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

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US-JAPAN COOPERATIVE RESEARCH ON TORNADO-INDUCED LOADS OF LOW-RISE BUILDINGS

Based on US-Japan collaborations in the Panel's Task Committee D on Wind Engineering, the Building Research Institute (BRI) and the National Institute for Land and Infrastructure Management (NILIM), Japan and Iowa State University (ISU), U.S. initiated cooperative research on tornado-induced loads of low-rise buildings. Dr. Hitomitsu Kikitsu (NILIM) spent a year at ISU as a visiting scholar until September 2008, conducted joint experiments with Professor Partha P. Sarkar (ISU) to investigate the parameters influencing tornado-induced structural damage to buildings using the ISU tornado simulator (see fig. 1).

Tornadoes produce rotating winds with updraft and downdraft and radial flows that intensify significantly near the ground. In most commonly occurring tornadoes that are EF-2 or of less intensity on the newly implemented Enhanced Fujita Scale (EF), winds could reach 60 m/s (or 135 mph) near the ground. As a result of passage of a tornado directly over a building, transient loads are produced that peaks when the center of the tornado is within one core radius, where maximum tangential wind speed occurs, from the center of the building. These types of wind load effects are considered to generate devastating structural damage to low-rise buildings.

The main objectives of this collaborative research was to study the role of internal pressure in producing the resultant wind loads in a tornado-like vortex as a function of porosity and dominant opening in a building envelope (see fig. 2) and to find the strike probabilities of wind-borne debris that could create these dominant openings as a function of their relative location to the building (see fig. 3 and fig. 4). It is known that the internal pressure inside a building is a function of air leakages through the building envelope and any dominant opening that could be triggered by a puncture in this envelope by wind-borne debris.

The experimental results obtained in this collaborative study will be presented at the 41st meeting of the US-Japan Panel on Wind and Seismic effects that will be held at NILIM, Tsukuba during 18-20 May 2009. This work will improve the predictions of tornado wind loads on low-rise buildings and contribute to a probability-based design framework.

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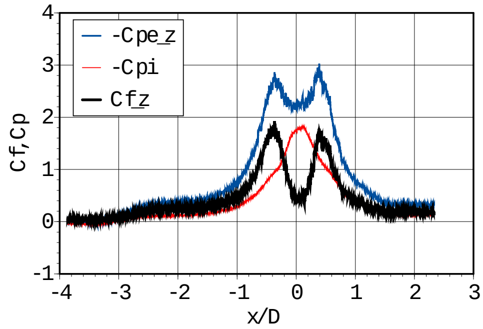
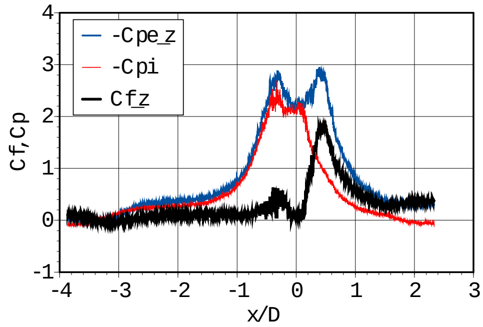
Figure 1. ISU Tornado Simulator



(*a*) only leakage on walls



(*b*) leakage plus dominant opening on windward wall

Figure 2. Wind Force Coefficients on the Roof

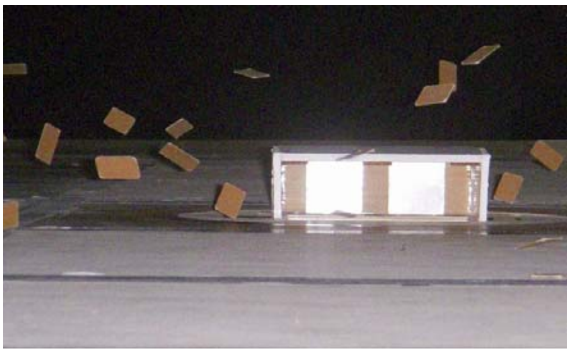


Figure 3. Debris Models Flying around Building Model

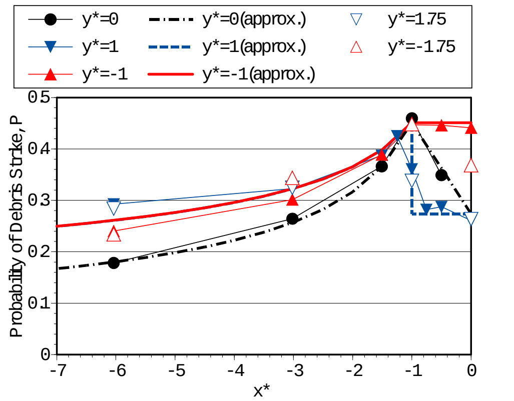


Figure 4. Location of Potential Wind-Borne Debris *vs.* Probability of Debris Strike

SHAKE TABLE TESTING OF BRIDGE RC COLUMNS UNDER COMBINED ACTIONS AT UNIVERSITY OF NEVADA RENO, USA

In order to address the complex behavior of bridge members under combined loadings and its impact on system response, a comprehensive project sponsored by the National Science Foundation was established in 2006. This project includes researchers of six U.S. institutions that are working to develop a fundamental knowledge of the impact of combined actions on column performance and their implications on bridge response through analytical and experimental research.

