either because they were retired or not in private practice (e.g., those who were employed as building officials or county engineers, or by steel companies or university research organizations). Of the 21 remaining firms, another 15 were eliminated--five did not work on URM buildings, three were unreachable, and for seven we were unable to ascertain whether the firm undertook URM projects.

Vignette No. 4: Building Renovation Under Division 68[6]

Clifton's Cafeteria has operated at the same South Broadway location in downtown Los Angeles for some 40 years. Clifton's is notable in that it is open 7 days-a-week and 24 hours-a-day. The cafeteria occupies a 5-story, unreinforced masonry building that was constructed in approximately 1918. The building is described as not being in very good shape, reflecting its heavy use and numerous changes and remodeling over the years (such as the addition of ductwork from the basement kitchen to the 5th floor baker).

In August 1981, the building's owner was issued a compliance order under Division 68, and engaged a Glendale engineer to develop plans to renovate the building. To strengthen the building, the engineer will add new plywood floor diaphragms, three full-height steel rigid frames, the required shear bolts and anchorage, and gunite to the front and back walls of the building. The engineer said that if Division 68 had not allowed the use of existing materials in conjunction with new materials in conjunction with new materials, the renovation would have been much more costly--perhaps prohibitive.

Vignette No. 5: Building Renovation Under Division 68[7]

Amid a larger complex of light industrial buildings stands a two-story, milk-bottling and ice-cream production plant. The building, constructed in approximately 1925, is in generally good condition, and is the place of work for 30 to 40 people.

The building's owner was issued a compliance order under Division 68 of the Los Angeles Municipal Code, and he engaged a Los Angeles structural engineering firm to perform the required tests and develop a plan for strengthening the building. Two steps are required to retrofit the building. First, because the building's walls are tall and slender, additional steel columns and cross-members will be needed to reduce the height-to-thickness ratio of the walls. Second, plywood is to be added to the roof and floor diaphragms to strengthen them; adding shear walls was not possible because the production facilities could not be separated by the walls.

The engineer designing the retrofit for this building recounts that the "different philosophy" of Division 68--that of rehabilitating to preserve life, rather than prevent property damage--was the chief feature of Division 68 that will allow the building to be strengthened to withstand a moderate earthquake at an affordable cost.

Therefore, of the original sample of 51 members identified, only six remained to be interviewed. Of the six engineers interviewed, only one was currently involved in renovation of URM buildings. Of the other five, three did not undertake URM rehabilitation projects, one would but had not done so, and the final one had not done so since the passage of the Los Angeles URM ordinance.

Buildings Subject to Division 68. The ultimate evidence of use of the ABK research is the renovation of URM buildings.[9] Even if we were unable to locate a single engineer who had knowledge of the ABK research, the fact that buildings are currently being renovated subject to ordinances that are based in part on ABK research, is evidence of the use of the research.

In Los Angeles, 8,000 URM buildings have been identified; in Santa Ana, 200 buildings are subject to its URM ordinance. Buildings in both cities have been ranked in order of need to comply with each cities' ordinance, from priority I, those buildings that must comply immediately (e.g., essential buildings, such as hospitals or other emergency facilities); to priority IV, those buildings that pose the least threat to life in the event of an earthquake (e.g., limited-use buildings).

At the time this case study was being conducted (February 1983), 900-950 notices had been issued to building owners in Los Angeles, ordering them to comply with Division 68. During each of the next six months, 50 additional citations per month were to be issued, and, following that, the rate was to be increased somewhat until all orders have been issued.[10] The goal is to issue all of the compliance orders within 5 to 6 years.[11]

Not all compliance orders will result in retrofitting. Owners have six options upon receiving an order. They can: 1) provide evidence that the building is not within the scope of Division 68, or that it meets the standards as it exists; 2) appeal the notice; 3) file plans to renovate; 4) obtain a permit to demolish the building; 5) vacate the building, or 6) do nothing, and wait until the city issues a vacate order.

