NATIONAL CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
Headquartered at the State University of New York at Buffalo
A Summary of Earthquake Reconnaissance Efforts of the National Center for Earthquake Engineering Research
NCEER RESPONSE

Preliminary Reports from the Hyogo-ken Nambu Earthquake of January 17, 1995

The Hyogo-ken Nambu earthquake occurred January 17, 1995 at 5:47 a.m. local time near the city of Kobe, Japan. The earthquake caused over 5,000 deaths and extensive property damage in a highly urbanized area of Japan.

Several NCEER investigators were in nearby Osaka, Japan when the earthquake occurred, to attend the *Fourth U.S.-Japan Workshop on Urban Hazards Reduction*, organized by the Earthquake Engineering Research Institute (EERI). They participated in reconnaissance efforts following the earthquake, and their insights and first impressions are presented in this issue of **NCEER Response**, a supplement to the January **NCEER Bulletin**. Several NCEER researchers have visited Kobe since the earthquake and have also contributed to this preliminary report. A more detailed reconnaissance report is expected to be published by NCEER this spring.

Summary of the Earthquake

by Masanobu Shinozuka

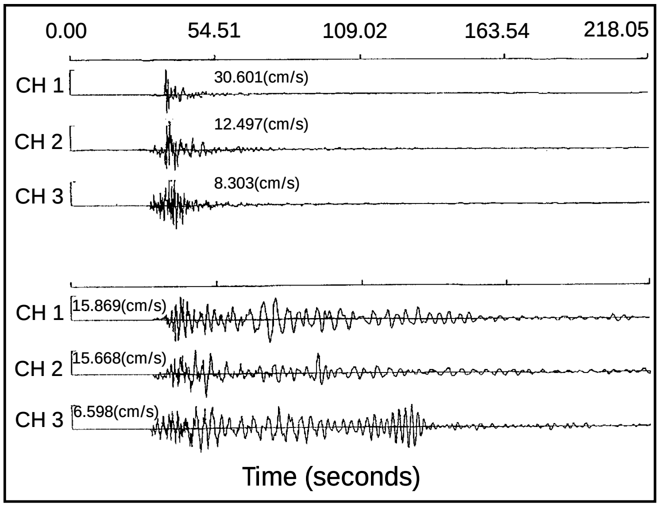
The Hyogo-ken Nambu (Hyogo Prefecture, South Part) earthquake struck at 5:47 a.m. on January 17, 1995 (January 16, 3:47 p.m. EST in the U.S.). The Northridge earthquake occurred on exactly the same calendar day one year earlier. The earthquake occurred on a northeast trending fault extending from Awaji Island to the City of Kobe, on the main island of Honshu.

The Japanese Meteorological Agency (JMA) indicates a magnitude 7.2 (M_w 6.8) with approximately 40 km of bilateral rupture from an epicenter centered at about the northern tip of Awaji Island. According to Scawthorn, surface faulting has been found on Awaji Island with a horizontal displacement of about 1 m and a vertical offset also of about 1 m. According to JMA, the seismic intensity scale was VII (equivalent to MMI = X~XII) in the narrow corridor of 2 to 4 km width, stretching 40 km or so along the coast of the Osaka Bay in the general east-west direction. In this narrow strip, Kobe's major business, industrial and port facilities, and residential houses and buildings form a bustling city of approximately 1.5 million people. The ground motion recorded at the Kobe Oceanic Meteorological Observatory (shown in table 1) represents one of the strongest ground motion records observed. The duration of the earthquake was measured at the Observatory at less than 15 seconds. Velocity time histories of rock sites elsewhere in the Kobe-Osaka region are consistent with this observation. Some soft soil sites, however, show durations of strong shaking as long as 100 seconds.

Direction	Acceleration	Displacement
North-South	818 Gal	180 mm
East-West	617 Gal	180 mm
Up-Down	332 Gal	100 mm

Table 1: Ground Motion Recorded at the Kobe Oceanic Meteorological Observatory (980 Gal = 1g.)

