One of the four-bay New Orleans canal platforms under construction

# Keeping New Orleans Flooding at Bay

## Structural analysis helps to predict vibration for pumping equipment in flood-prone New Orleans.

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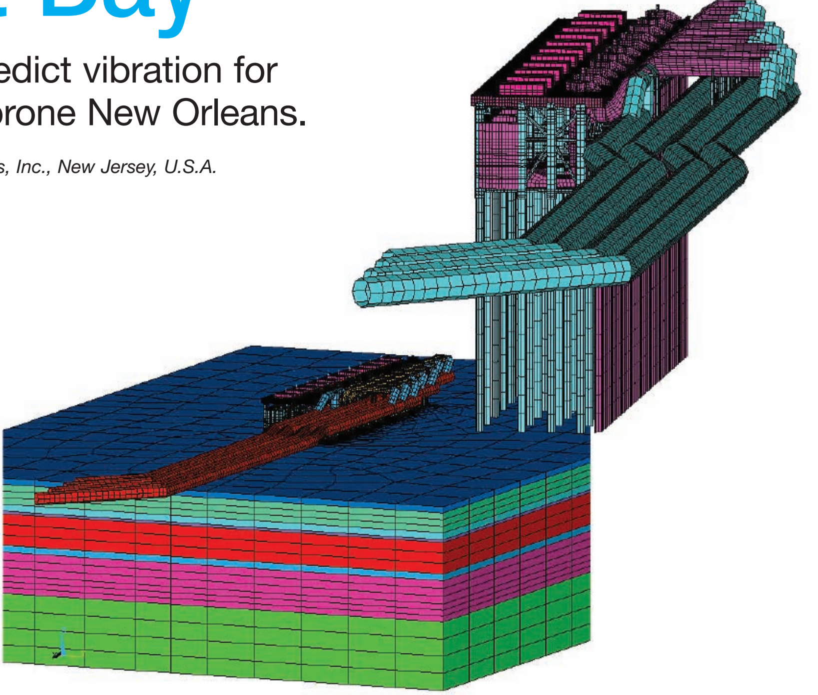
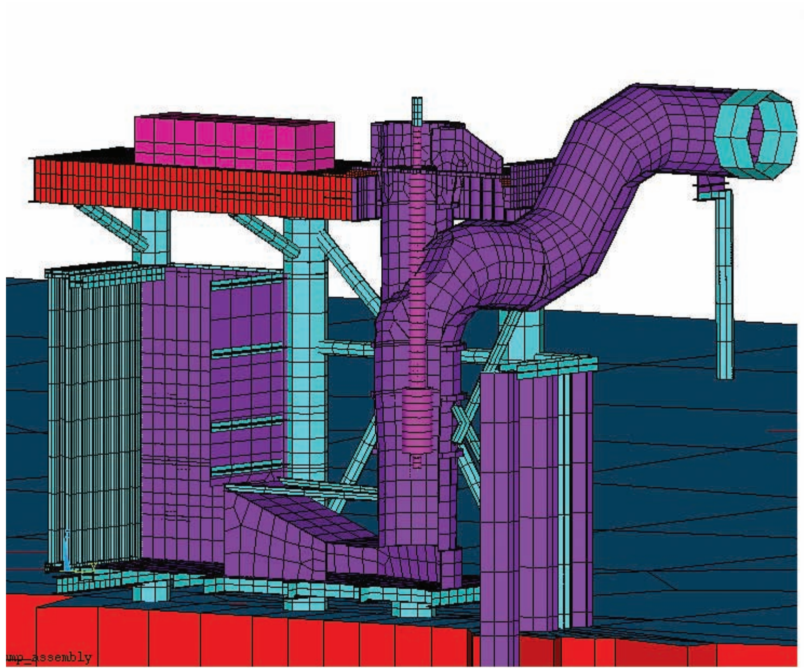
In response to the flood damage to New Orleans by Hurricane Katrina in 2006, the U.S. Army Corps of Engineers Hurricane Protection Office awarded a design and build contract to Weston Solutions, Inc., an environmental and redevelopment firm. The contract goal was to increase the pumping capacity at the London Avenue and 17th Street outfall canals to allow for additional storm drainage out of the city and into Lake Pontchartrain. Specifically, the 17th Street Canal pumping station capacity needed to increase flow capacity to 7,600 cubic feet per second.

