PROJECT

Bank of America Corporate Center

LOCATION

Charlotte, North Carolina

OWNER

Bank of America

ARCHITECTS

Cesar Pelli & Associates (Design) HKS, Inc. Dallas, TX (Production)

STRUCTURAL ENGINEER

Walter P. Moore and Associates, Houston, TX

GENERAL CONTRACTOR

McDevitt & Street, Charlotte, NC

CONCRETE SUPPLIER

Concrete Supply Company, Charlotte, NC

CONCRETE PUMPING

Concrete Placement, Inc. Charlotte, NC

LIGHTWEIGHT CERAMIC AGGREGATE PRODUCER

Solite Corporation

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Pumping Solite Lightweight Aggregate Concrete 60 Stories Was No Tall Order

Building is Southeast's Tallest Concrete Structure

Article by Virginia Kent Dorris; Introduction by Solite

The Bank of America Corporate Center (formerly NCNB/NationsBank) is a 60-story, 830-foot-high building in Charlotte, NC. Lightweight aggregate was selected for the floors to minimize weight and to achieve required floor fire ratings. More than 30,000 cubic yards of Solite lightweight aggregate concrete was pumped at rates exceeding 60 cubic yards per hour. Designed for total performance, Solite lightweight aggregate concrete combines structural, insulating and fire resistance qualities in construction material.

BANK OF AMERICA TOWER LIFTS CHARLOTTE'S SKYLINE

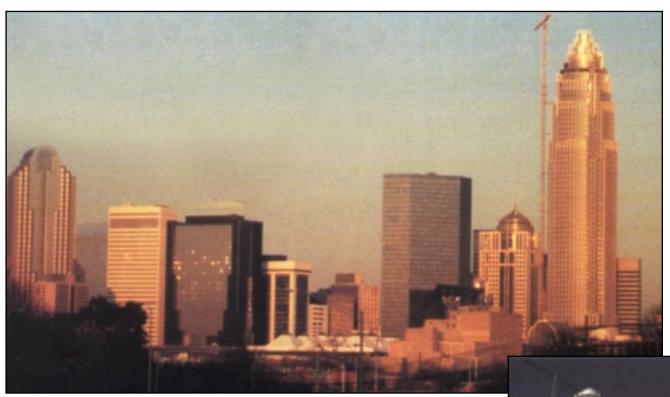
Officials of Bank of America (formerly NCNB / NationsBank) wanted their new headquarters building in Charlotte, NC, to be a recognizable structure: one that could serve as a symbol of "the Queen City." They found it in a 60-story Cesar Pelli-designed concrete tower topped by a 100-ft crown of aluminum spires.

"NCNB wanted to put Charlotte on the map and give it a skyline,: says Pelli, principal in Cesar Pelli & Associates, New Haven, CT. "They wanted the tallest, thinnest and most efficient building possible, and one that was not extravagant.

The objectives of maximum height, efficiency and economy



NationsBank Corporate Centers is a 60story, 870-foot-high, poured-in-place concrete tower



NationsBank Tower rises high above the Charlotte skyline.

were achieved with an 879-ft-high poured-in-place concrete tower with 12-ft 8 in. floor-to-floor heights and 48-ft column-free spans from perimeter to core. When completed, the tower was the tallest building in the southeast-ern U.S. and the third-tallest all concrete building in the country. Although North Carolina's building codes did not require it when the building was designed, engineers detailed the tower to satisfy seismic standards for moderate earthquake risk.

The \$118-million, 1.2-million-sq-ft tower is part of a \$150-million project, the Bank of America Corporate Center, that occupies a block in Charlotte's business district. The project was a joint venture of NCNB Corp. and Charter Properties, both based in Charlotte, and was developed by Dallasbased Lincoln Properties Company. McDevitt & Street Company, also based in Charlotte, was the general contractor.

Connected to the tower is a 35,000-sq-ft atrium building called Founders Hall that contains shops and public spaces. A hotel planned for one corner of the site was scrapped because of a hotel glut in Charlotte. In its place,

contractors are building a 50,000-sq-ft extension to Founders Hall, also designed by Pelli. The six-story extension will contain restaurants, shops, health clubs and the bank's trading annex.

