UJNR Panel on Wind and Seismic Effects **Panel Update**

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This issue of ***Panel Update*** Volume 3 Number 1 begins the third year of the Panel's eNewsletter aimed as sharing Panel activities. We value your readership and welcome your comments about content and format. The June issues of each eNewsletter deviates from its normal two page format by sharing the highlights from the Panel's recently conducted annual Joint Meeting.

HIGHLIGHTS OF THE 37th JOINT MEETING OF THE PANEL ON WIND AND SEISMIC EFFECTS 16-21 MAY 2005

The 37th Joint Meeting of the Panel on Wind and Seismic Effects was held during 16-21 May 2005, Japan. The Panel's technical meetings were held during 16-18 May at the National Institute for Land and Infrastructure Management, Tsukuba, Japan followed by technical site visits during 19-21 May 2005 in the greater Osaka area and Niigata Prefecture, Japan.

Technical Meetings, 16-18 May

- 28 technical presentations (14 paper per side) in nine technical sessions
  - Lessons Learned from Recent Natural Disasters (Indian Ocean Tsunami)/Storm Surge and Tsunamis
  - Lessons learned from Recent natural Disasters (Mid-Niigata prefecture Earthquake)
  - Geotechnical Engineering and Ground Motion
  - Next-generation Building and Infrastructure Systems
  - Dams
  - Wind Engineering
  - Advanced Information and Communication Technology for Disaster Prevention and Public Health Evaluation
  - Transportation Systems
  - Fire performance of Buildings and Transportation Structures/Progressive Collapse
- Technical presentations highlighted work by the US and Japan Panel organizations:
  - Japan's public works projects and civil engineering research and their applications of research into practice,
  - Strong motion monitoring in Japan and US,
  - Modeling of earthquake response of dams and stability evaluation of dams,
  - Framework for real-time global natural hazards simulations and data exchanges led to partnerships between NSF's NEES and NIED's E-Defense (Earthquake Defense) and research collaborations in areas of steel buildings with innovative systems, bridges, and cyber infrastructure (initiated under auspices of the Panel),
  - Real time disaster information systems,
  - New technologies in remote sensing/data fusion for infrastructure hazard mapping, remote sensing data integration,
  - Construction of Japan's 15 m x 20 m, 12 MN (1 200 ton) 3-D shake table test facility,
  - Research data for major revisions of highway bridge design criteria and for seismic retrofit,
  - Analytical and experimental research results on wind engineering,
  - Application of research findings to revisions and creation of both country's codes and standards.
- Panel Task Committees (T/C) serve as an effective vehicle to exchange in-depth advanced seismic, wind, and storm surge and tsunami technologies. A new T/C was

created on Fire Performance of Structures. Five T/C workshops are planned for the coming year.

- The Panel's web site was expanded with Panel and T/C activities and its bimonthly Panel eNewsletter *Panel Updates* highlights Panel activities and results.

Technical Site Visits 19-21 May

1. HANSHIN EXPRESSWAY PUBLIC CORPORATION

The Hanshin Expressway Public Corporation (HEPC) was created in 1962 by the national and local governments in the Kansai Metropolitan Area to improve the traffic conditions that had significantly deteriorated from the rapidly growing population within the Osaka-Kobe-Kyoto area. HEPC performs construction and management of expressways (such as the Hanshin Expressway) urban redevelopment projects as requested by the local governments; construction of related roads when the roads are integral to the expressway construction; road surveys and studies; and construction of offices, stores and other buildings which are integrated with its road structure. Construction funding is raised through bonds (90 percent); the remainder from interest-free investments and loans. Since its creation the HEPC operates 234 km of Expressways that soon will be expanded to 24 routes totaling 280 km. These new segments of expressways are designed and constructed to provide emergency access to the region especially after earthquakes. The delegation was briefed on HEPC's seismic retrofit projects and visited several HEPC projects including:

