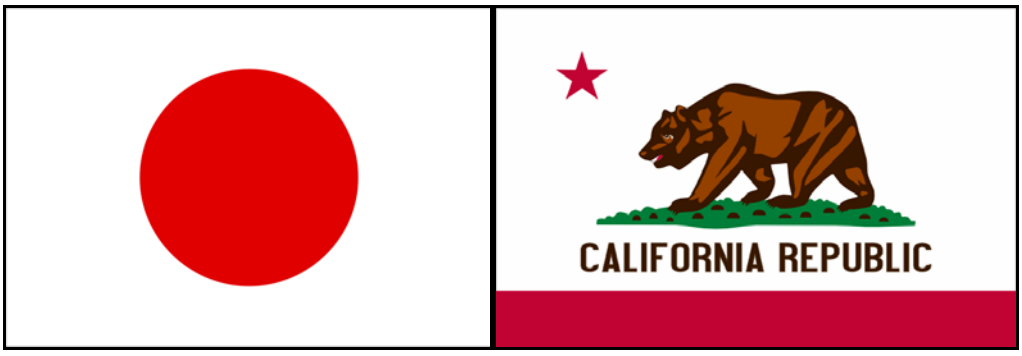
Niigata Chuetsu-oki, Japan Earthquake and Disaster Preparedness in Shizuoka Prefecture:

Lessons for California



Alfred E. Alquist Seismic Safety Commission

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The people of Japan and California have suffered loss of life and damage to the built environment from earthquakes...and the risk presented by earthquakes will always exist. However, this shared risk has created a unique partnership between Japan and California that has lead to the development, implementation of extraordinary policies, programs, and activities in the areas of earthquake risk reduction, emergency response, recovery, insurance, tsunami, and education.

I was honored to lead the Alfred E. Alquist Seismic Safety Commission's (Commission) Investigative Travel Team to see first hand the fruits of California's relationship with Japan. I was amazed by the dedication and resilience of the Japanese people in their attempt to reduce the impact that earthquakes have on their lives. This resiliency was fully illustrated for me by the actions taken by Niigata and Shizuoka Prefectures. They have integrated efforts of the central, prefectural, and city governments, along with private industry, small businesses, universities, and residents, in recovering from past earthquakes and preparing for future earthquakes. Japan truly is a leader in its attempt to protect its residents from one of the world's worst and most unforgiving natural hazards.

Although the Investigative Travel Team focused on the July 16, 2007 Niigata Chuetsu-oki earthquake, this report also includes its best efforts to identify lessons learned from Shizuoka Prefecture's preparation for the inevitable Tokai Earthquake forecast to occur in the future. Continuation of this unique partnership between Japan and California is of paramount importance and represents just one cost-effective way to reduce the earthquake risk to millions of people.

California must remain vigilant in its efforts to partner with other nations which face earthquake threats. The Japan-California model is a successful collaborative and demonstrates the importance of global relationships that focus on making a safer world for all.

Rosario Marin, Secretary

State and Consumer Services Agency

"Japan's Niigata earthquake in July 2007 was the most costly global disaster of the year."

- United Nations Report on International Strategy for Disaster Reduction

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I. Introduction

California sent a team to Japan on November 3-10, 2007 to investigate the effect a 2007 earthquake had on the economy and infrastructure of Niigata Prefecture, as well as, review disaster preparedness plans and mitigation activities in Shizuoka Prefecture. The investigation team was comprised of the Secretary of the State and Consumer Services Agency, the Governor's Office of the Insurance Advisor, representatives from the Alfred E. Alquist Seismic Safety Commission (Commission), the Building Standards Commission, the California Science Center, and San Jose State University. The team was facilitated in Japan by the efforts and generosity of the Crisis and Environmental Management Policy Institute (CeMI), the national government, and the governments of the Niigata and Shizuoka Prefectures.

The team explored three geographic areas (Figure 1) and examined economic recovery issues faced by the affected regions, viewed specific damage to infrastructure and facilities, strengthened the Cooperative Agreement with Shizuoka Prefecture, reviewed Japan's recently implemented earthquake early warning (EEW) system managed by the Japan Meteorological Agency (JMA), reviewed earthquake insurance in Japan, and explored earthquake mitigation programs and activities.

It should be noted three years earlier, October 23, 2004, another earthquake, the Niigata-ken Chuetsu Earthquake, occurred in the same region. This earlier earthquake had a magnitude (M)6.6 with its epicenter south of Niigata and approximately 120 northwest of Tokyo.

