CURRENT PRACTICES IN EARTHQUAKE PREPAREDNESS AND MITIGATION FOR CRITICAL FACILITIES

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In this paper an attempt is made to briefly address the broad issues of earthquake preparedness and mitigation for critical facilities. Critical facilities considered herein are divided into two major groups: industrial and public.

Critical industrial facilities are defined as those facilities that, if damaged by an earthquake occurrence, could result in the release of substances harmful to the public, employees, or the environment or that could result in what owners consider as unacceptable financial losses. Examples of such facilities are nuclear power plants, chemical processing plants, research and development facilities, and high-technology manufacturing plants.

Critical public facilities are defined as those facilities that, if damaged by an earthquake occurrence, could result in large numbers of the public experiencing life, life-support systems, or financial losses. Examples of such facilities are hospitals, schools, stadiums, fire stations, dams, and bridges.

CURRENT PRACTICES

Practice vs Hazard

Current practice today is actually based on the perception of the earthquake hazard. All one has to do to recognize this is to compare earthquake design practice in the State of California to that in the State of Tennessee for example. In California, the perception is that there is an earthquake hazard, rightfully so. As a result, there are uniformly accepted seismic preparedness and mitigating practices, primarily in the form of accepted seismic design codes. In Tennessee, the perception is that there is no earthquake hazard, which is wrongfully so. As a result, not only are there no uniform seismic preparedness and mitigating practices, they are virtually nonexistent.

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Four Levels of Practice

Regardless of the general perception of the earthquake hazard, today's practice in earthquake preparedness and mitigation for critical facilities from an engineering point of view can be divided into four general levels:

> Level I--Complex earthquake hazard evaluation and facility seismic analysis and design as is conducted for nuclear power plants (U.S. Nuclear Regulatory Commission, 1975).
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> Level II--Earthquake hazard evaluation and seismic analysis and design as is conducted for an important chemical plant or, on occasion, possibly a hospital (Manrod et al., 1981).
>
> Level III--Normal earthquake hazard evaluation and facilities analysis and design procedures as is conducted using the Uniform Building Code (UBC) or similar codes (International Conference of Building Officials, 1982; Structural Engineers Association of California, 1975).
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> Level IV--No earthquake hazard evaluation or facility seismic analysis or design provisions except for the inherent lateral resistance provided by wind analysis and design requirements.

Level I provides for a thorough evaluation of the earthquake hazard at the location of interest to the point of simulating the expected ground motions. The ground motions are then used as input to a rigorous seismic analysis of the facilities followed by detail design and documentation procedures. In many cases, Level I is considered as a very conservative approach to earthquake preparedness and mitigation.

Level II generally represents an adjusted medium between the approach in Level I and the approach used in Level III. The Applied Technology Council provisions (Applied Technology Council, 1978) represent a Level II approach for buildings. Manrod and co-workers (1981) discuss a Level II approach for preparedness and mitigation of existing critical industrial facilities.

Unfortunately, the preparedness and mitigation actions taken for most structures built in the United States today, many of which may be considered critical, fall under Level IV.

Except in California and one or two other states, there are virtually no adopted earthquake hazard evaluation or seismic analysis and design guidelines or codes in the cities, counties, or municipalities.

Levels of Application vs Critical Facilities

All nuclear power plants being constructed today fall under the strict seismic evaluation, analysis, and design requirements set forth by the U.S. Nuclear Regulatory Commission identified herein as Level I. Other similar critical facilities, such as plutonium facilities, generally fall under the same requirements.

Chemical processing facilities, uranium enrichment facilities, and high technology manufacturing plants usually will fall into the Level III approach and, in some circumstances, Level II at the discretion of the owners--be they government or private industry. However, in many cases, using the minimum requirements of the UBC seismic design provision (the Level III application) may not be adequate for such facilities.

Critical public facilities such as dams and bridges may also fall under Level II and III seismic provisions depending upon the perceived earthquake hazard of the builder/owner. Schools, hospitals, fire stations, and stadiums will fall under the seismic provisions as described in either Level III or IV. Since the mid-1970s, most hospital designs fall under the Level III procedures. However, hospitals built before the mid-1970s and schools (except California), fire stations, and stadiums built today may actually fall under Level IV.