Only actions taken under the third of these options--filing plans to renovate a building--are evidence of use of the ABK research. Owners can renovate either by undertaking all the necessary actions required by Division 68 (these actions will vary with each building), or by installing wall anchors and getting a time extension ranging from 1 to 7 years, depending on the priority category of the building. The ABK research influenced both the anchorage and total retrofit standards included in Division 68. Thus, either action--anchorage or complete compliance--is considered evidence of the use of the ABK research. At the time of this case study, a total of 72 buildings had been either anchored or brought up to full compliance with Division 68.[12]

NOTES TO SECTION III

1. These three "uses" of R&D are discussed in detail in the introductory volume to this series of case studies. Briefly, the new knowledge resulting from R&D can be used to inform decisionmaking about legislation, regulation, or program development. R&D knowledge can be used to identify new or modify existing practice of professionals or within organizations. And R&D knowledge can lead to awareness of or recognition of certain basic issues--enlightenment.

2. These codes are developed by one of a number of code-writing bodies, which are usually a type of formal, professional engineering association. The two bodies that are relevant in this case are the Applied Technology Council and the International Conference of Building Officials (ICBO). The codes developed by these bodies are generally adopted, in whole or in part, by states and local governments to guide the practice of engineering. States and local governments can design statutes and ordinances other than those included in the standard codes, however, the most typical pattern is for a state or local government to adopt and use large portions of standard codes. For example, California has adopted the Uniform Building Code (UBC), which is developed by ICBO, as the state standard, and local governments can adopt all or none of the UBC. However, most local governments follow a state's guidance.

3. Vignette No. 1 is based on information from an interview with Earl Schwartz, Chief, Convservative Bureau, Los Angeles Department of Building & Safety, and Allen A. Asakura and Art Devine of the Division of Earthquake Safety of the same department on February 1, 1983.

4. Vignette No. 2 is based on information obtained in a telephone interview with Bob Tyler, Department of Planning and Development Services, City of Santa Ana, Calif., on May 24, 1983.

5. Vignette No. 3 is based on information obtained in a telephone interview with Mehdi Saberi, from the firm of Raymond Steinberg, Consulting Structural Engineer, Van Nuys, Calif., on March 21, 1983.

6. Vignette No. 4 is based on information obtained in a telephone interview with Robert D. Grossman, Grossman & Speer Associates, Inc., Glendale, Calif., on March 23, 1983.

7. Vignette No. 5 is based on information obtained in a telephone interview with Albin W. Johnson, S.B. Barnes and Associates, Los Angeles, Calif., March 25, 1983.

8. Based on information provided by John Kariotis, on January 31, 1983, and Art Devine, on June 2, 1983.

9. Los Angeles was the first United States city with a URM ordinance; the second city we are aware of with a URM ordinance, Santa Ana, Calif., modelled its ordinance after the Los Angeles one.

10. This increase in the number of orders issued will result from an increase from three to eight inspectors in the Los Angeles Department of Buildings & Safety.

11. Interview with Art Devine, February 5, 1983.

12. Telephone contact with Art Devine, March 25, 1983.

IV. EXPLAINING UTILIZATION

One criterion for defining a successful research project is when the "new knowledge, insights, and techniques that are produced [by it are] applied" (Glaser and Taylor, 1973, p. 140). A number of studies have been devoted to understanding the factors that influence the success of research projects and the utilization of their results by three potential audiences or "users" (see, for example, Glaser and Taylor, 1973; White and Haas, 1975; Ball and Anderson, 1977; Weiss, 1980):

- -Policymakers, at the federal, state, and local levels, who must make decisions about resource allocations, program support, or new legislation and regulations;
- -Service Providers, who are involved in the operation of actual services, e.g., emergency and disaster planning and relief activities; and
- -Citizens, who may be the victims of earthquakes and other natural disasters.

Not included as potential users of natural hazards research are other researchers, who do indeed use research results, but whose utilization experiences do not raise the same public policy questions as use by the three preceding audiences.