As far as residential and office buildings are concerned, there is a clear indication that the extent of



Velocity time histories recorded on a rock site at Toyonara (above) and a soft soil site at Sakai (below) Source: LDEO.

the damage sustained by these buildings depended upon when, and under which design code, they were constructed. A recent study by Ohbayashi Corporation on the performance of the residential and office buildings it constructed is summarized in table 2, as reported by the Nikkei Shinbun newspaper (2/4/95 edition).

Table 2 clearly indicates the effect of upgrading the seismic design code. For example, green tagged buildings counted only 42% among the buildings of pre-1971 vintage, while they counted 84% among those constructed under the new seismic design code. Such a global evaluation of seismic performance of buildings must in turn be used to evaluate the effectiveness of the design code. Older wooden residential houses in Kobe's less affluent district, Nagata-ku, appear to have sustained the most damage, first by extremely severe ground shaking and then by fire. The valuable lesson here is the need to retrofit older buildings designed below the current seismic standard and, in particular, the many older wooden houses that were built without any seismic provisions.

	Green Tags	Yellow Tags	Red Tags
Pre-1971 Old Seismic Design Code	42%	22%	36%
1972-80 Transitional Period	72%	17%	11%
Post-1981 New Seismic Design Code	84%	10%	6%

Table 2: Performance of Buildings Constructed by Ohbayashi Corporation

Liquefaction was particularly destructive for Kobe's port facilities including those located on Port Island and Rokko Island, both built on reclaimed land. Derricks and cranes were either severely damaged or made unusable due to liquefaction-induced ground deformation. The Kobe area port facilities were constructed under the Ministry of Transportation's Construction Standard B (as opposed to more stringent A and Super A Standards). After the fact, and considering the importance of Kobe's facilities in that they handle 30% of Japan's container freight traffic, this is now considered substandard. Current Japanese seismic codes do not consider importance factors.

Flexural failure and skewed monorail column. (Photo courtesy of C. Scawthorn.)

Collapse of a 500 m segment of the Hanshin expressway truly surprised the Japanese civil engineering community. However, this elevated segment was constructed in 1968-1969 under older seismic provisions and slated for retrofitting in the future by the Hanshin Expressway Public Corporation. The elevated segment had a structural configuration and followed construction procedures representative of concrete bridges popular in Europe, particularly in Germany. The elevated highway was acclaimed for its aesthetic harmony with Kobe's coastal environment at the time of construction. Also, some of the welded box type steel columns were crushed in compression under

Detail of flexural failure to Monorail column. (Photo courtesy of C. Scawthorn.)

the high level of vertical ground acceleration due to brittle fracture of welded parts, separating the four sides of the box column into four independent plates. This is reminiscent of brittle fracture of welded joints of steel frame buildings in California under the Northridge earthquake.

Several spans of the elevated structures supporting bullet train tracks near Shin-Kobe station collapsed at two different sites and a number of bridge piers sustained severe damage apparently through concrete joints. These structures were constructed around 1965 and were reported to have been designed under older design codes. Because of these collapses bullet train operation between Osaka and Okayama will not resume until sometime in May this year, resulting in huge restoration costs and revenue loss to Japan Rail, and causing significant inconvenience to passengers.

A few reinforced concrete bridge columns were irreparably damaged even though they were designed under the most current seismic design provisions, indicating the severity of the seismic ground motion and the influence of liquefaction-induced ground deformation. Indeed, these columns tended to be located at the boundaries between Kobe's original coastline and the two man-made islands. Four collapsed spans of elevated Portliner (automated train) connecting Kobe and Port Island occurred at such a location.

Electric power was restored very quickly and telecommunications relatively quickly considering the extent of the devastation. Gas and water supply are a different story. As of February 6, 725,000 customers are still without gas supply. Restoration of service is expected to be completed by the middle of March. Also, 29,000 customers are without water. The expected date of total restoration of water service is February 20. These numbers include the cities of Kobe, Nishinomiya and Ashiya, and are in spite of the fact that both the Kobe Water Department and Osaka Gas Company made a sincere effort to implement antiseismic measures to prevent such service interruptions from occurring.

