# **Rebirth:** One World Trade Center

umping progress has been sending One World Trade Center (1WTC) skyward at one floor per week. Set to top out at 1,386 feet in spring 2012, the high rise is being constructed with two concrete cores and concrete on metal decks utilizing an innovative placing system. The system was conceived in cooperation with the manufacturer of the pumping equipment and Collavino Construction Company Limited, a U.S./Canadianbased company and American Concrete Pumping Association (ACPA) member. Forming, pumping and finishing all cast-in-place concrete for the project, Collavino is employing

Photos courtesy of Joe Woolhead

some of the highest strength mixes ever used. The final structure will have a shrouded mast that will bring it to 1,776 feet, making it the tallest building in the U.S.

Situated on the 16-acre World Trade Center Site in lower Manhattan, excavation for the 80-foot deep hole is located over a slab from the original World Trade Center, which separates the excavation from an existing subway line. Crews worked around the slab and the 300,000 commuters who use the subway system daily. Collavino moved a Schwing S 58 SX to the site to start mass pours of slabs, varying from 12 to 36 inches thick and Steel precedes concrete; the combination of two separate placing booms and two cranes mounted on the climbing forms are able to complete one floor per week.

core walls and columns as thick as six and a half feet. Pumping from street level, the truck-mounted boom pump reached as much as 175 feet horizontally while managing to meet all pour schedules with its 213 cubic yard per hour capability. The pump's Super X curved outriggers, with a front spread of 29 feet two inches, kept the footprint to a minimum in the crowded downtown New York City setting.

# **SPECS**

Owner/Developer: Port Authority of New York Architects: Skidmore, Owings and Merrill LLP—New York, New York Construction Manager: Tishman Construction—New York, New York Prime Concrete Sub-Contractor: Collavino Construction—Windsor, Canada Equipment: Schwing S 58 SX truck-mounted boom pump, two SP 8800 stationary concrete pumps, two Schwing SPB 31 five-section separate placing booms, Schwing S 31 XT truck-mounted boom pump

### Going Up

Test pumping of the 14,000-psi mix assured the construction team that the mix could be placed at required volumes. The mix design includes: 300 pounds of cement, 70 pounds of fly ash, 475 pounds of slag, three-quarter inch nominal aggregate, three percent air, and a water/cement ratio of 0.3 average for the 14,000 psi which was used up to the third floor. Then the concrete strength requirement for the core was reduced to 12,000 psi up to the 35th floor, 10,000 psi to the 77th, and then 8,000 psi to the roof. The amount of cement in the mix met a LEED requirement set by the owners of the project.

The 14,000-psi concrete on the elevator shaft had a 160-degree Fahrenheit maximum temperature requirement on the inner wall with a maximum 30degree Fahrenheit differential on the outer surface. That meant pouring ice on the core wall to control the temperature differential due to the heat of hydration. The chilled concrete also provided some insurance against extended haul times through the two-mile Battery Tunnel underneath the East River which connects the batch plant on Long Island with Manhattan. Most trips average 30 minutes.

Collavino's 58-meter was supplemented by smaller booms operated by Our Rental Corporation of Long Island, long-time ACPA member, as construction accelerated on the five levels of below-grade concrete, culminating in 50,000 cubic yards being pumped by early 2010. "We are on schedule, but in retrospect, I believe we should have started with the form-mounted placing system we designed for the above-grade pours right from the start, because real estate is hard to come by when pumping from the street in New York," explained Renzo Collavino, president of the concrete firm. The above-grade placing



Below-grade pumping was handled by the Schwing S 58 SX with Super X outriggers, allowing a compact footprint and maximum reach of the 175-foot boom.

system is the result of collaboration among Schwing's staff, reaching all the way to the home office in Germany.

