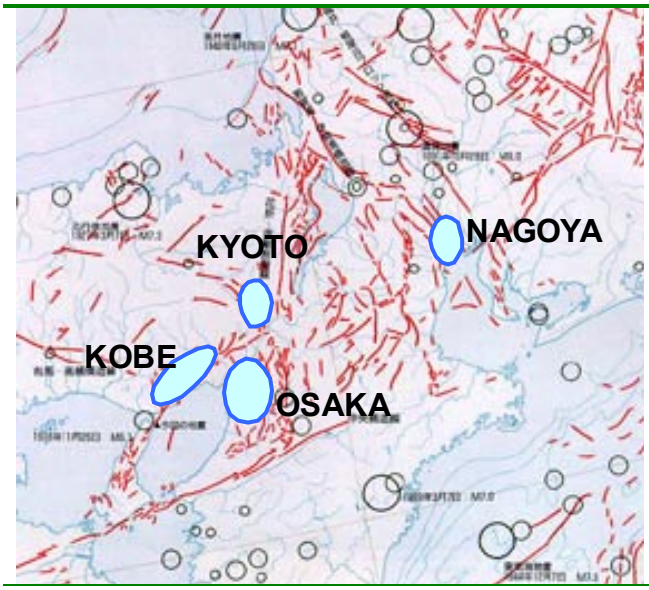
Plenary Discussion

KONAGAI: Thanks to you all, we got 17 valuable contributions to this workshop and about 80 participants registered. We talked a lot about the Kocaeli and Duzce Earthquakes in Turkey and the Chi-Chi Earthquake in Taiwan, and we are now starting the plenary discussion. It will be a formal way for us to be divided in two groups, a panel of experts on stage and the audience. But I don't like to stick to this formality. If you don't mind it, I would like to have a face-to-face discussion sitting in circle.

Needless to say, one of the most spectacular aspects of these earthquakes was the damage to structures inflicted by faulting, and is posing us difficult problems about minimizing the fault-related damage. In some less populated regions, limiting development within known and active fault zones would be very effective, and indeed in California, USA, a law to this effect has been enacted since the early 1970s. This limitation, however, might be very difficult in such overpopulated countries as Taiwan and Japan. This viewgraph shows recognized fault traces in the mid-western part of Japan. On this map, some cities of large populations exceeding a million are found just on thick fault traces. They include Kyoto of 1.5 millions population above Hanaori fault, a historical city with a large number of temples and shrines, Osaka with 2.6 millions population above Uemachi fault, Nagoya, 2.2 million, with Tenpaku fault … and Kobe is right here. You can recognize that Kobe city spreads over a bundle of faults running parallel. Some faults, being hidden below, may not be mapped yet, and our country, as well as Taiwan, is cracked up into thousands of pieces. After a big event, you can tell the presence of the fault, but before it, you cannot.

With this kind of information provided, what kind of actions should we take? … Sounds like we are tackling impossible or almost impossible missions.



Active fault traces in Kinki, Japan

Densely populated urbanized areas are found on or slightly off active fault traces in the mid-western part of Japan. They include:
Nagoya: 2.2 millions,
Kyoto: 1.5 millions,
Osaka: 2.6 millions and
Kobe: 1.5 millions population.

BRAY: I think we cannot bury our heads in the sand as much as we love soils. So we have to do our best. "To make your best" is.. first for the issues difficult to notice, to make it public and the government officials understand the problem, .. and then "**zone**". The zoning should be such that this zone may or may not contain active faults that may or may not affect structures if they rupture, and that an additional study should be urged for new developments. So I think that what we can do is … it's always difficult to retrofit and enforce retrofit, but there is no excuse for allowing continuing development in areas of high risk. Sometimes, on some projects, a minor change in the design of foundations makes a very big difference. In Kobe, I saw new, some huge structures. They had very

great beam foundations, and even though they were in liquefied areas that moved, the houses were not damaged. And so, we look at the total cost of the house. The hard wooden floors and fancy tiles cost more than an extra couple of thousands of dollars for the foundations. So I think we can argue that a minimal amount of extra reinforcement taken in slabs can really help us, and that's something we should do for development. Now for all developments, we can learn messages from a lot of earthquakes where we knew un-reinforced masonry buildings were more heavily damaged. So city of Oakland started giving tax rebates to people who have dangerous buildings to retrofit, so you could provide some kind of economic incentives. So we have to do something and we should start the new development first and then start to look at the ways of getting more dangerous structures retrofitted. But we have to start with zoning, but the zoning should be such that it allows engineers to be creative.

