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The Excavation: Planning, Precision and Pain

By JAMES GLANZ and ERIC LIPTON

Cranes crisscross against the skyline. Steel-treaded vehicles with scissorlike hands crawl up mounds of wreckage, snapping at twisted beams. Work crews lash cables to the tottering remains of a skyscraper, yanking and twisting, until pieces of the structure finally shiver and tear.

This is the end of a rescue operation and the beginning of something very different. The smoke has thinned at the World Trade Center site. The hope of survivors has dissipated. What remains is an excavation job, part demolition, part salvage, that has few parallels in American history.

Piece by piece, an army of laborers, ironworkers, demolition specialists, heavy equipment operators and engineers are clearing a 1.2-million-ton mountain of steel and concrete that used to be bustling office suites, a shopping center and a transportation depot. They also must recover any remains of the thousands who died there.

The operation, a $100-million-a-week exercise, relies on a combination of disciplined crews, hard-nosed engineering and much improvisation. Everything is open for consideration: sledgehammers were taken to the remains of a granite statue in the World Trade Center plaza to build the base for a crane that would be used to lift wreckage; steel from the wreckage itself is being jury-rigged into construction tools.

Like a postwar cleanup, the operation has a decidedly military quality.

More than 1,000 workers are divided into four quadrants, with more than 150 pieces of heavy equipment available, like the Caterpillar 345 Ultra High excavator, a giant device brought in from Illinois that has 80-foot-long arms with shears that can slice through steel beams. Flatbed trucks and barges stand ready to cart debris. A dozen governmental agencies are involved, as well as the city's largest construction companies, all under the strict command of the city's Office of Emergency Management.

The site, with the giant earth-moving machines rumbling back and forth, the debris piles that reach six stories into the sky, and the 20 cranes that tower toward the clouds, is one that seems superhuman in scale. But nothing here at ground zero gets done without human labor.

It is a task that is already taking its toll, physically and emotionally. Some workers' blood and lung tests have been supplemented by psychological counseling. Every step is carefully choreographed, with daily attack plans for each quadrant ironed out at evening staff meetings and the work orders that cover the next 24-hour period distributed at morning sessions that are held in a nearby public school.

All of this precision is critical, as the task at hand is much more complicated than just clearing a mountain of rubble.

The timeline will depend a great deal on the condition of an underground retaining wall that encircles much of the site, holding back the waters of the Hudson River, engineers said. The wall could be compromised without proper precautions. Empty pockets within the wreckage must also be identified and mapped out as pieces above are pulled out to prevent catastrophic cave-ins that could swallow up people and machines.

And everything, of course, must come to a stop at unpredictable intervals, as a beam is pulled up and human remains suddenly surface. Firefighters descend and the bodies or body parts are swiftly recovered.

Dr. Paul Fussell, a historian and author of "The Great War and Modern Memory" (Oxford University Press, 1975), compared the task in Lower Manhattan to the devastation in Europe and the Soviet Union at the close of World War II. Stalingrad, in particular, came to mind. "They thought about it for a long time and decided to sweep it all together and make a hill out of it," he said of the remains of the Russian city.

The plan here, of course, is far different. A round-the-clock effort is under way at the southern tip of Manhattan to, as much as is humanly possible, cleanse the soil.

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How long it all might take has been estimated as anywhere from six months to a year and a half, said Dan Hahn, an engineer at Mueser Rutledge. He admitted, though, that even that range was no better than, in the slightly cleaned-up parlance that construction workers often use, a wild guess.

The Morning Meeting

"The greatest excavation job in city history is being coordinated out of the second floor of Public School/ Intermediate School 89, just north of ground zero. Boxes filled with hard hats, goggles and respirators are stacked in an entrance hallway, next to a "Where's Waldo?" book left behind by schoolchildren.

Each day at 9 a.m., the engineers, fire department chiefs, federal emergency response coordinators and representatives from a collection of other city agencies, from sanitation to transportation, pack into a classroom. Michael J. Burton, the executive deputy commissioner of the city's Department of Design and Construction, presides.

In the room are the top officials from the four contractors that are doing the heavy work in each of four quadrants mapped on the site: Bovis Lend Lease, Amec Construction Management, Turner Construction Company and Tully Construction Company. They all have extensive and impressive accomplishments in building: Euro Disney to the International Arrivals Terminal at Kennedy Airport.

By the time the morning meeting convenes, a game plan has already, to a large extent, been worked out. Mr. Burton, consulting with engineers and others, has examined aerial maps of progress from the day before and infrared maps that track the shifting locations of remaining fires.

Daily plans of action for the four quadrants are then laid out. The collection of talent is remarkable, but so far the egos have been suppressed. The participants say the meetings, driven by the awesome challenge sitting just beyond the school's playground, have been sharp, the disputes limited.

"Any issue that might come up, any question can be answered right there on the spot," said Daniel A. Cuoco, a managing principal at LZA/ Thornton-Tomasetti, one of the engineering companies: "It is boom, boom, boom, one topic after another. There is nothing at all superfluous."

