EARTHQUAKE PREDICTION AND HAZARDS EVALUATION IN THE YEAR 2000 -- A DIALOGUE [1]

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Decisionmakers have different perspectives about geologic hazards than scientists and engineers. These differences, which have been summarized by Szanton (1981, table 3-1)[2], are the reasons that implementation of loss reduction measures are difficult. The differences are:

- The ultimate objective of the decisionmaker is the approval of the electorate; it is the respect of peers for the scientist/engineer,
- The time horizon for the decisionmaker is short; it is long for the scientist/engineer,
- The focus of the decisionmaker is on the external logic of the problem; it is on the internal logic for the scientist/engineer,
- The mode of thought for the decisionmaker is deductive and particular; it is inductive and generic for the scientist/engineer,
- The most valued outcome for the decisionmaker is a reliable solution; it is original insight for the scientist/engineer,
- The mode of expression is simple and absolute for the decisionmaker; it is abstruse and qualified for the scientist/engineer, and
- The preferred form of conclusion for the decisionmaker is one of "best solution" with uncertainties submerged; it is multiple possibilities with uncertainties emphasized for the scientist/engineer.

With these principles in mind, let us now turn the clock forward to the year 2000 and a discussion between a decisionmaker and a scientist as they seek to resolve their philosophical differences and reach solutions to problems of earthquake-hazards reduction.

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1 Transcribed, condensed, and edited from audiotapes.
2 Szanton, Peter, 1981, Not well advised: Russell Sage Foundation and The Ford Foundation, New York, 173 p.

Richard Andrews: I became involved in the earthquake business about four-and-one-half years ago. Literally the first day I worked in this business after 14 years as a professor of history, I attended a cocktail party that was held in West Los Angeles where a number of people were gathered to inaugurate the beginning of an earthquake task force in the state of California. A comely young lady came up to me and said, "You realize, of course, that earthquakes are Mother Nature's way of crying out for love." Having dismissed that comment, I thought we had made considerable progress in earthquake-hazards reduction efforts here in California during the past four-and-one-half years. However, in the aftermath of the 1985 Mexico earthquake, many emergency services workers here became subjects of great media attention. One Friday afternoon, a colleague and I had the pleasure of appearing on a mid-afternoon television talk show before a live audience. We were last on the program, following Prince and Michael Jackson look-alikes, Melissa Manchester, Redd Foxx, and a break-dancing act. We then had the pleasure of telling the audience about all the death and destruction facing southern California in a major earthquake. It was then that I thought back to the young woman's comment at the cocktail party, and wondered if we truly had made any progress in the past four-and-one-half years.

What I would like to do very briefly is to provide an overview of where we are and where we might be going in this business that we're collectively involved with. I returned recently from Mexico City. One of the major lessons I came away with from that experience was that the problems the Mexican government and people encountered in that tragic series of events were compounded by the difficulty of various systems of government and various disciplines knowing how to talk to one another. In some cases it was literally the problem of physically not being able to talk to each other, but more importantly it was a problem of really not knowing what the other one was saying. I think conferences like this workshop are very important to bridge that gap so that we do learn to talk to one another. As Bill Medigovich, the director of California Office of Emergency Services, said this morning in his opening comments, we need mutual respect among the disciplines. There is need for an early dialogue in which the users of geotechnical information help define what the information needs to be.

In California, the fundamental problem we face is simply the issue of time. All of the discussions that we've had today could be much more informed if we knew what time frame we were talking about. How quickly do we need to apply the information that we have? Do we have five years, five days, or five hours before an event occurs here that is on the scale we have talked about. In the absence of that basic knowledge, we are left with a high degree of uncertainty that causes much impatience. Those of use who are involved in the policy side or the emergency response side of earthquake hazards reduction get very impatient with some of the debates that go on. In part that impatience is the consequence of two different systems -- the academic research system colliding with people who are involved in emergency response and in direct life-saving activities.

