IMPLEMENTING ARRANGEMENT
Between the
DEPARTMENT OF TRANSPORTATION OF THE UNITED STATES OF AMERICA
and the
MINISTRY OF TRANSPORT OF JAPAN
IN RESEARCH ON A COOPERATION PROJECT CONCERNING THE EFFECT OF EARTHQUAKES ON RAILROAD TRACK, STRUCTURES, AND FACILITIES

Report from Committee 9 - Seismic Design, and
The Federal Railroad Administration
before the
STRUCTURES SESSION
of the
AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION
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Thank you for the opportunity to speak on behalf of AREMA Committee 9 - Seismic Design, and the Federal Railroad Administration. Our topic is an Arrangement between FRA and the Railway Bureau of the Ministry of Transport of Japan to promote the exchange of information between railway engineers of both nations on the effects of earthquakes on railroad facilities and operations.

This Arrangement provides a rare opportunity to improve our understanding of earthquakes and their effect on railroads. Making this opportunity work will require participation and cooperation from the railroad industry, the engineering profession and the Federal government. That is why we want you to hear about this Arrangement and to understand the benefits to be gained by it.

Background.

Our understanding of earthquakes and their effects has advanced rapidly in the past decade. AREMA Committee 9 - Seismic Design, was organized to focus attention on these issues, and to provide the railway engineering profession with information and recommended practices for mitigation of the damaging effects of earthquakes on railroad facilities and operations.

Several major earthquakes have occurred during the past decade or so, particularly in Northridge and Loma Prieta, California and Kobe, Japan. These events have focused public **a**ttention on the vulnerability of the works of man to these calamities.

Our railroads are no exception. Railroads in California weathered the earthquakes quite well, but other facilities, including highway bridges, suffered severe damage with multiple human casualties. The earthquake in Kobe was of a greater magnitude, with unfavorable soil conditions. The railroads in Kobe suffered some severe damage in that event.

The USDOT had some interest in sending a delegation of experts to Japan immediately following the Kobe quake to see the railroad damage first hand. However, considering the difficulties facing the Japanese people in the area at the time, and the absence of prior arrangements, it was thought better to wait and take a more long-term approach.

The United States Department of Transportation (DOT) and the Ministry of Transport of Japan (MOT) have had for some years an agreement for the exchange of technical information on transportation issues. This agreement has provided for very useful exchanges of information in several important areas of interest. DOT and MOT meet annually under this agreement, alternating between nations.

Railroad agencies of both nations participate in the agreement. The Railway Technical Research Institute of Japan (RTRI), owned by the private railroad companies of Japan, supports the Ministry of Transport in railroad technical issues.

At the 1996 annual meeting in Tokyo, Japan, the FRA proposed an arrangement for the exchange of information between the United States and Japan on the effects of earthquakes on railroads. This proposal was well received by our Japanese counterparts. While we were still in Tokyo they provided us with an excellent briefing on the effects of the Kobe earthquake on the railroads, with a detailed report written in Japanese.

The Arrangement was signed by Federal Railroad Administrator Jolene Molitoris at the annual DOT/MOT meeting in Washington in 1997. It has been signed by the Director of the Railway Bureau of the Ministry of Transport of Japan, and is now in effect.

The next annual meeting is scheduled for Tokyo in October of this year. We plan to discuss further details of implementation with our Japanese counterparts at that meeting.

Participants in the Arrangement:

The two primary participant organizations, representing their governments, are the Ministry of Transport of Japan (MOT), through the Railway Bureau; and the United States Department of Transportation, through the Federal Railroad Administration (FRA).

Supporting MOT are the Railway Technical Research Institute of Japan (RTRI) and the privately-owned Japanese railroad companies. The formerly state-owned Japanese National Railways have been privatized. RTRI is their jointly-owned research organization.

Supporting the FRA are AREMA Committee 9 - Seismic Design, which the FRA recognizes as the primary source of expertise in the field of railroad seismic issues; the railroad industry of the United States; and the Federal Transit Administration with regard to the involvement of the rail transit industry.

