UJNR Panel on Wind and Seismic Effects

Panel Update

Volume 1, Number 5, February 2004

US-Japan Cooperative Structural Testing Research Program on Smart Structural Systems

The Building Research Institute and the National Institute for Land and Infrastructure Management, Japan and the U.S. National Science Foundation, in 1998 initiated a five-year research and development project (1998-2003), "Smart Materials and Structural Systems". This joint research is conducted under the auspices of the U.S-Japan Panel on Wind and Seismic Effects of the U.S.-Japan Natural Resources (UJNR) Program. Smart Structural Systems are systems that can automatically adjust their structural characteristics, in response to the change in external disturbance and environments, toward structural safety and serviceability as well as the elongation of structural service life. The joint research and development effort addressed the development and evaluation of: 1) performance evaluation methods of smart structure systems, 2) health monitoring system, and 3) structural elements using smart materials. Findings from this five-year R&D project included: 1) rocking structural system that has auto-adaptive features (figure 1), 2) health monitoring system for an existing building and 3) semi-active isolation systems using magnetorheological (MR) damper (figure 2). In the last year of the project three Technology Utilizing Guidelines were published 1) *Performance Evaluation Guideline of Smart Structural Systems*, 2) *Technology Utilizing Guideline of Health Monitoring Systems*, and 3) *Technology Utilizing Guideline on Effectors*. These guidelines are written in Japanese (figure 3). An English language abstract is underdevelopment and will be available at the BRI website (http://www.kenken.go.jp/english/contents/topics/structual/intelligence/main.htm).

The National Science Foundation has been actively funding research projects in smart systems, structural health monitoring, and sensors.

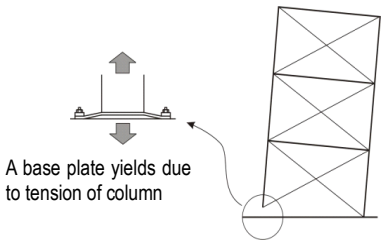

Figure 1: Rocking structural system

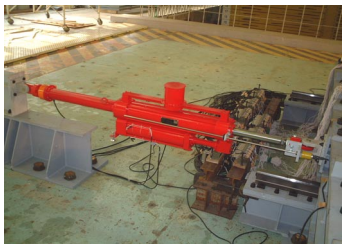

Figure 2: Magnetorheological damper

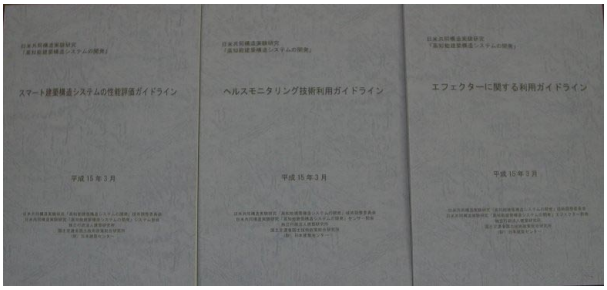

Figure 3: Cover page of guidelines (in Japanese)

There are close collaborations between the US and Japanese colleagues in the area of smart structures. This partnership has been extremely productive and resulted in important advances for both countries. One example is in the area of MR damper technology and deployment. A project led by Prof. B.F. Spencer of the University of Illinois at Urbana-Champaign *"Smart Damping Strategies for Seismic Protection of Urban Structures," CMS-9900234,* under the auspices of the US-Japan Urban Earthquake Disaster Mitigation Research Initiative, has focused on the development of MR fluid dampers for protection of civil engineering structures. This project has led to the commercial availability of large-scale MR dampers for civil engineering applications (e.g., the Lord Corporation in the USA and Sanwa-Tekki Corporation in Japan), and the world's first full-scale implementations of these smart dampers in civil engineering structures. The first full-scale implementation of MR dampers was seen in the Nihon-Kagaku-Miraikan Building, an exhibition hall in the Tokyo Bay area designed by the Nikken Sekkei Corporation for futuristic science and technology. Two 30-ton, MR Fluid dampers built by the Sanwa Tekki Corporation using Lord MR fluid are installed between the 3rd and 5th floors (see Fig. 4 below). In China, the first full-scale smart damping control of cable stays will be implemented on the Dongting Lake Bridge, located in Yueyang City, Hunan Province, China (see Fig. 5 below). This project

constitutes the world's first full-scale implementation of smart damping strategies for mitigation of stay-cable vibration on long-span bridges, and the world's first full-scale implementation of magnetorheological dampers for bridge structures. In 2004 the second building application was completed in Japan in the form of a "smart" base-isolated structure (see Fig. 6). The US-Japan collaboration was essential in facilitating these projects and notable achievements.

The benefits of the research activities in Japan stress system applications and proof-of-concept demonstrations; in the U.S. the focus is on enabling concepts and fundamental aspects of the technological elements. Additional information on the joint research is available at:

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Figure 4a. Nihon-Kagaku-Miraikan Building in Tokyo

Figure 5a. Dongting Lake Bridge in Yueyang City, Hunan Province, China

Figure 5b. MR dampers on stays

Figure 6a. Base-isolated structure in Japan

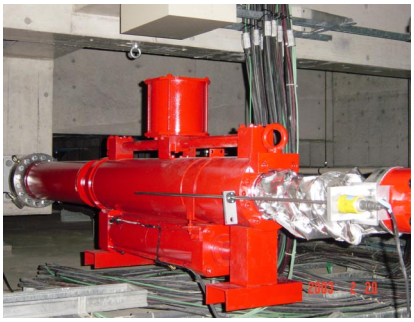

Figure 6b. MR damper