Developing 'Central Park' in Texas

New public safety and recreation facilities overcome design and schedule challenges.

By Michael W. Whitney, Ph.D., P.E.

In June 2010, the city of Grand Prairie, Texas, officially opened its new municipal development, known as Central Park. New construction at the site features a $47 million, 150,000-square-foot Public Safety Facility, a $19 million, 57,000-square-foot recreation facility christened "The Summit," and $23 million for civil, site, and landscaping that includes five new site lakes.

The Public Safety Facility serves as the new headquarters for city law enforcement and emergency services, and includes a detention wing with a capacity for 233 detainees that more than doubles the capacity of the previous facility. Several support structures for police and fire also were part of the project.

The Summit is a state-of-the-art fitness and activity club that places an emphasis on a wide variety of uses for the 50-years-of-age-or-older community of Grand Prairie. A few of the facility's features include: a state-of-the-art fitness area, an indoor saltwater aquatic center with a 10,000-gallon resistant exercise vortex, a lap pool and hot tub, a

Grand Prairie Central Park

Owner
City of Grand Prairie, Grand Prairie, Texas

Structural engineer
Structural Engenuity, Inc., Dallas

Design architect
Brinkley Sargent Architects, Dallas

MEP engineer
M-E Engineers, Inc., Denver

Civil engineer
Halff Associates, Grand Prairie, Texas

Geotechnical engineer
CMJ Engineering, Inc., Fort Worth, Texas

Contractor/construction manager
Manhattan Construction Company, Dallas

The building exterior outward lean of 19 degrees and the side leans of 10 degrees were resolved by a combination of concrete leaner columns, post-tensioned concrete, and a steel structural system at the roof.

luxurious dining room and ballrooms overlooking the development's five lakes, a 100-seat theater, a game room, a basketball court, an aerobics room, an 1/10 mile indoor track, a café and wine bar, a teaching kitchen, an outdoor kitchen, and a fireplace.

Schedule and design

Grand Prairie's urgent demand for new fire and police facilities, and the city's desire to open the major elements of Central Park simultaneously drove an aggressive schedule. The contractor and project construction manager (CM) determined that the size and complexity of the Public Safety Facility demanded construction documents be issued three months prior to those of The Summit if both were to have the same completion date.

The structural engineer was given the go-ahead to proceed with final design for the Public Safety Facility on June 15, 2008. Construction documents for piers were issued along with a progress set for the balance of the building on July 15. Final construction documents were scheduled to be issued on Sept. 15. Pier construction began on Oct. 27, while construction documents for the architectural and mechanical/electrical/plumbing (MEP) were not issued until Dec. 15, 2008. Issuing coordinated structural documents months ahead of the remainder of the design team required extensive coordination between all design team disciplines, the contractor, and the primary structural sub-contractors.

Though the construction documents for the Public Safety Facility were produced using AutoCAD, the structural engineer used a building information model (BIM) and an integrated project delivery (IPD) approach to help the design team and CM coordinate the building's structural complexities during the design and construction phases. The Summit facility construction documents were produced using a total BIM and IPD approach. The BIM provided visualization for the owner, design team, and CM, and provided for coordination of the complex architectural, mechanical, and structural systems during the design and construction phases. On both facilities, integrated BIM and structural models allowed for rapid bi-directional updates between the structural analysis and design models and the BIM model.

Structural solutions: Public Safety Facility

Due to the highly expansive clays that occur at the Grand Prairie site, a structured first floor with crawl

Q&A with the structural engineer

Structural Engenuity's Michael W. Whitney, Ph.D., P.E. (MWW), structural engineer-of-record and project principal of the Grand Prairie Central Park development, discussed the project with the editors of **Structural Engineer** magazine (SE).

SE: What was the first task you needed to do to get started on the design?

MWW: The project was fast-track and involved two very different structures, so our first task was to determine the most cost-effective structural systems for each of the two buildings that would meet the building form and performance requirements. In addition to the geometric and occupancy complexities, the project is located on a site with highly expansive clays, which impacted the overall structural systems considered. Structural Engenuity provided several different structural systems for each building that were evaluated by the architect and construction manager for cost, schedule, and performance.

SE: What types and how many structural systems did you and your team evaluate for this project?

MWW: For the Public Safety Building, we considered three structural systems which included a concrete pan joist foundation with crawl space and all-steel superstructure, a concrete pan joist foundation and superstructure with a steel roof, and a concrete pan joist foundation, post-tensioned flat plate floor system, and a steel roof structure. All foundations utilized straight-shaft deep drilled piers. The latter system was chosen for cost, schedule, and providing the best system for the architectural constraints. For The Summit building, we considered three structural systems which included a concrete pan joist foundation with crawl space and a combination tilt-wall and steel superstructure, a slab-on-carton forms with concrete grade beam foundation with a combination tilt-wall and steel superstructure, and a slab-on-carton forms with concrete grade beam foundation with a combination load-bearing CMU and steel superstructure. All foundations utilized straight-shaft deep drilled piers. The latter system was chosen for cost and schedule considerations.