II. 2007 Niigata Chuetsu-oki Earthquake

A M6.6 earthquake occurred on July 16, 2007 at 10:13 a.m. The JMA named this earthquake the Niigata Chuetsu-oki Earthquake, reflecting the fact that the epicenter was in the Sea of Japan, approximately 6.2 miles (10 kilometers) west south west from Niigata coastline and approximately 6.2 miles (10 kilometers) deep. This was a relatively strong earthquake with a magnitude comparable to the 1989 Loma Prieta Earthquake (M6.9) and the 1994 Northridge Earthquake (M6.7).

Figure 1. The travel team visited Tokyo, Niigata, Nagaoka, Kashiwazaki, Shizuoka, and Yaizu.

Table 1 provides a comparison among recent and forecasted earthquakes in Japan and California. While the 2004 and 2007 Niigata earthquakes released similar amounts of energy, their losses were dramatically different. The earthquakes with higher losses occurred in regions with larger populations. In the case of the 1995 Kobe earthquake, approximately half of the lives were lost in the ensuing fires.

Table 1. Comparison of Recent and Future Earthquakes in Japan and California

	Niigata Chuetsu-oki	Niigata Chuetsu-Ken	*Shizuoka Prefecture*	Kobe	Northridge CA**	Loma Prieta, CA***
Date **Magnitude**	7/16/2007 M6.6	10/23/2004 M6.6	*Tokai Earthquake** *M8.0*	1/17/1995 M6.9	1/17/1994 M6.7	10/17/1989 M6.9
Property Losses (USD)	$12.8 B	$25.5 B	*$338 B*	$200 B	$46 B	$10 B
Injuries	2,315	3,000+	*104,000*	14,678	11,846	3,757
Deaths	14	67	*4,800*	6,434	57	63
Population	810,000	812,705	*3,740,000*	1,500,000	62,949	9,396
Representative Industries	Fishing; agriculture; precision instruments and tools; Nippon Seiki; Riken.	Fishing; agriculture; light manufacturing.	*Commercial fishing; shipping; agriculture; electrical supplies, ocean products, motorcycles, textiles.*	Sea port; steel; 100 international corporations	Professional, academic, financial, mixed-use commercial.	Semiconductor manufacturing , biotechnology, financial, academic

* The JMA forecasts a M8.0 Tokai Earthquake affecting the Shizuoka Prefecture. The figures represent estimated impacts.
** The Northridge Earthquake impacted the greater Los Angeles region with a much larger population as well.
*** The Loma Prieta Earthquake impacted the entire San Francisco Bay Area; hardest hit were Santa Cruz and Watsonville.

III. Japan Meteorological Agency

The JMA continuously monitors seismic activities, and plays a vital role in natural disaster prevention and mitigation activities through the cooperation and coordination with relevant national and local government authorities. JMA is the single national authority that issues weather-related and earthquake and tsunami warnings and advisories. It is responsible for providing reliable and timely information to governmental agencies and residents for natural disaster prevention and mitigation.

Earthquake Early Warning System

The EEW System is operated by the JMA and uses information from their seismic monitoring networks to provide warnings that an earthquake is underway, just before the shaking from the earthquake actually arrives at more distant sites.

Formal presentations were made by the JMA and Tokio Marine and Nichido Risk Consulting Company on the EEW System. The EEW System uses information from JMA's seismic networks to provide warnings that an earthquake is underway; sometimes providing many seconds of advance warning. Since October 2007, these warnings have been disseminated to the public to save lives and protect property.

Tsunamis

The JMA has divided the coastal areas of Japan into 66 individual coastal regions and also issues a Tsunami Warning (above 0.5 meter estimated height) or a Tsunami Advisory (below 0.5 meter estimated height) for each region.

Forecast Tokai Earthquake

JMA has been anticipating extensive damage from the yet-to-occur Tokai Earthquake (Shizuoka Prefecture and vicinity) since its forecast in 1976. It has responded by providing information on the Tokai earthquake consistent with the Large Scale Earthquake Countermeasures Act by operating a dense seismic observation network and by conducting centralized monitoring in concert with various agencies including Shizuoka Prefecture and local jurisdictions. Also, Shizuoka Prefecture, on its own initiative, has taken further measures (Section VI) to mitigate the risk of the forecast Tokai Earthquake.