It's important to recognize that we have made great advances, particularly in awareness. If the big earthquake happens tommorrow, there will be fewer people in southern California surprised that it happened than would have been surprised four-and-one-half years ago. I think we have convinced people that this is inevitable in our future, but beyond that again the question is time.

Unquestionably, the research that has been carried on over the last decade has helped narrow that focus of time, but we are still left with a high degree of uncertainty. In California there have been unprecedented levels of commitment to the earthquake program. Just in the last 15 months, Governor Deukmejian has signed legislation appropriating over 2.5 million dollars for previously non-existent programs in the area of seismic safety. It's clear that there is a commitment by both the Governor and the Legislature to seismic safety. If I was asked what would have the greatest impact in the short run for managing an earthquake disaster in California, I think it is the emergency response phase. After reviewing the events in Mexico City, I don't care how good a communications system we have or how rapidly we respond. If we have thousands of people trapped in large buildings, no matter how effective our search and rescue efforts are, we are not going to save a lot of those people. In the long run, the way we're going to save people is through building safe structures. We know how to build earthquake-resistant buildings. The question is simply: who should do it and who should pay for it? Once we resolve these problems, we'll be along the way towards creating an earthquake-resistant environment.

A little bit about earthquake prediction. The only way we're going to make advances in earthquake prediction is to continue the dialogue we're undertaking here today. We must learn how to understand and to have mutual respect for one another. I think for the scientific community there is a tremendous challenge in learning how to deal in the public arena, and learning how to deal with real-time geology and real-time seismology. It's a very different situation than dealing with the research laboratory or dealing with scientific exchanges with colleagues. We've made some progress in that area, but we need to learn from every experience that comes along, from things like the Parkfield prediction and from the San Diego earthquake-warning experience we had in June, 1985. In spite of all the denials by scientists that we can predict earthquakes, I walk in on a Tuesday and someone hands me a paper and says, "Guess what, the USGS thinks there's an increased probability that over the next five days there may be an earthquake of damaging potential in the San Diego area." At that point, all the probabilistic statements go out the window and you're forced to deal with a real situation. It was in part only because of the relationship that had been established between the emergency managers in California and the scientific community that we were able to work our way through.

I think we need to continue to talk to each other, I think, though, we do need to change the order. It's not simply that we are the users of the this information, I think we are also the ones who need to define the direction to go. After all, the name of the program is "The Earthquake Hazards Reduction Program" not the earthquake research program. The name of the game is saving lives, not simply doing eloquent papers.

Clarence Allen: I am going to try to hit two topics in the next few minutes. First of all, where are we likely to be in the year 2000 in terms of the scientific effort in earthquake hazards reduction, and secondly, what are the difficulties and the frustrations that we have as scientists in our interactions with users? One thing that impresses me is that the year 2000 is not very far away. It's only 15 years; I might still be here. If we had asked, "What might be the status of hazard reduction in 100 years?" it would be much easier to answer. I could then wave my arms about

prevention and control and all sorts of intriguing possibilities, but for the next 15 years, I think we're forced to be somewhat more realistic and more practical in what we think might actually happen in that relatively short time period.

Let's look back 15 years and see what the next 15 might hold in store. Where were we in 1970? Well, partly because of the fact that the 1971 San Fernando earthquake hadn't yet happened, I think there was far less general concern among the populace in the United States than there is today about earthquake hazards. The 1964 Alaskan earthquake had indeed been a major disaster, but somehow that didn't come as close to home as an earthquake in a metropolitan area such as Los Angeles.

In 1970, interest in this country was increasing in the field of earthquake prediction. Some very intriguing results had come out of Russia that were well known at that time. Many of you will remember the Vp/Vs controversy. I think it's safe to say that we were just beginning to get a real interest in earthquake prediction, but that it wasn't yet a major scientific effort. The USGS professional paper on the 1968 Borrego Mountain earthquake was in preparation in 1970, and one very significant chapter by Malcolm Clark and others described a trench excavation across the Coyote Creek fault that was used to infer slip rates and, under certain assumptions, recurrence intervals of earthquakes.