The purpose of the present case study is to draw from what is known about the utilization process, and compare it with the ABK utilization experience, to develop specific, operational advice to promote the utilization of the results of natural hazards research by policymakers, service providers, and citizens.[1]

Models of Research Utilization

A number of explanatory models of the knowledge dissemination and utilization process have been developed--three by Havelock (1969) and four additional ones by Weiss (1979).[2] The seven models predict the presence or absence of different kinds and sequencing of events and interactions in the utilization process, and help to identify the activities that are likely to promote dissemination and utilization.

However, the models are, as a group, overly general. They provide too broad and diverse a perspective for specific operational action, should one desire to promote utilization in the future. Thus, the purpose of case studies such as the present one is to compare the models with actual experience, in the hope of discovering which models may be more critical and what specific actions might be considered in the future. In this sense, the models provide the opportunity for a "pattern-matching" effort (Campbell, 1975), where the preferred model becomes the one that is most consistent with the known facts of a situation. As an example of but one part of a pattern, for the problem-solver model to be supported, a practical or decisional problem must have been identified before the research was initiated; the model would not be applicable if the research had not addressed a problem specified before the research was started. Through this type of "matching" of circumstances between case experience and a theoretical model, consistent and operational explanations of utilization behavior can be generated.

The three Havelock models are:

- the problem-solver model,
- the research, development, and diffusion model, and
- the social interaction model.

The four Weiss models are:

- the political model,
- the tactical model,
- the enlightenment model, and
- the research as intellectual enterprise model.

For the present case study, the three Havelock models are relevant, and are discussed below. The Weiss models deal with situations inappropriate to the ABK case, and hence, are not discussed.[3]

The Problem-Solver Model. This model assumes that knowledge utilization is part of a user's problem-solving process, where the user specifies a problem and research is conducted to address it. The model is thus "user-oriented" and asserts that:

> -the user's world is the only sensible place from which to begin to consider utilization;
>
> -knowledge utilization must include a diagnostic phase where user-need is considered and translated into a problem statement;
>
> -any external assistance [to the user] should primarily serve as a catalyst, collaborator, or consultant on how to plan change and bring about a solution;
>
> -internal knowledge retrieval [by the user] and the marshalling of internal resources should be given at least equal emphasis with external retrieval; and
>
> -self-initiation by the user or client system creates the best motivational climate for lasting change (Havelock, 1969, p. 11-13).

The crux of the problem-solver model as an explanation for utilization rests on a two-fold "pattern" of characteristics: 1) that research is initiated to address a previously-defined problem, and 2) that potential users are instrumental in defining the research problem.

Much of the ABK utilization experience is in fact explained by the problem-solver model. The problem addressed by the research--that of strengthening URM buildings--had been identified and defined by at least two groups before the research had been started. Officials in Los Angeles, observing damages to URM buildings in the 1971 San Fernando earthquake, identified thousands of other buildings that would be jeopardized by an earthquake in the Los Angeles area. The officials began developing an ordinance to require the rehabilitation of URM buildings.

Also, NSF officials began to realize the national scope and consequence of the URM problem, and took two actions: 1) it supported a conference of engineers to identify research needs in the URM area and, 2) it made URM research a priority. NSF solicited proposals for research to "develop methods to assess the risk posed by structures not designed and constructed to be earthquake resistant" (NSF, 1977, p. 17).

The second facet of the problem-solver model is also apparent in the ABK utilization experience, in that potential users of the research were instrumental in defining the research problem. The chief of the Earthquake Safety Division of the Los Angeles Department of Building & Safety,[4] participated in the NSF-sponsored workshop. Also, practicing engineers were involved in this problem-definition workshop. Thus, the problem-solver model explains much of the ABK utilization experience.