KONAGAI: And you said in your lecture that zoning should be flexible.
BRAY: Yes.

KAWASHIMA: What one of my students is analyzing is how a pile foundation can be displaced when a fault crosses a part of it. In such a case, what we really need … what really lacking is how the fault causes the ground surface to rupture. So when we have a fault, it's a question what would be the maximum width within which the strain is distributed … say … 10 meters? Such kind of information is really lacking. So I am very much interested in the information that Prof. Bray has provided in his paper. When we have a fault, … say … a strike-and-slip fault, how does the deformation propagate from it? How does it slide in axial or transverse direction of the bridge? They are all important in designing structures, and important issues which both scientists and engineers should collaborate on.

KONAGAI: Regarding zonings, what I wanted to say is … Well, in your (Bray's) talk you said we'd better begin with a quite simple model, and you assumed a horizontal layer spreading over a horizontal base rock, and gave a continuous dislocation to its bottom. But as long as a real situation is concerned, it is rather seldom that we have such an ideal soil deposit. Kobe, for example, spreads over alluvial fans. With the Rokko mountains rising behind, the alluvial fans cover undulating or dipping base rocks, a typical configuration that a continual dislocation of a fault has created. So in order to provide zoning maps… what do you think we should do (with the simple assumptions)? Do you think we could do something more?

BRAY: My recommendation is just one. And I think you have to get many different points of view. My view would be … I've seen so many different personalities. If I lower the door for the average height of the persons in this room, half of us will bump our heads. So I think that my view is to make very broad zones that … say … there is a fault in this area, and then allow, on a case by case basis, for the most complicated things which can not be generalized. I see some faults are very clear, and I feel confident when I am very close to them, but other faults are I am afraid not. So don't try to make the map so exact because you have arguments of the details. Make the maps of very broad brush, and then force people, on a project-by-project basis, to do additional studies like fault trenching to better-understand the hazard in the area.

COELHO: I'd like to comment that there is a quite big difference between micro-zoning a vast area and a site investigation for a specific structure, because it's a problem of scale. Zoning maps have always the problem. They include many questions and judgments. So, I agree with Pro. Bray ... I mean … maps should be very general. Then for specific problems, we should go through specific steps.

BRAY: Let me just add that …. The Alquist-Priolo is not a zone to find active traces. The exact words are to have appropriately wide zones that will contain active traces. So, the Alquist-Priolo zone on the maps might be a km wide, and there is a fault somewhere in the zone. So when you do a development project in the zone, you don't have to design for fault rupture. You just have to look for

the fault rupture. You dig trenches, and if you don't see a bedrock that is broken, you don't have to design for fault rupture. If you find a fault, then you need to set back from it. Don't go within the 50 ft distance. You have to set back in appropriate distance depending on the structure and the fault.

KAWASHIMA: I have a question to Prof. Bray. In United States, are there any structures like bridges, buildings or large culverts for which you have particular codes requiring countermeasures for fault dislocations?

BRAY: For example, CALTRANS, California, does not have them in their regulations. But their necessity was recognized. I can point the case. I worked on a project, where I'd been hired to develop a mitigation scheme for buildings. The Claremont tunnel, which Prof. Hamada talked about, was widen in an area where it crosses the Hayward fault. A number of dams had been newly built on faults, and they were just made wider to accommodate the strike-slip fault putting their priorities on the zone of the Calavaras fault. So we now know a belt a couple of faults, and expand them on case-by-case basis. So I think this kind of discussions is going to allow us to start to consolidate so that others can benefit from the experience. But I think it's always going to require a team of engineering geologists, geotechnical engineers and structural engineers working together on a project-by-project basis, because each fault and structures are so unique.

HORI: I will speak a different opinion. I work for the Earthquake Research Institution, University of Tokyo, where most of members are scientists. They appreciate engineers' works for seismic design. What we use … what we introduce is a simple and basic idea, but it does work. So they appreciate it. As for faults, we can say the same thing. With simple and effective tools, we can predict behaviors of surface soils … whether a fault appears or not… When you predict it, you now have to worry about it. But we have to establish something, which can be trusted by others.

KONAGAI: It was a couple of days ago we got a reform of ministries. And systems here have changed a lot, and we are planning to submit one application to get our research funded, and I am asking … since I am on civil engineering side … I am asking many geologists to join us. If we fortunately get our project funded, we could start something new … And I wanted to ask your opinion about what kind of tactics we should map out.

HORI: For me, it is very important to make some good tools.
KONAGAI: Yes, and indeed, you showed us interesting numerical results.