Overview of Structural Damage

By Charles Scawthorn

Kobe is the western most part of the greater urban expanse of the Yodogawa Basin centered on Osaka and bordering on Osaka Bay. The entire regional population is in excess of 10 million. Kobe (population 1.5 million) lies on the bay margin and lower slopes of Rokko Mountain, in a 2~4 kilometer wide densely built-up urban corridor between Osaka and the main routes to southern Honshu. Several smaller cities (Ashiya, Nishinomiya) lie between Kobe and Osaka. The Kobe corridor is the main transportation corridor between central and southern Honshu, with several major highways and four railroads. Kobe is one of the great ports of the world which, in recent years, has seen major development of offshore man-made islands (Port Island, Rokko Island) in the Osaka Bay margins. Heavily damaged areas include most of Kobe, Ashiya and Nishinomiya, particularly in the lower elevations, and Awaji Island.

While the official name of the event is the Hyogo-ken Nambu earthquake, the disaster is increasingly being referred to in Japan as the *Hanshin Daishinsai* (Osaka-Kobe Great Earthquake Disaster). This region is not as seismically active as the Tokyo area and some other parts of Japan, but has experienced magnitude 7 or greater events in historical times (eg, 1956). A

Kobe is situated to the west of Tokyo on the southern coast of Honshu Island.

1916 M6.1 event occurred at almost the same epicentral location.

Building Performance

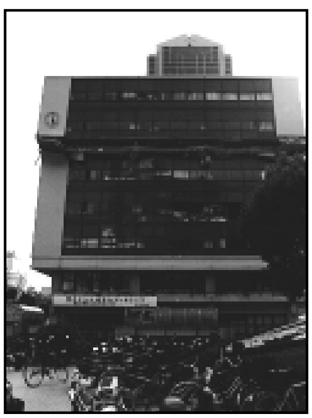
The most recent major revision of the Building Code was in 1981, and design requirements for buildings in this area are similar to those for Tokyo. Approximately 75,000 buildings were reported destroyed by the earthquake.

Wood

The great majority of the destroyed buildings are non-engineered wood frame traditional Japanese buildings, which are typically unbraced or lightly braced one- and two-story post and beam construction with heavy tile roofs. As in past earthquakes, this event resulted in the complete collapse of the first story of these houses and light commercial structures, if not both stories.The 1981 code introduced more stringent seismic requirements, so that newer buildings performed much better. Most recently, U.S.-style stud-wall construction has been entering the Japanese market, although it is not yet a major influence.

Concrete

Well in excess of 100 mid-rise buildings constructed during the 1960's and 1970's from reinforced concrete were observed to have failed, in many cases catastrophically. Most failures appear to have been shear failures of columns, which were observed to have very light transverse reinforcement. A number of mid-height single story pancake collapses were observed. An example was the 1960's vintage eight-story Kobe City Hall, which sustained a complete collapse of the sixth floor, while the neighboring 1980's vintage 16-story New City Hall was undamaged.



The sixth floor of the old Kobe City Hall collapsed. (Photo courtesy of C. Scawthorn.)

Steel

Relatively few steel buildings were observed to have significant damage, with the exception of the 51 building Ashiyahama Seaside Town complex. These buildings, of late 1970's vintage, range in height from about 10 to 29 stories, and are of non-conventional construction. That is, the structure consists of large trussed-steel column-beam frames, with typically a two-legged bent per building. A number of 500 m square steel box columns (50 m wall thickness) were observed to have totally fractured.

Transportation

A major impact of the earthquake was damage to the transportation system. Kobe is the main transportation corridor between central and southern Honshu. Due to damage to roads and other land transportation, the only land access along this corridor was via city streets, which resulted in major congestion, greatly exacerbating relief efforts. Bypassing by alternative road or rail lines added hours to travel times.

