# TOWER CRANES

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| Effective: | May 2, 2025 |
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| Approved: | Fire Chief Mike Kennedy |

## I. PURPOSE

With significant vertical growth occurring throughout the City of Ann Arbor, there is a continual use of tower cranes at construction sites. This procedure and associated material from the Fire Department of New York (FDNY) is intended to educate members on tower crane incidents.

## II. DEFINITIONS

Base - A reinforced concrete pad or grillage, constructed on site, to which the mast / tower is connected. The mast/tower can also be welded or bolted to a steel base structure, the existing building or a cantilever structure.

Mast / tower - The vertical steel framework made of individual sections bolted or pinned together that the crane superstructure rotates on and are added as required to get to the desired height.

Operator's cab - Where the crane operator controls the crane's operation. To access the cab, the operator must climb a ladder in the mast/tower from ground level or access a catwalk higher in the building and climb a shorter distance via the mast / tower ladder.

Jib - As related to a tower crane, the fixed or luffing structure that supports the load. A similar and more familiar term might be "boom," which is used for a crawler crane. A boom moves up and down, similar to a luffing jib. Construction personnel may refer to all of the various jibs as simply "the jib."

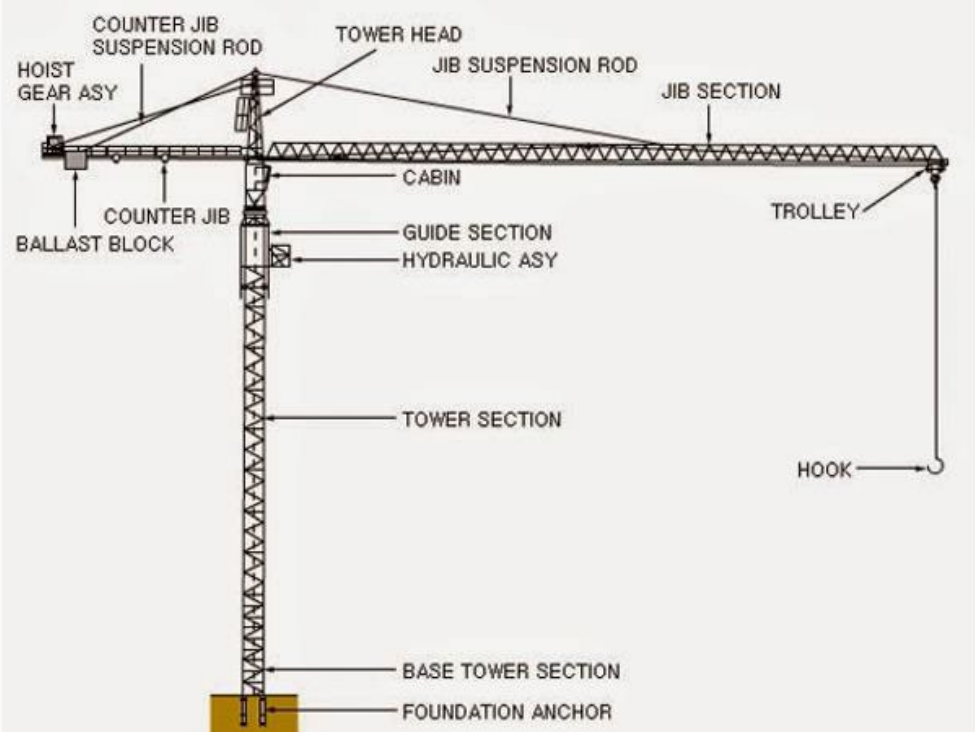
Hammerhead tower crane – Has a long horizontal jib that cannot move up or down. It has a trolley system built into it to move the location of the cable and hook for lifting and moving loads.

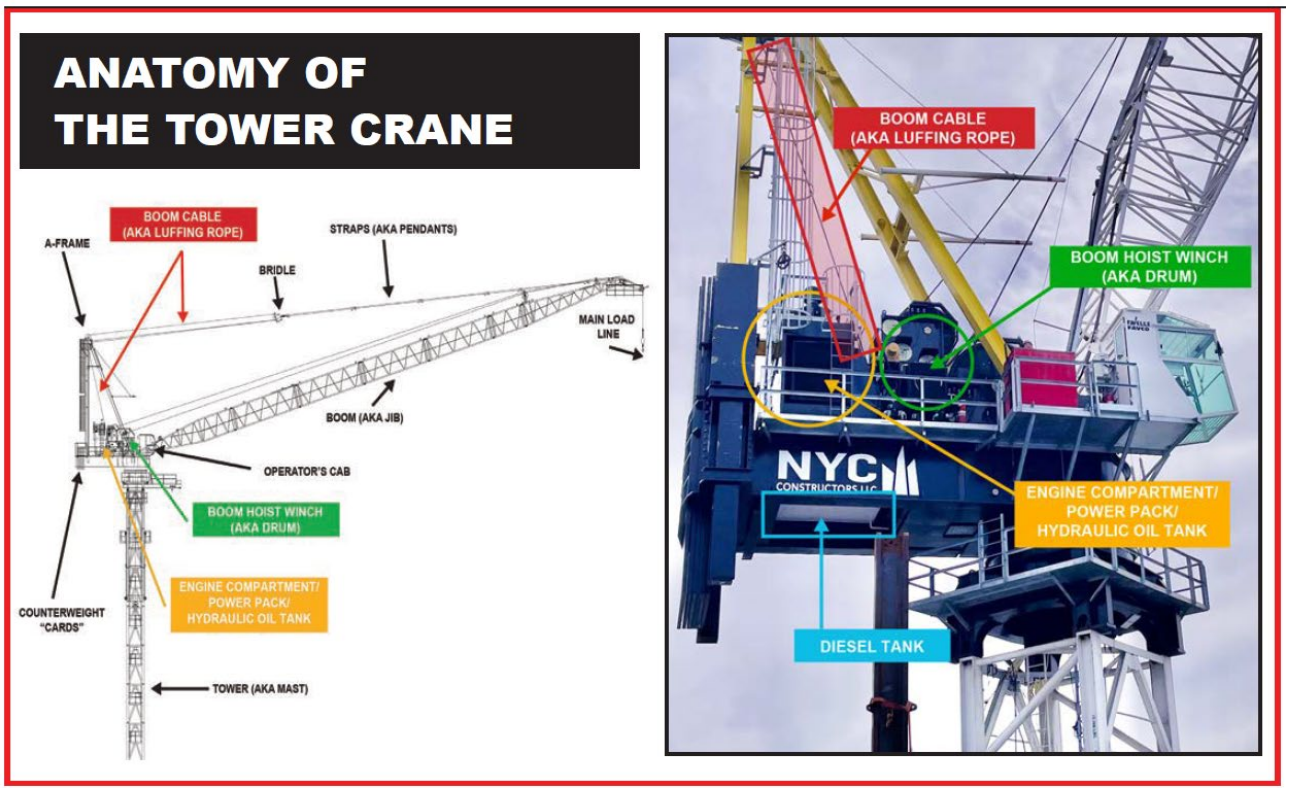
Luffing jib tower crane - Has the capability to move the jib up and down to lift and move loads.

Counter jib - The jib opposite the working jib used to offset the weight being lifted. Concrete slabs can be added to act as counterweights.

Tie-backs - Steel components that provide additional stability to the mast/tower by connecting it to the building at different floor levels.

## Anatomy of a Tower Crane



## III. BACKGROUND

Tower cranes (also known as sky cranes) can reach from 86' to 262' in height; when attached to a building, they can be more than 400' in height. Operators of these cranes work in a booth or cab located at or near the top of the crane. If they require medical assistance or rescue, access is via ladders.