SE: What was the most challenging aspect of the structural design? How was it solved?

MWW: There were two very challenging aspects of the structural design, namely the 10- and 19-degree outward sloping sides and front of the Public Safety Facility and the very thin floor and sun shade requirements at each level at the front of the Public Safety Facility. Sloping leaner columns and lateral shear walls were used to support the sloping sides and front and a post-tensioned flat plate that tapered to provide the thin floor cantilevered sunshades at each level.

Firm facts

Structural Engenuity, Inc., is a structural engineering firm established in 2001 that practices in the following areas: structural engineering consulting; structural engineering design; preparation of structural construction documents; preparation of structural building information models; peer reviews; structural framing cost evaluations; existing facilty structural assessments; repairs, renovations, and modifications of existing facilities; forensic engineering; and vibration design. Headquartered in Dallas, the firm has four partners and 10 employees.

Q&A with the architect

Harold Sargent, AIA (HS), president, principal-in-charge, and design partner at Brinkley Sargent Architects shared the following information about the project. The architects of record for the Public Safety Facility and The Summit building were Greg Read, AIA, principal, and Stephen Springs, AIA, principal, respectively.

SE: What was the most unique problem to solve on the project? How was it solved?

HS: Although the buildings were defined and budgeted, the 177-acre site scope of work was unknown. The city gave the team $100 million to do everything with the direction to provide the best park possible within budget. Working with the CMAR, funds were reviewed for maximum value. The structural aspects were constantly evaluated for best value.

SE: What unique challenges were solved with direct collaboration with the structural engineering team that would have been difficult otherwise?

HS: The Public Safety Facility required larger floor plates at each level from the ground. The Summit has dramatic cantilevers and structured shading devices as well as a "signature" running track protruding from the main structure.

SE: What lessons did you learn from this project that you will apply toward future projects?

HS: Realizing exemplary architecture requires exemplary engineering.

These images of the natatorium as-built (left) and the BIM (right) illustrate the coordination of the complex architectural, mechanical, and structural systems afforded by using IPD.

space was required. The calculated potential-vertical-rise (PVR) of the expansive clays was determined by the geotechnical engineer to be more than 7 inches. The crawl space allows access to the under-slab MEP systems and isolates these systems and their connection to the building from the heaving soils. The foundation is supported by concrete straight-shaft drilled piers as much as 60 feet deep, with embedment into the bearing stratum of 15 to 30 feet. Lightly loaded pier designs were controlled by the uplift forces that result from swelling clays, rather than gravity forces.

The Public Safety Facility marries a number of different types of structural systems, including concrete pan-joist at the first level, post-tensioned concrete at the upper floors, and a steel roof structure supported by concrete columns utilizing both steel beams and joists. Pan-joist construction was used for the first floor due to the high line-loads from CMU walls and to avoid the elastic shortening isolation complexities for post-tensioned construction at the concrete foundation beams. The Public Safety Facility is laterally supported by concrete shear walls, which are placed to minimize the forces on these walls due to the post-tensioned concrete elastic and creep-shortening forces. The selected structural systems helped the building achieve LEED Silver Certification, upholding the city's commitment to sustainable design for all new facilities.

The architect envisioned an unobstructed, panoramic view of the surrounding Central Park, so a principal structural design element was the support of an outward-sloping exterior facade. Portions of three faces of the main building feature a 10- to 19-degree outward slope from vertical, which was matched by concrete leaner columns to support the exterior structure and facade.

The detention area is, by necessity, irregularly shaped and requires many elevation changes in the first floor by way of ramps and stairs. The pan-joist foundation was provided on an orthogonal grid, but designed to support the irregular load patterns of the CMU walls that make up the two-level detention wing and the various first floor elevations, ramps, and stairs. Dowels for the masonry walls were all post-installed, which limited what would otherwise have been extensive coordination efforts between the concrete and masonry placement. The detention wing outside the cell block area and support buildings use load-bearing CMU and structural steel roofs. The cell block area uses concrete flat plate at the second level and at the roof for security reasons. Lateral support for the detention and support buildings is by masonry shear walls. In stark contrast to the sloping facade of the administrative wing of the facility, portions of the face of the detention wing used a steel framing facade over the load bearing CMU walls to provide an inward-sloping wall face. The steel structure is constructed with tubes running in each direction, into which is filled a system of studs, windows, and other architectural facade.