In 1970 the communication between scientists and engineers, and with the user groups, was minimal as compared to what we have today. A meeting such as this workshop was almost unheard of at that time. A lot has happened in the 15 years since 1970, and I see no particular reason why the next 15 years should not be equally productive. A lot more people are working on the problem than there were 15 years ago, including many from industry. Indeed many of the most significant fundamental contributions to our scientific understanding of earthquakes and hazard evaluation have come from people in the consulting geotechnical and engineering communities. Moreover, earth scientists are working together with the engineers far better today than we were at that time.

Where are we going to be in the year 2000, only 15 years down the line? I think that we're going to find that earthquake prediction in the medium- or short-term sense -- which is really what the term "prediction" means to the public -- will not be a routine procedure by the year 2000. We hope we will have made major progress, but I simply don't visualize that we will be routinely predicting damaging earthquakes by that time.

By the year 2000, another Parkfield earthquake should have occurred. I think the whole future of the prediction research program is going to depend to a significant degree on what happens at Parkfield. A very major effort is being made there. We will have very good instrumentation in that area and I think that the experiment is going to be critical. If the earthquake is really preceded by precursors -- even if they're recognized only in retrospect -- a very significant boost to the earthquake prediction program will occur. However, if the earthquake is not preceded by physical precursors, which is certainly a real possibility, we may instead be turning a greater proportion of our effort toward hazard evaluation. So, I would emphasize that the Parkfield experiment is very critical, and we must be very honest in our evaluation of it. If the earthquake occurs, and we in fact see no

physical precursors, I think we will have to reconsider the possibilities of realistic predictions in other earthquake-prone areas during the coming years.

I think we're going to find by the year 2000 that geodetic measurements are of greatly increased importance, not only in terms of possible prediction, but in terms of hazard evaluation. The implementation of new systems such as the Global Positioning Satellite (GPS) is going to revolutionize geodesy. We'll have a much better idea 15 years from now of what kinds of deformation are taking place within the State, not only short-term deformations that might be precursory to individual earthquakes, but long-term deformations that might be telling us what parts of the State are the most dangerous in terms of strain that is slowly building up. I think we are going to find that geodetic measurements will be a more important part of our scientific program than they are now, largely because of improvements in instrumentation.

Furthermore, I think we're going to find, as we've already seen in the last two or three years, an increased reliance on probabilistic approaches, and not just those that depend on a and b values from historic earthquakes. These probabilistic approaches will depend very heavily on other kinds of relevant data such as geologic deformation rates and paleoseismicity. Paleoseismicity studies will have multiplied manyfold, and maybe by that time we'll even understand why the 1886 Charleston, South Carolina, earthquake occurred. By the year 2000, further disastrous earthquakes will have hit the United States. Although probably the "biggie" on the San Andreas will not have occurred yet, we can say that two or three magnitude 6 or 6-plus earthquakes will probably have occurred in the southern California region, and one or two of those probably will have occurred in the metropolitan areas of Los Angeles, San Bernardino, or San Diego. I also predict that at least one or two of these earthquakes will come as a complete surprise to the geologists and the geophysicists and will have occurred in an unexpected place, at an unexpected time, and in an unexpected way -- in somewhat the same manner as the 1984 Coalinga earthquake surprised us.

Let me turn now to some of the problems that we as scientists face in interacting with the users. One of these is the rather surprising speed with which the disaster preparation people have leapt upon the possibility of earthquake prediction, even though the scientists are still far away from that ultimate objective. Now I appreciate that we as scientists have to bear some of the guilt. Perhaps we oversold the program to you people. Yet, we are surprised that people are gearing up to respond to an earthquake prediction when we're really not very close to making realistic scientific earthquake predictions in most areas. Secondly, I think we're a bit frustrated at the willingness and even the eagerness of the public, the press, and even some government agencies to accept alleged earthquake predictions from some questionable sources. Again, we're not without guilt in our dealings with the news media and with the public, but this is an area where we feel very uneasy and a have certain sense of frustration. Thirdly, I think we're a bit unhappy with the lack of understanding or even sympathy towards probabilistic kinds of statements. I remember several years ago a dam owner telling me: "Don't give me all this nonsense about 'probabilities and acceptable risk', just tell me whether the dam is safe or not." Well, I wish that the world were that simple. I think the increasing trend towards probabilistic approaches is indeed very valuable, although Dick Andrews might disagree with this.