There are two key personnel in tower crane operations: the operator and the bellman. The operator works in the cab and, due to the height and energy required to make the climb, they often stay in the cab their entire shift. The bellman works below and serves as the operator's eyes for the operation.

Ask the site foreman or site safety person what type of work is being done at the site. Shut down any equipment that will interfere with the operation and safety.

The bellman can tell the crane's height and distance from the departure point to the ground, and if there is an auxiliary winch that can be used to haul equipment up to the machine deck.

## IV. RESCUES

For non-fire emergencies requiring the rescue of the crane operator or other personnel from height, the Washtenaw County Technical Rescue Team shall be immediately requested in addition to a first alarm assignment.

## V. FIRES

Please reference attached article from FDNY on tower crane fires. Some operational points are below.

- All initial efforts should be directed toward evacuating construction workers and civilians from the hazardous area and setting up a collapse zone.
- Apparatus should park well away from the collapse zone, gaining access to the fire building on side streets only if it is safe to do so.
- Firefighting efforts should be a secondary priority after people are evacuated, as it is unlikely that forces will be able to establish an effective water stream quickly enough to prevent the failure of the boom cable or main load line. The use of the outer stream tip of portable master streams increases the reach of the stream for fire extinguishment.
- If and when the boom collapses, assessing the tie-ins and collars of the remaining tower crane should be a high priority.
- Be aware of falling debris throughout the incident. Ensure that appropriate PPE is used including helmets.
- Overload the response early on to stay ahead of the incident; this is completed through the prompt transmission of additional alarms.

## VI. HOIST RESCUE – UNITED STATES COAST GUARD

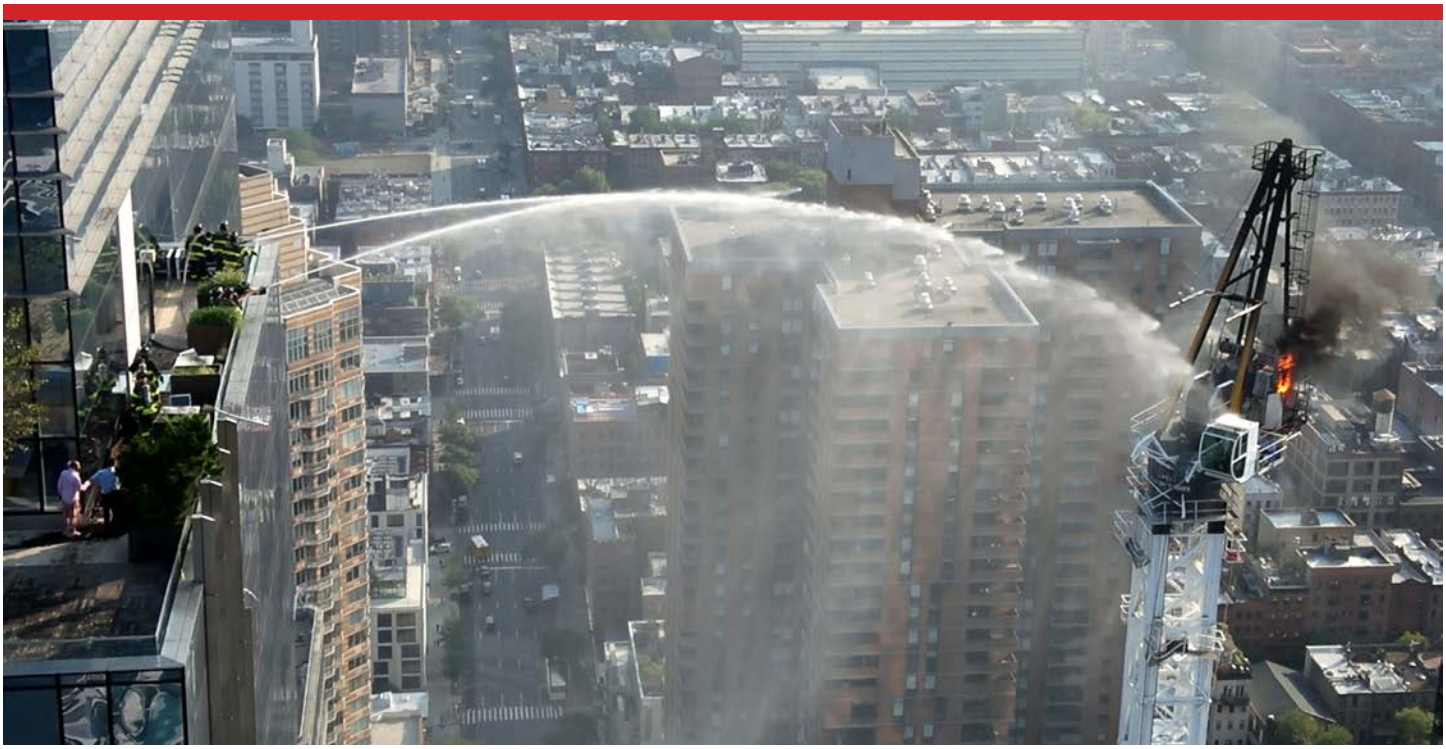
In the event a crane operator is trapped by fire and ground rescue is not feasible, a request shall be made to the US Coast Guard. US Coast Guard Air Station Detroit is located on the Selfridge Air National Guard base. Air Station Detroit is dispatched from the Ninth District Command Center 1-800-321-4400.

The USCG will not provide a standing agreement to do a hoist rescue. However, if the incident commander or other senior officer calls with a person trapped and no other options, there is a good chance they will come.

Radio communication can be made with the air crew via the following MPSCS talkgroups. These are in the Statewide E zone on all radios.
Air LZ 1
Air LZ 2
USCG Aviation 1
USCG Aviation 2

# OPERATIONAL CASE STUDY: TOWER CRANE FIRE AND COLLAPSE ON 10TH AVENUE

By Battalion Chief Jason Cascone and Battalion Chief Devon Maguire



*Companies initially attacked the fire from the patio of a luxury high-rise building at 555 10th Ave., directly across the street from the building under construction. (Photo by the Command Tactical Unit)*

The FDNY has a large body of institutional knowledge concerning the collapse of burning buildings. As part of the promotional exam process, nearly every experienced officer and chief has read Deputy Chief Vincent Dunn's important work, "Collapse of Burning Buildings," and Francis L. Brannigan's "Building Construction for the Fire Service."

But the FDNY has relatively few members who are proficient in crane operations and rigging. As for "Collapse of Burning Cranes," the book has yet to be written. So, when a Favelle Favco M440D tower crane's 180-foot boom came crashing down onto 10th Avenue only four minutes after the signal 10-75 had been transmitted for a crane fire, virtually none of the FDNY members on the scene expected it. The FDNY, in fact, learned a new lesson: A serious fire affecting any of the rigging components on the machine deck of a tower crane constitutes an imminent collapse hazard.

## THE RESPONSE

July 26, 2023, was a typical midsummer Wednesday morning in Midtown Manhattan as units were taking up from a Class-3 alarm at the Russian Tea Room, an iconic restaurant on 57th Street, just before 0730 hours. As Battalion 9 made a U-turn on 57th Street, another run came over the MDT. Battalion Chief Anthony Pascocello read the ticket, noting the nature of the call: "crane fire." Despite being an experienced chief who had spent a good portion of his career in Manhattan—including Squad 18—he had never seen a serious crane fire. He figured maybe it was a small "knuckle-boom crane" that had overheated while delivering sheetrock or building materials.

As Battalion 9 drove south on 7th Avenue, they received an updated address from the dispatcher of W. 41st Street and 10th Avenue. Then he read the Critical Information Dispatch System (CIDS) information, which indicated a zero-story excavation site. As they made the turn onto W. 41st Street, Pascocello looked up and saw that, indeed, there was a crane on fire with smoke and flames emanating skyward. It was also clear that a large building under construction now stood in the excavation site described in the CIDS, rendering the CIDS information obsolete. From this vantage point, Pascocello transmitted a signal 10-75 from two avenues east of the incident. "I figured that was a good signal to start us off, to see how things were progressing once I arrived," he said.