Seismic Intensity Scale

The JMA seismic intensity scale is used to indicate the strength of earthquakes and is measured in "Shindo" units (degree of shaking). The JMA scale describes the degree of shaking at a point on the Earth's surface. (The Richter magnitude scale measures the total magnitude of an earthquake and is similar in concept to the Modified Mercalli Intensity Scale used in the United States describes the energy released during and earthquake but not the shaking intensity.) As a result,

the measure of the earthquake varies from place to place, and a given quake may be described as "Shindo 4 in Tokyo and Shindo 2 in Shizuoka".

Table 2. Seismic Intensity Scale

JMA Scale	Peak Ground Acceleration (g)	Damage perception
0	< 0.08 % g	Imperceptible
1	0.08 to 0.3 % g	No Description
2	0.3 to 0.8 % g	Felt by Most People
3	0.8 to 3.0 % g	No Description
4	3.0 to 8.0 % g	People Frightened
5	8.0 to 26 % g	Slight Damage
6	26 to 41 % g	Significant Damage
7	Greater than 41% g	Severe Damage

IV. 2007 Niigata Chuetsu-oki Earthquake Impacts

Region Impacted

The two communities most directly impacted by the July 16, 2007 Niigata Chuetsu-oki Earthquake were the City of Kashiwazaki and the village of Kariwa, with populations of approximately 90,000 and 4,500 respectively. Kashiwazaki relies on small commercial business and light industry. The surrounding vicinity is largely agricultural with small fishing villages and tourist sites along the coast.

The 2007 earthquake and the 2004 earthquake nearby, exacerbated population reduction in the Niigata Prefecture and its vicinity.

Casualties and Direct Damage

Damage from the earthquake was significant for the region. The two biggest issues emerging from the earthquake were damage to homes and older commercial districts as well as the impacts to the nearby nuclear power plant. In short:

- 13 people were killed in Kashiwazaki and one in Kariwa due to building collapses.
- 2,315 people were injured.
- 11,410 were evacuated from the affected region at its peak.

- 1,007 temporary housing units were erected for 2,420 residents (approximately 2.5 percent of the population).
- 1,082 houses were destroyed, 1,987 seriously damaged, 25,102 partially damaged, and over 18,657 non-residential buildings were damaged.
- Total direct losses were estimated at $12.8 billion United States dollars (USD).

Impacts to Lifelines and Utilities

Disruption to lifelines was significant. Landslides disrupted a major rail line (freight and passenger) near Oumigawa Station and other roadways near the coast. Ground deformations buckled rails. One two-car passenger train derailed at the Kashiwazaki Station; fortunately there were no injuries. By July 31, two weeks after the earthquake, train service was partially restored.

Pavement at roadway bridge abutments and culverts settled, causing many roads to be temporarily impassable. Road repairs and lane restrictions along major routes were apparent during the team's visit in November. Also, the Port of Kashiwazaki experienced damage to its quay walls caused by lateral spreading and liquefaction.

Approximately 31,000 buildings had disruptions to natural gas supply and were restored by August 27, five weeks after the earthquake. Water supply was lost to 40,260 buildings and fully restored by August 4. Electricity to 23,300 buildings was restored by July 18.
It should also be noted that the world's largest nuclear power plant, with seven reactors, owned by Tokyo Electric Power Company (TEPCO) is located in the Kashiwasaki-Kariwa area and is very close to the epicenter of the earthquake. The team did not visit the nuclear power plant. However, the plant was shut down after the earthquake and was not in operation while the team was in Niigata Prefecture.

Emergency Management Following the Disaster

Japan's emergency management capabilities were substantially enhanced after the 1995 Kobe Earthquake. The direct result of these enhanced capabilities saw the Niigata Prefecture and national government agencies quickly step in to help the local governments of the City of Kashiwazaki, Kariwa village, and other affected communities to respond to, and recover from, the 2007 earthquake. Furthermore, the private sector also provided very significant resources to accelerate recovery.

It should be noted that Japan's comprehensive data gathering following the earthquake used geographic information systems that helped governmental agencies identify the highest priority needs and quickly direct resources. An impressive array of maps and lists depicting the geographic distribution of damage, as well as the specific locations of response and recovery efforts were quickly available. Efforts were made to help the elderly and disabled evacuate and recover. Japan's ability to monitor and document progress and identify recovery priorities is an outgrowth of many past experiences.