Highways and Roads

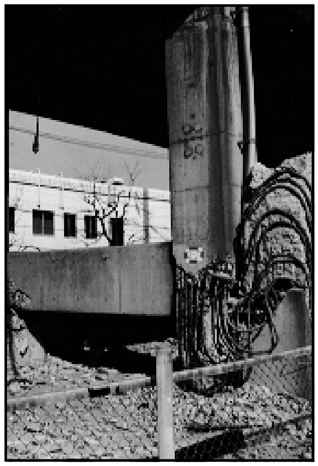
Only two limited access highways exist in the narrow transportation corridor. The Hanshin Expressway is carried on single large hammerhead reinforced concrete piers, many of the concrete sections failing in shear and/or flexure over a 20 kilometer length. Along the harbor shore is the Wangan (Harbor) Expressway, a newly elevated highway generally of steel and crossing a number of navigable waterways on major crossings. Many of the steel girders appear to have jumped

A portion of the Shinkansen (Bullet Train) that collapsed during the earthquake. (Photo courtesy of C. Scawthorn.)

from their beam seats and were askew, although few had collapsed.

Rail

Rail facilities were particularly hard hit in this earthquake (for further information on damage to underground rapid transit facilities, see article by Thomas O'Rourke on page 6). Three main lines (JR West, Hankyu and Hanshin) run through the corridor, in general on elevated embankments, and all sustained embankment failures, overpass collapses, distorted rails and other severe damage. In Kobe, the Shinkansen (Bullet Train) is generally in a tunnel through Rokko Mountain. No information was available regarding the tunnel. At the east portal of the tunnel, the line is carried on an elevated viaduct, built in the 1960's. For a length of three kilometers, this viaduct was severely damaged, with a number of the longer spans collapsing. In general, these collapses were due to shear failure of the supporting columns.



A detailed view of a sheared column which supports the Shinkansen. (Photo courtesy of C. Scawthorn.)

Ports and Harbors

The Port of Kobe, one of the largest container facilities in the world, sustained major damage. Rokko and Port Islands experienced widespread liquefaction and, on Rokko Island, a number of gantry container cranes failed due to crane rail distortions, with one collapse. Shipping in general had to be diverted to other ports (Osaka, Nagoya, Yokohama), while passenger and some vehicle ferry service was gradually established in the days following the earthquake. The Port of Osaka experienced almost no damage.

Airports

Kansai International Airport was only recently completed (1994) on a man-made island some 30 kilometers to the southeast of the epicenter. Itami is the former international airport for Osaka, and now handles much of the domestic traffic. It lies about 10 kilometers east of the heavily damaged area. Neither airport appears to have sustained significant damage.

Lifelines

Performance of lifelines was varied in this event, with electric power and telecommunications maintaining system functionality, but water, wastewater and gas utilities losing service to most of Kobe. (For specific statistics on lifeline restoration, see article by Masanobu Shinozuka on page 1.)

Electric power performed very well in the earthquake, with very little reduction in service. Electric distribution was available to all parts of the cities, except where overhead distribution poles were damaged by collapsing buildings.

Telecommunications also performed very well in the earthquake, with very little reduction in service. No information was available regarding damage to telephone exchange buildings. Telephone service was available in the most heavily damaged areas the day following the earthquake.

Underground water pipelines sustained severe damage in the earthquake, with numerous breaks resulting in general lack of service in Kobe, Ashiya and Nishinomiya.

The gas system sustained numerous breaks in its underground distribution system, with general curtailment of service. The population in the heavily impacted areas were informed to plan for no gas service for about two months. Information on other gas system facilities was not available, although a large gas holder in Kobe, near the port, was observed to have no obvious structural damage.

Fire Following Earthquake

The Kobe Fire Department (KFD) had minimal staffing on duty at the time of the earthquake. Initial actions included recall of off-duty personnel, and responding to fire calls. Approximately 100 fires broke out within minutes, primarily in densely built-up low-rise areas of the central city (Nada, Higashinada, Hyogo and Suma wards) which are comprised of mixed residential-commercial occupancies, predominantly of wood construction. The total number of fires for January 17 is 142. Water for firefighting purposes was available for two to three hours, including use of underground cisterns. Subsequently, water was available only from tanker trucks. Wind was calm, and fire advance was relatively slow. In a number of cases, fires are observed to have stopped at relatively narrow fire breaks (eg, 10 m) or, in at least one case, at a high-rise apartment building (concrete walls but well fenestrated, so that the reason for this building not being consumed is unclear). Final burnt area in Kobe is estimated at 1 million sq. meters, with 50% of this in Nagata ward.