All critical facilities, as a minimum, should meet earthquake preparedness and mitigation requirements as defined in the UBC and, in many cases, go beyond the requirements of the UBC. However, as a cautionary note, it must be remembered when using the UBC, especially for industrial facilities, that it is a building code and judgment must be used where the code does not directly apply.

Today's Application

Although it was stated above that most structures built in the United States today are not designed to earthquake preparedness and mitigation provisions (a Level IV approach), nor are such provisions required by law, a process is occurring in this country where such provision are being applied more and more each day. This process is happening because of the educational program occurring within the professional groups (engineers, architects, scientists, etc.) and the liability responsibilities of such professionals. For example, most engineers are now aware of the need for earthquake hazard preparedness and mitigation practices in the design of any new facility. Although no local enforcement codes may require such procedures, architects and engineers are acutely aware of recent decisions in the courts where following the minimum requirements of building codes is not justification for not using prudent engineering judgment. As a result, many architects and engineers are now applying earthquake hazard preparedness and mitigation provisions in their facility design. For critical facilities, architects and engineers usually have no trouble convincing the builder/owner of the necessity for such provisions and the builder/owner is willing to accept the additional costs. However, for noncritical facilities, it is extremely difficult for the engineer or architect to convince the builder/owner of the long-term cost benefit of applying such provisions, and in many cases, the builder/owner will refuse--creating a professional dilemma for the architect or engineer.

TODAY'S TECHNOLOGY

Progress

Today's technology can best be described as a "forever changing state of the art." After each major earthquake, scientists and engineers seem to gain new insights as to how earthquake ground-shaking occurs and how man-made structures respond. The state of the art has advanced tremendously during the past 20 years as a result of the 1964 Alaskan Earthquake, the 1971 San Fernando Earthquake, other large but less notable earthquakes (e.g., Coalinga 1983), engineers' and scientists' success at obtaining instrumental recordings of earthquake motions and structural response, the "national" emphasis placed on understanding the earthquake phenomena to provide safe nuclear power plants, and the passage of the Earthquake Hazards Reduction Act of 1977.

The nuclear power industry can be contributed with being the catalyst that sparked a strong earthquake and earthquake engineering research program in the mid-1960s that may have peaked as we entered the 1980s.

Although a lot has been learned during the past 20 years, our current understanding of the earthquake phenomena and how man-made structures respond to such events still has many shortcomings.

Understanding the Problem

We now understand the general phenomena of what causes earthquakes based on the concept of plate tectonics. This concept applies very well on the West Coast of the United States. However, understanding the concept of earthquake occurrences at intra-plate locations like the midwestern and eastern parts of the United States is extremely lacking. The lack of understanding can be based on two primary reasons: infrequent earthquake occurrences and earthquake occurrences at depth with no surface faulting. We do know enough about intra-plate earthquakes to know that the same design and analysis principles that are used on the West Coast may not be directly applicable in the Midwest and East because of the infrequency of such events and the attenuation rates.

From a purely engineering point of view, a such high state of technology exists regarding our ability to analyze complex structures to great detail. The phenomenal growth of the computer industry has provided us with this capability. However, our understanding of material properties and our ability to construct structures to such precise detail is far behind. In fact, our ability to analyze and design structures to earthquake ground motions far exceeds our ability to understand what the motions might be.

Lag Time

As engineers and scientists learn more about preparedness and mitigation of the earthquake hazard and our development of technology, they begin the process of adopting this new found knowledge to practice. Like any industry, when trying to put new technology into practice, there is a lag time. However, in the case of nuclear power plants where the Level I approach to preparedness and mitigation occurs, technology has been placed directly into practice with little or no lag time. The Level I approach to preparedness and mitigation has been the leader of the "earthquake industry." In the Level II approach, an assessment would be made of the new developments in the Level I approach and these developments would be either rejected or accepted as deemed appropriate and practical for the particular critical facility under consideration. For those developments deemed appropriate for a Level II application, the lag time was usually relatively short. Those developments not deemed appropriate for a Level II application have been put aside--it may take years before such developments become practice.