Japan assigns a high priority to rapid recovery following disasters. The national government established a 160 billion Yen recovery fund (approximately $1.4 billion USD). Requests for volunteers with specific expertise were issued. In response, 19,926 volunteers mobilized to assist in recovery efforts. Within the private sector disrupted by the earthquake, companies (sometimes competitors) provided industry-specific mutual aid to help minimize the loss of productivity as illustrated by the Riken Corporation example below.

Riken Corporation

The Riken Corporation Plant in Kashiwazaki manufactures about half of the piston rings used by the entire automobile industry in Japan. Riken has 1,741 employees who produce 31 million piston rings per month in addition to 580 million compressor rings per month. The nine satellite companies in the region that are Riken's suppliers have another 1,400 employees. Although Riken was on holiday hours at the time of the earthquake, 45 employees were injured, 13 of whom were working. Another four workers were injured during recovery efforts.

Figure 2. Riken Corporation official pointing to a piston ring. Riken's Kashiwazaki plant was shut down for one week resulting in delayed production of 130,000 automobiles.

Many companies, including Riken's clients, provided 850 skilled volunteers with expertise in manufacturing and machine tool maintenance and repair. In all, 7,900 volunteers helped clean up and repair the damage to manufacturing equipment, nonstructural failures, and the loss of building contents. Recovery work was fully completed by August 11th. Overall, the impact to the automobile industry was relatively minimal due to the automobile industry assisting Riken restore its production rates by July 30. Riken's loss was estimated at 1 billion Yen (approximately $10 million USD).

Fortunately, Riken officials recognized the earlier 2004 earthquake as a wake-up call. Recognizing the damage an earthquake can cause and the frequency of earthquakes in Niigata,

Riken developed and instituted an earthquake hazards mitigation program that includes structural and non-structural retrofits, emergency preparedness, and business continuity planning. This effort bore fruit during the 2007 earthquake by reducing the extent of damage and enabling rapid recovery.

It should also be noted that 96 percent of Riken's employees reported to work after the earthquake even though many had lost their homes and were living in shelters. Riken had a strong commitment to reach out and help their satellite companies recover as well. Riken now plans to improve its post-disaster communications with its employees.

Economic Impacts and Recovery Plans

The tourism industry in particular experienced significant decline. As of November 2007, the industry was hoping for a recovery during the winter ski season since the summer season experienced a 50 percent reduction in activity after the 2007 earthquake. It should be noted that economic recovery is made difficult, not only by damage to infrastructure, but by the perception of damage by business and competitors located outside of the disaster area.

The estimated total direct property loss from this earthquake of $12.8 billion USD does not include indirect losses, such as unemployment or other secondary disruptions, to the economy. Insured losses were estimated at 7.8 billion Yen (approximately $70 million USD).

Japan's laws require recovery planning with 10 year objectives. These are reevaluated every three years. The vision for recovery from the 2004 earthquake was defined as "Stability, Prevention, and Safety". Niigata Prefecture indicated that it is developing similar recovery plans for the 2007 earthquake. The City of Kashiwazaki also indicated that it had recently completed updating its recovery plans prior to the 2007 earthquake.

V. Earthquake Insurance in Japan

The team heard presentations from the Tokio Marine and Nichido Risk Consulting Company Ltd. (the first insurer to securitize earthquake risks in Japan using the international capital market) and the General Insurance Association (GIA) of Japan (a trade association representing licensed general insurance companies in Japan).

Insurance coverage for industrial earthquake risk in Japan was introduced in 1956. The 1964 Niigata Earthquake prompted further discussion of a residential earthquake program resulting in the establishment of the Law of Earthquake Insurance of 1966. The goals of the Japanese insurance program are to:

- Facilitate a stable and predictable lifestyle for residents by preparing for earthquakes.
- Introduce a private/public system of participation that ensures premiums collected go directly to reserve funding less operational expenses.

- Establish limits on the amounts of coverage available and on total benefits paid.
- Share responsibility by government for coverage with private insurers, creating a government backstop funded through a special account arranged through the Japan Earthquake Reinsurance Company (JER).

Government oversight of the insurance industry in Japan is unique. As a result of a reorganization of the financial administrative structure, the Financial Services Agency (FSA) was established in July 1, 2000, functioning as an external ministerial entity of the Japanese Cabinet Office (previously the Office of the Prime Minister). The FSA is responsible for all aspects of financial administration, including the policy planning and coordination of financial systems, international affairs, and supervision and inspection of financial institutions, including insurance companies. Through this entity, the team observed the strong relationships between government operations responsible for emergency and catastrophic response and their partnership with the private sector. Specifically, the EEW System is a valued resource and tool utilized by members of the insurance industry including Tokio Marine.