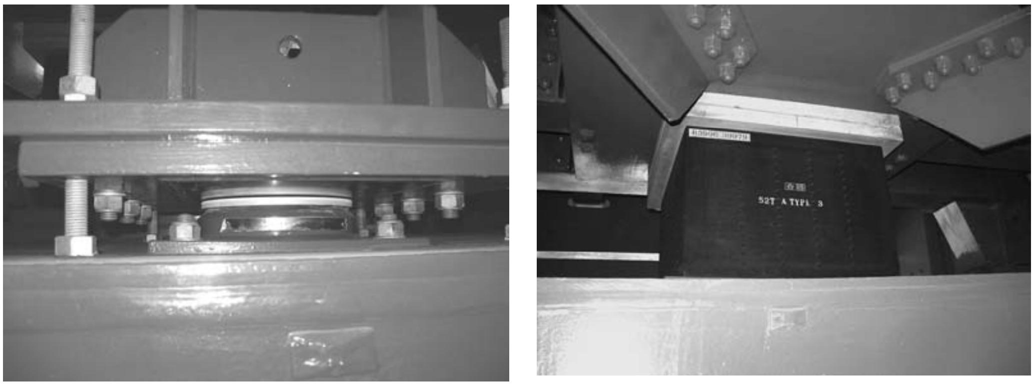
a. <u>Seismic Retrofit of the Minato Bridge, Osaka</u>. The Minato Bridge is a long-span cantilever truss bridge on the Wangan route of the Hanshin Expressway in the Port of Osaka. It was constructed in 1974 to link Osaka with the industrial port city of Amagasaki on Osaka Bay. It consists of two 235 m side-spans and a 510 m main span, and it is 22.5 m wide. With total length of 980 m, it is the longest truss bridge in Japan, and the third longest truss bridge in the world. The floor system has two levels (double floor decks). The bearings of the intermediate part are fixed against horizontal movements, and have design capacity of 131.4MN for dead and live load. The foundation type is caisson at the intermediate part, and steel piles at the edge piers. A 3D global model of the bridge, which included the effects of soil-structure interaction, gave the following estimates for the first and second mode periods of the bridge: 2.8 s and 1.4 s for longitudinal vibrations, and 4.4 s and 1.9 s for transverse vibrations.

The Hyogo-ken Nanbu Earthquake of January 17, 1995, which occurred at epicentral distance of about 40 km from the bridge and the bridge was subjected to a $33 million seismic retrofit. The adopted retrofit strategy was response modification by seismic isolation. The old bearings were replaced by a combination of sliding isolation bearings, and lateral rubber bearings on the floor deck. Non-linear rubber bearings were used at the base of the tower and elastic ones at the end supports. Also, lateral damping bracing and sway damper bracing (buckling restrained braces) were installed between chord members.

3D linear and non-linear analyses were performed using Japanese code and ABACUS. Various scale models of a new brace was constructed and tested under cyclic horizontal loadings. Ground motions were input at each support in a phased manner. The bridge was evaluated and designed for two components of horizontal ground motion but did not include a vertical component. This retrofit did not include instrumentation for response to earthquakes. Additional information about the seismic retrofit of this bridge can be found in:

- Kanaji, H., Hamada, N, and Naganuma T. (2005). "Seismic Retrofit of a Cantilever Truss Bridge in the Hanshin Expressway," Proc. International Symposium on Earthquake Engineering, January 13-16, 2005, Kobe, Japan.
- Kanaji, H., Kitazawa, M., and Suzuki, N. (2005). "Seismic Retrofit Strategy Using Damage Control Design Concept and the Response Reduction Effect for a Long-

span Truss Bridge," Proc. 19th US - Japan Bridge Engineering Workshop, October 27-29, 2003, Tsukuba Science City, Japan.



Photos of a newly installed sliding isolation bearing (left) and a rubber isolation bearing (right). Photo taken by M. Todorovska

b. **<u>Aburanokoji Route Overpass Road Ramp Construction.</u>** The new Hanshin Expressway Public Corporation's Kyoto Expressway Aburanokoji Route from Osaka to Kyoto is under construction to reduce traffic congestion. The delegation visited a bridge overpass construction site at the intersection of the Aburanokji Route and the Meishin Expressway in southern Kyoto. Due to on-ground construction space limitation the two highway approach ramps to the Aburanokoji Route Bridge were constructed directly on the new bridge, which was constructed using push-out method and temporary bents, crossing the Meishin Expressway. These two approach ramps will be lifted from the bridge and placed on their adjacent sides of the bridge by a Liebherr transport crane vehicle. The work will be performed in a series of steps involving lifting and rolling the ramps into their final location at the bridge pier columns.

c. **<u>Inariyama Tunnel</u>.** The extension of the north-south Kyoto Expressway Aburanokoji Route leads to the east-west Kyoto Expressway's Shin-Jujo-Dori Route (to significantly reduce loss of city functions from traffic jams). This Route travels 2.5 km through a mountain. Two tunneling methods were used 1) the New Austrian Tunneling Method (NATM) and 2) shield tunnel method using a tunnel boring machine. The delegation visited the west end of the mountain where the shield tunnel method was used. The east end of the route was completed several years ago using the NATM. The delegation was briefed on the pressurized slurry shield tunneling method. The shield method uses a steel shell with cutters at the front to bore through the ground. The evacuated ground is prevented from collapsing by the pressure of slurry, etc., pumped back to the work face. Segment prefabricated with steel shells and precast concrete sections are installed inside the shield behind the work face to finish the tunnel. Soil ahead of the 10.8 m diameter 70 mm thick shield cutting plate is stabilized through injection. Rate of shield travel averages 6 m per day. Bores are performed at 1.5 m per segment. Shield tunnel boring is computer operated; lasers make measurements for each cut. Soil is excavated by rotary blades and high pressure water. Soil and water are pumped to the surface. The soil is transported away from the site for possible other use. After cutting the tunnel a liner is installed, followed by a waterproofing membrane that is covered by a second concrete liner. The east bound shield tunneling machine is positioned to travel 150 m at a three percent decline then 150 m at 1.7 percent decline before leveling off to meet the NATM cut tunnel 900 m away. At this point the shield tunneling machine will make a U-Turn to cut the west bound tunnel. Obayashi Corporation is performing the tunneling work. This 10.8 m diameter tunnel is expected to cost $1 billion.