It was quite a sight. As the first-alarm units arrived at the scene, they encountered a 44-story building under construc-

tion at 550 10th Ave., on the east side of 10th Avenue spanning the block from W. 40th Street to W. 41st Street. The building under construction was clad with orange construction netting protecting the outer perimeter of the top three quarters of the building. The lower quarter of the building had a finished façade and new glass windows.

At the exposure 1/2 corner of the building, a Favelle Favco M440D tower crane soared majestically high above the top working floor of the building. It was constructed on the outside of the building, with horizontal steel brace struts, called "tie-ins" or "tie-backs," securing the crane to the building with a heavy steel "collar" that wrapped around the vertical tower sections every several floors. The white tower, or "mast," looked sleek and thin against the backdrop of the enormous building. It appeared that the crane's operating engineers had recently "jumped" the crane—a process whereby crane engineers raise the height of the crane in order to keep pace with the building's increasing elevation, leapfrogging ahead a few floors at a time as additional concrete floors are poured—because the machine deck was approximately 75 feet above the top working floor of the building.

From the machine deck at the top of the crane's tower, orange flames roared from the engine compartment, and a huge plume of heavy, black smoke filled the clear, blue sky.

## INITIAL OPERATIONS

Still responding in Battalion 9's vehicle as he assessed the situation, Pascocello's first concern was how to get water on the fire. The height of the platform above the top working floor would make it difficult for Fire Department hose streams to reach the burning engine compartment, even with a master stream.

Pascocello quickly considered the building across the street at 555 10th Ave. (exposure 1). This was a modern luxury high-rise multiple dwelling that was fully occupied, which meant it should provide safe, easy access to the upper floors using the building's elevators. He also figured the standpipe was likely to be a wet system in good working order.

Conversely, the building under construction (the fire building) would have no working elevators, other than the construction hoists. Also, the standpipe would be dry and filled with air, requiring members to bleed the air from the system.

"If it was dry, it was going to take us a long reflex time to try to get water there," said Pascocello.

He decided 555 10th Ave. was the best option to safely get quick water on the fire. He radioed Engine 54 to enter 555 10th Ave. and find a suitable area from which to attack the fire, either the roof or an upper floor. He also ordered 54 to bring their mini Akron monitor, a small master stream the company had piloted years earlier and retained on their rig.

## SIZING UP THE COLLAPSE POTENTIAL

Pascocello could see the crane, but he wasn't sure how long it would stay there.

"I had immediately, when I gave the 10-75, anticipated a possible collapse," he said. "So, I had told the dispatcher to have a high-ranking PD official, a lieutenant or higher, meet me at the command post, because I felt that there was a potential collapse zone and that we were going to have to initiate an evacuation area."

But despite being mindful of the collapse potential, he didn't consider it an imminent threat. "My anticipation for collapse was in the 20- to 60-minute range," said Pascocello. "I figured we had that much time."

He began mentally planning an offensive fire attack, but before Pascocello could implement the plan, things went totally sideways.

## THE COLLAPSE

Just as Battalion 9 approached the intersection of W. 41 Street and 10th Avenue, the skyline suddenly became dark. Pascocello saw people running and screaming. He heard a roar and started feeling debris hit the battalion vehicle. He hurriedly told his aide, "Turn right, turn right." He thought

*The moment the boom cable snapped, smashing the boom into the building across the street, then into the building under construction before crashing to the street below. The collapse debris struck FDNY responding vehicles. (Stills from video by Jimmy Farrington)*

the entire tower crane was coming down. Pencils flew out of their holder on the visor of the car as Battalion 9 swerved onto 10th Avenue, speeding north in an effort to evade the collapse.

"My thought was that this was not going to go well—that we were potentially going to be, you know, injured or worse," he said.

Then he heard a gigantic crash.

## INJURED MEMBER

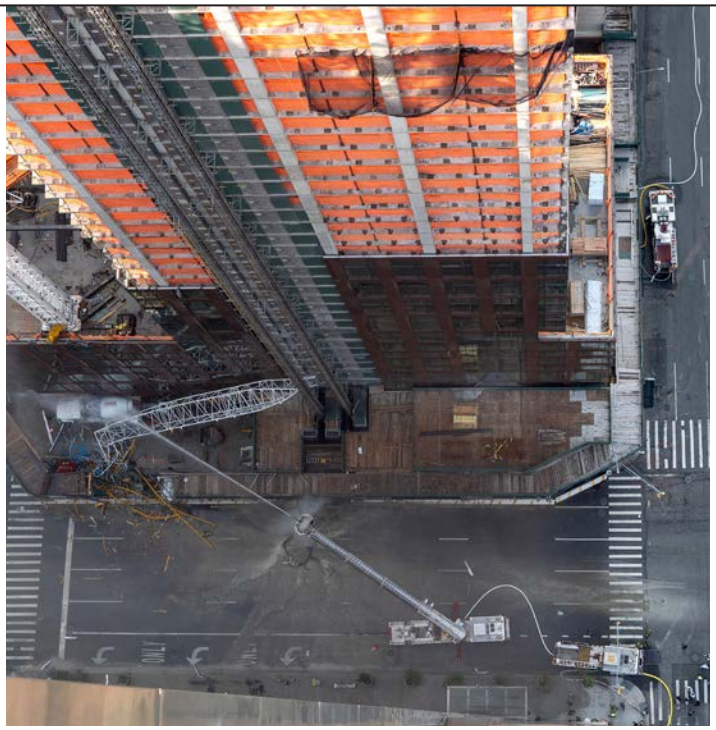
Meanwhile, numerous FDNY members from various units had already arrived on the scene and entered the building under construction. Members of Engine 34, Ladder 21, Ladder 4 and Rescue 1 were in various positions within the ground-floor area. Some had been consulting construction workers about the hoist and standpipe system, while others were seeking a stairway to the upper floors when the thundering collapse came. One member was struck with debris or shrapnel, causing serious injuries to his leg. Multiple mayday transmissions were made, and members assisted the injured firefighter out of the building. Everyone was rattled. Some of the senior members were reminded of the collapses of the World Trade Center.

## BATTLE DAMAGE ASSESSMENT

In the immediate aftermath, Pascocello assessed the damage.

The crane had been lifting a large bucket filled with 16,000 pounds of wet concrete. The bucket landed in the middle of 10th Avenue, splattering its contents in all directions and covering the street. But it didn't appear that anyone had been hit.

The construction workers who were evacuating the building deserve tremendous credit: On their way out, they quickly closed 10th Avenue, clearing the area below the crane and preventing vehicles and pedestrians from entering the hazardous area. This heroic action undoubtedly saved civilian lives.

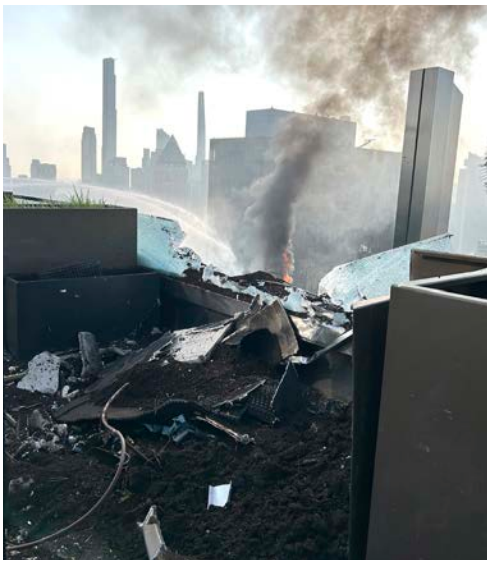


*The boom crash sparked a small fire in the collapse wreckage, which Ladder 12 extinguished by extending their unattended tower ladder bucket.*

In addition to the concrete load, there were also pieces of building debris from 555 10th Ave. (exposure 1) scattered in the street. When the boom fell, its tip struck the exposure 1 building, first impacting a narrow roof deck that contained lawn furniture and planters full of dirt and plants. Then it scraped the outside of the gleaming residential building on its way down, slicing through the windows of the occupied apartments on the top two floors. Investigators later found a piece of the boom inside one of the apartments.