Geotechnical Effects

by Thomas D. O'Rourke

There was severe and widespread liquefaction as a result of the earthquake. Over 50 linear km of quay walls and waterfront retaining structures have been damaged because of liquefaction in Kobe and adjacent artificial islands. Liquefaction-induced damage is prominent on Kobe Port Island and Rokko Island, which cover approximately 10 km^2 and 6 km^2, respectively. Both islands have been constructed with fill derived from decomposed granite. The average, uncorrected standard penetration resistance of the fill (blow count) is about 6. The grain size of the fill varies from gravel and cobble-sized particles to fine sand. There is less than 10% by weight which is less than silt sized particles, and the mean grain size is approximately 2 mm. The thickness of submerged fill on Port Island is about 12 m, and settlement over a large part of the island is between 0.5 m and 0.75 m. Many of the quay walls are gravity wall-type structures which have displaced laterally by one to several meters. Crane rails have displaced causing severe distortion or collapse of virtually all cranes used to load and unload container vessels. Subsidence behind laterally displaced quay walls is as large as 2 to 3 m. On the north side of Port Island, liquefaction-induced lateral displacement has caused foundation piles to pull away and break beneath the pile caps of warehouses. Lateral ground deformation has caused the piers of the highway bridge and electric rail bridge between Port Island and Kobe to lean between 2° and 3° towards the waterfront. Severe lateral movements were generally confined to a distance of 100 to 200 m from the waterfront. Port facilities were heavily damaged. Approximately 179 of 186 of the heavy shipping berths are inoperable.

Crane collapse due to ground subsidence caused by liquefaction. (Photo courtesy M. Hamada.)

There also has been damage to underground rapid transit facilities. The Daikai Station of the Kobe Rapid Transit Railway has collapsed. The station was built by cut-and-cover techniques. The collapsed portion is approximately 100 m long. It is a reinforced concrete box structure, 5.5 m high and 15.3 m wide at a depth of 4.6 m from the street surface to the top of the structure. Preliminary information indicates that the station was constructed in sands underlain by stiff clay. The central reinforced concrete columns of the station failed, apparently by a combination of shear and vertical loading. There was only nominal confining steel (9 mm diameter on 180 mm spacing) for the 20 mm diameter longitudinal rebar on 140 mm centers in the concrete. Collapse of the columns caused subsidence at the street surface of a maximum 2.5 m, with substantial settlement over an area of 100 m by 20 m. Apart from the structural collapse-induced movement, there was no clear evidence of permanent ground deformation at the site induced by other causes, such as liquefaction.

This failure is highly significant because it is the first instance of severe earthquake damage to a modern tunnel for reasons other than fault displacement and instability near the portal. Damage of a less severe nature has been reported for other parts of the Kobe underground rapid transit railways.

Initial Reconnaissance Efforts

by Jelena Pantelic

On the day of the earthquake, it was spontaneously decided by the participants at the *Fourth U.S.-Japan Workshop on Urban Hazards Reduction* to change the agenda for the meeting, and attempt to assist our Japanese colleagues in reconnaissance efforts. The organizers of the workshop arranged for transportation to the effected areas of Kobe through the sponsorship of major Japanese newspapers, and television and radio stations. Taxies were hired and dispatched to the field with maps of the city of Kobe and damage locations. In each of the cars was a driver, one reporter from the sponsoring agency, and two to three researchers. My unit included Guna Selvaduray, San Jose State University, Tadashi Ashimi, Osaka Civil Engineering Technology Foundation, and Junichi Taki, a newspaper reporter from Nikkei, Nihon Keizai Shinbun.

Taxis were hired and dispatched to the field with maps of the city of Kobe and damage locations.