The Research, Development, and Diffusion Model. The research, development, and diffusion model (RD&D) presents the utilization process as a linear sequence of activities. These activities are represented by a three-fold pattern of characteristics where: 1) the research to be performed is defined by the knowledge producer; 2) the idea being pursued moves from basic and applied research to development, packaging, and dissemination and utilization; and 3) the ultimate use of the research takes place in a commercial marketplace. Although this model is often considered in connection with the development and commercialization of "hardware" innovations (e.g., teflon-coated cookware), it is equally applicable to social science research where the "product" of the research can be, in Yin and Heinsohn's (1980) terms, "usable products--e.g., instruments, handbooks, manuals, and other social science tools."

In the case of the ABK research, however, the RD&D model does not add to the understanding of the utilization of the research. For it to do so, the research would have to have been initiated in the absence of a particular problem focus, but rather with origins in the pursuit of new knowledge (e.g., basic research). In addition, the research would have had to demonstrate the movement of a research idea from this basic research stage to commercial introduction of a new product or process. None of these circumstances was apparent in the ABK research experience.

The Social Interaction Model. This model emphasizes communications between knowledge producers and users, especially through interpersonal networks, as a key to utilization. The user's networking characteristics should follow four basic principles:[5]

- The social network of the user is important and must be operative before utilization will succeed.
- Personal, one-to-one contacts within the network are important forces in facilitating utilization.
- The greater number and variety of "reference groups" a user has, the more likely the user is to be innovative and use new ideas.[6]
- The user's position in that network will help to predict utilization behavior.

Beyond these principles, the crux of the social interaction model is a three-fold "pattern" of characteristics: 1) knowledge producers and users will belong to some overlapping network; 2) communication between them will occur while the research is in progress; and 3) communication will continue, or occur, after the research is completed.

The social interaction model contributes a great deal to understanding the utilization of the ABK research. First, members of the research team (producers) and the potential users belonged to an overlapping network, and communicated throughout the conduct of the research. That network, the Structural Engineers Association of Southern California (SEASC), played a key role in facilitating the utilization of the ABK research. Two of the three principals in ABK, major officials in the Los Angeles Department of Building & Safety, and, of course, practicing engineers, were members of SEASC. As such, a natural communications forum existed. In fact, all of the engineers identified by the Los Angeles Department of Building & Safety as having retrofitted buildings subject to Division 68 were SEASC members.[7]

Further, a special committee of SEASC, the Hazardous Building Committee (which included Barnes and Kariotis), was asked by Los Angeles to formally comment on Division 68 during the period when it was being considered.

The second pattern predicted by the social interaction model is also evident in that SEASC activities occurred during the period in which the research project was still active. For example, in April and May of 1981, just four months after the adoption of Division 68, SEASC held a 3-day workshop for engineers, architects, and building owners in Los Angeles to acquaint them with the technical and legal aspects of Division 68. Subsequently, other workshops were held, with attendance exceeding 400 persons for the first two workshops alone. Each of the principals of the ABK research project were presentors at these workshops.

The third characteristic of the social interaction model--communication between producers and users after the research is completed--is not yet evident in the ABK case, because the research was ongoing at the time this case study was being conducted. However, there is every reason to believe that this communication will occur after the research is completed, because a series of regional workshops is planned for the end of the project. The workshops will acquaint engineers and local officials in earthquake-prone states with the project's findings. Also, the SEASC forum will remain intact, and continue to facilitate interchange between the producers and users.

The social interaction model also suggests that if "opinion leaders" exist within a social network, they are likely to influence the behavior of potential users within that network. This characteristic is evident in the ABK case. As has been noted previously, in California, structural engineering is a specialized and specially-licensed practice. SEASC, therefore, represents this licensed professional group, and it thus serves an opinion leader role, helping to promote the uses of the ABK research.

In short, the patterns observed in the ABK research project closely match those predicted by the social interaction model.