d. **Hanshin Earthquake Exhibition Hall.** The delegation visited the Hanshin Earthquake Exhibition Hall that featured selected damaged structures from the 1995 Hanshin-Awaji Earthquake along the Hanshin Expressway's Kobe Route (Route 3) and the Wangan Route (Route 5). This Exhibition Hall was created to educate the public about the reasons for the Hanshin Expressway failures and to illustrate methods used to repair and retrofit the Expressway against future earthquakes. The exhibit hall contains portions of the failed structures and photographs that illustrate how earthquakes occur, their damaging forces, and methods to reduce such damages from future earthquakes.

2. NIED'S SHAKE TABLE

The delegation visited the National Research Institute for Earth Science and Disaster Prevention's (NIED) Three-Dimensional Full-Scale Earthquake Testing Facility (E-Defense) at the Hyogo Earthquake Engineering Research Center in Miki City, Japan. The facility houses the world's largest and most advanced shake table for testing full-scale structures. The shake table has a surface dimension of 15 m X 20 m with 5 actuators each in two orthogonal horizontal directions and 14 actuators in the vertical direction. It has a load capacity of 1,200 ton and maximum acceleration, velocity and displacement of 900 cm/s^2; 200 cm/s; and $\pm$100 cm, respectively in the horizontal direction; and 1500 cm/s^2; 70 cm/s; and $\pm$50 cm, respectively in the vertical direction. A test preparation tower with a 2200 m^2 surface, 29 m clearance height, and two 400 ton cranes are devoted to experimental specimen assembly. The delegation members discussed a recent shake table test of the response of a typical full-size two-story residential building subject to the full-scale 1995 Hyogoken-Nanbu ("Kobe") earthquake excitation (see photo below). The building specimen was displayed inside the test facility. It was observed that although there was noticeable damage to the façade of some interior and exterior walls, we were told the building sustained no significant structural damage. These test results were comforting to the citizens of Japan as most of them live in such buildings.

Photo of two-story typical residential house that was tested on NIED's shake table. Photo taken by S. Yim

3. NIIGATA CHUETSU EARTHQUAKE

The delegation was briefed on the Niigata Chuetsu Earthquake during the Panel's technical meetings and during a mini-symposium hosted by the National Research Institute for Earth Science and Disaster Prevention's (NIED) Nagaoka Institute of Snow and Ice Studies as an introduction to several of the damaged sites. Greater background and specificity on the earthquake and about damage locations the delegation visited are available from four papers published in the Proceedings of the 37th Joint Meeting of the US-Japan Panel on Wind and Seismic Effects 16-18 May 2005 (see below); the last paper is from NIED's mini-symposium:

- NILIM-PWRI Joint Reconnaissance Team on the Damage Caused by the Mid-Niigata Prefecture Earthquake in 2004, *Report on the Damage to Infrastructures by the Mid-Niigata Prefecture Earthquake in 2004*,
- NILIM-BRI Joint Reconnaissance Team of Damage of Buildings, *Outline of Reconnaissance Report of damage of Buildings During the Mid-Niigata Prefecture Earthquake in 2004*,
- Yasuda, N., Kondo, M., Sano, T., Yoshioka, H., Yamaguchi, Y., Sasaki, T., and Tomita, N., *Effects of the Mid-Niigata Prefecture Earthquake in 2004 on Dams,*
- Sato, H., Sekiguchi, T., Kojior, R., Suzuki, Y., Iida, M., and Sugiyama, M., *The Relationship between Landslide Distribution and the Superposition of Geology, Geomorphology, and Hypocenter: The Mid-Niigata Earthquakes in 2004,*
- Koyama, S., Kashima, T., Okawa, I., Iiba, M., and Morita, K., *Characteristics of Earthquake Ground Motion During the Aftershocks of the Mid-Niigata Prefecture Earthquake in 2004.*