The work at University of Nevada, Reno (UNR) focuses on the development of refined analysis and experimental studies on the impact of different levels of biaxial bending, torsion, and axial load on circular and non-circular sections (double interlocking spirals). For that, eight scaled columns will be test on the bidirectional shake table facility at UNR. As part of the project, a unique inertial loading system was developed to test on shake table single cantilever-type columns under biaxial ground motions. The system is composed by a 3D four columns frame and a platform that sets on ball bearings located at the top of the columns. The platform is connected to the RCC specimen through links which transfer shear and torsion but not axial load (fig. 1a). Additional mass is set on the platform to simulate the weight of a portion of the bridge and this can be distributed in an asymmetric configuration to induce torsion in the system. Two examples are shown in Figure 2.

The axial load is applied directly to the specimen through a center hole ram equipped with a servo-valve (fig. 1b). The ram is connected to the specimen throughout an unbonded prestressed bar placed in an ungrouted conduit at the middle of the column and anchored at the footing. Since the designed system does not induce secondary moments (PD-effects) in the specimen and the unbonded prestressed bar inside the column would generate restoring lateral forces, additional dynamic actuators will be located at the top of the specimen to induce the equivalent force to have PD effects and to compensate the restoring force throughout hybrid simulation (fig. 1b).

The seismic performance of the specimens will be assessed in terms of strength, deformation, energy dissipation and failure mode. These results will be used to validate analytical tools, developing new inelastic models for RC columns under combined loadings and to propose new design methodologies. This work is sponsored through NEESR grant SG-0530737 by the NSF (National Foundation Science) a member of NEHRP (National Earthquake Hazards Reduction Program).

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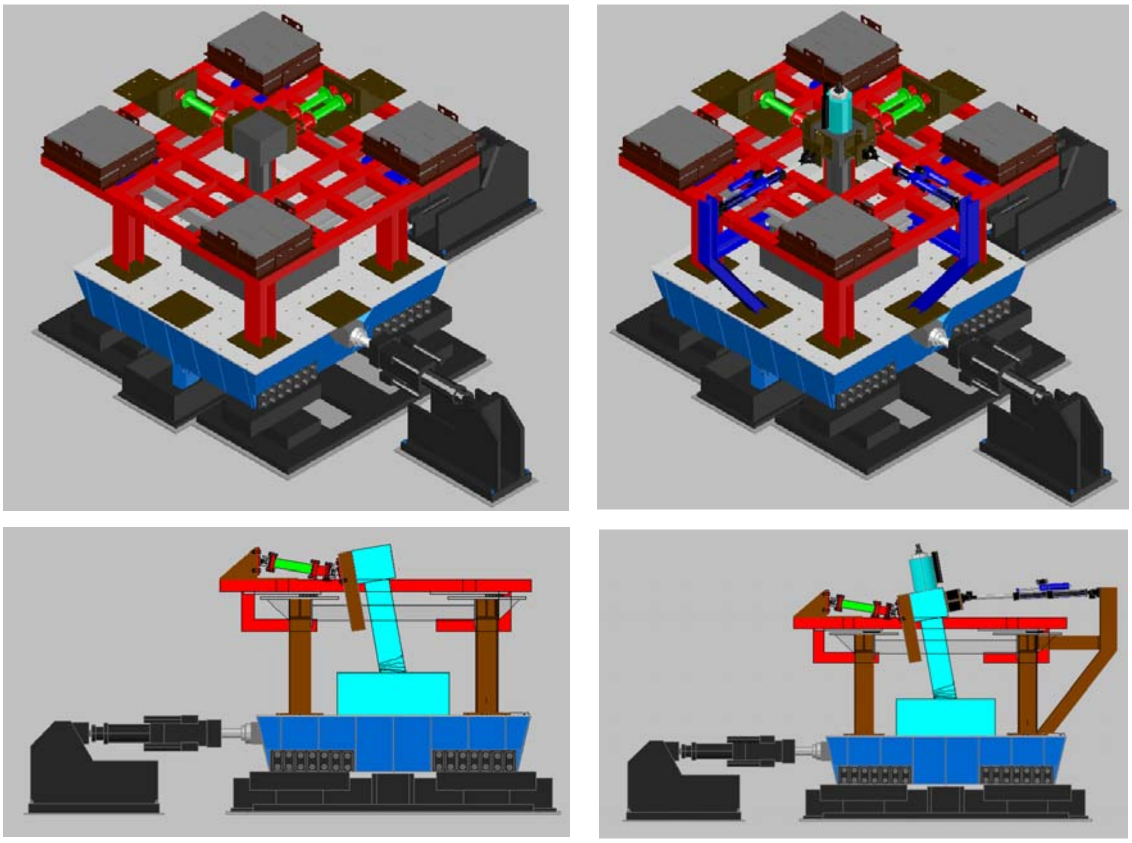

a: Without axial load.   b: With axial load (prestressed bar + actuators)

Figure 1. Inertial loading system at UNR.

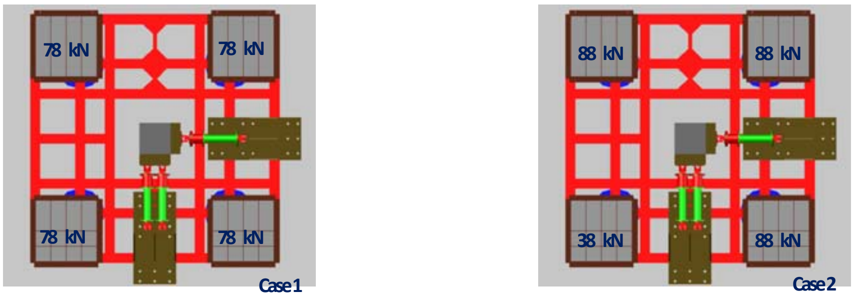

Figure 2. Mass distribution cases studied.