Earthquake insurance coverage is available through three different mechanisms, but only in conjunction with the main commercial or dwelling fire policies. Coverage for industrial/commercial policies is by endorsement, earthquake fire expense coverage is provided as a built-in coverage in the main fire policy, and earthquake insurance on dwellings.

Japan recognizes the need to provide an earthquake insurance system that contributes to the stabilization of the people impacted by earthquakes. The ongoing challenge is in the application of the law of large numbers in calculating frequency and severity due to the unpredictable nature of earthquakes and the potential for extraordinary loss of property and causalities. The earthquake insurance policy is designed to provide partial relief (selection of 30 to 50 percent of primary policy building limits with a 3 percent building deductible and limited contents coverage) to policyholders through an affordable risk based mechanism. Japan's insurance program fully recognizes the responsibility of individuals, insurance companies, and government as vested stakeholders committed to providing realistic recovery strategies and appropriate incentives (discounts and tax deductions) to facilitate a commitment to financial preparedness. Japan has developed a multi-tiered earthquake recovery program through partnerships that includes comprehensive education, preparedness, and mitigation actions.

VI. Earthquake Mitigation Programs and Activities

Education Centers for Earthquake, Fire Safety, and Mitigation

The team visited the Honjo Life Safety Learning Center (Tokyo) and the Earthquake Disaster Preparedness and Information Center (Shizuoka). Both mitigation and educational facilities offer a variety of experiential learning opportunities designed to modify residents' behavior regarding the risks involved in earthquakes, increasing their understanding of damaging impacts, and educating them about disaster mitigation and preparation. At the Honjo Center, participatory simulations included a "Smoke Exit Drill", a "Typhoon Simulation", a "Fire Extinguisher

Demonstration", and an "Earthquake Shaking Table", all engaging experiences eliciting powerful physical and emotional responses.

Figure 3. School children participate in earthquake education activities at the Honjo Life Safety Learning Center in Tokyo.

In addition, numerous interactive multimedia and exhibit modules, including a full-scale model home frame at the Shizuoka Preparedness Center, graphically show what people should do to reduce damage resulting from earthquakes and fire following earthquakes. The wood framed model (Figure 4) illustrates methods for retrofitting houses, anchoring furniture to the walls, and a display of all the supplies necessary for 3 to 5 days' survival.

The educational approach of these centers combines emotional engagement with practical information that demonstrates what needs to be done and how to do it. The centers offer guided tours with full-time docents and staff dedicated to conducting the tours to fully achieve their respective center objectives. It should be noted that these centers are funded by the Tokyo Metropolitan Government and the Shizuoka Prefectural government and represents a major commitment to reduce earthquake risk. Furthermore, the entire country conducts an earthquake preparedness drill each year on September 1st.

Figure 4. At the Shizuoka Disaster Preparedness Center, a full scale model home is constructed. Note the bracing and non-structural items used to educate the public on mitigation actions and preparedness.

It should be noted that the fire "Exit Signs" are located on the floors or on the wall approximately 30 to 48 inches above the ground. The placement of the exit signs in Japan in this manner is consistent with the belief that fires can follow earthquakes (and fires in general). This placement would allow a person leaving a building to have some direction on how to exit as smoke rises since smoke could conceal or hide the exit signs when placed nearer the ceilings. Crouching while exiting also allows a person to look at the ground while avoiding harmful smoke.

Preparedness Surveys

The Shizuoka Prefectural Disaster Prevention Bureau provided an insightful presentation on public surveys conducted every two years. The "Prefectural Survey about the Forecasted M8.0 Tokai Earthquake" is designed to assess the level of awareness about, and preparedness for the Tokai Earthquake. The survey also measures the extent of implementation of mitigation measures. The use of this metric is a very important tool to the Shizuoka Prefectural government. Shizuoka conducts these surveys, in a very professional and periodic manner, and uses the results to drive its public policy priorities and fiscal expenditures.

VII. Shizuoka Prefecture

Shizuoka Prefecture is unique because this is the first instance in the world where the occurrence of a future M8.0 or greater earthquake has been forecast. The national and prefectural governments have been very active, since the forecast of the Tokai Earthquake was issued in 1976, in developing and implementing comprehensive plans to minimize potential damage. Collectively, these activities are referred to as the "Tokai Earthquake Countermeasures". Note that the yet-to-occur earthquake has already been named!