The massive boom then swung down like a pendulum, crashed against the building under construction and fell straight down. One end of the 180-foot boom came to rest against the side of the building, supported by one of the two

*A large bucket filled with 16,000 lbs. of wet concrete landed in the middle of 10th Ave., splattering its contents in all directions and covering the street. The mangled tip of the collapsed boom lies crumpled in the background.*



*Damage caused by the falling boom as its tip smashed into a roof deck in the building across the street.*

construction hoists that was attached to the exterior of the building. The hoist was used by workers to reach the upper floors of the work site. The way the crane landed dictated how the members would ultimately reach the fire: It would render both hoist cars out of service, nullifying elevator access to the top working floor.

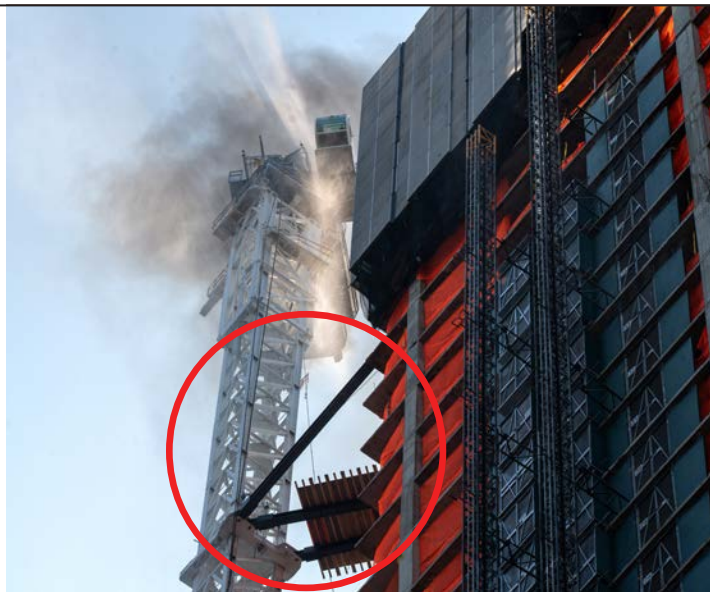
The other end of the boom struck a concrete-mixer truck, which was near a fuel tank containing 500 gallons of diesel fuel. This tank was used to refuel the crane. The great crash sparked a small fire in the collapse wreckage. Ladder 12 would ultimately extinguish the fire using their unattended tower ladder bucket.

## TIE-INS AND COLLARS INTACT

Perhaps one of the most important command factors determining the scope and consequences of the collapse was the condition of the crane's steel tie-ins and collars, which were attaching the vertical tower to the building. These crane components had been central to a previous crane accident on March 15, 2008, when an entire Favco tower crane detached from a building at 303 E. 51st St. in Manhattan. In this case, an improperly secured tie-in collar dropped from the 18th floor while workers were jumping the crane. The collar slid straight down the vertical tower, hitting another collar below at the ninth floor. It, too, was dislodged, and both collars dropped to the third floor, along with the brace struts. With nothing supporting it, the tower crane toppled over, damaging several other buildings, destroying a town house and killing seven people.

At 555 10th Ave., the horizontal steel brace-strut tie-ins appeared to be undamaged, and the collars looked secure. Soon after, the site safety manager and the crane operator, who were summoned to the incident command post, were able to reaffirm that judgment.

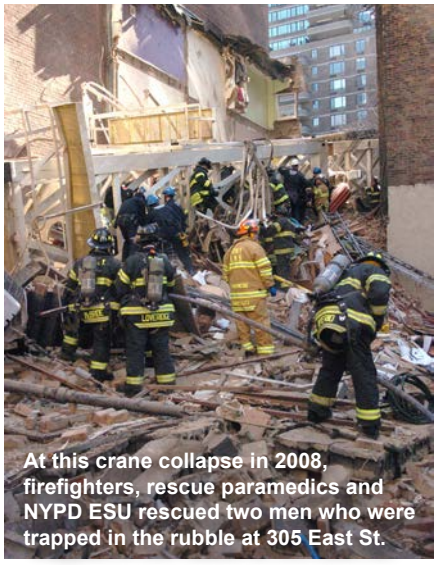
If the tie-ins or collars had been damaged, this would mean that the entire tower could be in jeopardy of a secondary collapse. The effects of a tower collapse would be catastrophic, as the Favelle Favco crane weighed hundreds of thousands of pounds and was roughly 500 feet tall. The counterweights alone weighed about 86,000 pounds. Located on the rear section of the machine deck at the top of the tower, the counterweights were making the remaining tower crane abnormally off balance given that the boom had fallen. To complicate matters, the counterweights are made up of a series of steel plates (a.k.a. "cards") that are predominantly held in place by gravity, meaning they would likely be ejected if the tower were to topple over. But, fortunately, at 550 10th Ave., the tie-ins and collars appeared to be unaffected by the boom collapse—they looked secure. FDNY members now perceived a measure of security with respect to the stability of the remaining tower.



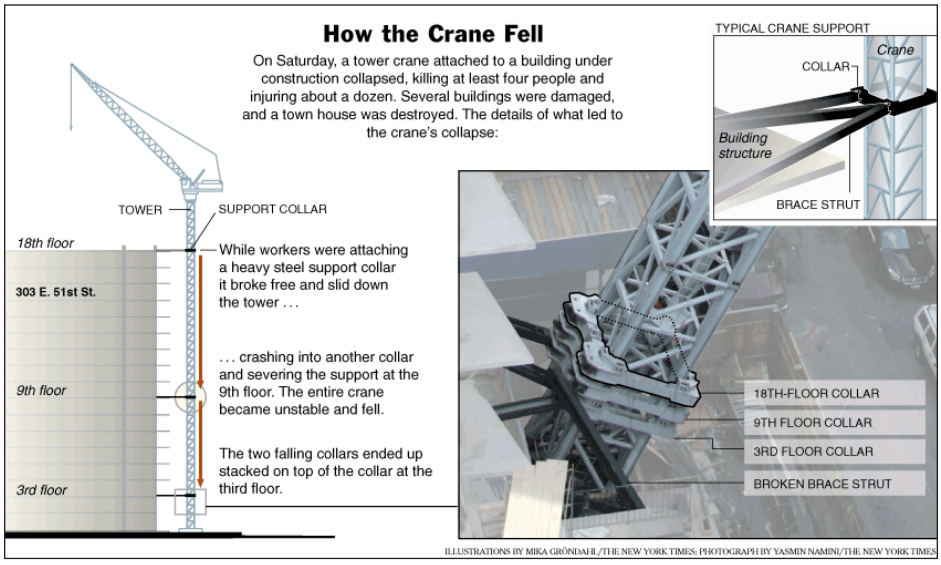
*The horizontal steel brace struts (a.k.a. tie-ins) and collars that connect the crane to building remained secure after the collapse.*

## DEADLY CRANE COLLAPSE - MARCH 15, 2008

**303 E. 51st St., Manhattan**



**At this crane collapse in 2008, firefighters, rescue paramedics and NYPD ESU rescued two men who were trapped in the rubble at 305 East St.**



Despite being rattled by the near miss, FDNY members soon realized they were lucky in the sense that nobody—neither civilians, construction workers nor members—had been crushed by the falling boom, building wreckage or 16,000-pound concrete load. Collapse debris had struck at least two FDNY vehicles, including Battalion 9 and Rescue 1, and one FDNY member had been injured. Yet, miraculously, nobody was killed in the collapse.