JOHANSON: When I was in Taiwan in September, a friend of mine from University of California, Berkeley, was going to cooperate with a Taiwanese University, but he did not obtain as much information as he could and wanted. Another problem is that a private company in a country does not want its information ending up in a company in a different country.

KONAGAI: It was yesterday, when we were walking around this campus, Dr. Kung said, in Taiwan, it is not allowed to take maps out of his country, but just by e-mailing, he could easily do it…

KUNG: It is very difficult to deal with this issue of circulating information. It is very important for us to be open-minded. For example in the case of Shih-Kang dam, I was struggling to get all information, and that was within my own country. If you are dealing with a foreign country, it is even more difficult. So the idea of keeping a website of this kind (… pointing what displayed on the screen) is very important for circulating and providing information. Long time ago, we were not conscious of the risk in the area but now we are. And through some discussions, we set the zone wide. So, let engineers judge by themselves. But in many cases, engineers are simple-minded. With some criterion provided, some smart engineers could solve the problem. But a majority of engineers would say, "I don't know the boundary conditions". So stop it and we must activate discussions in this field by circulating information more smoothly. We also shouldn't forget there are different cultural backgrounds. We were talking about Turkey and Taiwan, not only about earthquakes but

also about their effects. So Japan is different and so is the United States. People think in different ways in different countries. To get information from any country, the best way to obtain information is first to have a contact in the country. If you find the right person, that is the best way.

BRAY: I have a question (to Dr. Kung). We have talked a lot about California, but what is Taiwan doing about fault zoning?

KUNG: Before the Chi-Chi earthquake, they were discussing this issue, and they liked the idea of the California law of 50 ft., but now, after the earthquake, a lot of discussion is still going on. A personal experience which demonstrates the difficulty in making a law; there was a house exactly on the hanging wall, and it tilted. The farmer destroyed it to build a new stronger one, which would, according to the farmer, survive in the next earthquake. This farmer has of course a right to vote and he probably won't vote to a zoning act that would make him move. It is a difficult situation the Taiwanese politicians are facing, when making a zoning law.

BRAY: But you don't need to move … you just stay there and will have to get your house engineered for a possible fault rupture.

KUNG: Well, that's the ideal case for an engineer, but not for bureaucrats. Who takes the responsibility of doing this? In the case of a private house, the owner has to do it, but in the case of a public building such as a school, who is responsible?

URAL: URAL: Just coming back to your (Johansson's) question of data allotting criterion, in Turkey we have a number of problems …I don't know how I shall show the problems but …in the past year and half, we requested in a lot of investigation from the private sectors. So they performed a lot of soil tests separately, and we had after all an obligation not to publish that information with their name and location. It was a very difficult puzzle how to give that information appropriately.

Coming back to Jon's (Bray's) question about what to do with fault zones, Turkish officials would like to optimize these ideas about how we can specify zones, how we should urge some changes, who would be responsible to achieve it, how to deal with legal aspects of this. I don't know if the Alquist-Priolo is just California or a national program. So in Turkey, we have a target as a national program.

BRAY: The 1971 San Fernando earthquake had hazards of fault rupture, ground shaking, liquefaction and seismic stability. All of those were going into a law. But the bureaucrats, lawyers and land developers did not agree, and the only one that went into a law was the fault rupture, because it's obvious why you wouldn't want to have houses on top of a fault. It took the Loma Prieta earthquake and then the Northridge earthquake for the bureaucrats to realize the ground shaking, liquefaction and seismic stability are all important, and now we have the seismic hazards mapping act. Ground shaking is a kind of difficult to zone, where is the line to divide areas of strong shaking from areas of weak shaking. But we now have the act in southern California. The zone area that may have liquefaction hazard does not mean there will be the liquefaction hazard; you just have to investigate the liquefaction risk. Unfortunately, it takes disasters to allow you to go forward. But the most obvious hazard is the surface rupture and perhaps Turkey and Taiwan could get a surface rupture act now (and later an act for other seismic hazards).

URAL: Is it a state or nation act?

BRAY: This is a California State act. It has not become national because the surface fault rupture is not as large hazard in terms of risk as the other threats to the United States. But the NEHRP, the National Earthquake Hazard Reduction Program, has used California's program for the nation. But in the California hazards mapping act in 1990, which is being implemented in California, California obviously serves as an example for the rest of the country.

One problem is that architects and developers are not listening or they don't want to know, so we, as engineers, have to be more pragmatic and explain to them about the possible damage. We so to say have to scare them to realize the hazards.

KONAGAI: It's now time to finish this discussion. I thank you very much for your interesting and valuable contributions.

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