The design and construction of the 17th Street Canal pumping station required the inclusion of several pieces of equipment



Complete ANSYS Mechanical model of 17th Street Canal pumping station (bottom). The detailed view of the model has removed the soil to expose the piles (top)



Cutaway view of a single bay of the platform

including massive platforms, 11 vertical turbine pumps, diesel engines, gearboxes and associated piping. Weston's design team included architectural and engineering firm Gresham, Smith and Partners, BBG&S Engineering Consultants, and Mechanical Solutions, Inc (MSI). A design and analysis consultant, MSI was responsible for evaluating the platform designs' vibration responses during operation of the high-power mechanical equipment. Simulation provided the team with time to make assessments and, when necessary, to address design problems prior to the construction completion date, targeted for early fall 2007 — before the onset of the next hurricane season.

The starting point of MSI's analysis was a set of detailed 2-D drawings of the platforms and associated mechanical equipment and piping. Weston provided data on the geotechnical properties of the soil strata, since it was expected that soil conditions would play a role in the vibrational response. MSI performed some initial CAD work to generate solid models for the equipment. Once imported into the ANSYS Mechanical tool, the team used a combination of solid, shell, beam and mass point elements to mesh the models, resulting in a structural dynamic model with approximately 5 million degrees of freedom (DOF). The section data capabilities of BEAM189 and SHELL281 were well suited for modeling the complicated truss platform support structure.

The structural natural frequencies and vibration levels at various locations were of particular interest. Avoiding resonant conditions that could lead to structural or performance failure was one specific requirement. To predict this behavior, MSI performed a modal analysis followed by a mode superposition harmonic response analysis. The analysis team used high-side estimates for the forcing functions imparted to the platform by the diesel engines, gearboxes and pumps. They analyzed frequencies up to 120 hertz, which corresponded to the cylinder firing frequency for the diesel engines, and they accounted for rotating imbalance loads and phase conditions imposed by the gears and pump impellers. The results indicated that the worst-case loading occurred when the imbalance loads of all 11 pumps were in phase.

Analysis of the large DOF model over the full frequency range of interest presented considerable difficulty in terms of computer resources, even with multiprocessor capabilities available. The large number of plate and beam elements resulted in thousands of natural frequencies and intractable computer runtimes. To alleviate this, MSI employed substructuring techniques available in ANSYS Mechanical software, significantly reducing DOF without loss of accuracy. Since each of the pumping section bays that made up the platforms were identical, the model comprised one superelement that represented a single bay, repeated for each of the other bays. Analysts then attached the bay superelements to the discharge piping and the soil models.

Virtual sensors, placed at various locations including gearboxes, pump columns, platform corners and engines, provided vibrational frequency response functions in a forced-response FEA analysis. Peaks within the spectra revealed excitable structural natural frequencies, though the magnitude of the loading, the size of the structure, and the damping that was present prevented the vibration levels from being excessive.

In addition to conducting a vibration analysis, MSI performed an acoustic evaluation of the discharge piping to assess the potential for acoustic resonance within the 9 foot diameter manifolds leading to the lake. No such problems were apparent.

The analytical results verified that the 17th Street Canal pump platform would withstand the loadings of the mechanical equipment without excessive vibration at any key location throughout the system. This result was confirmed by test engineers and, later, by mother nature herself. In the 2008 season, the platforms and pumps operated as designed when Category 2 Hurricane Gustav hit, keeping the potential flood waters from Gustav safely in check. ■