UJNR Panel on Wind and Seismic Effects

Panel Update

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HIGHLIGHTS OF THE 35th JOINT MEETING OF THE PANEL ON WIND AND SEISMIC EFFECTS 12-17 MAY 2003

The 35th Joint Meeting of the Panel on Wind and Seismic Effects was conducted during 12-17 May 2003, Japan. The Panel's technical meetings were held during 12-14 May at the National Institute for Land and Infrastructure Management, Tsukuba, Japan followed by technical site visits during 15-17 May 2003 in Tokyo and Hokkaido, Japan.

Technical Meetings, 12-14 May

- 30 technical presentations (15 paper per side)
- Seven themes
  - Geotechnical Engineering and Ground Motion
  - Next-generation Building and Infrastructure Systems
  - Dams
  - Wind Engineering
  - Transportation Systems
  - Advanced Information and Communication Technology for Disaster Prevention and Public Health Evaluation
  - Progressive Collapse
- Technical presentations highlighted important work by the US and Japan Panel organizations:
  - Useful information gained about Japan's public works projects and civil engineering research and their applications of research into practice,
  - much work in strong motion monitoring in Japan and US,
  - damage detection procedure based on seismic time histories to assess building structural characteristics,
  - opportunities for systematic modeling of earthquake response of dams and stability evaluation of dams,
  - framework for real-time global natural hazards simulations and data exchanges leading to partnerships between NSF's NEES and NIED's E-Defense (Earthquake Defense) 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: excellent opportunities for partnering with Panel's Task Committees and other UJNR Panels,
  - methods to evaluate physical and mental health of disaster survivors and disaster responders,
  - construction of Japan's 15 m x 20 m, 1 200 ton 3-D shake table test facility by 2004,
  - build on US-Japan cooperative smart structural systems testing program,
  - research demonstrates basis for major revisions of highway bridge design criteria,
  - analytical and experimental research results on wind engineering,

- practical, rational techniques for extreme wind loss prediction of residences,
- systematic use of Fred Hartman bridge to develop and improve models for wind response and vibration mitigation of stay-cable bridges,
- technologies presented to significantly reduce progressive collapse,
- findings influence US and Japan structural engineering research and contribute to revisions and creation of both country's codes and standards.

- Panel Task Committees (T/C) activities grow in strength and are working well under current structure. They are an effective vehicle to exchange in-depth advanced seismic and wind technologies being used by both countries. They increasingly seek partnering activities with other Panel T/Cs and other UJNR Panels. A new T/C was created on Advanced Information for Disaster Prevention and Public Health Evaluation. Four T/C workshops are planned for the coming year.
- The Panel's web site will be expanded with Panel and T/C achievements through regular focused broadcast of its contributions targeted to its member organizations and other customers on its activities and results.

Technical Site Visits, 15-17 May 2003

During the 35th Joint Panel Meeting the delegation visited seven sites:

1. Tsukuba Express Train Construction Project.
A new express railway is being constructed from Tokyo (Akihabara) to Tsukuba by the Japan Railway Construction (Public) Corporation (JRCC) called the Tsukuba Express Joban Shin-sen Line. The 58.3 km line has 20 stations, and will allow 6-car trains to traverse the line at speeds of up to 130 km/hr in 45 minutes. The route was designed to provide a significant number of connections with the Japan Rail (JR) and other train and subway lines. The new line is expected to go into service in Fall, 2005, with an anticipated usage of 280 000 passengers per day (22 000 passing through the Tsukuba Station, the northeastern terminus station). The system is designed for future expansion to eight-car trains, and to operate at higher speeds.

The purpose of constructing this express line is to: enhance the transportation system between Tokyo and Tsukuba (Japan's Science City) and this region in Tokyo's northeastern metropolitan area; reduce the congestion of other rail lines; and encourage construction of industrial and residential infrastructure within this metropolitan/rural area.

The total project cost is expected to be 940 B yen ($8 B). Financing was provided through a combination of public (local, regional, and national governments) and private sources to the JRCC. When operational, the line will repay the investors over a (planned) 40-year period. Major construction is almost complete over most sections of the line, and test trains are running over a portion of track near the main vehicle depot.