The FRA, the United States railroads, and the railroad engineering profession stand to benefit from this Arrangement. By gaining a better understanding of Japanese seismic engineering practices we may be enabled to improve our ability to protect lives and property in the event of an earthquake and permit earlier resumption of railroad service. The FRA also has a major interest in the development of design standards for high speed railroad passenger service, with seismic issues being an important factor.

This information exchange is not a one-way street. The Japanese have an interest as well, from a practical as well as a humanitarian standpoint. They are interested in understanding the overall good performance of our

structures in earthquakes, and our generally economical structural design practices. Of course, there is continuing interest in developing commercial opportunities.

Major Points in the Arrangement:

The Arrangement includes three major points. I will outline them here, and then discuss each one in more detail.

First, the Arrangement promotes the free exchange of information on the development of recommended practices and engineering standards for seismic design of railroad facilities, and on the known effects of earthquakes on railroads.

Second, the Arrangement promotes the exchange of correspondence and routine visits between railroad engineers of the United States and Japan to discuss railroad seismic issues, and to maintain personal familiarity with each others' interests and concerns.

Third, the Arrangement provides that each nation will facilitate visits by engineers from the other in the event of an earthquake in either nation.

Information Exchange:

Both Japan and the U.S. have seismic design standards for railroad structures. In Japan, these standards were written by railroad engineers from the several railroad corporations and RTRI, and they are administrated by the Railway Bureau of the Ministry of Transport. In the U.S., they are published as recommended practice in Chapter 9 of the AREMA Manual for Railway Engineering, which is in the charge of AREMA Committee 9, Seismic Design.

The Japanese standards have been in place for several decades, with regular updates following based upon experience and research. They are more detailed than AREMA Chapter 9, but owing to differences in design practice they cannot be applied directly to North American railroad structures.

Some of the Japanese details and experience might be incorporated into North American practices. Before that happens, we should be sure that we understand the reason for their use in Japan, the engineering principles on which they are based, the nature of the structures on which they are used, and Japan's experience with the practice in actual earthquakes if it has been so tested.

Both Japan and the U.S. have systems for early warning of earthquakes. Although we are not able to predict the time and location of an earthquake, we can prevent accidents by restricting railroad traffic in the affected areas and by performing post-event inspections before lifting the restrictions. RTRI operates a comprehensive early warning system for the Japanese railroads, while the U.S. railroads generally receive early warnings from the National Earthquake Information Center in Golden, Colorado. Seismometer networks worldwide are generally interconnected. Early warning procedures may be a topic of discussion under the Arrangement.

The Japanese railroads have experienced derailments during earthquakes. Some of the derailments have occurred in the absence of prior track or bridge damage, caused only by ground motion accelerations. The Japanese have analyzed these derailments in light of the recorded ground motions. Their work is well quantified and documented, and could be considered by North American railroads in the formulation of operating restrictions during earthquakes.

Establish and Maintain Contacts:

Good information exchange involves more than mailing papers back and forth between organizations. It works best when the people involved understand each others' interests and capabilities. The Arrangement calls for establishment of channels for organizational and personal communication through routine exchanges of visits and other means of communication and correspondence.

Routine visits are anticipated about once per year, or as found desirable by the correspondents. They might be held in either country, either with the annual USDOT/MOT meetings, AREMA Committee 9 meetings, or other gatherings related to railroad seismic issues.

We have found that E-mail is a very efficient means of communication with our Japanese counterparts, because of its speed, its low cost, and its accommodation of the time zone differences.

Post-Event Visits to Either Nation:

Following an earthquake, either nation may request or invite a small group of perhaps two to five people to travel to the site of the earthquake and view railroad facilities that are damaged and undamaged by the earthquake. It is important to note that the structures that withstand seismic loads can provide important information, especially when the ground motion parameters are well understood.

The travelers would normally come from a larger group who would have expressed an interest and willingness to participate. Accommodations in the affected area would probably be sub-standard at best following an earthquake. The visit would be solely at the option of the host nation, but each nation's agency will use their best offices to facilitate a visit.