Another area of frustration for us, to be very blunt, is the absence of stability in the disaster preparation agencies, which seem to be political footballs whose ranking people come and go with the tides of political change. I'm not sure any of us know the answer to that problem, but trying to deal with the rapid turnover in governmental agencies certainly has been an area of some frustration.

Fifthly, and I suspect Dick Andrews would agree with this, is the lack of response from the community despite our repeated warnings. Just how many times do we have to repeat that the San Andreas is capable of a large earthquake? I've lived here since 1930, and I've heard this statement repeatedly since that time, yet we still have people saying, "Oh, the San Andreas is a dangerous fault? Why didn't you tell us?"

Finally, I'd like to close with a question for Dick Andrews. For those of us in the scientific community, it's really not completely clear what type of scientific information on earthquake hazards is of the greatest use to the public. Let me just ask this question. The newly published USGS Professional Paper 1360 speaks of a magnitude 6.5 earthquake on the Newport-Inglewood fault as being of serious concern to the Los Angeles area. Dick, which would be more valuable to the user community: a valid prediction of a magnitude 6.5 earthquake on the Newport-Inglewood fault at a specific place next week, or a valid probabilistic statement of its likely occurrence during the next 50 years? Those two scenarios aren't necessarily mutually exclusive, but to some degree they represent different avenues of our research.

Andrews: Being one of those short-time political people from a disaster preparedness agency, I'll ask for the short-term prediction!

I think that Clarence has raised many good points. The year 2000 is not very far away and to acomplish anything in the way of significant hazard reduction in southern California, or in the state of California, or even across the United States we're going to have to inaugurate additional programs now. I think the whole issue of probabilistic statements for expressing earthquake potential to the public is one that we need to approach through trial and error. In the San Diego experience, the final public announcement said that one in 20 sequences like the one that occurred the night before have resulted in a damaging earthquake. We thought this was a marvelous way of getting around the uncertainty of saying 5 percent -- 5 percent of what? Then we had a session in San Diego with the various people there who were involved with the issuance of the prediction and one man from the media said "Who ever came up with that stupid idea saying one in 20 historical incidences? Why didn't you say 5 percent? Everybody understands that." The whole issue of how the statements that we make to the public are expressed is one we really need to approach carefully.

One of the things I think is most frustrating for people involved in public agencies at any level is the difficulty of having to choose among the experts at a time when the decision needs to be made. It is frustrating to poll seven or eight seismologists and to get different opinions about what may be going on. I think the scientists need to recognize that they are dealing in a public arena with something that is of much greater consequence than simply the respect of their colleagues: namely the life and safety of the people of California. We need to be closely

coordinated on any kind of future predictions that are made. It's just not good to have one group of scientists saying that "Yes, it is going to happen with this kind of probability" and to have three or four other scientists quoted the same day in the paper disputing this conclusion. I think that undermines the entire effort that we're involved in.