The line consists of elevated and underground portions for much of its length. Elevated sections are generally 4-unit precast girders, or arch-slab concrete structures. Tunneling in the Tsukuba area featured the use of "super adjacent" parallel shield tunnels. These tunnels are at some locations separated by only 300 mm at mid-height.

Eight of the stations are underground, including the Tsukuba Station. This station, along with others on the line, exhibits state-of-the-art features including better accessibility for persons with disability, and 1.3 m high walls that separate the riders from the arriving trains. The station has a maximum depth of 20 m below the surface (at Akihabara the depth is 40 m) and features for aesthetic purposes an open plaza area of dimension 19 m x 50 m at one end. Underground tunnels were formed with 7.3 m diameter shield tunnel boring machines and at the Tsukuba Station they cut at the rate of 3 cm/min.

Figure 1. Delegation at the Tsukuba Underground Station.

2. Seismic Isolated Building, Kawasaki City.

Taisei Corporation, Japan designed and constructed this high-rise residential building. The material used was high-strength concrete with strength of 100 N/mm^2. The building, features a 41-story 135 m tall reinforced concrete tower with plan dimensions of approximately 40 m x 33 m, is supported by a combination of rubber and sliding bearings. This currently represents the tallest base isolated building in the world. The combined use of both rubber and sliding seismic isolation devices also represents a unique feature.

The isolators are placed between an underground parking garage and the 41-story superstructure. A total of 10-1.35 m diameter flat sliding isolators are used beneath the central columns, while 26-1.5 m diameter rubber isolators are positioned under the peripheral columns (see fig. 2). Each isolator carries about 2 300 tons of weight. The flat sliding bearings are designed for 50 cm displacement; expect only 36 cm displacement during a major earthquake. The superstructure consists of precast beams and columns, with the beam-column connections completed on-site.

Based upon analysis performed by Taisei Corporation, the fundamental natural period of the structure is 3.5 s. The period elongates to approximately 6.5 s for the post-sliding condition. As a result, the relative displacement response of the superstructure is reduced by approximately 30 % to 40 % with the addition of the seismic isolators under design level earthquake ground motions. The corresponding maximum displacement at the isolators is approximately 35 cm. However, the devices are designed for translations of 50 cm with a design life of 100 years. Unfortunately, there is reportedly no instrumentation to record the actual response of the structure.

Figure 2. Rubber Isolator.

3. Muroran Institute of Technology (MIT), Hokkaido.

Muroran Institute of Technology (MIT), Muroran is in the southwestern part of Japan's northern most island of Hokkaido. MIT was founded in 1949 (by consolidating two schools founded in 1887 and 1939) and is one of five National Institutes of Technology in Japan. There are approximately 3 400 students including 550 graduate students at the Institute within six departments:

- Civil Engineering and Architecture,
- Mechanical Systems Engineering,
- Computer Science and Systems Engineering,
- Electrical and Electronic Engineering,
- Materials Science and Engineering, and
- Applied Chemistry.

The delegation was hosted by Professor Norimitsu Kishi, Head of the Department of Civil Engineering and Architecture (see fig. 3). Professor Kishi's research includes: the development of impact resistant reinforced concrete members, seismic retrofitting and upgrading of steel and reinforced concrete members using FRP sheets and development of the limit state design method for frames. Facilities in the Department's Structural Division include hydraulic and screw jacks with capacities of 500 kN and 300 kN respectively and specimen capacity of 2.5 m x 1 m x 7 m in length. In addition to posters highlighting the Department's research, Professor Kishi conducted a test on a steel pipe column that was wrapped with an aramid fiber reinforced plastic sheet (see Fig. 4). A constant axial load was applied followed by a cyclic lateral load. The purpose of the test was to determine if the aramid fiber sheets are effective in increasing the strength and ductility of the steel pipe columns. Depending upon the number of sheets applied, the strength can be increased by 30 % and the displacement ductility level from 3.9 to 5.9.