It is very important that the visit must not interfere in any way with rescue and recovery operations that follow an earthquake.

The FRA does not have a large budget for this effort. We plan to ask that the visitors be supported by their employers or themselves.

The Arrangement provides that the results and findings of a post-event visit will be provided to the host nation for review before they are published. That is common courtesy, and it will permit the correction of factual errors or misunderstandings, and the refinement of translation.

So we see that the Arrangement has three major points:

1. To provide a way to exchange information on railroad seismic issues.

2. To provide for routine visits and communications for information exchange.

3. To make possible visits between nations in the event of a major earthquake.

Of course, someone has to do all this. More than a dozen members of Committee 9 have already expressed a willingness to participate. Neither the list of participants, nor the membership of Committee 9, has been filled. We are still looking for qualified people to assist in this endeavor, to

1. Assist a small group in the U.S.

2. Travel to Japan, either routine or on short notice

1. 3 Assist with information exchange

Membership on Committee 9 is not a requirement.

Members of a team to travel to Japan following an earthquake should have expertise in a field related to railroad structural or geotechnical work, and a railroad industry affiliation, such as employment with a railroad company or a bona fide railroad consulting organization, or an academic institution. Of course, support of the employer is important.

Members of a post-event team should be able to travel to Japan on short notice. Of course, individual circumstances change from day to day, and we would not expect a firm commitment in advance for travel on short notice. That is one reason we should have a larger group from which to draw participants.

Other necessary qualifications would include a passport and Japanese visa, good health and stamina, and a willingness to share work with the group and the world.

If an earthquake in the United States should affect our railroads, the FRA would coordinate any visits by a Japanese group under this arrangement. The itinerary would depend on the circumstances of location and severity of the earthquake, the location of affected railroad property, and the wishes of both the visitors and the affected railroads and transit properties.

In case of a visit by the Japanese after major U. S. earthquake, Committee 9 and the FRA might ask some engineers from non-affected railroads to assist with conducting the group. We would need at least one interpreter unless the Japanese group includes one.

Of course, we would ask for the cooperation from the affected railroads, with the understanding that they will probably have problems with higher priorities but that the visitors might be able to provide some insight and advice that could be very useful in restoration efforts. It would be best if:

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Thus far in this project, we have made some observations that might be useful. There is a pronounced language difference between Japan and the United States. Many Japanese engineers, but not all, speak English well. Far fewer Americans speak Japanese. Translation of technical Japanese is not a trivial pursuit. Technical translation requires close cooperation between a translator who knows the language, and an engineer who knows the subject.

Differences in the configuration of our respective railroad systems should be kept in mind. The track gauge of the Japanese general system is 3 feet 6 inches, but the Shin-kan-sen, or high speed line, is our standard gauge of 4'-8 1/2". Passenger traffic in Japan is heavy, and electrification is common.

Some differences in railroad bridge practice can be noted. Concrete rigid frame trestles are common in Japan, because noise attenuation is important and land is precious. In these concrete trestles, continuous spans are common, with moment resisting column-girder connections. Japanese seismic design standards were revised in mid-1980's. The 1985 standards seem to have performed better in Kobe than did bridges built to earlier standards.

The Kobe Earthquake of January 17, 1995 had a major effect on railroad bridges. RTRI did a thorough investigation of the damage, and classed failure modes into shear failures and flexure failures. Shear Failures were more common in pre-1985 bridges. In these cases,

1. Concrete fails before reinforcing steel yields
2. Diagonal cracks open at mid-height of columns
3. Heavy loss of concrete appears at the cracks
4. The reinforcing steel then has no compressive strength, and
5. The entire column might fail.

Flexure Failures were more common in post-1985 bridges. In these cases,

1. Tension cracks occurred at tops of columns at cap and girder connections to columns
2. Reinforcing steel yields in tension before concrete fails
3. Concrete remains in place supporting bridge
4. The connection can often be jacked and repaired.