The lag time in getting new developments into practice at the Level III stage of application usually is several years unless the development results in the awareness of a serious deficiency in the Level III approach. Even then it would probably take one or two years to get the code bodies changed.

Dynamic Analysis--Practice

As an example of the difficulty of taking technological development and applying it to practice, let's consider the case of dynamic analysis. Dynamic analysis capability has been around for 30 years and engineers recognize that structures subjected to earthquake loads are more properly analyzed using some form of dynamic analysis. But in the UBC, which is an accepted nationwide Level III type application, there are no provisions for such analyses. This exists for several reasons including, for example, perceived added costs of doing such analyses which are more complex than a simple static analysis, an undergraduate engineering educational level that does not require a dynamic analysis background (reserving it for graduate students), perceived low earthquake hazards by engineers and the public, and the tendency to keep legislated codes as simple as possible in an attempt to insure more uniform application of such requirements.

Applied Technology Council

In an attempt to overcome the obstacles to placing current technology into the hands of practice in as practical a way as possible, the Applied Technology Council (1978) developed the Tentative Provisions for the Development of Seismic Regulations for Buildings. This effort began in the early 1970s and when the result was published in 1978, it represented a very good recommendation for earthquake technology transfer to practice. Excellent work is still going on to substantiate and justify the cost benefits of this technology transfer. However, except for isolated cases on a voluntary basis, none of this technology transfer has actually occurred.

EXISTING CRITICAL FACILITIES

Although earthquake hazard preparedness and mitigation practices have been occurring for new critical facilities during recent years, very little has been done to retrofit existing critical facilities. Most owners are not willing to provide the funds to retrofit such facilities because of the high cost involved. The high costs occur when the retrofit requirements are based on bringing the existing facilities under total compliance of a Level I, II, or III approach.

To avoid the high costs of total retrofit, much can still be done in costing critical facilities to minimize the earthquake risks. For example, anchoring equipment and piping systems in existing facilities is an effective way to conduct earthquake hazard preparedness and mitigation procedure.

TECHNOLOGY TRANSFER COMMITMENTS

Several technology initiatives could be developed for the transfer of earthquake hazard preparedness and mitigation technology to practice. However, to be successful, several commitments must be made.

There must be a commitment by government, industry, and the public to appropriate the funds required for such initiatives. In addition, the public, industrial and government managers, and political representatives must have a reasonable understanding of what the earthquake hazards are in their area of concern. As stated earlier, the problem here is that other than in, say, California, the earthquake hazard is perceived by these groups to be no hazard. The professional groups--architects, engineers, and scientists--must do their utmost to understand the earthquake hazard and develop proper preparedness and mitigation procedures--technology transferred to practice. The political and industrial communities must be committed to support and promote the initiatives.

For critical industrial facilities, today's social and political environment in the United States is very conductive for obtaining the commitment of the public and the political community. To get the same level of commitment for many critical public facilities is, and will be, considerably more difficult and will not occur until the public has some understanding of the earthquake hazard. However, because critical facilities are "critical," there is an ever-increasing commitment by architects, engineers, builders, and owners to transfer today's earthquake technology to practice.

SUMMARY

Although scientists and engineers continue to strive for a better understanding of earthquake hazard preparedness and mitigation, the technological state of the art seems far ahead of that technology, except for highly visible and critical facilities, used in current practice.

An education program involving all phases of training is needed. However, public information and awareness programs should be placed at the top of the list. Until the public has a better understanding of what the earthquake hazards are, progress toward earthquake preparedness and mitigation will be slow unless regulation occurs--and regulators are the public.

REFERENCES

Applied Technology Council. 1978. Tentative Provisions for the Development of Seismic Regulations for Buildings. Washington, D.C.: U.S. Government Printing Office.

International Conference of Building Officials. 1982. Uniform Building Code. Whittier, California: ICBO.

Manrod, W. E., W. J. Hall, and J. E. Beavers. 1981. "Seismic Evaluation Criteria for Existing Industrial Facilities." In Earthquakes and Earthquake Engineering: The Eastern United States, edited by J. E. Beavers. Ann Arbor, Michigan: Ann Arbor Science Publishers.