Between 1979 and 2005, the Shizuoka Prefecture estimates that it has expended 1,740,000 million Yen (approximately $16 billion USD) on earthquake preparedness and mitigation programs. While the full scales of these activities are too vast to be included here, the following examples are noteworthy:

- Construction and improvements to evacuation areas and routes that ensure more rapid and secure evacuations.
- Improvements to fire fighting facilities and water tanks to mitigate fire damage and reduce the total number of buildings destroyed by fire following the earthquake down by approximately 26 percent.
- Implementing earthquake resistance improvements for hospitals, schools, and social services facilities to enhance the safety of users and ensure facilities can be used as shelters and relief centers after earthquakes.
- Tsunami mitigation measures that reduce flood areas by 36 percent and provide vertical evacuation routes should the area be inundated.
- Landslide prevention measures are expected to reduce human casualties by 16 percent.
- Direct technical and financial assistance to homeowners for seismic evaluation and retrofit of homes.

- Motivation of businesses and industries to develop and implement hazard reduction practices and management systems, including business continuity planning.

Shizuoka also funds a homeowner program. Homeowners are encouraged to conduct self-examination of their homes using a simple test developed by the National Housing Bureau. The government provides 300,000 Yen (approximately $30,000 USD) grants as incentives for the retrofits of older residential dwellings that are vulnerable to collapse in earthquakes. This also includes a structural engineering evaluation of the homes at no cost to the homeowner. Modern, earthquake-resistant homes are not eligible. Homeowners file for grant applications and the determination of eligibility is made by government officials. The prefecture's goal is to reduce the potential for life loss by 50 percent by 2015.

Japan's subsidy system that provides financial support to promote earthquake safety evaluations and retrofits has recently been expanded. Tax reduction measures to encourage residential and commercial retrofits have been established.

While the team did not hear specific presentations on Japan's building codes, it is worth briefly mentioning since the codes affect building resiliency, damage, and economic survival during earthquakes. The Ministry of Construction is responsible for the building regulation in Japan through the Building Standard Law and related Enforcement Order, Ministry Order, and Notifications and applies to all buildings throughout Japan. The objective of the Building Standard Law is to protect lives and property from disasters and to protect health by ensuring environmental sanitation. The Building Standard Law and related Orders and Notifications became effective in June 2000. However, the building codes are not necessarily uniform over the entire country since some building codes are determined in accordance with regional conditions such as snow accumulation and seismic activities.

California and Shizuoka Prefecture have an ongoing and mutual relationship since 1981. California currently has a formal Cooperative Agreement (Agreement) in place with Shizuoka Prefecture since 2002. One objective of the Agreement is to "develop and reinforce emergency management for large scale earthquakes and response to and recovery from disasters". The team reinforced not only the tenets of the Agreement, but helped to foster a need to share concerns and solutions as Japan and California mitigate earthquake risk.

Yamaha Motor Co., Ltd.

Yamaha Motor Co., Ltd. is a comprehensive manufacturer of products ranging from sports and leisure goods to health and industrial equipment. Yamaha Motor Company's Shizuoka Plant is also its world headquarters and is located in a region that will be affected by the Tokai Earthquake. As a result of the prefecture's policies and recognition of its vulnerability to the Tokai Earthquake, Yamaha has embarked on an aggressive, ambitious and comprehensive disaster mitigation and preparedness effort that enjoys high priority within the company.

Specific actions taken include seismic retrofitting of its main buildings and structures, establishing systems that will facilitate rapid post-earthquake restoration. Lights, electrical, communication, and other non-structural systems have been retrofitted so that the company can

be up and running within a matter of hours. Yamaha regularly reviews these systems and measures with the aim of minimizing damage and achieving early restoration in the event of an earthquake.

Yamaha developed emergency management planning with their employees, with its community and region in mind. Yamaha includes attention to the employee's welfare both at work and at home. In Yamaha's opinion, there exists inextricable links between conducting business and economic recovery of the company and the region, and the role employees have in their respective "family continuity planning"

City of Yaizu: Tsunamis

The team visited the Port City of Yaizu to view presentations and actions taken in coastal population centers in preparation of tsunamis caused by the Tokai Earthquake and other events.