Our well-organized visit to the damage sites proved to be a hair-raising experience. Cars and buses smashed under tons of concrete, railway lines twisted or just hanging in the air, derailed railway cars, tipped over apartment buildings, smoldering blocks, and huge lines of people waiting patiently for water and food were among the scenes of devastation. The weather was fortunately still mild, but later turned for the worse, and contributed to the magnitude of the disaster. Sand boils could be seen throughout Kobe.

Experiencing a moderate earthquake in a country which puts a high priority on earthquake hazard reduction should serve as an alert to other nations: when it comes to earthquakes, nothing can be taken for granted.

Societal Impacts and Emergency Response

By Joanne Nigg

The Hyogo-ken Nambu earthquake was the most damaging earthquake to effect a major urban area in Japan in 50 years. This type of earthquake and the magnitude of its consequences have not occurred in the U.S. since the 1906 San Francisco earthquake. As a result, the lessons learned from this event will not only be of importance to the people of Japan but also to citizens of the United States.

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The observations included here were made in the first 36 hours after the event, and reflect the earliest stages of the response period.

Societal Impacts

The losses in this earthquake were extremely widespread throughout the metropolitan area of Kobe and extended to Osaka and Kyoto. These losses took place in an area that did not expect a seismic event of this magnitude or intensity. Unlike the Tokai region that has been preparing for a similar type of event, the Kansai region had not engaged in a similar level of earthquake planning and mitigation. Although recent efforts had been made to prepare the region (especially Kobe) for mud/debris-flow and flood disasters, that planning did not prepare either citizens or government for the catastrophe created by this earthquake, especially with respect to housing losses and lifeline disruption.

Human Behavioral Responses

In general, citizens were pro-social in their behavior following the earthquake.They were observed engaging in a variety of voluntary helping actions in the hours after the earthquake, including participating in search and rescue activities, fire fighting, and establishing neighborhood shelters. Courtesy and politeness were observed in terms of queuing for water, phone service, and other necessities, and in retrieving goods from partially or totally collapsed structures.

Organizational and Governmental Response

During the early hours after the earthquake, there was no apparent coordination at the "street level" of public safety and response personnel. Efforts by police, fire fighters, transportation repair personnel, and medical professionals to reach the hazard areas were further hampered by the damage to transportation systems (especially in fire spread areas).

The scope of the disaster was unclear for several hours after the earthquake.

The scope of the disaster was unclear for the first several hours after the earthquake. The number of collapsed homes and potential casualties, fire outbreaks and damages to lifelines was not widely known. This situation contributed to a lag in time of requests for assistance (especially for search and rescue) and mutual aid (for fire suppression), which made prioritizing response needs difficult.

There was no apparent attempt to control access to or movement within high hazard or severely damaged areas. Further, there was no official system in place for inspecting buildings or regulating entry into or near dangerous structures.

Social Impacts

By James D. Goltz

The most significant societal impact of the Hyogo-ken Nambu earthquake was the tremendous loss of human life; the earthquake, with a duration of approximately 10-12 seconds, caused over 5,000 deaths. There were in excess of 26,000 injuries. Although the total number of rescues is unknown, news reports which appeared during the first three days after the earthquake indicated that over 1,000 people were missing, most of whom were presumed to be buried under collapsed structures. Currently, the number of missing has been reduced to less than thirty. For over 300,000 survivors in the heavily impacted cities of Kobe, Ashiya and Nishinomiya who were displaced from their homes, there were the hardships of finding shelter, securing food and water, locating friends and family members and acquiring warm clothing for the cold, damp winter weather.

Although some of the displaced were taken in by relatives and friends, and others possessed the means to relocate to hotels, those requiring emergency shelter reached a peak of 235,443 on Tuesday evening, the day of the earthquake. Many camped in public parks or assembled make-shift shelters from materials salvaged from the wreckage of their homes. The 1,100 shelters included community centers, schools and other available and undamaged public buildings but facilities were too few to avoid severe crowding in some shelters causing sanitation problems and increased risks of communicable disease. Indeed, two weeks after the earthquake, reports of influenza and pneumonia are becoming common. On Saturday, January 21, the Hyogo Prefectural Police opened a 24-hour counseling service which could be accessed either by phone or in person at police headquarters in Kobe.