Structural Engineers Association of California, Seismology Committee. 1975. Recommended Lateral Force Requirements and Commentary. Los Angeles, California: Structural Engineers Association of California.

U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation. 1975. Standard Review Plan. Washington, D.C.: U.S. Nuclear Regulatory Commission.

DEVELOPMENT OF SEISMIC SAFETY CODES

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The history of the codes and standards system in the United States is an interesting one; however, of greater importance in this context is what it can tell us about the likely future course of codes and standards development, and the wisdom of working within that system to effect nationwide change in building hazard mitigation practices.

The first model code, the National Building Code, was prepared in 1905 by the National Board of Fire Underwriters, now the American Insurance Association. Concerned about the huge fire losses in American cities and towns, the Board drafted the code with the hope that it would be adopted into law by these cities and towns. Of course, the code dealt with more than fire safety, so it also held the promise of helping reduce the wide variations in the content of building codes--a problem that already was becoming apparent as community after community made a tailored response to perceived public health and safety needs and to public demands for such protection. As early as 1921, a U.S. Senate committee called attention to the high costs of construction that it felt were a consequence of the growing number of municipal codes and the lack of uniformity among those codes. Therefore, the lack of uniformity in building codes, as well as the extent and adequacy of their coverage, is hardly a new concern--just one that is rediscovered from time to time.

In 1927, the first edition of the Uniform Building Code was published by what today is the West Coast headquartered International Conference of Building Officials (ICBO).

In 1939, it was the U.S. National Bureau of Standards that issued a report calling for greater code uniformity. At the same time, it called for the use of nationally recognized building standards in building codes and for the development of means for the acceptance of new materials and methods--the concept of a total system for both regulation and the introduction of technology.

Following World War II (in 1946), the Southern Building Code Congress (SBCC), headquartered in Alabama, was formed and its model code, the Standard Building Code, was first published. Then, in 1950, the Building

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Officials and Code Administrators (BOCA), which was created in 1915 and is headquartered in Chicago, published its model code, the Basic Building Code.

There now were four model codes--the National Building Code, the Uniform Building Code, the Standard Building Code, and the Basic Building Code. The latter three were and are prepared by building officials with input from the building community.

The National Building Code was last revised in 1976, and in 1980, the National Conference of States on Building Codes and Standards--a body that received its impetus from the National Bureau of Standards--obtained the rights to the code and proposed to develop it as a consensus document in the manner of standards of the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI). Although the concept of a consensus code--as distant from a document produced with building officials as the sole decision-makers--was lauded by many and a degree of progress was made in organizing for the task, the concern for the creation of yet another model code, just as it appeared that the number would be reduced to three, led to the ultimate abandonment of the effort. Today, BOCA has the rights to the national building code name.

The three model code bodies have been quite aggressive and competitive in seeking adoptions of their respective codes. Nevertheless, there still are communities across the country that have no code, particularly communities in rural and newly developing areas, and areas where the code treats only or principally facilities involving public use or occupancy. Also, many of the communities that have adopted one of the model codes have not done so without additions, deletions, and modifications --not infrequently, extensive such deviations. Further, not all codes are up to date by any means, which leads to even further lack of uniformity among various jurisdictions.

The difficulty was compounded by a move in the late 1960s and early 1970s to foster more state rather than local codes--leaving us with a greater mixture of both. Finally, many of our nation's largest cities continue to have their own code. Thus, the dream of uniformity or, what is perhaps a better way of phrasing the need, harmony of provisions is far from a reality.

As early as 1949, the model code organizations, together with several national organizations such as ASTM, the American Insurance Association and the Underwriter's Laboratories, several federal agencies, and the National Research Council of Canada formed the Joint Committee on Building Codes (JCBC) to seek greater code uniformity. In 1959, the JCBC became the Model Codes Standardization Council (MCSC) and the design professions became advisory members. The MCSC was further expanded in 1970 to include construction industry representatives, also as advisory members.