The prefecture has taken significant steps to reduce the tsunami risk by implementing tsunami countermeasures for the safety of its residents, thus protecting lives and economic stability. The prefecture built a system of tsunami walls that include 8 moveable gates along the inland perimeter of Yaizu Port, the gates are operated automatically in the event of a tsunami. Alarms sound before the gates are activated. The prefecture has also constructed vertical evacuation platforms on the seaside portion of the tsunami walls and gates in the event that people and workers in the ports are unable to evacuate inland before damaging waters arrive. The tsunami platforms can each accommodate over 100 people.

Figure 5. A demonstration on the operation of the moveable tsunami gates is led by a member of the Yaizu City Fire and Disaster Prevention Department. To the left and behind the traffic control device is a seismic intensity measuring device.

Earthquake Early Warning System

Seismic waves consist of primary wave (P-wave) and secondary wave (S-wave). When the P-wave arrives at a seismic station closest to the earthquake epicenter, data from the seismic stations are transmitted to a data processing center in Tokyo. The EEW System quickly determines the hypocenter and magnitude of the earthquake by a few seconds of P-wave data at the station, and estimates arrival time of S-wave and seismic intensity at each location. The estimated P-wave information is provided in advance of the S-wave arrival (in tens of seconds) and is the principle behind the EEW System.

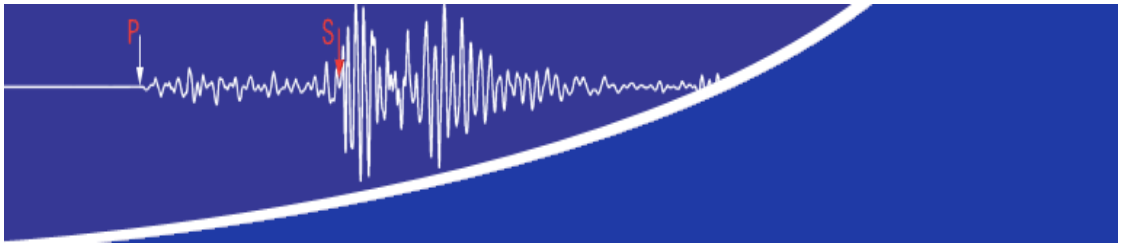

Figure 6. Seismic waves consist of P-wave and S-wave and the time interval between these waves lies at the heart of the EEW System.

The early warning provided by the Japanese system is sent to locations that will experience JMA Intensity Scale 4 or greater in the form of an announcement ("strong ground shaking to arrive in a specified number of seconds") via radio, television, and personal communications devices, as well as, to automated and/or computerized systems to trigger certain operations (e.g., bringing elevators to the nearest floor, opening fire station doors, closing rail road crossings, stopping high-speed trains, and closing access to toll bridges). The specific content of the EEW System includes the origin time, the epicentral region name, and regions where strong shaking is expected.

Modern seismic networks are essentially composed of two types of seismic recorders: accelerometers (seismic intensity meters in Japan) and seismometers. Compared to California, Japan has more seismic recording stations. California has unified its seismic networks into the California Integrated Seismic Network (CISN) and could use this system to begin to build its own EEW System after investment (upgrade the computers at each seismic station; expand the number of stations etc.).