Founders Hall is connected by a pedestrian bridge to a new 1,600-space parking garage across the street. The tower's site is also shared by a new \$45-million performing arts center, also designed by Pelli for the non-profit North Carolina Performing Arts Center, Inc, being built by Becon Construction Company, Inc, Houston.

BIDDING SUBCONTRACTS

Lincoln Property's decision to bid some of the subcontracts itself and assign the pre-selected subs to the general contractor caused tension during the general contractor bidding process, but it was not a significant factor during construction, said parties involved. "As is its custom, Lincoln chose several of the major subs – including the elevator, mechanical, electrical, sprinkler and curtain wall stone subcontractors – and assigned them to low-bid general contractor McDevitt & Street," said Larry S. Moon, vice president of construction for Lincoln Property. McDevitt & Street then signed contracts with subcontractors.

Moon said Lincoln likes to bid some of the major subcontracts itself because it allows the developer to hire "proven subcontractors" it has worked with on prior jobs. The process also earns Lincoln the "loyalty of the subcontractor, a little bit," said Moon.

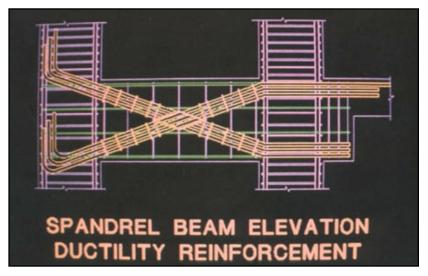
McDevitt & Street, which has a lump-sum, guaranteed-maximum-price contract with lincoln, was not disturbed by the preassigning of some subcontractors, says John R. Nicolay, a McDevitt & Street senior project manager. The contractor has a "prior favorable relationship" with Lincoln, developed when the two built an earlier project together, Nicolay added.

The preassigned subs generally performed satisfactorily, said Sherwood L. Webb, a McDevitt & Street senior project manager, but trouble arose with three of the con-

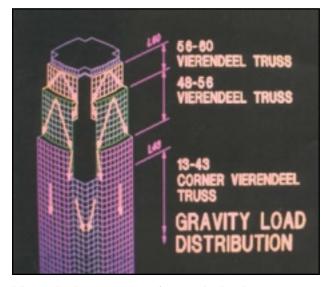
tractor's own subs, who left the job and were replaced.

Project structural engineer Walter P. Moore and Associates, Inc., Houston, used normal weight concrete – ranging in strength from 8,000 psi near the building's base to 6,000 psi at the top – to create a reinforced concrete perimeter tube to resist lateral loads. Engineers also used lightweight concrete for the floor slabs and floor beams to decrease building weight and give floors the required fire rating.

The tower's columns are spaced 10 ft. on center and are connected by 40-in-deep spandrel beams. The building has a roughly square plan at the base, but above the 13th floor it resembles a square set over a slightly larger cross, with the building's four corners recessed and its four major faces bowed



Diagonal reinforcement was used to provide ductility for seismic safety and concrete shrinkage



Vierendeel trusses transfer gravity loads at setbacks



Extra ties were required on column reinforcing to meet seismic requirements. Tower's floor slabs and floor beams were formed of 5,000 psi lightweight concrete.



slightly outward.

To maintain the structural tube between the 13th and 43rd floors, engineers used L-shaped Vierendeel trusses to continue the tube around the corners, says Javier F. Horvilleur, a Walter P. Moore vice president. Instead of using transfer girders when the building stepped back, engineers used the building's column-and-spandrel structure to create multilevel Vierendeel trusses on the building's main facades. Those massive Vierendeels transferred loads using another set of Vierdndeel trusses perpendicular to the facade at the edges of the recessed corners.

Differential shortening was a concern during design because the core columns would be under significantly higher stresses than the closely spaced perimeter columns. Mark Fintel, a consulting engineer and concrete creep-and-shrinkage specialist based in Boca Raton, Fla., analyzed the structure and calculated the anticipated shrinkage. To compensate for the shortening of the core columns and to avoid ending up with sloping floors, the core columns were constructed slightly longer than the perimeter columns and the floor slab forms were tilted accordingly. At the 40th floor, for example, core columns were poured 1 inch higher than perimeter columns and the adjacent slab forms also were tilted about 1 inch.