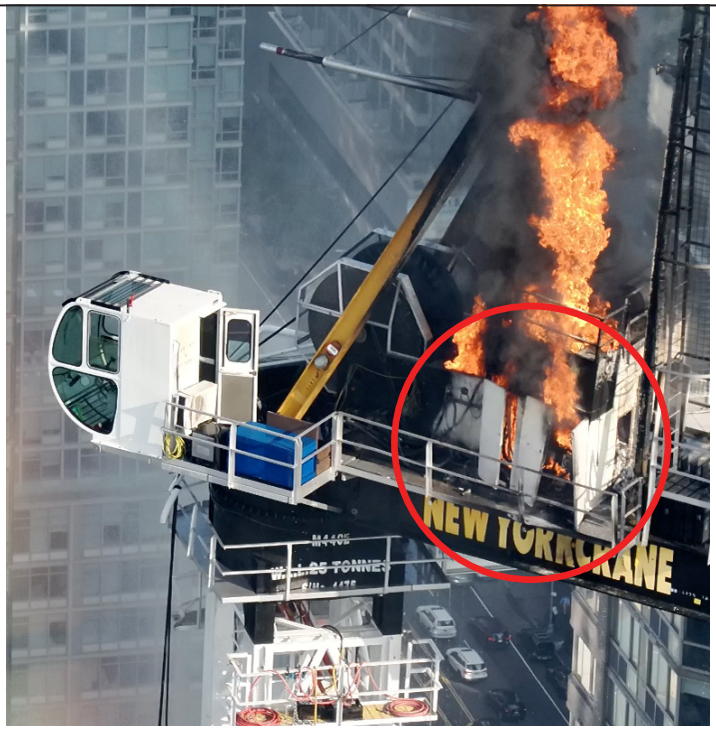
## FIREFIGHTING OPERATIONS

Notwithstanding the fact that they had narrowly avoided being killed by a crane collapse, FDNY members continued to advance. There would be no shortage of obstacles.

With heavy fire roaring on the machine deck of the tower crane, there were now two separate sectors from which FDNY members simultaneously attempted to establish water streams: one in the building under construction at 550 10th Ave. (the fire building), and the other across the street at 555 10th Ave. (exposure 1). The struggle to extinguish the fire would center mainly on the height of the machine deck above the fire building's top working floor, and the width of 10th Avenue between the fire building and exposure 1. This fire would be very hard to reach.

Even so, the fire situation could have been much worse. The engine compartment fire was being fed by a roughly 250-gallon tank full of combustible hydraulic oil, which sat directly on top of the engine compartment. The only good news was that the diesel fuel tank, which could hold 500 to 700 gallons of fuel, was not involved in the fire. The diesel tank sat below the machine deck, underneath the diesel engine power pack. At no point would the fire involve any diesel fuel within the tank.

In the fire building, members knew they needed to get to the top working floor of the building. But Engine 34, Rescue 1 and Battalion 7 had decided that using the construction hoist was not going to be an option. One of the construction hoist masts had been damaged by the falling boom and was showing signs of visible deflection. But even using the parallel hoist, which hadn't actually been hit by the boom, seemed sketchy.



*The hard-to-reach fire, fed by the combustible hydraulic oil tank on top of the engine compartment, roars from the machine deck of the tower crane. (Photo by the Command Tactical Unit)*

The result was, of course, that FDNY members would now have to climb the interior stairs to the top working floor on foot, carrying their hose and equipment. Indeed, they would also soon learn that the top several floors had no stairs at all. Members would need to climb ladders to ascend from floor to floor. All of this would take a considerable amount of time, as members regrouped every five to ten floors.

At the same time, members of Engine 54, Engine 26 and Squad 18 had already gained access to the roof deck of exposure 1 and placed their mini Akron in operation. However, they had had the luxury of using regular elevators and a normal standpipe system. Soon, an additional 2 ½-inch hoseline was in operation as well. After adding an outer-stream tip to the nozzle, the Akron was just able to reach the machine deck of the crane, producing some visible steam and white smoke as water spray hit the hot metal. The water stream succeeded in diminishing some of the fire, but the seat of the fire was deep inside a large metal engine-compartment cabinet—and the cabinet doors, which were partially open, were facing the side opposite the hose stream. To reach the fire inside the open cabinet doors, a water stream would be needed from the top working floor of the fire building.


*Left to right, DC Christopher Paolicelli, BC John Flatley, AC Michael Ajello, DAC Brian Gorman and BC Anthony Pascocello discuss the deployment of units and establishing the collapse zone.*

Gradually, members made progress in the fire building. Before long, members of Engine 34, Engine 65, Ladder 4, Rescue 1, Squad 288

and Battalion 8 reached the top working floor, with open sky above them. The formwork below their feet constituted the 44th floor. But the standpipe had been capped at the 41st floor, three floors below the top working floor. The building's staircase terminated on 41 as well. From there, wooden construction ladders—made of two-by-fours with rungs in two-foot intervals—had been built to access the upper three floors.

The wooden ladders had been placed over an elevator shaft that went all the way to the bottom, making this an unattractive option. As an alternative, construction workers had also placed metal portable ladders from floor to floor within 2-foot holes that had been cut in the concrete. Although the elevator shaft would have been a shorter stretch, the portable ladders were clearly safer—so members stretched five lengths of hose up the portable ladders.

Once the line reached the top working floor, members needed to navigate a rebar mat. This consisted of a gridwork of steel rebar to reinforce the concrete floor that was being poured. The rebar had been placed on hangers several inches above the plywood formwork, making it difficult to walk on the floor. To create a safer working platform, members of Rescue 1 located sheets of plywood and laid them over the rebar mat. This made it much easier and safer to operate.

As an additional safety measure, members of Squad 288 and Rescue 1 used a 300-foot length of rope, tying off to a substantial object to create a safety line with butterfly knots every few feet that members could clip into with their personal harnesses. Difficult as it was to operate in this environment, Engine 34 was finally able to establish a 2 ½-inch hoseline.

But the water stream was inadequate. With Engine 34's control firefighter reporting 50 psi at the outlet, the stream wasn't even close to reaching the crane's machine deck, even with an outer-stream tip. And Engine 3's chauffeur, who was connected to the building's fire department connection (FDC) at street level, was reporting that his discharge pressure was at its absolute limit—the rig was screaming. Engine 3 is a conventional pumper, not a high pressure or third-stage pumper, so he could not provide any additional pressure.