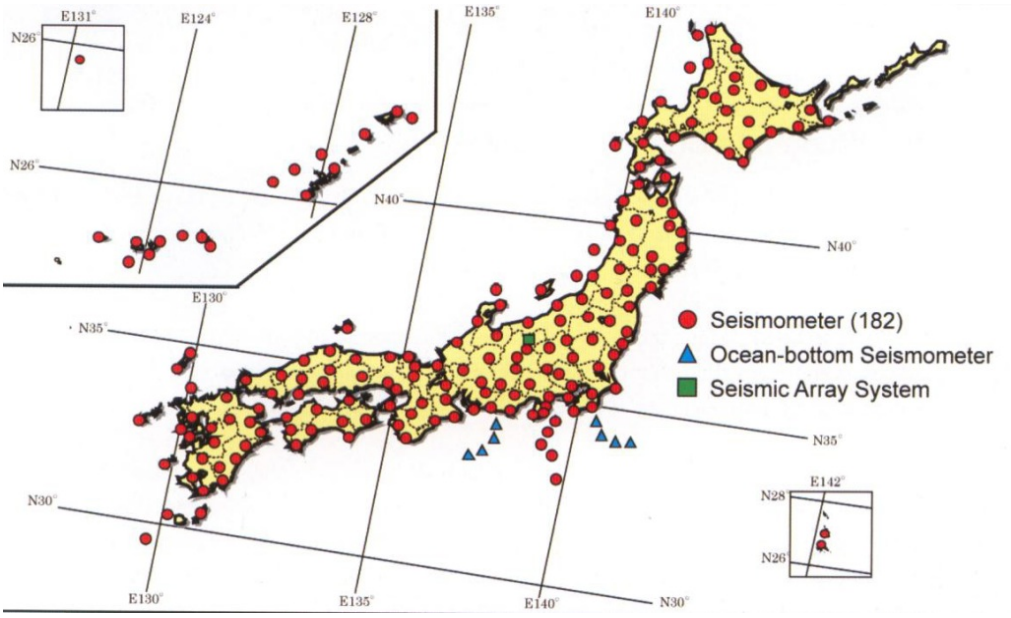

Figure 7. A map of the distribution of seismometers throughout Japan.

Many private companies have developed warning devices for consumers in Japan. In December, Japan launched its text messaging system for cellular phones. In addition to Japan, Mexico is also operating an EEW system for Mexico City. Several other countries are developing EEW systems, including Italy, Turkey, Taiwan, and Romania.

VIII. Conclusions

1. The collaboration between California and Japan has led to policies and products that can be exported to nations that face similar earthquake risks.
2. Economic recovery is made difficult, not only by the structural and nonstructural damage, but also by the *perception* of damage.
3. Earthquake damage to critical subcontractor facilities can have a major impact on the operation of major industrial facilities, which in turn can impact regional and national economies.
4. Earthquake early warning represents a major step in alerting the public in advance that an earthquake has occurred at some distance, and shaking is imminent, thereby providing many potential victims precious time to take preventative actions before the most severe shaking arrives.
5. Japanese earthquake mitigation and education programs illustrate how California can intensify its earthquake loss reduction and preparedness programs.
6. California does not have a building code relating to the seismic retrofit of existing wood frame buildings. The development and adoption of a base standard by the California Building Standards Commission for existing structures would provide uniformity to designers, contractors, and the building enforcement community. Additionally, a code would provide a base for homeowners to use to evaluate the safety of their home.

7. Japan's earthquake insurance program embraces an alternative approach to preparing for and mitigating economic loss when compared to California. Japan's dedication to the goals of their earthquake insurance system coupled with a commitment to the exploration of program enhancements is laudable and a model for others facing natural catastrophic risks.

IX. Recommendations

1. The State should undertake a major outreach and education effort to warn industries of the major economic impact that earthquake damage can have on their operations and the operations of their suppliers and how these impacts can be minimized. Furthermore, the State should encourage business continuity planning, adoption of hazard reduction practices, and strengthened relationships with local governments in this regard.
2. Joint meetings between representatives from California and Japan will support the identification of new strategies that will lead to the development and application of new technologies; education and outreach methods; and effective mitigation programs that result in the reduction of life loss, injuries, and damage to the built environment.
3. The State should make a detailed and interdisciplinary evaluation of Japan's Earthquake Early Warning System, track its progress on how effectively it provides warnings to the public in Japan, and then evaluate the feasibility of implementation in California.
4. The State should evaluate the mitigation and tracking practices employed by Shizuoka Prefecture and determine which practices are applicable in reducing California's earthquake risk.
5. The Commission should work with the California Science Center, private entities, and non-governmental organizations to construct a facility similar to the ones visited in Shizuoka Prefecture and Tokyo for the purpose of educating the public on earthquake impacts and to increase personal behavior modification to take actions that mitigate earthquake risk.
6. The Commission in partnership with the Governor's Office of Emergency Services (OES) and the University of California, Los Angeles is currently conducting a "Household Mitigation and Preparedness Survey" in California on preparedness and includes questions on insurance. Results of this survey, coupled with input from the California Earthquake Authority, the Department of Insurance, the Commission, and the private sector should be utilized to develop a strategic plan that would incorporate Japanese earthquake preparedness, mitigation, economic recovery programs that can be applied in California.
7. Following the Japanese model, the State should designate a day every year as "earthquake preparedness day" and provide linkages to major earthquake outreach efforts in the State.
8. The effectiveness of Japan's guidelines and incentive programs for seismic retrofit public education and awareness campaigns should be evaluated for application.
9. California should develop proactive plans, short and long term economic recovery policies, and strategies to respond to perceptions of damage and to offset potential economic damage resulting from adverse media stories and out-of- state and international market competitors immediately after destructive earthquakes.