Figure 3. Professor Kishi Describing Laboratory and Tests to the Panel Delegation.

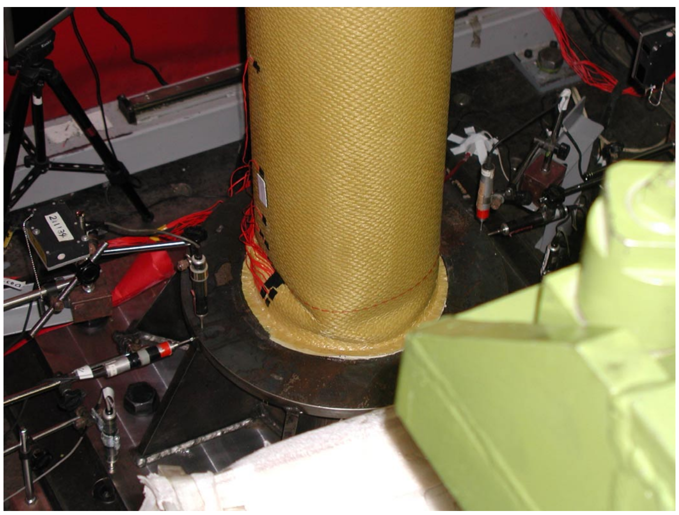

Figure 4. Failure of Steel Pipe Column Wrapped with an Aramid Fiber Reinforced Plastic Sheet.

4. New Muroran Highway, Muroran, Hokkaido – Weather Resistant Steel.

The delegation visited the New Muroran Highway, Muroran, Hokkaido, Japan then inspected the weather resistant steel used in the superstructure in parts of the elevated highway section. The highway was constructed in 1975. This 27-year old urban four lane divided highway is 8.23 km with a 600 m tunnel section and 4.18 km of elevated sections restricted to vehicular traffic. The highway design speed is 60 km/hr.

The environmental conditions in this marine coastal city of high humidity and salts provide a challenging environment for maintaining exposed corrosive steel members. Also, considering this region's significant winters, maintaining an ice-free driving surface on elevated sections cause addition corrosive conditions, especially, when road salt is used. The designers of this highway decided to use steel beams in selected sections with a new surface treatment developed in Japan between eight of the pier sections. A total of 7 800 tons of this surface treated weather resistant steel was used.

The section visited was selected because it was the poorest performing section yet it was remarkably free of corrosion damage especially considering the extremely corrosive environment and the length of exposure of 27-years. Areas that were moderately corroded were where there was concentrated water leakage from the highway (see fig. 5).

The highway department is considering remediation of the corroded areas. However, they have not decided how they will accomplish this maintenance. This is surface treated steel and once the protection is breached a different surface treatment is necessary, as the original treatment cannot be replicated.

The highway department is satisfied with the performance of this weather resistant steel. Although this is a weather resistant steel there may be some issues to address in treating corroded areas. Another issue that may exist is any environmentally detrimental releases from this surface treatment or its interaction with adjoining materials. Staining of the concrete piers was not noticed. The steel's color is a dark brown similar to weathered steel. This may be an esthetic limitation in its use. It is interesting to note that none of this type steel was used in the new Hakucho suspension bridge constructed nearby (see highlight 6 below).

This may be a good case history and should be considered for presentation in the next UNJR Bridge Workshop.

Figure 5. Viaduct Using Weather Resistant Steel.

5. Japan Steel Works Ltd., Muroran Plant.
The Japan Steel Works (JSW) first steel mill, the Muroran Plant, was completed in 1907 on reclaimed land facing the Muroran Harbor and the Hakucho Suspension Bridge. JSW was founded as a joint venture by three companies: Hokkaido Colliery Steamship Company of Japan; Armstrong Whitworth Co., Ltd., UK; and Vickers Sons and Maxim, Ltd, UK. In 1919 it merged with Hokkaido Steel and Iron Company and started the business of mining and iron-making. In 1947 it was privatized and became incorporated in 1950. The Company produces materials and components and supplies large forged and cast steel products, steel plates, pressure vessels for the chemical and petrochemical industries, and a wide range of industrial machinery. Nine hundred persons are employed at the Muroran Plant.