Summary. The nature and extent of utilization of the ABK research can be explained by comparing the pattern of events in the ABK research with three models of the utilization process: the problem-solver model; the research, development, and diffusion model; and the social interaction model. The ABK research is largely consistent with the problem-solver model in that the research was undertaken to address a previously-defined problem, and potential users were active in defining the problem. In addition, the characteristics of the social interaction model are also consistent with the ABK case, especially with regard to the social networking and interpersonal contact afforded by membership in SEASC. Finally, the ABK research is not consistent with the pattern of characteristics in the RD&D model.

Implications for Future Utilization Activities

The present case study covers just one set of experiences in which research was put to use. The purpose of the case study is not just to explain the utilization outcomes, but is also to discuss the implications for recommending future activities to promote R&D utilization.

Fifteen potential utilization-oriented activities have been identified[8] as opportunities for taking action to promote utilization. These activities have been further categorized to reflect their apparent role with regard to the problem-solver, RD&D, and social interaction models. Such a nonoverlapping scheme necessarily oversimplifies each activity, as some may be partially relevant to more than one model. Nevertheless, our desire was to examine the policy implications in this more simplistic manner, and there was sufficient match between the activities and the models to feel confident about the appropriateness of the basic scheme.

Table 4 presents the 15 activities, organized according to the three models, and indicates the actions that can be taken (either as part of the research project or by an R&D funding agency) to initiate each of the activities. The remainder of this section reviews the ABK experience as a way of suggesting which activities might be more preferred in the future. (The numbers in parentheses in the following paragraphs correspond to the number of the activity in Table 4.)

Activities Consonant with the Problem-Solver Model. Both of the activities drawn from the problem-solver model were evident in the ABK case. First, NSF sponsored a workshop prior to the research project, at which potential users identified research needs, and NSF included related

Table 4

ACTIVITIES FOR PROMOTING THE UTILIZATION OF RESEARCH FINDINGS

Activity and Associated Model	Individual Research Project Action	R&D Funding Agency Action
Problem-Solver Model:		
1. User-oriented guidelines for new research.	Conduct some type of needs assessment at start of project.	Encourage and support R&D agenda conferences dominated by users.
2. Training sessions and workshops for users.	Initiate and conduct specific sessions during and after project.	Encourage and support specific sessions.
Research, Development, and Diffusion Model:		
3. Researcher-oriented guidelines for new research.	Review literature and consult other investigators at start of project.	Encourage and support R&D agenda conferences dominated by researchers.
4. Formal reviews and syntheses of previous research.	--	Support such research syntheses projects.
5. "Development" and applied research projects.	--	Support "development" and applied research projects.
6. Researcher training and and communication.	Enhance researcher training and professional development in project work.	Support researcher training and communication activities or programs.

Table 4, page 2

Activity and Associated Model	Individual Research Project Action	R&D Funding Agency Action
7. Commercial trade shows.	Participate in such shows at end of project.	Support trade shows.
8. Marketing and advertising of new products.	Do marketing and advertising.	--
Social Interaction Model:		
9. User advisory panel for individual research projects.	Use panel for life of project.	Require panel.
10. Research applications conferences.	Project staff should sponsor or attend conferences.	Encourage and support conferences.
11. Report dissemination.	Disseminate project reports.	Support computer-based clearinghouses and information services.
12. Special newsletters and journals about research findings and users' needs and experiences.	--	Support newsletters and journals.
13. Summer "institutes" for researcher-user interaction.	--	Support summer institutes.
14. Changes in practitioner certification requirements.	*	Support practitioner associations in reviewing certification requirements.
15. Changes in practitioner standards and codes.	*	Support practitioner associations in reviewing standards and codes.

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*These two activities are mainly undertaken by professional associations.

topics in its programatic guidelines (1). Second, numerous training sessions and workshops were held throughout the conduct of the project, in particular by SEASC (2). SEASC arranged three, three-day workshops for architects, engineers, and building owners. The first two, attended by some 400 people, were held between April and June 1981. The third one, also well-attended, took place in March 1983.

Activities Consonant with the RD&D Model. None of the eight activities associated with the RD&D model were apparent in the ABK case.

