AWARD WINNING PROJECTS

The Naperville Millennium Carillon project overview is the first in a year long series dedicated to Award Winning Projects. The Millennium Carillon was presented a Merit Award in the NCSEA Fifth Annual Excellence in Engineering Award competition, October 2002.

The Naperville Millennium Carillon

A Midwest community brings art and music to its most treasured resource.

By Thomas McCluskey

Project Team

Project Name:	Naperville Millennium Carillon
Location:	Naperville, Illinois
Owner:	Millennium Carillon Foundation
Architect:	Charles Vincent George Design Group, Inc.
Structural Engineer:	McCluskey Engineering Corp.
Construction Managers:	Shramm Construction Company
Bellfounder:	Royal Eijbouts Bellfounders
Precast Manufacturer:	Advance Cast Stone Company
Structural Steel Fabricator:	Corsetti Structural Steel

The Vision

Along the banks of the DuPage River, the community of Naperville, Illinois takes pride in a nature walk that offers an appealing backdrop to surrounding shops and restaurants. Residents recently set out to erect the crowning touch to their most treasured resource.

The Bells

Carillons date back to 12th century Europe. A carillon is a bell tower (campanile) with a musical range of at least two octaves. The first carillon built in this country was at Notre Dame University in 1856, housing 24 bells. Today, a four-octave range (about 48 bells) is common. Naperville's carillon, with its 72 bells and a range of six octaves, is the fourth largest in the world and is among a select few instruments classified as a "grand carillon."

The cast bronze bells were forged, engraved, and artfully ornamented by the Royal Eijsbouts Bellfounders in the Netherlands. The largest bell is about seven feet in diameter, weighing about six tons.

The carillon can also be played (in a limited range) electronically.

The Challenge

The project was constructed entirely of privately donated funds. When adequate funding levels were reached in the summer of 1999, it became clear that the construction schedule was very tight, and that the precast and structural steel would be erected during the harsh winter months of this Chicago area community.

The Materials

Project architect Peter Crawford originally envisioned a limestone façade that would reflect the early architecture of the community, largely built from the exhausted limestone quarries that the tower overlooks.

Preliminary design concepts considered reinforced and post-tensioned masonry, stone-clad cast-in-place concrete, and stone clad precast concrete. The construction schedule required the tower to be erected in the winter months, creating a significant economic burden on a site cast concrete or masonry solution due to the cost of winter protection. The ability of the precast manufacturer to create a simulated limestone finish using form liners and sand-blasting techniques, coupled with the budget and time constraints led to the selection of limestone simulated precast concrete for the façade and primary structural elements.

Considerations toward minimizing long term maintenance also played a role in material selection. Exposed structural steel at the upper levels is galvanized and precast connections at the roof level are stainless steel.

The Structure

The carillon structure consists of four major elements. The foundation and lower two levels are reinforced cast-in-place concrete bearing on bedrock. The most visible elements are the architectural precast concrete panels, which provide the primary vertical and lateral load supports. The belfry, upper level perimeter stairs, carollineur's cabin, exhibit gallery, observation deck and intermediate landings are all supported by an internal structural steel tower. Finally, eight rings, manufactured from structural steel tubes, are spaced throughout the height of the structure and tie the tower elements together, acting as diaphragms to transfer lateral loads to perpendicular walls. The internal steel framework includes girders at the 52-foot level, which transfer the weight of the belfry tower to the precast shell.

Each of the four precast elevations consists of 33 panels, each panel different from the one below. The horizontal joint locations were determined by crane weight restrictions balanced by the aesthetic requirements of the project. Panel sizes vary from 18'-11 by 5'-4 by 2'-5 high at the base to 24'-6 by 12'-7 by 9" thick at the roof. Maximum panel weight is about 40,000 pounds.

Considerable attention was given in the design to mitigating volume change restraint forces. While the steel towers are supported by the precast at the 52-foot level, the precast and steel must be allowed to move independently above that level. This allows for differential movement that results from elastic and creep shortening due to post-tensioning of the precast panels as well as changes in temperature and humidity, which are significant in the Chicago area community. While support of the steel rings is provided by the precast at some levels and by the steel tower at other levels, the rings provide lateral bracing to both elements requiring careful detailing of the connections.

Precast Fabrication

Due to the complexity of the geometry and the extensive amount of form construction required, Advance Cast Stone Company of Random Lake, Wisconsin was the only precast manufacturer to accept the challenge of this project. One stipulation was that the design teams provide panel mold, fabrication, and erection drawings including component design.