With all of this, progress was still painfully slow on the issue of uniformity and/or harmonization. The nation and building technology were growing rapidly and there still were strong feelings that codes were growing rapidly and there still were strong feelings that codes were a major deterrent to progress and a cause of increased building costs. As a result, Congress created the National Commission on Urban Problems--more popularly known as the Douglas Commission after its chairman, the late Senator Paul Douglas of Illinois. The Douglas Commission made a rather exhaustive study of the codes and standards situation across the United States. Its findings were detailed in a 1969 report, and one of those findings was that an entirely new instrument was needed to address the problem--one that would have the backing of the Congress and the clear mission of bringing about a more rational and responsive building regulatory environment and a nationwide system for facilitating the introduction of new technology. The new instrument was designated the National Institute of Building Sciences (NIBS) by the Commission.

NIBS was a long time coming into being. Not only did the Congress have to be convinced that it was needed--particularly in the form of a private, nongovernmental body authorized by the Congress--but the many diverse and divided public and private interests in the building community itself had to be convinced that NIBS was necessary or at least worth a try.

It took from 1969 until 1974 to be authorized by the Congress, and until mid-1976 for the President of the United States to appoint its first Board of Directors. NIBS received its first of five start-up capital appropriations from the Congress in late 1977 and effectively began operations at the beginning of 1978. And, during these years, the building community and the code bodies were not idle.

In 1972, the three model code bodies formed the Council of American Building Officials (CABO), and CABO in turn created the Board for the Coordination of Model Codes (BCMC) and the National Research Board (NRB) to begin a process for reviewing and recognizing building products and systems. This was not the first effort made by the three model codes to find a way to work together but it has been the only one to have withstood the test of time to date. No doubt the creation of NIBS and the events that surrounded it provided considerable impetus to succeed.

One example of CABO achievements is that it succeeded in creating a one- and two-family dwelling code that, because of its adoption by reference by the three parent model code bodies, has become a nationwide model. It must be pointed out at this juncture, however, that there are few who are familiar with the regulatory scene in this country who would like to see a national model code--or, perhaps it would be more to the point to say that there are a few who would want to see a single national model code that could easily become a national building code by legislative action. The building community has gained a healthy respect for the value of divided authority whether private or public. This is not to say, however, that there is not a desire for greater harmonization of the provisions of both model and actual codes. The same can be said for working to eliminate needless overlap, duplication, and conflict among the standards referenced and available for referencing in codes.

For example, when NIBS recommended the gradual phasing-out of the HUD Minimum Property Standards in favor of an improved CABO One- and Two Family Dwelling Code for that type of housing and any of the three nationally recognized model codes or their equivalent for multifamily housing, a great opportunity was created for achieving increased harmonization of code provisions, at least in this one area of building regulation. Both HUD and CABO have followed through with this recommendation. Further, because the One- and Two-Family Dwelling Code process is more open to building community participation than is the case with the model codes themselves, there has been the opportunity to bring a diversity of building industry talents to bear on at least one area of model code formulation in a manner akin to that of voluntary consensus standards development.

With this gradual movement toward greater harmonization of the model codes, there also has been a gradual movement toward the adoption of these model codes by the nation's states and communities. However, it must be stressed again that adoptions are by no means universal and certainly not adoptions without modification; that most of the major cities continue to have a code that is in many ways unique to that city and reflective of its history and political character, that not all jurisdictions keep their codes up to date, and that appeals and resulting variances make it virtually impossible to be able to say that provisions that even appear to be the same are truly the same at any given point in time.

Therefore, with perhaps as many as 16,000 code issuing jurisdictions in the country, some at the state level, some at the local level and some at both, and with all of these forces at work, there remains a great deal of disharmony among the resulting codes and code provisions in force. It also is the case that many federal agencies have their own construction requirements which add to the lack of harmony. As an aside, the relatively recent action of the Office of Management and Budget in issuing a bulletin that calls upon all federal agencies to rely on voluntary consensus standards to the maximum extent possible is helping the cause of harmonization significantly.

It should be clear at this point that there is no one point of entry for effecting code changes even though input through the model code change process can have a significant effect on the whole of code practice. It always must be remembered that ultimately it is the body having political jurisdiction that must decide what performance level will be sought and what specific requirements will be imposed to achieve that level of performance. This applies to the location, design, construction, and rehabilitation of its own facilities as well as to those under private ownership.

