TECHNIQUES by Vincent P. Wnuk

MONITORING SYSTEM PROVES ROOFTOP SAFE AFTER SEATTLE EARTHQUAKE

Safeco Field is home to the Seattle Mariners. It has seating for approximately 47,000 spectators as well as containing a stadium club, restaurant and state of the art clubhouses.

A unique design feature of Safeco Field is its nearly 11-acre retractable roof. The roof is designed to expose as many fans as possible to the outdoors and be retracted to cover the field in 10 minutes time in inclement weather. The roof is comprised of three self-supporting sections weighing 11,000 tons and contains enough steel to build a 55-story skyscraper. Integrated into the roof are a total of eight 800,000 kip viscous dampers mounted between the horizontal trusses and the down-turned north legs. These dampers act as large shock absorbers to dampen lateral loads on the roof structure during wind and seismic events like those that occurred during the February 28, 2001 earthquake.

A state of the art autonomous monitoring system was designed and built, which can continuously monitor the roof structure for changes from, or comparison to, baseline values. The system uses a wireless local area network (LAN) to gather data from remotely positioned signal processing units (SPUs). Integrated into this system are strain gages that were selected for their ruggedness and proven reliability. The strain gages are installed on the viscous dampers. The SPUs continuously monitor forces, loads, displacement and acceleration of the roof components and correlate the measurements with seismic activity and wind conditions at the roof level. This monitoring system will quickly pinpoint any degradation in the performance or potential problems, assuring full safety and entertainment for the fans and players while also assuring efficient preservation of the community investment. This system can be used on other roof or structural health monitoring applications. Snow loads, seismic events, and wind effects are only a few of the criteria that can be monitored and quantified for safety and economic reasons.

Figure 1 shows the actual force as recorded during the earthquake and also the force fundamental mode only. Figure 2 is a plot of damper forces and damper displacements. Although no units are shown here, the data is in line with the anticipated values for this kind of a seismic event. Figure 3 is a plot of the ground movement from differing perspectives. This data can be compared with other data recorded during the same seismic event.

Data taken during the February 28th earthquake is shown and clearly illustrates that the roof structure measurements fell within anticipated ranges and that the entire monitoring system performs well during potentially cataclysmic events.

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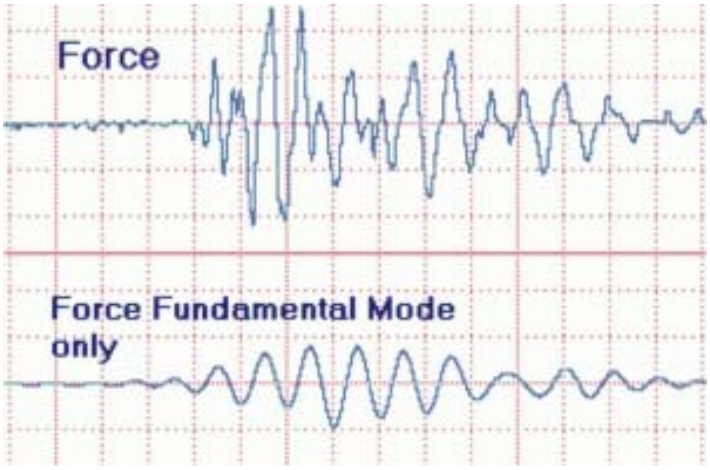

Fig. 1: Seismic event measurements

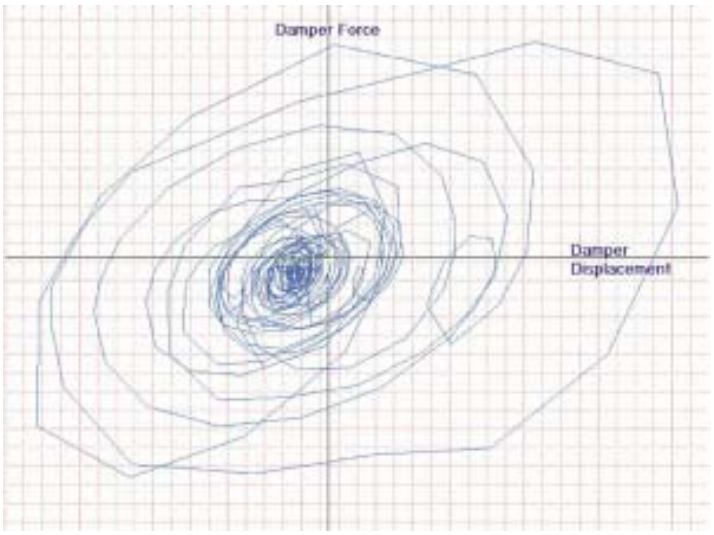

Fig. 2: Force vs. displacement during seismic event on February 28, 2001

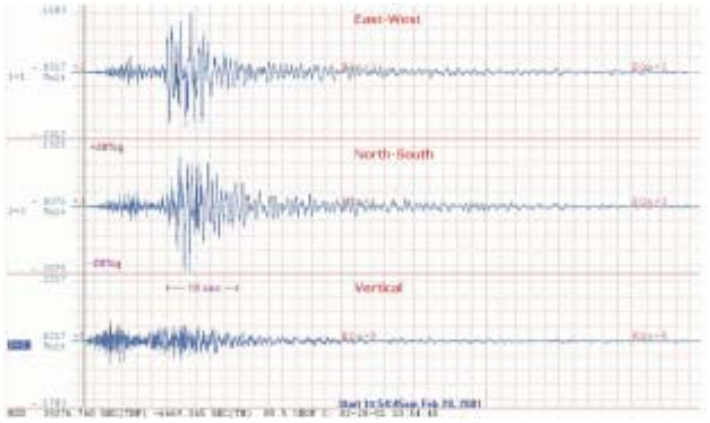

Fig. 3: Ground movement