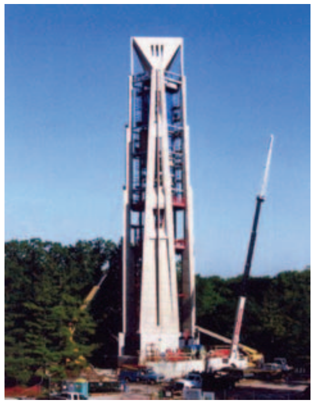
The aesthetic requirements included both smooth face and rock face simulated limestone. The stone texture was accomplished using elastomeric form liners. A combination of gray and white cement with a pigment achieved the desired color and light sandblasting added additional texture.

Panels were vertically cast to achieve consistency of finish on all sides with panels as high as 10'-6. This method of casting required plant form builders to incorporate form building and bracing techniques often used for cast-in-place concrete, but seldom seen in a precast plant.

Precast Erection

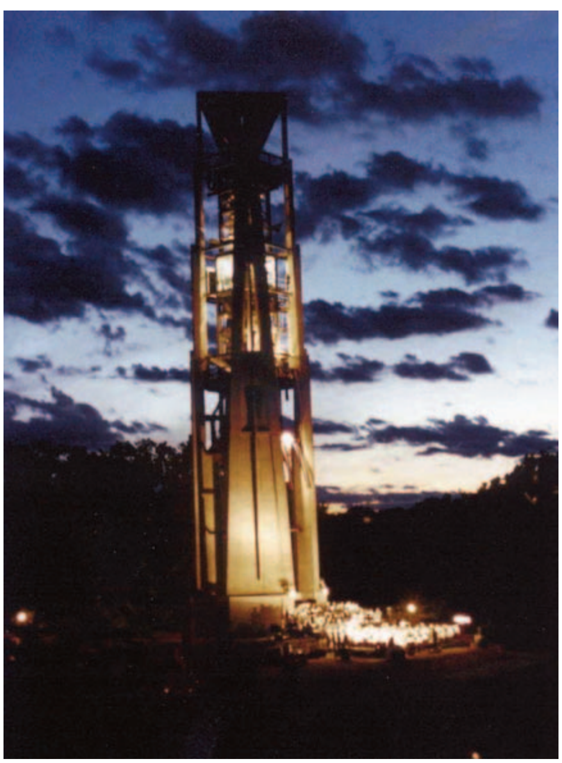
The panels are vertically post-tensioned, each with four 1 3/8-inch diameter high strength threaded steel rods supplied by Dywidag - Systems, International. The vertical post-tensioning proved to be a simple and convenient method of providing hidden continuity connections between the precast elements to resist lateral loads and control tension stresses in the precast elements.

The post-tensioning rods are about 20 feet long, which allowed most of the panels to be erected without the need for temporary bracing, saving time and money.



For each precast elevation, four rods were threaded into specially designed inserts cast into the cast-in-place concrete structure supporting the tower. Each level of precast contained four vertical ducts that allowed the panels to be threaded over the rods. When precast erection reached the top of each group of rods, a high-strength steel bearing plate and locking nut were installed and the rods tensioned. A coupling nut and the next lift of rods were installed. Grout was pressure injected into the ducts through cast-in injection ports.

To allow the panels to be threaded onto the post-tensioning rods, the rods had to be vertical, despite the generally sloping sides of the tower elements. This required transition panels to allow the rods to step in toward the panel centerline. Since the system was self-bracing as erection continued, the location and amount of tension in the post-tensioning rods had to be calculated for each section of precast erection as well as for the final structure.



Structural Steel

The steel towers were pre-assembled on site in two sections and lifted into place with just two crane picks, minimizing down time for the precast erection crew. Each steel ring was shop fabricated and shipped to the job in two pieces where they were welded together prior to erection, also providing maximum schedule efficiency. The precast and steel erectors shared the crane to reduce mobilization time and expense.

The Future

Future phases include stairs from grade to the observation level at the top of the tower, an elevator and exterior glazing up to the exhibit gallery level, limestone facing of the concrete base, interior finishes at several levels, and more extensive landscaping.

Carillonneurs from around the world have brought a rich spectrum of music to this Midwest town with the promise of much more to come as the bells signal the enduring march of time.

Thomas McCluskey, S.E. is president of McCluskey Engineering Corporation, located in Naperville, Illinois. In addition to building design, the firm specializes in consulting to the precast concrete industry.

All photos credited to Scott Allman.