A video presentation showed a profile of JSW's current work focusing on research into new materials including supper-alloys and powder metallurgy. The main products are steel castings and forgings (up to 600 tons), steel plates, welding assembly, environment and plant engineering, industrial machinery, hydrogen absorbing alloys, medical care and welfare as well as maintenance and inspection services, including a variety of NDT technologies. Other products include rolling mill component, large castings and forging for bridge applications, and powder metallurgy applications. JSW has a long history of providing steel forgings for hydroelectric and nuclear power plants. Their visitor room displays some JSW research activities. Included were posters illustrating development of:

- manufacturing process for an ultra large ingot weighing more than 600 tons,
- magnesium alloy injection molding machine as a more durable substitute for plastics for automobile components, personal computers, mobile phones, etc.,
- high corrosion resistance alloy clad steel plate for environmental protection equipment,
- manufacturing techniques for Ni-base super alloy for large gas turbine forgings,
- hydrogen absorbing alloy and its applications,
- methane fermentation technology,
- clad (stainless + carbon) steel plates for reactor vessels and boilers,
- Stainless steel plates for reactor vessels and boilers.

Recent activity has included a focus on environmental technologies including composting, methane fermentation, wind power, recycling of used tires and gasification methods.

Present and Future areas of interest for JSW

A review was provided on JSW's research on metal hydrides as a substitute for fossil fuels through development of various metal hydride alloys. Hydrogen absorbing alloys have the promise to hold up to 1000 times its weight for use as fuel cells. Metal hydride storage systems have applications for use as heat pumps, refrigeration systems, hydrogen purifiers, actuators and static compressors, magnesium alloy injection molding machines. JSW is seeking an entrée into the green environmental by building on a hydrogen society. See http://www.jsw.co.jp/msb_f/msb_index_e.htm for more information.

The delegation visited JSW's museum, a 1911 building that served as accommodations for the Crown Prince who later became Emperor Taisho, and was father of Emperor Hirohito, when he visited JSW. Today the building is a guesthouse for members of the Imperial family and high level dignitaries. Also, the delegation visited JSW's Japanese Sword Smith Shop, founded 1918, where the traditional and cultural heritage of making Japanese swords continues. These traditional Japanese swords require 12 months to become born and cost about $9 000.

6. Muroran-Highway Traffic Control System and the Hakucho Suspension Bridge.
The Hakucho Ohashi Bridge (Swan Bridge) is a 3 span 1 380 m continuous steel box girder suspension bridge spanning the Muroran Port in Japan's northern prefecture, Hokkaido. Muroran is a major commercial port. The city's commerce is known for its iron and steel industry and its protected deep draft harbor. The bridge was proposed in 1955 by the Muroran Development & Construction Bureau, Hokkaido Development Bureau to provide a ring road around the city of Muroran. To accommodate the growth of Muroran's economy, along with concerted efforts by the municipal government and businesses, and to facilitate urban access officially led to the approval

of its construction in 1981. Ground was broken in 1985. Construction commenced in 1985, was completed in 1997, and the bridge opened on 13 June 1998. The Hakucho Bridge's total length is 1 380 m; its end spans are 330 m and a center span measures 720 m. The towers are 140 m high. This is the longest suspension bridge in eastern Japan.

The bridge owner is the Hokkaido Development Bureau. It was constructed by Kawasaki Heavy Industries. Matsuo Bridge Co. Ltd. provided 13 500 tons of steel. This is the first Japanese suspension bridge constructed in a heavy snowy cold area; it required new design technology to handle elimination of snow accumulation on the bridge and control vibration.


Figure 6. Hakucho Suspension Bridge.