Activities Consonant with the Social Interaction Model. Three of the five activities associated with the social interaction model were observed in the ABK case. First, a user advisory panel was constituted early in the research (9). The panel was composed of engineering experts from across the country, and included the chief of the Earthquake Safety Division of the Los Angeles Department of Building & Safety.[9] The panel was active in the early, technical-planning and testing phases of the research, although it was relatively inactive in the latter stages of the research. The chief of the Earthquake Safety Division, a subsequent user, recalls that his membership on the panel as his first introduction to the research.

Two other activities--user applications conferences and dissemination of reports--are planned as a part of the ABK project, but because the project was ongoing at the time of this case study, have not yet occurred. The conferences are to be held in six different cities throughout the country, representing four seismic regions (10). Each conference will focus on the special seismic conditions of the individual regions. Project staff intend a wide distribution of their final report, "The Methodology," which will summarize the findings for the entire project (11). A more limited distribution of the preceding seven topical reports is planned because the these reports are voluminous and detailed, and are believed to be of interest to only a limited number of specialists.

In addition, the ABK project staff pursued a number of other dissemination activities, and prepared some 30 papers and presentations for professional meetings, conferences, and workshops in the United States, China, Japan, Puerto Rico, and Yugoslavia (see Appendix II). These activities, referred to by ABK's principal investigator as "unplanned utilization activities," increased in frequency as the results from the research began to emerge.

The final activity that is likely to be apparent in the future is the modification of professional standards and codes (15). The International Conference of Building Officials, the group that develops the Uniform Building Code (UBC), plans to consider amendments to the UBC based on the ABK findings.

Summary. This section has shown that much of the use of the ABK research is explained by matching the events observed in the case with the problem-solver and social interaction models. The specific utilization activities apparent in the ABK case help to provide concrete illustrations of how future policies might be designed to promote increased research utilization in the future.

NOTES TO SECTION IV

1. The present case study is one of a series of nine case studies, each examining the utilization experience of a different natural hazards research project. The findings relating to the ABK case are reported here; findings from all nine cases are reported in the summary volume.

2. Weiss actually specified seven models, but three correspond with the three Havelock models. Thus, those three Weiss models are not identified here. Each of these models is described in detail in the summary volume.

3. The political and tactical models explain utilization as a function of political strategy or bureaucratic tactic, where the research is "used" to support a predetermined position or to fend off criticism. The enlightenment model deals with the use of a body of research ideas, often accumulated over a period of many years. Finally, the "research as intellectual enterprise" model de-emphasizes the importance of individual research efforts in favor of the pursuit of knowledge generally.

4. Earl Schwartz, who is currently the Chief of the Conservation Bureau in the Department of Building & Safety, was previously the Chief of the Earthquake Safety Division.

5. Actually, Havelock specified six assumptions relative to the social interaction models. Two are not included here: one that deals with the adoption behavior of users, and the other that deals with how strategies to influence adoption decisions change with the five phases in the adoption process (awareness, interest, evaluation, trial, and adoption). Because adoption is but one portion of the utilization process, and because it deals with knowledge user rather than the knowledge producer behavior, these two aspects of the social interaction model are not discussed relative to the ABK utilization experience.

6. A "reference group" represents, for the user, a set of individuals possessing attitudes and behaviors that the user perceives as normative.

7. Interview with Art Devine and Al Asakura, February 1, 1983.

8. This list was compiled from two sources. First, some strategies were adapted from an article by Robert K. Yin and Margaret K. Gwaltney (Yin and Gwaltney, 1981). Second, a meeting was convened during the present case study of a number of government policymakers and others engaged in supporting or using natural hazards research. At that meeting, a number of strategies, based on the experience of those present, were added to the Yin and Gwaltney list.