The Mid-Niigata Prefecture Earthquake occurred on 23 October 2004 registering $M_{JMA}6.8$ on the Japan Meteorological Agency (JMA) scale. The hypocenter was at a depth of 13 km with peak ground accelerations measuring 1.675 m/s^2 E-W, 1.141 m/s^2 N-S, and 0.869 m/s^2 vertical components. Within 40-minutes after the main shock, three aftershocks occurred with magnitudes from $M_{JMA}6.0$ to $M_{JMA}6.5$. Peak horizontal accelerations of 1.5 g were recorded during the main shock at Ojiya City about 260 kilometers northwest of Tokyo. Forty persons were killed and more than 4,000 persons injured. Nearly 4 thousand landslides and slope failures occurred in the area. Many infrastructures sustained damage including sewer lifelines, river dykes, six irrigation and hydroelectric dams, roads and tunnels, and 16 bridges. In addition, several local hospitals sustained damage. This earthquake derailed a Shinkansen train linking Niigata with Tokyo near Ojiya City, the first since service started 40-years ago. Evidence of liquefaction was found at many sites. Serious damages included partial and total collapses of embankments that are constructed on steep mountain slopes producing a flow-like movement of debris. The greatest infrastructure damages occurred near Ojiya City. More than 2,700 houses were destroyed, about 10,000 were partly destroyed, and about 100,000 were damaged, the majority of these buildings was old and weakened wooden houses located in the area of Ojiya City. Newer wooden structures were reported to have performed much better. Newer dwellings are constructed on first-floor reinforced concrete walls designed for huge snow loads; they provided lateral load resistance. The delegation visited several damage sites in the vicinity of Ojiya City, the region which suffered the greatest amount of damage from the earthquake. Some sites included:

<u>JR 3rd Daisan Wanatsu Viaduct</u>. A number of pier walls sustained shear-induced damage from lack of confining reinforcement. These damages are similar to damaged pier walls from the Hyogo-ken Nanbu (Kobe) Earthquake. Damaged portions of the pier were removed after shoring the beam spans, new longitudinal and hoop reinforcements were added and concrete was applied. A series of JR patented lateral confining reinforcement were applied externally to improve the shear capacity of the pier.

<u>JR Uonogawa Bridge</u>. The Uonogawa Bridge is comprised of 3-span concrete box girders supported on two-6.5 m diameter concrete piers. During the Mid-Niigata Earthquake the longitudinal reinforcement buckled at the mid-level of the piers. The reinforced concrete and steel jackets (below the water level only) were applied to strengthen the piers.

<u>JHPC Imonogawa Bridge</u>. The bridge was constructed during the late 1970s before Japan's introduction in 1980 or more stringent seismic design criteria. The bridge experienced some pier damage. The bearing was replaced with a rubber bearing during retrofit and piers will be reinforced in 25 cm thick concrete jacket. The delegation visited Pier 4 that lost a bearing during the earthquake. Its expansion joint separated by about 20 cm. The bridge is 271 m long precast 3-span continuous concrete girder bridge that is 15 m over the Imo River.

JR Shin Yamamoto Regulating Reservoir. The embankment dam reservoir has an impervious core with granular fill shells is used for generating hydroelectric power for the East Japan Railway Company during peak operating hours. Water is diverted approximately 27 km from the Shinano River through diversion tunnels and stored in the reservoir. Releases are made through an outlet tunnel to hydro power facility where electricity is generated for use as far away as Tokyo. Discharges from the hydro power facility are returned to the Shinano River. The damage to the embankment sections consisted of longitudinal cracks and vertical offsets (one meter) in the shell near the top of the dam and caused settlement near the shoulder of the reservoir side slope. The reservoir was 60 percent full at the time of the earthquake. The dam was instrumented with sensors to monitor behavior changes. The reservoir was emptied for inspection and repairs. The repairs consisted of removing the shell and replacing and recompacting the shell with a combination of existing and imported material. The dam sustained damage but did not fail. The impervious core was determined to be undamaged allowing the dam to be repaired and returned to service. During this renovation period the JR is purchasing power from neighboring plants at a cost of about $20,000 per day.

4. SAGURIGAWA DAM

The Sagurigawa Dam is a 120 m high rockfill dam with crest length of 420 m constructed during the 1980s and completed in the early 1990s to provide flood control on the Shinano River, maintain a river environment for the public's recreation, make available a source of drinking water, and supply hydroelectric power as a self sustaining measure and for sale as a profit making venture. The Ministry of Infrastructure Land and Transport (formerly the Ministry of Construction) is the owner and responsible for the dam design. Taisei, Tobishima, and Konoike Corporations were responsible for the dam construction. This structure is one of the steepest rockfill dams in Japan. Its construction was completed ahead of schedule even though dam construction was limited to six-months of the year due to the mountainous terrain that experiences very heavy annual snow falls. The specific weight of the stone used – granite- is greater than normal rocks. The dam's volume is 7 million m^3 with a reservoir storage capacity of 30 million m^3. The dam did not experience structural damage from the Niigata Earthquake. The dam management is provided by the Hokuriku Regional Construction Bureau.