*Firefighters attacked the fire using Engine 54's mini Akron from a balcony in the building across the street.*

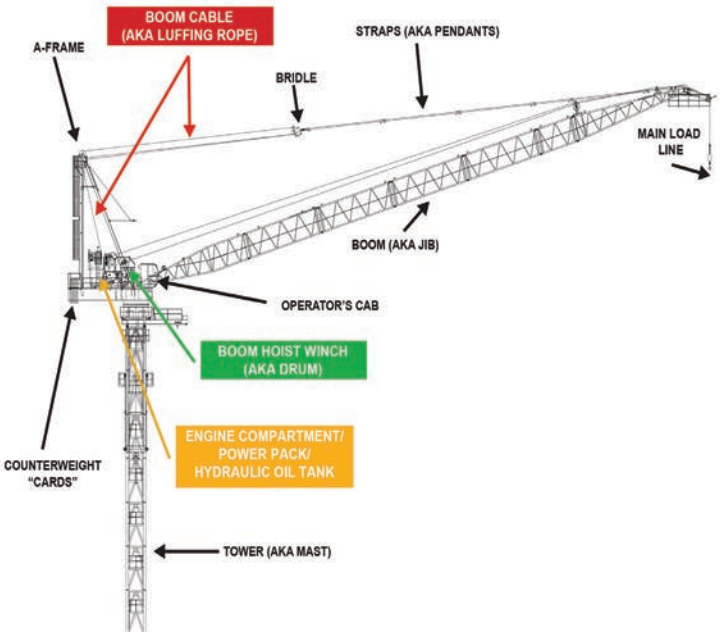
*After a challenging climb to the top floor, units augmented Engine 34's 2 ½-inch hoseline with Engine 54's third-stage pumper to reach the fire and extinguish the flames 75 feet above them.*

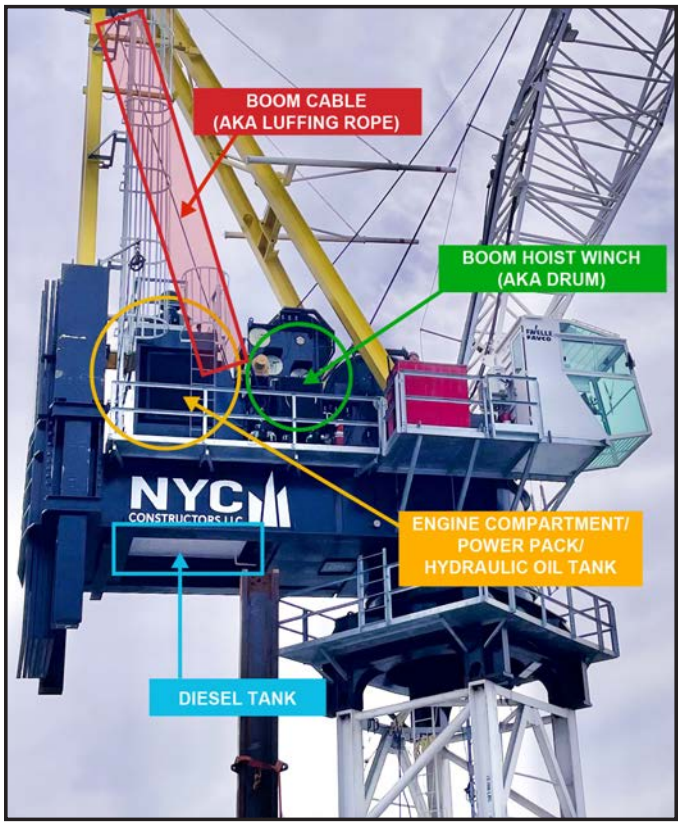
The solution was to have Engine 54 augment the system. Unlike Engine 3, Engine 54 is a high-pressure pumper with third-stage capabilities, allowing it to deliver up to 500 gpm at 700 psi. As Engine 54 throttled up, Engine 34's 2 ½-inch hoseline gained the additional pressure it needed to reach the burning tower crane's machine deck. This allowed the FDNY to finally extinguish the last flames within the engine compartment.

## WHY DID THE BOOM COLLAPSE? THE ANATOMY OF A TOWER CRANE FIRE AND COLLAPSE

While the exact cause of the tower crane fire and collapse at 550 10th Ave. is still being investigated by the NYC Department of Buildings (DOB), the visual evidence, historical precedent and detailed accounts from operating engineers within the crane industry all suggest that a combination of mechanical component failures and tightly coupled systems allowed a fire in the crane's engine compartment to interact with the

## ANATOMY OF THE TOWER CRANE




crane's boom cable, leading to a catastrophic collapse of the boom.

To grasp how this complex accident happened, it helps to understand the basics of tower-crane construction. The tower crane's engine compartment sits alongside the crane operator's cabin on the machine deck, which is perched high atop the vertical tower reaching hundreds of feet into the sky. Within the engine compartment, there are two main systems that are tightly coupled together. First, there is a hydraulic "power pack," which provides the enormous lifting force that hauls heavy loads—like a 16,000-pound bucket of concrete—on the main load line. And second, there is a large diesel engine that provides overall power to the crane. This diesel engine is roughly equivalent to the engine in an 18-wheeler tractor-trailer.

Next, it is important to understand the basics of the crane's rigging system. Directly above the engine compartment, an A-frame assembly of steel "I" beams supports a network of sheaves and pullies. Below the A-frame and next to the engine compartment, a boom-hoist winch, or "drum," provides hundreds of feet of boom cable (a.k.a. luffing rope or rope), which is a 1 ¼-inch steel cable. This cable goes straight up above the boom-hoist winch to a series of sheaves at the peak of the A-frame. The boom cable is connected to a bridle, and the bridle connects to a series of steel straps or "pendants" that reach all the way to the end of the boom (a.k.a. jib). This rigging system supports the boom. In order for the boom to remain stable, the boom cable—a single wire rope—cannot fail. At 550 10th Ave., the boom cable failed.

*"Based on the FDNY's extensive analysis, if there is a single lesson to be learned, it is this: Given a serious fire affecting any of the rigging components on the machine deck of a tower crane, a cable failure is likely, and the situation constitutes an imminent collapse hazard."*

The working theory among NYC crane-industry professionals is that a hydraulic hose may have leaked or burst, spraying an atomized mist of hydraulic oil under pressure within the engine compartment. This combustible fluid, with an ignition temperature of 500 to 700 degrees, instantly reached the diesel engine, which was situated inches away. The exhaust and turbocharger components of the engine have a surface temperature of roughly 1,000 degrees. The result was a flash fire that was being fueled by a 250-gallon tank of pressurized hydraulic oil, which sits directly on top of the engine compartment. The fire quickly reached blowtorch proportions, with flames extending high above the engine compartment. The fire was similar in nature to a large truck fire, but 500 feet above the street, inaccessible to firefighting forces.

*The only fire suppression system required by the NYC Fire Code for a crane is one portable fire extinguisher with a 10B:C rating.*

As the situation developed, the crane operator immediately noticed the fire and tried to intervene. He valiantly attempted to put it out with two small fire extinguishers, as the only extinguishing system required by the NYC Fire Code for a crane is one portable fire extinguisher with a 10B:C rating. This extinguisher has 2 ½ pounds of agent and a discharge time of 10 seconds.

But the fire was far too intense for the two extinguishers. After exhausting their content, the crane operator was lucky to escape through a narrow hatch near the operator's cabin. This led to safety down a series of 13-foot vertical ladders within the tower. With no other fire suppression system onboard, the fire grew rapidly, consuming the entire engine compartment and hydraulic oil tank.

As the fire intensified in the engine compartment, extreme heat began to impinge upon the boom cable coming off the boom-hoist winch, which is just in front of the engine. As its temperature increased, the 1 ¼-inch steel boom cable softened and failed. When this happened, the boom plunged in spectacular fashion, hitting the high-rise residential building across 10th Avenue, crashing to the ground below and nearly killing several FDNY members who were just arriving at the scene. This collapse happened roughly four minutes after the 9th Battalion transmitted a signal 10-75.

## CRITICAL LESSON LEARNED: A SERIOUS FIRE AFFECTING ANY OF THE RIGGING COMPONENTS ON THE MACHINE DECK OF A TOWER CRANE CONSTITUTES AN IMMINENT COLLAPSE HAZARD

In spite of the fact that many FDNY members said they had considered the possibility of a collapse, the consensus was that they did not expect it to happen so quickly.

"This was definitely something new that I don't think any of us could have expected," said Pascocello.

Based on the FDNY's extensive analysis, if there is a single lesson to be learned, it is this: Given a serious fire affecting any of the rigging components on the machine deck of a tower crane, a cable failure is likely, and the situation constitutes an imminent collapse hazard.

The fire need not originate in the engine compartment.