Structural solutions: The Summit

The Public Safety Facility and The Summit are separated by only a quarter-mile, so the soil conditions essentially were identical between the two; therefore, a structured foundation was needed to isolate the building from the more than 7 inches of potential vertical soil movement. The ground floor throughout The Summit consists of an 8-inch, two-way slab-on-carton forms, supported by straight-shaft drilled piers and grade beams. The pool is supported by a 14-inch, two-way slab on piers, with walls that cantilever from the pool foundation mat and follow a complex curvature as described by the aquatic engineer.

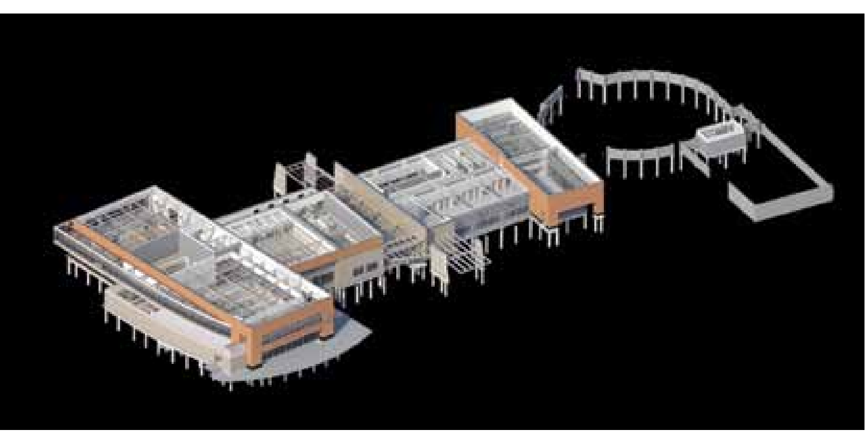
Most of the steel structure in The Summit is exposed architecturally and needed to give an appealing and uncluttered appearance. Careful consideration was given to the size and spacing of the exposed structural members to provide an overall structure that appeared uncluttered and well coordinated with the architecture and MEP requirements. BIM greatly enhanced the coordination and visualization by the owner, design team, and contractor.

A primary feature of The Summit is an elevated track that winds through the facility. The track is suspended above the gymnasium and natatorium and was designed by the architect to give walkers and runners a tour of the facility, as well as varied views of the surrounding landscape. This intent challenged the design team to support the track in a number of ways as it passes through the building from one type of construction to another, open both to the facility on one side and to

The Summit facility used a fully exposed steel structure on the interior in conjunction with large exterior curtainwall expanses. The exterior features exposed, galvanized, and painted steel trellises for sun shading of The Summit facility.

The exterior courtyards of The Summit facility utilize exposed steel trellises for sun shading during outside activities.

The design team and construction manager extensively used BIM for coordination of the exposed steel structure, architectural finishes, and mechanical systems during the design and construction phases.



windows presenting an exterior view on the other.

In the gymnasium, the track is supported by a series of P-shaped moment frames, which allow the track to have an unobstructed view of the exterior, and the interior gymnasium and pool, while appearing to float when viewed from outside. Detailed finite element analysis was used for design of the moment frames, with special care given to maintaining strict deflection and vibration criteria to ensure tack levelness and to reduce the possibility of perceptible track deflections or vibrations.

To complete its loop, the track must pass through a large second floor-to-roof-height truss twice in the natatorium. To accommodate pedestrians passing through the truss, the diagonals in the end panels were removed and the truss was designed to transfer the maximum shear forces through moment connections, rather than axially through a diagonal web member. Similar diagonal omissions were required in other trusses to allow the passing of large mechanical ducts.

This and other long-span built-up trusses from which the track hangs are supported at one end by deep long-span cambered steel beams. The truss and long-span beam cambers posed a constructability issue since the final elevation and levelness of the hanging track below was dependent on the final dead load deflections of the roof trusses and long-span beams. Predicting the exact final dead load deflections of the combined roof member system was impossible due to the enumerable number of construction variables that influence the final deflections. The design and construction team resolved this issue by having the contractor survey the track elevations throughout the construction process and slightly adjust the track hanger lengths by use of clevises at each end of the hangers, one at a time, as required to achieve track levelness.

Project conclusions

Since opening in June 2010, the Grand Prairie Central Park buildings have been met with approval and praise by the taxpayers of Grand Prairie, the facility users, and public safety and city officials around the country who have come to Grand Prairie to tour the new facilities. The users of the facilities praise the unobstructed views provided by the buildings and enjoy the vast array of amenities available. Though the project was very large, with a multitude of construction challenges, and with many separate buildings and significant weather delays, the grand opening was only one month behind the original schedule. The use of BIM and IPD greatly enabled the collaborative process between the design and construction teams and helped meet the aggressive construction schedule.

Michael W. Whitney Ph.D., P.E., has been a principal and part owner of Structural Engenuity, Inc., a Dallas-based structural engineering consulting firm, since 2001. He can be reached at 972-247-9250 or mwhitney@structuralengenuity.com.