9. The panel included: Paul Folkins, Boston Building Dept., Boston, Mass.; Albert A. Kelly, KPFF Consulting Engineers, Seattle, Wash.; James Noland, Atkinson-Noland & Assoc., Boulder, Colo.; Daniel Shapiro, Shapiro, Okino, Hom & Assoc., San Francisco, Calif.; Prof. Mete Sozen, University of Illinois, Urbana, Ill.; Donald Wakefield, representing the Masonry Institute, W. Jordan, Utah; and Delbert Ward, Structural Facilities, Inc., Salt Lake City, Utah. Also included from Los Angeles Department of Building and Safety were Earl Schwartz, Jack Fratt, and John Robb.

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ABK, A Joint Venture, "Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings: Wall Testing, Out-of-Plane," ABK-TR-04, El Segundo, Calif., December 1981.

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Appendix I

PERSONS INTERVIEWED FOR THE CASE STUDY*

Raymond W. Anderson, Agbabian Associates, El Segundo, Calif.

Allen A. Asakura, Structural Engineer, Earthquake Safety Division, Department of Building & Safety, Los Angeles, Calif.

Vincent Bush, International Conference of Building Officials, Whittier, Calif.

Art Devine, Chief, Earthquake Safety Division, Department of Building & Safety, Los Angeles, Calif.

Robert D. Ewing, Agbabian Associates, El Segundo, Calif. (principal investigator)

George J. Fosdyke, Geo. J. Fosdyke & Associates, Inc., Los Angeles, Calif.

Robert D. Grossman, Grossman & Speer Associates, Inc., Glendale, Calif.

Robert D. Hanson, Department of Civil Engineering, University of Michigan

Albin W. Johnson, S.B. Barnes and Associates, Los Angeles, Calif. (co-principal investigator)

John C. Kariotis, Kariotis & Associates, Pasadena, Calif. (co-principal investigator)

Edward M. McDermott, Executive Secretary, Structural Engineers Association of Southern California, Los Angeles, Calif.

Willima E. Myers, Director, Building & Code Compliance, Santa Rosa, Calif.

Mehdi Saberi, Raymond Steinberg, Consulting Structural Engineer, Van Nuys, Calif.

John B. Scalzi, Earthquake Hazard Mitigation Program, National Science Foundation, Washington, D.C. (NSF project officer)

Ben L. Schmid, Consulting Structural Engineer, Pasadena, Calif.

Earl Schwartz, Chief, Conservation Bureau, Department of Building & Safety, Los Angeles, Calif. (member, project advisory committee)

Roland Tibbetts, Small Business Innovation Research program, National Science Foundation, Washington, D.C. (initial NSF project officer)

Bob Tyler, Department of Planning and Development Services, City of Santa Ana, Calif.

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*Affiliations listed are those of the interviewees at the time this case study was being conducted. The formal role played in the ABK project, if any, is noted in parentheses.

Appendix II

PUBLICATIONS AND PRESENTATIONS BY ABK STAFF*
(In Chronological Order, through August 1982)

1. Ewing, R.D., A.W. Johnson, and J.C. Kariotis, "Seismic Hazard Mitigation in Unreinforced Masonry," presentation at ASCE Convention, Boston, Mass., April 1979.

2. Agbabian, M.S., "Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings," presentation at 11th Joint UJNR Conference, Tokyo, Japan, September 1979.

3. Agbabian, M.S., "Wood Diaphragms in Masonry Buildings," presentation at 11th Joint UJNR Conference, Tokyo, Japan, September 1979.

4. Kariotis, J.C., and R.D. Ewing, "Seismic Hazard Mitigation in Unreinforced Masonry: Methodology Overview," presentation at SEAOC Convention, Coronado, Calif., October 1979.

5. Ewing, R.D., and J.C. Kariotis, "Seismic Hazard Mitigation in Unreinforced Masonry: Influence of the Diaphragm," presentation at SEAOC Convention, Coronado, Calif., October 1979.

6. Ewing, R.D., T.J. Healey, and M.S. Agbabian, "Seismic Analysis of Wood Diaphragms in Masonry Buildings," presentation at ATC Wood Workshop, Los Angeles, Calif., November 1979.