Over the next 15 years I think the major thing we need to pay attention to, in addition to improving our response capability, is dealing with the thousands of hazardous structures we have in California. We need to develop a cost effective way to begin to retrofit these and we need to begin to recognize that it is fundamentally a political problem, not a technical problem, that we are dealing with. We clearly have enough information to significantly reduce the earthquake hazard here in California. Scientists need to recognize that their responsibility doesn't simply end with doing research, but that they need to participate in providing testimony to legislatures and they need to speak with a clear voice. I know that this goes against the grain in many ways of what the academic and research community is all about, but for too long some members of the earthquake research community have enjoyed being prophets without honor. They enjoy sitting in their rooms and saying, "Nobody pays attention to us and we really know what to do." Instead they need to be exposed to the light of day or to the glare of television cameras. I would emphasize that we need to go forward together in this enterprise. Clarence Allen pointed to the frustrations with regard to disaster preparedness and the fact that emergency managers have grabbed onto earthquake prediction. We're guilty of some of that, but from the public safety standpoint, earthquake prediction is not a research activity but an operational reality. We need to approach it from that standpoint and go forward together.

Allen: Dick, one of your charges is that the scientists don't have their act together and that various people are saying different things to the detriment of the rest of the community; certainly this has sometimes been true. I might point out that the people in academia have an advantage over those in government. Whenever somebody in government speaks at almost any level, the public somehow assumes that that person is speaking for the government. Everyone knows, however, that when a professor speaks, he's not representing anybody, and this has led to a certain amount of irresponsibility on the part of people in academia making statements, as I emphasized in my presidential address to the Seismological Society of America in 1975. Earthquake prediction represents a very special area, and if one wants to stick his or her neck out, then he or she then has an obligation to defend himself or herself in public. It's quite different from other scientific endeavors. Nevertheless, earthquake prediction is still in a research phase. No one in the world claims to have an earthquake prediction scheme that's operational and reliable. Thus, it's inevitable that scientists are going to have different opinions and, in our society, we think that's good. That's the way progress is made: by competing opinions, theories, and hypotheses.

Let me ask you this, do you think the Japanese have their act together better in the Tokai prediction than we do, and should we try to emulate them?

Andrews: Yes, I think they do. In the Tokai area they have a special situation in some ways comparable to Parkfield. They have identified what they think will be the site of a large earthquake and precursors that will only be manifested in the

short term before the event. Whether in fact that will happen or not, we don't know yet. But in terms of organizing and managing the earthquake prediction effort, I think they do have their act together. It is impressive to travel around Japan and talk to people who are involved in the prediction program. They all seem to understand how it is supposed to work if they begin to get anomalous behavior indicated on the instruments. In contrast, I think that if we went around this room and asked people to explain the functions of the National and the California Earthquake Prediction Evaluation Councils, fewer than 50 percent of the people could provide a very clear answer as to what their roles should be.

Allen: Let me give a somewhat less optimistic point of view on the Japanese effort. In the first place, we have to recognize that the Japanese are putting much more money into earthquake problems than we are. Clearly, the problem is more important in Japan than in the United States. But I think the Japanese scientists may be sticking their necks out a bit too far in the case of the Tokai prediction. They've identified only one area for an impending earthquake, and this is where virtually all the effort is going. I would be willing to predict, on the other hand, that the next major earthquake in Japan is not going to be in the Tokai area. I think that their scientific community and their political leaders are likely to find themselves in some trouble as a result. Although scientists in Japan may appear unified, I'm not sure that's entirely desirable. I would argue that the various voices we are hearing in this country on the prediction problem, as well as on other aspects of hazard reduction, are in fact beneficial to the long-term solution of the earthquake problem.

Andrews: Let me ask you a question, Clarence. What would you say is the responsibility of an individual scientist in the event that there is a statement from the California Earthquake Prediction Evaluation Council regarding a consensus that's been reached about an event that's expected within 10 days? What is the responsibility of other members of the scientific community. Should they comment on that publicly? And what role do you think they should play?

Allen: Well, I agree that they have to be very careful. The memberships of both the State and the National councils have been chosen to represent a wide spectrum of scientific opinion. If those councils come out with a judgement that represents a relatively unanimous opinion, then I think scientists have to be very careful in the statements they make. On the other hand, I see no reason for not offering criticism. I don't think it's necessarily irresponsible to offer criticism providing one does it in a way that allows one's opinions to be tested publicly. But I would certainly agree with you that once there seems to be a consensus, then one has to be careful as to what one says.