*This photo shows the hydraulic power pack, which provides the crane's lifting force. The fire likely began when one of these hoses burst or leaked, spraying an atomized mist of hydraulic oil with an ignition temperature of 500-700 degrees. The oil contacted a hot metal surface on the engine, which is inches away.*

*This is the diesel engine on a Favelle Favco M440D tower crane. The exhaust and turbocharger components have a surface temperature of roughly 1,000 degrees.*


*This photo shows the hydraulic oil tank on top of the engine compartment. The steel boom cable can be seen passing directly overhead. On July 26, 2023, the engine compartment fire, fed by the hydraulic oil tank, melted this steel boom cable, which caused the boom to drop onto 10th Avenue.*

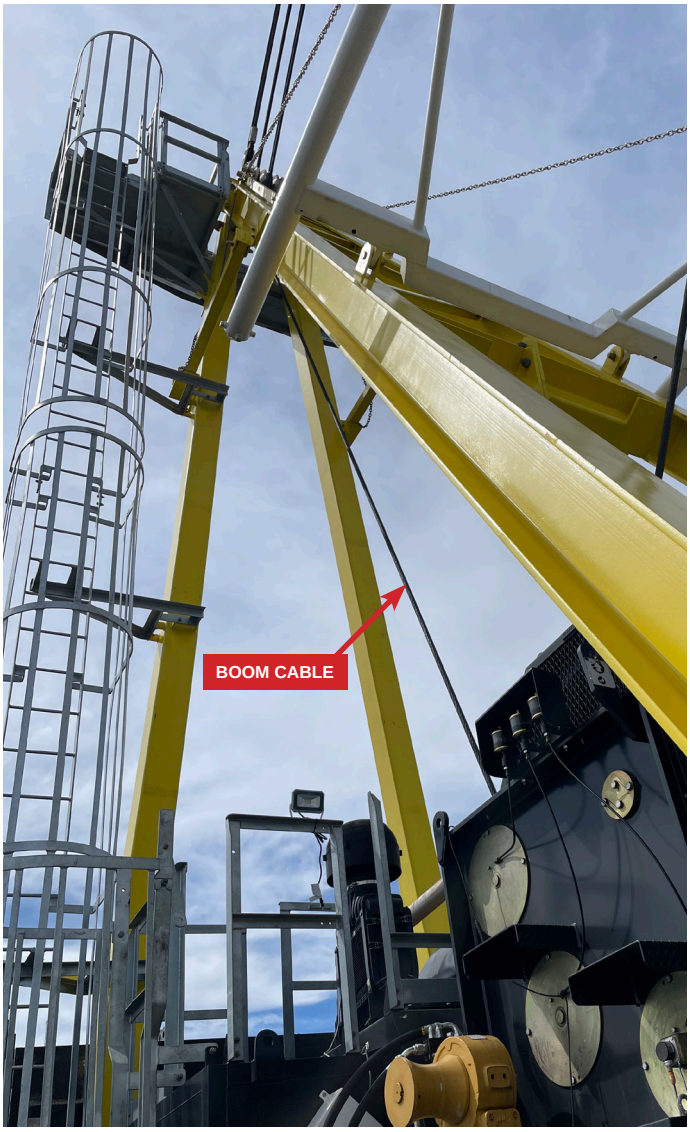
It could start in other crane components or extend from a building under construction. (See sidebar article “Historical precedent” concerning Corpus Christi, Texas.) If the fire reaches the machine deck of a tower crane, the result will be the same: a cable failure and collapse.

The FDNY may not have had this institutional knowledge on July 26, 2023, but that is no longer the case.

## APPLYING LESSONS LEARNED

In any case where a tower crane’s machine deck is involved in fire:

- All initial efforts should be directed toward evacuating construction workers and civilians from the hazardous area and setting up a collapse zone.
- FDNY units should park well away from the collapse zone, gaining access to the fire building on side streets only if it is safe to do so.
- Firefighting efforts should be a secondary priority after people are evacuated, as it is unlikely that forces will be able to establish an effective water stream quickly enough to prevent the failure of the boom cable or main load line.
- If and when the boom collapses, assessing the tie-ins and collars of the remaining tower crane should be a high priority.
- As long as the tower’s tie-ins and collars are secure and undamaged, the probability of a secondary collapse of the tower will be reduced. FDNY members should consult with the site safety manager, operating engineers, riggers, crane operator or members of the DOB’s Cranes and Derricks Unit to help make this assessment.
- If the tie-ins are damaged, the entire tower may be in jeopardy, and FDNY members must establish an appropriate collapse zone.
- Once these concerns are addressed, FDNY members can focus on firefighting operations.




*Here is another perspective of the boom cable rising vertically from the boom hoist winch toward the peak of the A-frame. The engine compartment can be seen behind the boom hoist winch. Extreme heat from the fire impinged upon this boom cable, causing it to fail. This single cable supported the entire boom.*

**About the author**
Battalion Chief Jason Cascone has served in the FDNY since 2001. He is assigned to Battalion 17. Prior assignments include Engine 67 and Ladder 36 as a firefighter, Engine 332 as a lieutenant and Ladder 11 UFO as a captain. He holds a BBA in accounting from Pace University and an MPA from Baruch College, Marxe School of Public and International Affairs. He attended the West Point Counterterrorism Leadership Program, the Naval Postgraduate School’s Center for Homeland Defense and Security, and the FDNY Mental Performance Initiative. He is a DiamondPlate content producer for the Bureau of Operations and the editor in chief of *WNYF*.

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*Sydney, Australia, November 2012: A fire in the engine compartment on the machine deck also caused the tower crane's boom cable to fail and the boom to collapse.*


*Texas, April 2023: A still frame from the Port of Corpus Cristi surveillance camera shows a large bucket of concrete falling from the tower crane.*

# HISTORICAL PRECEDENT:

## TOWER CRANE FIRES AND COLLAPSES IN SYDNEY, AUSTRALIA, AND CORPUS CHRISTI, TEXAS

The tower crane fire and collapse that occurred in NYC on July 26, 2023, was not unique. There have been other notable cases of tower crane fires causing collapses. In 2012, a strikingly similar tower crane fire and boom collapse occurred in Sydney, Australia, involving a Favelle Favco M660D tower crane.

The fact pattern in Sydney was nearly identical to the incident in NYC.

The Sydney fire began in the engine compartment on the machine deck and quickly melted the boom cable, or "luffing rope," which caused the entire boom to collapse. The boom landed on the roof of a building at the University of Technology—the Faculty of Engineering and Information Technology—in a heavily populated urban area of downtown Sydney. Incredibly, nobody was injured in the collapse, including the crane operator, who narrowly escaped after attempting to douse the fire with an extinguisher. The crane operator and his oiler were still descending the vertical ladder in the tower when the boom collapsed, indicating how quickly the collapse occurred.

A government report issued after the incident by the State Coroner's Court of New South Wales concluded that a possible hydraulic oil leak caused the fire in the engine compartment. And: "It is common ground that given the acceleration of the fire, the heat load caused the luffing rope to fail causing the [boom] collapse."

In another case on April 22, 2023, a serious fire occurred on the machine deck of a tower crane in Corpus Christi, Texas. Here, a 450-foot tower crane was working on a new bridge—known as Harbor Bridge—when an overheated drum brake ignited lubricating grease on the drum and cable.

"The crane operator tried to extinguish the fire and was almost successful, but they had to evacuate as it got worse," Assistant Fire Chief Doug Matthijetz of the Corpus Christi Fire Department told the Corpus Christi Caller Times.

Video of the fire shows that the main load line failed, dropping a large bucket of concrete hundreds of feet and creating a crater in the ground below, as a construction worker ran for cover. The worker escaped without injury, and there were no other workers in the area where the concrete bucket landed.