# **New York Style**

"We discussed the placing system with Mr. Schwing, his son, and representatives from Schwing America at the Bauma Fair," Collavino explained. The system they devised has provided high production, versatility and, through the help of the manufacturer's engineers, a material handling method for more than just the concrete. "This system works well with the New York style of high-rise construction, where the

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Twin SP 8800s painted especially for the project are located across the street from the structure with an underground pipeline system to the building.

steel is placed ahead of the core and decks, allowing us to place concrete on multiple levels simultaneously," stated Collavino. The placing system rides on two EFCO self-climbing form systems that are used to pour the dual 120-foot by 60-foot cores, including cells.

Pump placement is critical for ready mix access in downtown Manhattan. A site was chosen across the street from the building, with three pipelines running under the street and entering the building site one floor below grade. Two SP 8800 stationary pumps with Tier 3 Deutz 590 horsepower diesel engines are positioned under a temporary roof with dual chutes perpendicular to the hoppers. Truck mixers can be positioned on both sides of the pumps on ramps. The pumps feature high- and low-pressure settings, highpressure Rock Valves with dual shifting cylinders that provide piston side pressures up to 2,920 psi. Maximum output on the rod side is 123 cubic yards per hour at 31 strokes per minute.

### **Patriotic Pipelines**

The three pipelines—which are painted red, white and blue—are encased in a thrust block, making a 90-degree turn upward through the center of the building between the north and south elevator cores. Anchors are placed in the rising core to attach the pipeline sections. The five-inch ConForms<sup>®</sup> pipe is half-inch wall up to the 50th floor, at which point they will downsize to quarter-inch system.

Where the pipelines meet the forming system, one line is designated for the north core and the other for the south core. Each set of forms carries a fivesection separate placing boom that features a telescopic first section, providing 15 feet 11 inches of movement. A patented Auto-Scissors pipeline rotates to provide a continuous hard line during the telescopic process. The booms are mounted on octagonal masts, which are bolted to the climbing forms; they have 87 feet of horizontal reach from the slewing axis and can rotate 550 degrees. "Because the steel is always in the way of the pour, the versatility of these booms with 270-degree articulating fourth and fifth sections allow the crews to pour over and around obstacles," explained John Abbey, Collavino's supervisor of pumping.

The high-strength twin cores of the structure consume 325 tons of steel per 13 feet six inches lift below grade, 240 tons per lift up to the 20th floor, 145 tons per lift up to the 50th floor, 75 tons per lift to 75th floor, and 50 tons per lift to the roof. This massive requirement for reinforcement meant that a method of handling the rebar would have to be devised to keep up with the climbing form system and pumping combination. Collavino personnel asked the pump manufacturer's engineers if the same octagonal masts used for the separate placing boom mounting could be adapted for Fassi F800XP knuckle crane arms that would assist in handling the steel for the

cores. The engineers worked with Fassi personnel to devise a method, resulting in each climbing form system carrying a placing boom and a small crane. One of two tower cranes on the job offloads steel onto the decks, and the knuckle booms feed the steel into the forms. "The tower cranes drop steel when they can, and we take it from there with our Fassi cranes," commented Collavino.

Collavino crew's are maintaining one-week-per-floor cycles that consist of core pours Mondays and Fridays (1,000 yards); deck pours on Tuesdays (400 yards); and ring slabs (225 yards), which join the deck to the core walls, on Wednesdays and Thursdays. Stairwells and steps are poured with the system as well. The versatility of the "two pumptwo boom-two pipeline" system allows the cores to proceed at different rates. It also allows a deck to be poured at the same time a core pour is being accomplished at a different level. And both pumps can be devoted to one pour if necessary. The SP 8800's high-pressure setting is used to pour the high-strength mix at the upper levels and the high volume setting is used to pour the 4,000-psi deck mix. "We can be pouring on three floors in one day with the system," explains Abbey, "and we rely on our pumps because they must perform every day."



Metal deck forms are filled with a 4,000psi mix that is pumped utilizing the high volume setting on the pump.