These decisions--that is, whether and how to provide protection against any potential natural or man-made destructive force--are political simply because determining the level of risk and the costs and benefits that are likely to flow from taking any given set of protective measures is so much a matter of judgment. The challenge to the professional community, then, is to provide political decision-makers with ever more reliable information and recommendations to assist them in their awesome task of assessing the risks and establishing the costs and benefits of one decision over the other. This implies, of course, that the professional community will be able to reach a reasonable agreement on what information and recommendations are to be provided. And in this regard, the nation is at a turning point with regard to earthquake technology and its proper application.

Today, there is a major debate concerning how realistic the risk of damaging earthquakes is in much of the eastern two-thirds of the country and an even greater debate on what regulatory provisions can best address those perceived risks.

It is important to recognize that perhaps 80 percent of a building code is made up of reference standards or materials that have come from standards. In the United States, most of these standards are either voluntary consensus standards or industry standards; however, there continues to be reliance on a number of government standards as well, particularly standards promulgated by federal agencies for their own use or for regulatory purposes. Therefore, it is to these criteria and standards that one also must look if building practices are to be changed or influenced. It was not too many years ago that the sources of information and data on seismicity and seismic effects were numerous. Today, these sources are fewer.

At this point it might be best to refer to the June 1978 publication, Tentative Provisions for the Development of Seismic Regulations for Buildings, prepared by the Applied Technology Council of the Structural Engineers Association of California. Popularly known as ATC 3-06, this document has become the focus of proposed changes in seismic standards and codes because of its sponsorship by the National Science Foundation and wide participation by design professionals and representatives of code bodies, governmental agencies at all levels, and the materials industry.

The program effectively began with a workshop on disaster mitigation sponsored by NSF and the National Bureau of Standards (NBS) in Boulder, Colorado, in August 1972. Therefore, the current effort to upgrade disaster mitigation through improved codes and standards is already 12 years old. After ATC 3-06 was published, there was much debate as to the appropriateness of some of the proposed provisions, as to the extent of the proposed application of the provisions, and as to the usefulness of the document itself for the purpose implied in its title--i.e., as provisions for regulatory purposes--because of its mixture of criteria, design procedures, and commentary. Actually, it is clearly stated in the foreword to the document that:

> These provisions are tentative in nature. Their viability for the full range of applications should be established. We recommend this be done prior to their being used for regulatory purposes. Trial designs should be made for representative types of buildings from different areas of the country and detailed comparisons made with costs and hazard levels from existing design regulations.

Concern for a better way to assure consensus among all of the interested parties became a significant issue toward the end of the 1970s; therefore, in 1979, after much discussion among the key building community organizations and federal agencies, the Building Seismic Safety Council (BSSC) was created under the auspices of the aforementioned National Institute of Building Sciences. Today, BSSC operates within NIBS as an independent, voluntary body of some 58 separate organizations. The trial designs recommended by ATC are some 58 separate organizations. The trial designs recommended by ATC are well under way with funding by FEMA--indeed, the second series of these designs is now nearing completion. The next phase of the program will entail getting agreement of the members of the Council on any changes proposed by its committees as a result of previous balloting on the tentative provisions and any changes that seem needed as a result of the trial designs. Publication of the agreed upon seismic safety provisions will follow. It also will include an assessment of the socio-economic impact that could be expected as a consequence of implementing and utilizing the provisions, especially in communities east of the Rocky Mountains that to-date have been largely unconcerned with the seismic safety aspects of building design; a study of the likely impact of the provisions on building regulatory practices; and development of materials and plans for encouraging maximum use of the provisions. Next will come the arduous tasks of seeking changes in the model and actual codes and the appropriate reference standards and educating designers and other building community participants in their use. A good start on this latter task will already have been made because of the involvement of local firms across the country in the trial designs.

In the meantime, the federal government, working through an interagency committee, has been proceeding with applications for federal construction. And, it appears that the National Bureau of Standards, as the Secretariat for an American National Standards Institute standards committee known as A-58.1, already has introduced elements of ATC 3-06 into the 1982 edition of A58.1. For example, the A58.1-1982 seismic zone maps--i.e., maps of the 50 states and Puerto Rico which identify geographic areas of differing earthquake hazard (from 0 to 4)--is derived from maps contained in ATC 3-06.