The foundation is 73 m below sea level. They are constructed within a cast in place 34 m diameter 50 000 tons of concrete artificial islands. The 140 m towers consist of 15 segment units. Tuned mass dampers were installed at the top of each pylon to dampen sway from high winds. During its erection, the bridge towers employed active control to dampen wind induced vibrations but are limited to a small amplitude range. Such systems don't generally increase seismic safety during severe ground motion. Wind tunnel tests were performed by the Public Works Research Institute under the leadership of Dr. Hiroshi Sato who also is a member of the Japan-side Panel on Wind and Seismic Effects.

The 0.5 m thick cables are comprised of 52 strands of 127 lines of 5.2 mm piano wires. An innovative S-shaped cable wrapping method ties the cables together. That process was followed by a coating of fluoresin to protect the steel wires from moisture penetrating the cable and cable corrosion. Testing was performed on ½ scale models. Because of the special shape, this type of wrapping minimizes potential exposure due to thermal expansion-contraction cycles. An aeration system also was provided for the main cable, with several dehumidifiers and corresponding inlets and outlet points with the objective of maintaining internal relative humidity levels below 40 percent. Bridge instrumentation includes several anemometers.

The bridge deck is on a stiffening girder – streamlined flat box girder 18 m wide and 2.5 m high – that was selected to better resist winds. The girder has an airfoil-shaped fairing on both sides for aerolastic stability. Ultrasonic testing was performed to assess the welds.

The anchorage consists of 40 000 m^3 of cement. Since the 11 September 2001 World Trade Center/Pentagon Building terrorist attacks, Japan bridge security has been increased. Fences were installed around critical bridge entry locations and motion sensitive cameras were installed at each anchorage.

Many measures were taken to provide for the extreme cold and heavy snows that effect Hokkaido every year. Special procedures were used during the welding processes to account for the brittle nature of steel in cold temperatures. Additions also were made to the steel deck to protect the expansion joints from damage during snow plowing. Because of the demanding requirements to remove snow from the large accumulations, a special snow-removal vehicle was developed for this bridge. Standard snow-removal devices could be operated along the bridge lanes, but removal of significant snow accumulations on the fairings beyond the railing posed significant challenges. The special vehicle operates as a blower, with air speeds up to 150 m/sec with airflow of 500 m^3/min from two nozzles on the left side. A telescopic brush device facilitates snow-removal from the pylons and main cables. The cost of the vehicle was $1 M.

The traffic control office operates an information monitoring system staffed by personnel working in four six-hour shifts. This real time system is employed for the 83-km highway ring-road system using 23 cameras. Seven cameras are at the Hakucho Bridge. Earthquake and wind sensors are installed in the bridge. The bridge is put on alert status when winds exceed 15 m/sec and traffic is halted when wind speeds exceed 25 m/sec. Highest wind speed recorded to date was 30 m/sec resulting in no bridge damage. The design wind speed is 40 m/sec.

7. Mt. Usu, Overview of the Volcanic Effects, Disaster Countermeasures, and Recovery.

Mount Usu volcano is located in south eastern Hokkaido on the southern rim of Lake Toya. Usu is a 737 m stratovolcano located about 68 km southeast of Sapporo City. Five small communities totaling approximately 55,000 people live in the vicinity of the volcano. On Friday 31 March 2000, Usu erupted for the first time in 22 years, forcing the evacuation of 16 000 residents by helicopter, truck, and boat. Historical eruptions have been recorded, eleven times with a mean recurrence of 25-years: 1611, 1626, 1638, 1663, 1769, 1822, 1853, 1910, 1943-1945, 1977-1978, and 2000.

The region was shaken by thousands of tremors before the eruption. The field research group of Hokkaido University and Geological Survey of Hokkaido found small fractures in the northern part of the Usu Volcano. Although no lava flowed from the mountain, rocks and ash fell after the eruption. Ash was spewed 3 200 m and coated surrounding towns. No deaths or injuries were reported because the residents followed the recommendations of the Japan Meteorological Agency and the Mayor of the closest community to Usu to evacuate their houses and businesses. The Government invoked the Disaster Relief Law for the neighboring towns at 29 March requesting residents to evacuate immediately. The local headquarters for disaster prevention acted quickly using their video conferencing system to monitor the conditions of affected areas promptly and provide instructions for evacuation and later for rebuilding. A continual degassing continues at various points throughout the area. Although no known health effects have been reported for this eruption, an investigation of the long term human health effects of gases and ash may be in order.