I'm intrigued by your response that the magnitude 6.5 prediction will be better than the probabilistic statement. I'm not really sure I agree with you. I think that from the point of view of building codes and land-use planning over the next 50 years along the Newport-Inglewood fault and the adjacent parts of Los Angeles, a correct probabilistic assessment of what's going to happen on that fault in the next 50 years might be more beneficial to the citizens of this city than the prediction of an event two weeks from now, which is going to be hard to prepare for anyway.

Andrews: Again, I think we come down to a basic conflict of responsibilities to the many thousands of people that may be killed in that magnitude 6.5 event on the Newport-Inglewood fault. I think that the only thing they would be reminded of is the economist's statement that in the long run we are all dead anyway. In the short run, it is the problem that we would need to focus on and if we're talking about an event that could result in 35 or 40 billion dollars in property losses and tens of thousands of people being killed I think that, again, I would bet on the short-term prediction even recognizing that it would create tremendous problems.

Allen: How is the prediction going to save that 35 billion dollars?

Andrews: It's probably not.

Allen: What is the value of two week's lead notice?

Andrews: It will save lives; it has the potential of saving lives.

Allen: On the other hand, the long-term prediction might well save a large part of that 35 billion dollars, as well as many lives in the future.

Andrews: I hope that those aren't the type of binary choices that we're facing in all of this. Again I would say a 50-year probabilistic statement in some ways begs the fundamental question.

Allen: It's not really a choice of one to the exclusion of the other. The scientific efforts we're making towards trying to predict earthquakes are based upon identifying physical precursors for short- and medium-term predictions. In terms of hazard evaluation, we're looking at sequences of past earthquakes and probabilistic approaches. So to some degree the choice we have to make is about where to spend our money: how much should be put into earthquake prediction versus hazard evaluation? I think this is a serious and difficult question.

Andrews: If I had to make the choice it would be on the development of those kind of data that can help us in the long run reduce the overall seismic hazard. Earthquake prediction alone is not going to help solve the complex problems that are involved in seismic safety in California or elsewhere. I don't think our debate should be over how we divide up what is already a very small pie. We ought to be making a case of why we need to increase the overall level of effort and resources that are devoted to this problem. Many resources have to come from here in California because the problem is both a State problem and a local government problem. I think we have taken steps in the last few years to provide a certain kind of independence in California for the programs that we're involved with. And we need to continue that because I don't think the earthquake solution can be driven solely by Federal priorities and Federal funding.

EARTHQUAKE PREDICTION AND HAZARDS EVALUATION IN THE YEAR 2000 -- DISCUSSION

This session was moderated by Walter W. Hays. Those commenting were Clarence R. Allen, Richard A. Andrews, Valerie R. Kockelman, Anthony Prud'homme, James E. Slosson, James J. Watkins, Edward M. O'Connor, Rachel M. Gulliver, Gary C. Hart, and others who were not identified. The following was transcribed, condensed, and edited from audiotapes by William M. Brown III.

Valerie Kockelman thought that the public should be made aware of any earthquake prediction, thereby being given a choice about what actions to take. Allen agreed, suggesting that scientific predictors take a realistic point of view: if they tried to keep a prediction secret, that would almost guarantee that it would not be a secret.

Prud'homme expressed concern that the dialogue had focused almost exclusively on earthquake prediction, and called for more attention to preparedness planning. Given that there will be a major earthquake in southern California, concerted efforts should be made throughout the community to deal with hazardous buildings, nonstructural hazards, and emergency planning. Prud'homme felt that earthquake prediction was almost irrelevant, and that the focus should be on retrofitting buildings and educating the public about the inevitable earthquake.