SEISMIC DESIGN

When engineers designed the tower, the North Carolina building code "was silent" on seismic design, but required engineers to design for an 80-mph wind speed, says Horvilleur. However, the code allowed designers to substitute wind load criteria from boundary layer wind tunnel tests of the building. Horvilleur says wind loads from wind tunnel tests were substantially smaller than code wind loads because of the tower's shape, stiff frame, high damping and other factors.

Aware that Charlotte is located in an area of moderate earthquake risk, engineers considered the seismic provisions in the appropriate ACI code section and learned that while wind loads controlled the design of the lower two-thirds of the building, seismic forces controlled the design of the upper third. Horvilleur says engineers recommended to the owner that seismic design considerations be used.

To meet the seismic requirements, designers had to pay greater attention to concrete reinforcing and detailing of the structure. A number of ties were added to the reinforcing steel in the columns,

and stirrups were added to reinforcing in the beams. In addition, the reinforcing for critical beams, particularly at setback levels, was designed in an "X" configuration to provide greater ductility. The diagonal reinforcing also gave the beams the greater ductility needed to compensate for movement as a result of creep and shrinkage, says consultant Fintel.

Both standard and lightweight concrete were poured simultaneously. The normal weight concrete was used for perimeter columns, which ranged in size from 24 x 38 in. at the bottom to 24 x 24 in. at the top, as well as for the core columns, ranging from 2 x 18 ft. at the base to 2 x 3 ft. at the top.

Normal weight concrete was also used for the post-tensioned spandrels at the perimeter of each floor, but 5,000 psi lightweight concrete was used to form the 4 5/8-in-thick floor slabs and the 18-in.-deep, post-tensioned floor beams, spaced 10 ft. on center. The two types of concrete were poured in quick succession and "puddled" to avoid a cold joint, says J. Jeff Baber, McDevitt & Street's tower superintendent. Concrete was poured on a five-day cycle at night when the weather was cool, says

Baber. At the start of each pour, 30 cu. yds of normal weight concrete was pumped up through a 5-inch line for the perimeter spandrel beam. Lightweight concrete was then pumped through the same line to form the floor beams and slab. At the same time, normal weight concrete was bucketed to the necessary floor to complete the spandrel pour. Contractors had as little as half an hour to pour the second type of concrete after the first type was placed, says Bill M. Scott, chief engineer with Charlotte-based project concrete supplier, Concrete Supply Co.



PRESOAKING AGGREGATE

A superplasticizer was added to make both types of high-slump concrete easier to place, says Scott. To prevent the expanded-shale aggregate in the lightweight concrete from absorbing water when put under pressure during the pumping process, the aggregate was presoaked at the quarry 48 hours, says Scott. contractors used a hydraulic placement boom to place between 70 and 90 cu. yds. of concrete per hour, rather than the 50 cu. yds. an hour that would more typically have been placed with a pipe-and-hose system says Edward D. Lothamer, president of Concrete Pumper Concrete Placement Inc., Kansas City, KS.

Forming the floors could have been difficult because the columns, spaced 10 ft on center around the building's perimeter,



Concrete was pumped more than 750 feet to top the tower.



did not allow the contractor to fly out forms of any size. "It looked like spokes in a wheel, the columns were so close together," says Alan D. Combs, superintendent in the Tampa, FL office of forming contractor Capform Inc. Working together, Walter P. Moore engineers and Capform decided to delay construction of two of the building corners, keeping them about four stories behind the others, so larger forms could be moved out with a tower crane.

Concrete pouring went smoothly until contractors began the 60th floor and a severe thunderstorm hit, knocking out the electric pump and the lights and forcing the workers to evacuate the floor. In the two-hour period it took to restart the pour, about 60 cu. yds, of concrete hardened, says Baber. Although some of it was salvaged, the contractor spent more than a week chipping out what could not be saved.

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