Crustal movements created gaps and mudflow triggered by rainfall and melting snow caused much damage to the infrastructure and to the adjacent National Highway 230. The 2000 eruption mudflow destroyed much of the neighboring infrastructure and covered much of the developed area. A 650 ton bridge on National Highway 230 was washed 120 m away from its site (see fig. 7). A public bath, apartment, and other structures were destroyed. This area will be created into a future museum to educate visitors about the dangers of such eruptions and stress preventative measures.

Following the 1978 eruption, mud flow walls were constructed in several areas of this site to serve as water courses based on data suggesting the most highly probable areas for future mud flows. These flow channels limited the damage from the 2000 eruption. However, the national highway was destroyed in the 2000 event. In anticipation of future eruptions a tunnel is under construction through the raised ground from crustal movement of the 2000 volcano eruption that will serve as a protected area and an evacuation locations during future eruptions.

The actions performed just prior to and immediately after the volcanic eruption of Mount Usu showcases three key disaster reduction practices:

- An in-place early warning system that monitored the increase in earthquake tremors allowed for timely warnings of the communities residing close to the volcano,
- Effective coordination between the national government, the local authorities, and the private sector allowed for efficient information flow and smooth logistical evacuation procedures,
- A pilot project instigated by the Asian Disaster Reduction Center and the National Space Development Agency of Japan allowed for the live observation of the disaster, as it was unfolding, by satellite.

Figure 7. Bridge Washed Away by Mudflow.

8. Hokkaido Dams.

During the site visits in Hokkaido the delegation was briefed on six dams in the Hokkaido Prefecture. The Hokkaido government manages 20 dams. Detailed information about Japan's large dams, over 50 m high, is available in the publication, *Current Activities On Dams in Japan - 2003*, Japan Commission on Large Dams, Tokyo http://www.jcold.or.jp and email secretariat@jcold.or.jp. The dams highlighted during this briefing included:

- Kanayama Hollow Gravity Dam, constructed from 1961 to 1967 for flood control, potable water, hydroelectric power is 57.3 m high, 288.5 m long, and a volume of 220 x 10^3 m^3.
- Sasanagare Reinforced Concrete Buttress Dam, constructed during 1920 to 1923 for water supply is 25.3 m high, 199.4 m long, and a volume of 36.4 x 10^3 m^3 was reinforced in 1943 and 1968.

- Taisetsu Rock-filled Dam, constructed during 1968 to 1975 as a multi-purpose dam for flood control, electric power, and potable water is 86.5 m high, 440 m long, and a volume of 3,740 x 10^3 m^3.
- Jozankei Concrete Gravity Dam, constructed during 1978 to 1989 as a flood control, hydroelectric power, and water supply is 117.5 m high, 410 m long, and a volume of 1,185 x 10^3 m^3.
- Pirika Concrete Gravity and Rock-fill Dam, constructed during 1978 to 1991 and later widened to accommodate a fish ladder is 40 m high, 1,480 m long, and a volume of 360 x 10^3 m^3.
- Hoheikyo Concrete Arch Dam, constructed from 1967-1972 for flood control, hydroelectric power, irrigation, and potable water is 102.5 m high, 305 m long, and a volume of 285 x 10^3 m^3.

DR. WATABE PASSED AWAY

Dr. Makoto Watabe, an Associate Member of the Japan-side Panel, passed away on 12 June 2003, at the age of 69. His exemplary work has contributed enormously to the Panel on Wind and Seismic Effects, UJNR.

DR. WRIGHT ELECTED TO NATIONAL ACADEMY OF ENGINEERING

Dr. Richard N. Wright III, Director (retired), Building and Fire Research Laboratory, National Institute for Standards and Technology, and former Chair, U.S.-side Panel was elected as a Member of the National Academy of Engineering on 14 February 2003 for "Sustained leadership in building research, for the development of standards, and for representing the U.S. building industry and research community worldwide."