7. Kariotis, J.C., R.D. Ewing, and A.W. Johnson, "Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings," Masonry Research in Progress Conference, Marina Del Rey, Calif., March 1979.

8. Kariotis, J.C., B. Barclay, R.D. Ewing, and A.W. Johnson, "Unreinforced Masonry Performance--1979 Imperial Valley Earthquake," in D.J. Leeds (ed.) EEEI Reconnaissance Report, Imperial County California, Earthquake October 5, 1979, February 1980.

9. Ewing, R.D., A.W. Johnson, and J.C. Kariotis, "Mitigation of Seismic Hazards in Unreinforced Masonry," presentation at ASCE Convention, Portland, Oregon, April 1980.

10. Ewing, R.D., T.J. Healey, and M.S. Agbabian, "Seismic Analysis of Wood Diaphragms," presentation at ASCE Convention, Portland, Oregon, April 1980.

11. Agbabian, M.S., "Strength Evaluation and Seismic Hazard Mitigation of Existing Unreinforced Masonry Buildings," presentation at Earthquake Research Conference, Skopje, Yugoslavia, July 1980.

12. Kariotis, J.C., R.D. Ewing, and A.W. Johnson, "ABK, Research Status Report I," presentation at SEASC meeting, Los Angeles, Calif., June 1980.

13. Ewing, R.D., A.W. Johnson, and J.C. Kariotis, "Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings," status report to the National Science Foundation Interagency meeting, Washington, D.C., October 1980.

14. Kariotis, J.C., R.D. Ewing, and A.W. Johnson, "ABK, Research Status Report II," presentation at SEASC meeting, Los Angeles, Calif., November 1980.

15. Ewing, R.D., A.W. Johnson, and J.C. Kariotis, "Status Report for Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings," presentation at SEAOSD meeting, San Diego, Calif., November 1980.

16. Ewing, R.D., A.W. Johnson, and J.C. Kariotis, "Status Report for Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings," presentation at SEACC meeting, Sacramento, Calif., January 1981.

17. Agbabian, M.S., "Dynamic Simulation Testing of Unreinforced Masonry Walls," presentation at Lawrence Livermore National Laboratory, Livermore, Calif., January 1981.

18. Ewing, R.D., "Experimental Studies on Seismic Behavior of Unreinforced Masonry Walls," presentation at UCLA Mechanics and Structures Department seminar, Los Angeles, Calif., March 1981.

19. Agbabian, M.S., "Seismic Resistance of Unreinforced Masonry Walls," presentation at Stanford University Department of Civil Engineering, Palo Alto, Calif., April 1981.

20. Kariotis, J.C., et al., "Earthquake Hazard Mitigation of Unreinforced Masonry Buildings Built Prior to 1934," A Five-Session Seminar of SEASC, Los Angeles, Calif., April and May 1981.

21. Agbabian, M.S., "Evaluation of Unreinforced Masonry Building Components by Seismic Simulation Tests," presentation at UJNR Wind and Seismic Effects Panel meeting, Tsukuba City, Japan, May 1981.

22. Rothman, D., "Survival/Collapse of Unreinforced Masonry Walls Under Simulated Earthquakes," presentation at National Meeting of the American Statistical Association, Detroit, Mich., August 1981.

23. Ewing, R.D., A.W. Johnson, and J.C. Kariotis, "A Seismic Hazard Reduction Ordinance for the City of Los Angeles," presentation at ASCE National Spring Convention, Las Vegas, Nevada, April 1982.

24. Scalzi, John B., "Status Report for Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings," San Juan, Puerto Rico, May 1982.

25. Agbabian, M.S., "Earthquake Response of Buildings with Unreinforced Masonry Walls," presentation at US-PRC Bilateral Workshop on Earthquake Engineering, Harbin, China, August 1982.

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* List does not include the eight topical project reports prepared (or forthcoming) as project deliverables. See Table 2.