Andrews noted that the focus on prediction arose from the topic he was asked to address, but in general agreed with Prud'homme about a comprehensive, balanced approach to the earthquake problem. Andrews felt that the basic issue is the question of time, and quoted Paul Flores: "Quite simply, in Mexico City, the preparedness time ran out." Andrews described the phased approach to earthquake preparedness, noting that constructing earthquake-resistant buildings is a long-term solution. In the interim, however, cost-effective ways must be found to reduce the loss of life and property. Perhaps earthquake prediction fits into the interim strategy of preparedness.

Allen argued that recognizing the earthquake threat and preparing for it is not the whole answer. Engineers need to know which earthquake (magnitude, intensity, and local geology) to incorporate into their designs. For example, in the cases of the Diablo Canyon and San Onofre nuclear power plants, strong earthquake shaking has been designed for. The problem becomes one of designing those plants for appropriate levels of public safety. The appropriate level of shaking for that particular design is determined by geotechnical investigation.

Slosson noted that political perceptions about earthquake prediction were used to resist the implementation of a building strengthening ordinance for the City of Los Angeles. Because earthquake prediction technology seemed imminent, politicians argued against moving rapidly on the proposed ordinance on the basis that evacuation was less costly than strengthening. Slosson saw reliance on

prediction technology by politicians as an excuse for not making unpopular decisions.

Watkins noted scientists have forecast a probable catastrophic earthquake in southern California within the next 20 to 30 years, yet public officials are not taking appropriate action. Therefore, neither earthquake predictions nor probabilistic statements seem to be the proper motivators for comprehensive preparedness.

Allen suggested that the 1985 Mexico earthquake did motivate action in southern California. It was no accident that the Huntington-Sheraton Hotel in Pasadena, California was declared unsafe shortly after the Mexico earthquake. Also, a report on hazardous buildings on the University of California at Los Angeles campus was released, and the building strengthening program of the City of Los Angeles was accelerated immediately after the Mexico earthquake.

Andrews also expressed optimism about the political process with respect to earthquake safety. Although not all earthquake-safety-related bills presented by the California Legislature have been signed into law, none have been dismissed out of hand, and most of the unsuccessful bills were not signed for very good reasons. Andrews felt inactivity on the part of local government in earthquake preparedness was abetted by difficult political and economic issues. Andrews thought that programs to strengthen buildings would be more successful if there were a clearer indication of the time available before the next potentially catastrophic earthquake. A high degree of uncertainty about the time of its occurrence, with some projections placing it as far in the future as year 2225, obviates political or economic reasons to take rapid action on strengthening or rebuilding programs.

Allen, referring to Slosson's comments, agreed that politicians might rely on earthquake prediction as an easy solution to their preparedness problems. To some degree, however, scientists are responsible for that attitude because they were unduly optimistic a decade ago about predicting earthquakes. Currently, if scientists were to go before governmental bodies and say earthquakes cannot be predicted, it would be difficult to get those officials to believe them.

An unidentified participant expressed great concern about the consequences of predicting an earthquake that does not occur. Politicians do not look forward to being involved in the disruptions resulting from an earthquake prediction for a populated area. The consequences of possible evacuation, suspended economic activity, and similar problems may prevent politicians from taking strong, concerted action.

O'Connor speaking from his experience as a pioneer in prompting the strengthening of existing buildings, urged the scientific community to press for strengthening programs. Otherwise, decisions about strengthening are commonly left to the building official, who might not be willing to take the pressure of forcing owners to strengthen or rebuild their properties.

Gulliver asked about the prospects for dealing with hazardous structures other than unreinforced masonry buildings. These include tilt-up buildings, mid-rise reinforced concrete structures, structures with "soft" first stories, and certain single-column bridges.

Hart replied by referring to improperly framed 6- and 12-story buildings. In practice, Hart found that building owners generally will not review the earthquake safety of their buildings unless forced to do so by law. Hart recommended that the law require building owners to have earthquake-hazards reports prepared for their buildings, and that these reports be made public. If a report is prepared, and is not made public, then the effectiveness of that report is lost. The procedure is mainly a political one, and it should somehow be applied to all major construction types mentioned by Gulliver.