DUKE ENERGY CENTER
Charlotte, NC

The new 48-story Duke Energy Center tower at 764 ft (233 m) is the second tallest building in Charlotte, NC and the tallest in the world to use precast, prestressed double tees[1]. The office tower is one of several buildings in a project that was originally developed at the Wachovia Cultural Campus, now simply known as the First Street Cultural Campus. The original plan included a 42-story condominium tower, the Mint Museum of Art, the Bechtler Modern Art Museum, the Harvey B. Gantt Center for African-American Arts and the Knight Theater.

An Atlanta-based architectural firm tvsdesign designed the office tower with a nine-story annex “podium” that contains four floors of trading space for Wachovia/Wells Fargo, and an underground parking deck. Batson-Cook Co. in Atlanta was the building’s general contractor. The four floors of trading space have floor-to-ceiling heights of 20 ft. The eight-level below-grade parking garage for 2,200 cars reaches a depth of 95 ft below the street level with a loading dock on the lowest level. Trucks access the loading dock through a tunnel under the Harvey B. Gantt Center with a service entrance a block away. Cars access the parking garage through a second tunnel that sits above the service entrance tunnel. Because the project is located within Charlotte’s Uptown Mixed-Use District, the designers had to adhere to guidelines for service vehicles not backing onto the street. “A huge part of the project was to make the cultural campus pedestrian,” says Dave Brown, associate principal with tvsdesign. “We had to design as if it had no backyard. Everything was a front door[2].”

Both the office tower and podium use 12-ft-wide lightweight concrete precast, prestressed double tees with a lightweight concrete topping for their flooring system. The double tees were produced by Prestress of the Carolinas in Charlotte, NC. Double tees are used for all floors through the 45th story. The tower features a 70 ft x 70 ft cast-in-place shear-tube core, with a 160 ft x 160 ft cast-in-place perimeter frame structure. TRC Worldwide Engineering in Brentwood, TN, evaluated several systems before choosing the cantilevered punch tube system for the 160-ft square structure. Self-climbing metal forms were used to place the tube concrete. “A tube sticking straight in the air is very strong,” says Tommy Hagood, engineer of record and principal in charge for TRC2. This system is very rigid and acts as a shear wall and rigid frame combination. This eliminates the need for shear walls in the core area of the building and creates a more open design. The core is designed only for gravity loads and it houses the elevators, stairwells, utilities, etc. for the tower. Both seismic and wind loads controlled the lateral design for the exterior columns. An exterior cast-in-place frame takes the lateral wind and seismic loads. Columns were placed at 10 ft on center around the building. All of the cast-in-place concrete, including the lightweight concrete topping, was supplied by Concrete Supply Company of Charlotte, NC.

The lightweight concrete double tees span 43 ft from the exterior frame to the core. Britt Peters and Associates, Greenville, SC, designed all the double tees. Principal Edward Britt recommended the use of lightweight concrete for the double tees and the cast-in-place topping slab to reduce the volume of concrete. “To achieve a two-hour fire rating, the greater fire resistance of lightweight concrete allowed us to reduce the floor thickness of the cast-in-place topping by one inch. That is a big building. One inch added up to a lot of concrete and huge savings” said Mr. Britt. Don Davis, a consultant for Batson-Cook, confirmed Mr. Britt’s recommendation and was instrumental in the decision to use lightweight concrete in the double tee girders and the topping slab.

 

Mr. Frankie Smith, Plant Manager for Prestress of the Carolinas, said “The double tee system allowed Batson-Cook to complete a floor every four days. They used 32-in.-deep double tees in the tower and podium up to the ninth floor. Starting with the tenth floor of the tower, the double tees were only 19 in. deep.” The majority of the double tees had a design strength of 6,000 psi, but some of the beams were designed with up to 9,000 psi. “All of the lightweight concrete made strength,” according to Mr. Smith, who added that “All the 9,000 psi concrete broke near 12,000 psi.” Asheville, NC-based Southern Concrete Materials, who has a concrete batch plant adjoining the Prestress of the Carolinas plant, supplied all the lightweight concrete for the double tees.

The Duke Energy Center tower is thought to be the tallest building using double tees for the flooring system. Double tees are most commonly seen in parking structure construction. Parking garages typically require long span construction with a framing system of beams spanning approximately 60 ft across parking spaces on each side of a center driving aisle. According to Batson-Cook Project Executive Randy Thompson, “There are not many [high rise] buildings that use them, but in this particular case, and after evaluating all of the different structural types that we could use, that turned out to be the most cost effective, and it minimized the schedule[3].”

LIGHTWEIGHT CONCRETE BENEFITS

REDUCED WEIGHT

Lightweight concrete made with rotary kiln expanded aggregate offers many benefits in almost all structural applications, the most obvious being reduced weight. Reduced weight allows savings in the structural frame itself and especially in the foundations. The reduced weight also reduces the seismic loadings for design; this reduction in lateral force requirement can be of importance, not only in the structural frame, but also in the connection details and the foundations[4]. Reduced weight also facilitates transportation of precast pre-stressed elements. Since maximum hauling weights are limited on public roads, use of lightweight concrete may make it possible to haul a larger unit. Many precast producers use lightweight concrete to allow them to haul two double tees instead of just one. Similarly, on construction projects where crane capacities are limited, use of lightweight concrete permits larger single elements to be lifted and set into place.

INTERNAL CURING

Absorbed water contained in lightweight aggregate provides water for internal curing of concrete. This allows better hydration of the cementitious materials as moisture is slowly released from the reservoirs of absorbed water contained within the pores of the lightweight aggregate. The benefits of internal curing are increasingly important when supplementary cementitious materials, (silica fume, fly ash, metokaolin, as well as the fines of lightweight aggregate) are included in the mixture. It is well known that the pozzolanic reaction of finely divided alumina-silicates with calcium hydroxide liberated as cement hydrates is contingent upon the availability of moisture. Additionally, internal curing provided by absorbing water minimizes the "plastic" (early) shrinkage due to rapid drying of concretes exposed to unfavorable drying conditions[5].

GREATER FIRE RESISTANCE

Lightweight concrete has demonstrated greater fire endurance than equal-thickness members made with normal weight aggregates. Therefore, lightweight concrete typically offers significant savings on a project that calls for a fire rated floor, roof and wall assemblies by reducing the thickness of an element to achieve the same fire rating, as was noted by Mr. Britt in the design of the Duke Energy Center Tower. The superior performance of lightweight concrete is due to a combination of lower thermal conductivity (lower temperature rise on unexposed surfaces), lower coefficient of thermal expansion (lower forces developed under restraint), and the inherent thermal stability developed by aggregates that have been already exposed to temperatures greater than 2000 degrees F during the rotary kiln expansion process[6].

REFERENCES

1. Neuwald, A., "Towering Achievement, Design Changes Put a Producer to the Test," TheConcreteProducer.com, March 1, 2008.

2. Wood, D., "Features – Wachovia First Street," Southeast.Construction.com, McGraw Hill Construction, April 2009.

3. Jones, K., "Profile – Batson-Cook Construction," Construction-Today.com, March 19, 2008.

4. Gerwick, Jr., B. "Construction of Prestressed Concrete Structures, Second Edition," 1993 John Wiley & Sons, Inc., p. 78.

5. "Guide for Structural Lightweight Aggregate Concrete," ACI Committee 213, American Concrete Institute, Farmington Hills, MI, p. 34.

6. Chapter 46 "Lightweight Concrete and Aggregates," Significance of Tests and Properties of Concrete and Concrete-Making Materials, ASTM Special Technical Publication 169D, ASTM International, West Conshocken, PA, p.558.

Built with