From the day after the attack, the first assignment was obvious: clear access to the site for rescue workers and then clear space for the heavy machinery.

Through Tuesday, 115,000 tons of debris had already been cleared, everything from airplane parts to steel girders. Immense nets were dragged across the fronts of nearby buildings to prevent broken glass from snapping off and being carried by the wind into the demolition site.

Now, as the search for survivors winds down, the focus has turned to clearing some of the remaining structures from the site. The implosion of the two 110-story towers was so complete that the 1,350-foot-tall buildings crumbled into piles that reach no higher than 60 feet. But slivers of the skyscrapers survived, as did much larger sections of the surrounding buildings, 4, 5 and 6 World Trade Center.

Starting on Tuesday, crews turned to the now globally recognized piece of 2 World Trade Center, a Gothic-looking shard of steel that reaches 150 feet into the sky, as well as 80 feet into the ground, a piece some have suggested should be preserved as a memorial.

Demolition consultants examined a variety of options for bringing this piece down: planting small explosives; sending a worker to the top with a crane and cutting it down, piece by piece; or using giant excavators, with cables lashed around the structure, to yank it to the ground.

After reviewing the safety and speed of the options, they opted for the giant excavators. On Tuesday, shortly after 5 p.m., workers and emergency personnel were pulled away and the excavators started to yank back and forth. The steel swayed, slowly. But it did not break. Again and again came more pulling, yet the steel merely bent. Nearly a half-hour after this job started, the steel suddenly began to twist and crack. Debris flew into the air, the beams pivoted and then snapped. A plume of dust again rose into the air, as falling pieces hit the ground. But most of the steel remained, waiting for a second assault.

Ingenuity With Cranes

Of all the engineering challenges tackled at the site so far, the greatest, and most critical, was finding a way to safely find and anchor the giant cranes that would then begin the sad but impressive work of removing the largest pieces of the center's shattered remains.

The task, simple to state, but deeply risky to execute, was to find a way to position the cranes so they could reach far enough over the wreckage to do significant work, but somehow not create too much pressure on the ground on which the cranes sat. Underneath the site was the man-made wall, built deep in the center's foundation to keep out the Hudson River, that is called the "slurry wall."

"They asked us to give them a method of putting cranes around the site so that they do not collapse the slurry wall," Mr. Hahn said.

Some ingenuity ultimately provided the crane operators with the reach they wanted. Using steel beams from the wreckage itself, engineers built a submerged platform about 30 feet back from the retaining wall, placed another beam directly on top of it and ran a sort of steel bridge between the platform and the wall. One of the firms, Amec, then drove its largest crane, capable of lifting 500 tons of steel, onto the bridge.

Of course, not all of the engineering at the site is of the seat-of-the-pants variety. A computerized system keeps track of the positions, weights and reach of all the cranes on the site, and engineers are using sophisticated detection systems flown on planes and helicopters to keep track of everything from the warmth of the ground to its changing topography.

Beneath the surface, like astronauts exploring an unfamiliar planet, engineers are mapping the smashed geography of the basement that ran beneath nearly the entire complex.

The six concrete floors of the basement held up the slurry wall before the terrorist attacks. In some places, engineers said, they believe that only debris now holds it up. So construction crews must remove the debris with exquisite care, bracing the wall as they go.

Emotional Toil in the Rubble

The work proceeds each day according to the regimented plans. Remove one wrong beam, and an entire sector could cave in. Pull up the wrong pile of debris and flames shoot up. But it can be much worse: at any moment, workers can come across human remains.

"On the site, there are times when

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you are just doing work; it's almost like a normal job," said Leo DiRubbo, a senior vice president at Amec. "Then you uncover bodies, and it kind of brings you back to realize why you're there."

Hazards are at nearly every turn. The crews stand in slivers of glass and twisted steel, air that is filled with dust and smoke. No one involved in the cleanup effort so far has been seriously injured, said Kenneth Holden, commissioner of the city's Department of Design and Construction.

At least some of the workers are getting baseline blood screenings and pulmonary checks to keep track of any less-than-visible possible harm. The borders of ground zero are also lined with eye, face, body and clothing wash stations, as well as high-pressure hoses to remove dirt, and any possible contaminants, caked on trucks.

But there is no shortage of pain, and the supervisors and laborers say it tends to come in the more private moments. One official stops for a cigarette and breaks down. Another begins to sob as he drives home. Yet another supervisor, who has been screening his calls from friends, accidentally picks up a cell phone call from one of them as he works on the site. He loses his composure.

"I just had to walk away to get myself back together," said Leon Heyward, deputy commissioner of the Department of Transportation, which has 24 dump trucks and eight flatbed trucks carrying debris from the site.

Deputy Fire Commissioner Thomas Fitzpatrick has a technique that is sustaining him. Every truck of rubble, every piece of steel cleared, every victim recovered — he insists they be regarded as progress. Ultimately, he added, the city will have something it really needs: a sprawling foundation for what could become the next World Trade Center.

"As people see this thing coming back, as awesome as the tragedy was, I think they will be assured about our strength," Mr. Fitzpatrick said. "Progress begets confidence."

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