It appears likely that seismic design procedures will be considerably different if the current work stays on course. At present, the seismic force factors used in ANSI A58.1-1982 are quite similar to those used in the 1982 edition of the Uniform Building Code (UBC) and, because the UBC is the model code most used in the West where earthquakes of significant magnitude are a matter of fairly recent memory, the UBC is typically the most responsive to changes in earthquake engineering technology. The Standard Building Code (SBC) simply references the provisions of A58.1 and must be updated to reference new editions or to introduce other provisions. The lateral force factors in the Basic Building Code (BBC) are specified and are somewhat different from those in the UBC and A58.1-1982. The risk maps in the SBC and BBC are different than those in A59.1-1982. It might be reasoned that all of these standard reference works will come into greater harmony if not actually share the same provisions once the work of BSSC is finished and a reasonable consensus has been achieved on the seismic safety provisions thus recommended. However, even if this does occur, that is not to say that all states and communities will readily adopt the provisions appropriate to their area.

It does seem, however, that with the greater acceptance of decision-making processes such as those employed by the Building Seismic Safety Council and A58.1 (which deals with all dead, live, and environmental loads on buildings and not just earthquakes), the opportunity exists to influence those political bodies that ultimately must make the risk-taking decisions in the areas of public health, safety, and welfare. By bringing together representatives of all vital interests and expertise, the likelihood of finding adequate authority outside the process to challenge the collective judgments of those involved decreases dramatically.

One would think that concern for the potentially devastating effects of earthquakes would engender an eagerness to apply the regulatory provisions offered by technical experts. This simply has not been the case. Regardless of what the technical experts say, the evidence has not been sufficient to convince a lay public that has never experienced an earthquake or is aware that there has not been an earthquake of significance in their area in recorded history, that one of potentially devastating effect could occur tomorrow. And, perhaps more to the point, the lay public may not perceive the odds that such an earthquake will occur in their area during their lifetime to be great enough to justify spending large sums of public and/or private funds to provide or upgrade protection. A finding that the costs of providing adequate protection are minimal or within reason, would go a long way toward allaying these concerns--at least with new construction.

Unfortunately, much the same skepticism can be found with many design professionals and others directly involved with the building community who have never been taught seismic design and who are not required to possess such knowledge to be able to practice or fulfill their other roles in building. Such knowledge simply is of little use in an area where it is not needed for survival in the marketplace.

The answer to the question of whether there are problems that can be addressed by education, therefore, is a resounding yes. There is a big job of public education to be done. There is need to expand the education of building design professionals in seismic design practices. There is need to educate all those who would participate in housing, building, and planning on the state of the art in seismic technology. And, there is need to continue to educate everyone on the importance of achieving a voluntary consensus--one that includes the executive branches of government--on the standards and regulatory provisions that are to be recommended to the appropriate legislative bodies.

It appears that the knowledge and tools will soon be ready for making the next step up on seismic building design, construction, and rehabilitation practice. What is needed is a game plan for bringing those tools into play in an atmosphere of rationality--something that has not been done too well in the building arena in the past. Experience has shown that once a change is perceived as desirable or possible by those directly involved, the federal government has all too frequently agreed to lead the charge--not in a studied manner but in a rush and with an outsized and often frantic program with unreal goals and timetables. I hope I have indicated that the building community and the body politic as it deals with housing, building, and planning issues simply does not respond well to this kind of pressure.

What usually happens after one of these frantic efforts has been tried and fails is that the legislators that voted the resources and the consumers that have been stimulated to great expectations either become convinced that one cannot get from here to there or simply fall back to sleep. The effort is aborted and the goal is farther from achievement than if the program had never been launched--witness Operation Breakthrough and the Building Energy Performance Standards.

A continuation of the cooperative program already under way, with a steady hand on the tiller, will undoubtedly prove in the long run to have been the best course to follow. The old adage "haste makes wastes" certainly should not be forgotten in the case of the earthquake hazard reduction program. Its going well. Let's not break it.