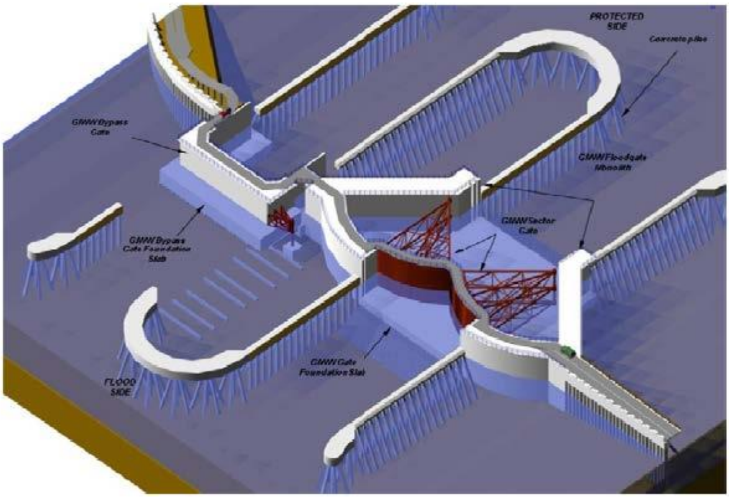
Hurricane Protection Project

Shaw Group, Ben C. Gerwick, Inc. & INCA Engineers, Inc.
New Orleans

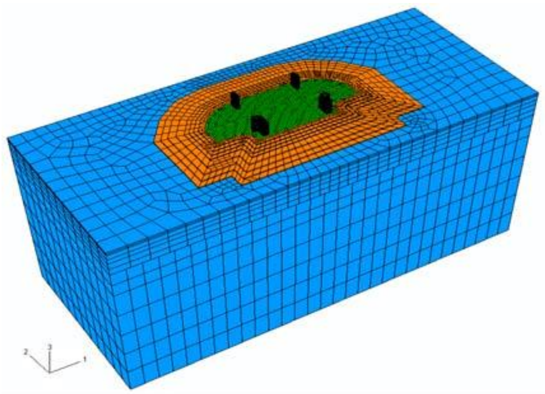
In the summer of 2005, New Orleans was overcome with catastrophic flooding from hurricane Katrina. To help prevent such a disaster in the future, the U.S. Army Corps of Engineers embarked on the largest fully funded design-build civil works contract in the Corps history . The project includes 1.5 miles of floodwall constructed east of the intersection of the Gulf Intercoastal Waterway (GIWW) and the Mississippi River Gulf Outlet (MRGO) to prevent storm surge from Lake Borgne from entering the industrial canal area of the city. To maintain navigation within the Inner Harbor Navigation Canal (IHNC), navigable floodgates are provided within the floodwall at the GIWW and the Bayou Bienvenue (BB) locations. The GIWW gates include a 150-foot wide sector gate and a 150-foot wide bypass gate, while that at the BB include a 56-foot wide gate. MMI Engineering was selected by the design team comprised of the Shaw Group, Ben C. Gerwick, Inc. and INCA Engineers, Inc. to provide design consulting services related to thermal response of the mass concrete elements of the floodgates. Thermal induced cracking that could undermine the structural integrity of the foundation system is a significant concern for the floodgate that are required to carry large hydraulic loads from storm surge.



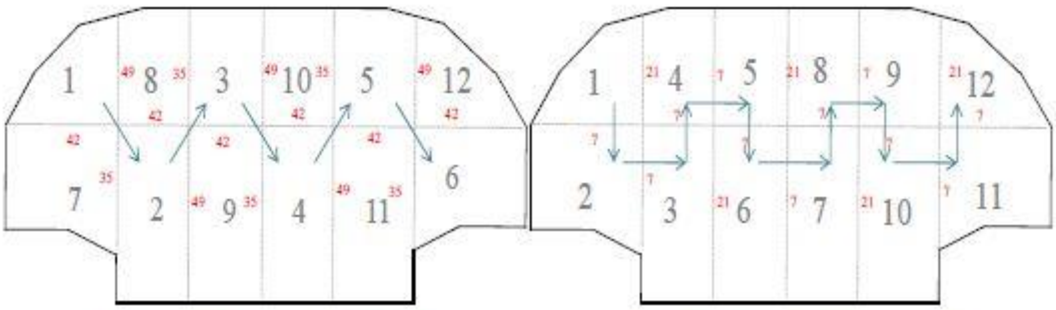
Located Hydration of concrete is an exothermic reaction and results in significant heat generation. The volumetric change from thermal effects together with the subsequent cooling and drying shrinkage of concrete induces strains that when resisted due to internal restraint from hardened concrete or any external restraints can cause concrete to crack if these strains exceed the tensile strain capacity of concrete.

For this project, MMI is employing the NISA methodology, a complex analysis procedure involving thermal and mechanical effects of concrete and its environment. The procedure considers, in detail, various time dependent parameters associated with the thermal response of concrete and the resulting potential for cracking. Hydration of concrete is an exothermic reaction and results in significant heat generation. Concrete, especially mass concrete, is a poor conductor of heat and can retain heat for a long time after placement. Depending upon the size of the structure, it can take up to several years for the structure to reach a stable temperature distribution in equilibrium with the ambient conditions. Initially when concrete is still young and fairly plastic it can accommodate thermal expansion; however, during subsequent cooling (and resulting contraction) as the concrete gains strength, the internal restraint provided by its mass and any external constraints can cause high tensile strains. Because of the relatively low tensile strength of concrete, it is subject to cracking if the induced tensile strains exceed the concrete's tensile strain capacity.

MMI's analysis considers a range of time dependent variables including adiabatic temperature rise, initial concrete placement temperature, solar radiation, and convective heat loss to air and surrounding water with consideration to the daily and seasonal variation in air and water temperatures; time dependent variation of concrete properties (creep, shrinkage, modulus of elasticity, and tensile and compressive strengths), and straining of concrete due to thermal and gravity loads. The non-linear finite element analysis program, ABAQUS™, in conjunction with a special concrete material model, is used to include the effects of creep, shrinkage and tensile cracking. The analysis procedure requires that the finite element mesh change in time to model the incremental construction process and changes in the boundary conditions and loads.



Mobile gates have the potential for extreme loads such as water pressure and storm surge and for the structure to carry these loads and continue to perform its function maintaining the integrity of concrete is essential. Analysis of thermal induced stresses for massive concrete structure with the level of detail employed by MMI for this project are not commonly part of typical structural engineering design projects and represent one of the most challenging applications within the practice.



Hopscoth placement sequence   Serpentine placement sequence

MMI's analyses showed that the originally proposed hopscotch placement sequence for the foundation slab resulted in cracking in subsequent pours when placed against pours that had already hardened. MMI recommended an alternate serpentine pour sequence that eliminated cracking in the foundation slab thus minimizing the need for surface treatment of concrete.