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The number of people who received psychological counseling through this service and others is not known at this time.

Food, water for drinking and sanitation, blankets and warm clothing were in short supply for at least the first few days after the earthquake and many people from the wards hardest hit made the long walk to the Nishinomiya railway station, journeyed to Osaka for necessities, then returned via rail with whatever they were able to transport by hand. By Friday, January 20, both official and volunteer efforts to supply the basic needs of the impact area were becoming increasingly evident. Corporations and other non-governmental organizations donated goods and transportation was provided by both business and government vehicles. In some cases, normal production schedules and processes were modified to assist in the relief effort. Kirin Breweries, for example, filled quart-sized bottles with drinking water and shipped thousands of cases into the Kobe area.

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Amid the overwhelming need for safe shelter, some residents chose to remain in damaged residential buildings despite uncertainty regarding structural integrity. There was little evidence during the first week that access and egress of even the most severely damaged homes and apartment buildings was being monitored, and cordoned areas were few and unenforced. Although temporary housing is now being constructed and rent-free rooms have been offered by apartment owners, the demand for longer-term housing exceeds availability by a factor of ten. Those displaced by the earthquake are likely to compete for available housing with construction workers, technicians and engineers who are converging on the Kobe-Osaka-Kyoto area anticipating large contracts for reconstruction.

Sources: personal observations at the disaster site from January 18th to 25th; interviews with those in the high impact areas; and news reports from both local and international media.

Economic Impacts

By Stephanie E. Chang

Official estimates released one week after the Hyogo-ken Nambu earthquake place the economic toll at up to 10 trillion yen (roughly $100 billion) in repair costs alone, but we may never know the full extent of the disaster's economic impact. Now being referred to as the *Great Hanshin Earthquake*, this disaster has paralyzed the economy of Kobe in a way previously unexperienced in a modern urban area.

The severity of the socioeconomic impact arises largely from the urban geography of the Kobe region. Hemmed in by mountains on one side and ocean on the other, Kobe represents a development corridor of high population and infrastructure density. In the most heavily impacted wards and cities in the area, population density varies from 3,900 to 10,800 persons per square kilometer; by contrast, the cities of Los Angeles and Oakland, which were heavily impacted in the Northridge and Loma Prieta earthquakes, have population densities of 2,900 and 2,600 persons per square kilometer, respectively. Furthermore, the region served as an important rail and road transportation corridor between northern and southern Japan, and Kobe port was important for international ocean freight.

The severe damage to the region's transportation infrastructure is already having significant economic repercussions. Cessation of port functions has impeded the shipment of raw materials and parts between businesses in Japan and their subsidiaries or partners overseas, impacting firms in the electronics, apparel, and auto manufacturing industries, among others. Rail and road transportation disruption has affected a number of firms relying upon just-in-time

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production systems; in several instances, this caused automobile and motorcycle manufacturers to temporarily shut down plants located far from the shaken region.

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Structural damage as well as losses of other lifelines, primarily water and gas, have also severely impacted business activity in the region. In the first week after the earthquake, virtually no businesses were operating; those that were open were establishments such as repair shops, shoe stores, banks and gas stations which did not rely heavily upon these lifelines. Many small businesses, including concentrations of knitted goods and synthetic leather shoe manufacturers, suffered severe structural, equipment, and fire damage. However, in some instances, facilities were shut down despite the absence of structural damage. One striking example is Kobe University which sustained apparently no structural losses, but which, several days after the earthquake, had no definite plans to reopen; according to faculty members, the institution is devastated by the destruction of building contents, the lack of water and heat, and the deaths of many of its students.

Sources: personal observations in the disaster-affected region from January 19th to 24th; discussions with disaster victims; news reports; and statistical reference books.

Selected Bibliography

By Dorothy Tao

The following bibliography is a selected listing of items available through the University at Buffalo libraries. The list provides an overview of available materials and is meant to be a starting point for further reading. Additional materials can be obtained by contacting the NCEER Information Service.

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