But the fire and resulting failure of the main load line sent shrapnel flying into adjacent Whataburger Field, a minor-league baseball stadium packed with thousands of spectators at a Corpus Christi Hooks baseball game. A chunk of metal struck a woman who was pushing a baby carriage inside the stadium. She was transported to the hospital with serious injuries. Two vehicles in the stadium's parking lot were also hit with shrapnel, a pickup truck's tailgate torn open like a tin can. A large chuck of metal debris from the crane was recovered nearby.

There were differences in the Corpus Christi incident from those in New York and Sydney. The cause of the fire was different, and the fire triggered a failure of a different type of cable. The main load line failed as opposed to the boom cable. This meant that the Corpus Christi collapse consisted only of the crane's load instead of the entire boom. But the arc of the story was the same: a fire that quickly caused a cable failure and collapse.

But firefighters rolling up to a tower crane fire won't have time to determine which cable is at immediate risk. And with the lessons of New York, Sydney and Corpus Christi top of mind, it is critically important that the incident commander establish a conservative collapse zone. ■

# Tower Crane Accident on West 57th Street

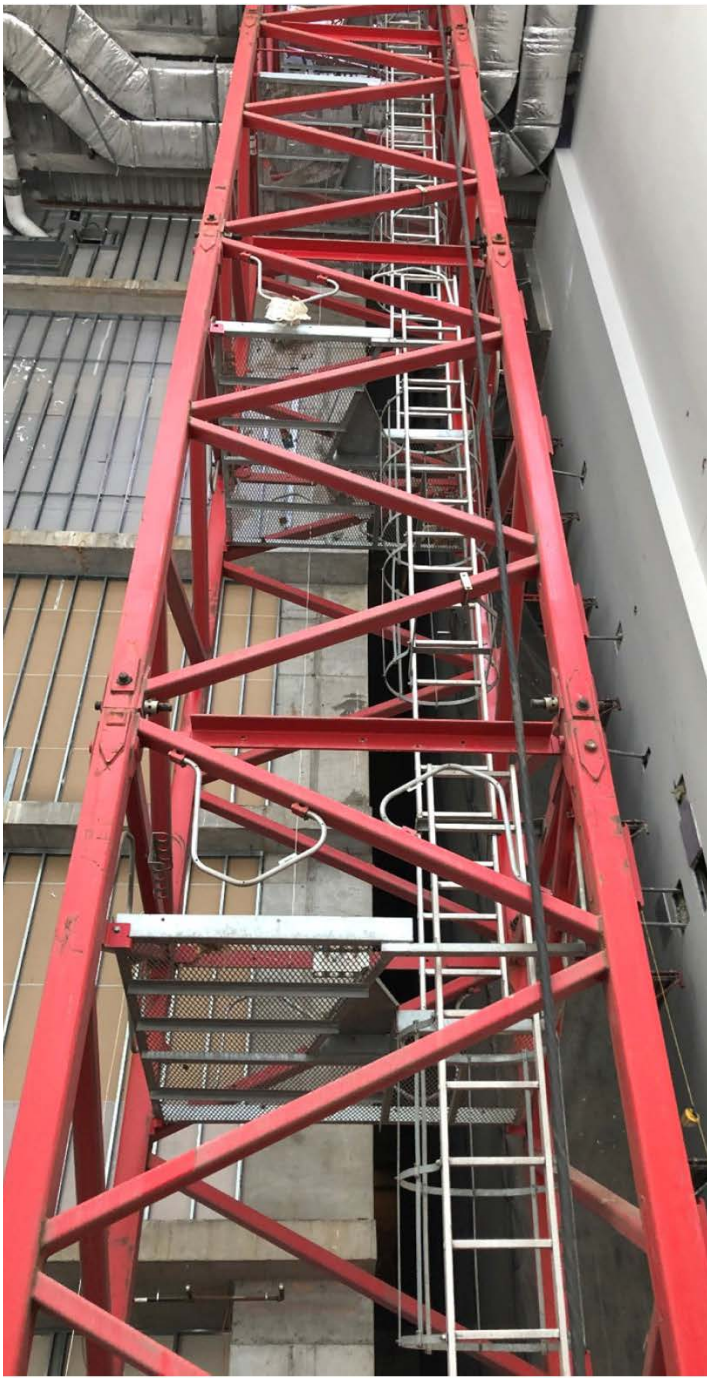
By Deputy Assistant Chief Fred Schaaf

You arrive for the night tour, and after you have done all your preparations for your shift, the tones go off for the first run of the night. The only information given is a street location and the statement, "Crane falling from building." As you arrive on location, you observe debris in the street, some of it large and heavy. Initially unknown to you, a tower crane is spinning in the wind with its lift cable striking the building. Pieces of glass and metal, carried by the wind, are hurtling to the ground. Looking around, you observe vehicles and pedestrians in the area as you stand at the intersection of 6th Avenue and West 57th Street in Manhattan. Thoughts quickly race through your mind regarding which steps need to be taken immediately to protect life, and to supply the needed resources to manage this incident. This is a high-risk, low-frequency event, and you will draw on lessons learned from your prior experience and that of previous FDNY commanders.

On October 29, 2020, this was the exact scenario confronting units that responded to Manhattan Box 0916. In the dark and overcast night, it was not immediately apparent what was causing the debris to fall and the full scope of the danger it still presented. It would be almost nine hours until the incident would be placed under control, with FDNY units maintaining a watch-line presence well after. This article will look at the challenges confronted by units that night and the actions taken to safeguard the area while mitigating the incident.

Arriving on scene, Chief Anthony Pascocello (Battalion 9) immediately directed incoming units to block the area to any incoming traffic while requesting that the NYPD respond to close off West 57th Street between 6th and 7th Avenues. The operational area would ultimately expand to cover West 53rd to West 59th Streets between 5th and 8th Avenues. Searches of the area included rooftops for damage from debris, as well as injured civilians. The few civilians encountered would be guided out of the area or directed back into their buildings to shelter in place. Each search sector established would cover one street, with initial priority given to West 56th to 58th Streets between 6th and 7th Avenues, as they were closest to the Incident. As the searches were completed, sectors expanded to 5th and 8th Avenues in order to ensure that no debris had reached these outer areas. As more units arrived or could be redeployed, the search area ultimately expanded to 53rd and 59th Streets. This was performed based on reports of debris found, the wind speed and direction, and an abundance of caution. Every search sector would be staffed with a minimum of a battalion chief, ladder and engine with Certified First Responder – Defibrillation (CFR-D) supplies ready.

Operations simultaneously began in the mega high-rise at



The tower/mast is constructed in sections pinned or bolted together to achieve the desired height. Note the climbing ladder and platforms.

**About the Author**

Deputy Assistant Chief Fred Schaaf has served the FDNY since 1993. He is the Queens Borough Commander. Previous assignments include Engine 26 and Ladder 18 as a firefighter, Ladder 116 as a lieutenant, captain of Engine 315, Battalion 38 as a battalion chief, and Division 11 commander as a deputy chief. He holds an associate degree in liberal arts from Nassau Community College and a bachelor's degree in fire and emergency services from John Jay College. Additionally, he is a graduate of the West Point Counterterrorism course, FDNY Officers Management Institute (FOMI) and the Advanced Leadership course.

111 West 57th Street. Units were dispatched to check on the stability of the tower crane and to access and report on any damage to the building. The main structural sections of a tower crane include the base, mast, operator's cab, tie-backs and jib (terms defined at the end of this article). After taking an elevator to the 77th floor, Rescue 1 gave an initial report of a strong wind condition and observed debris hanging on some of the tie-backs that held the mast to the building. All of the tie-backs would eventually be checked and found to be secure and undamaged. After proceeding higher to the location of the operator's cab, Rescue 1 informed Battalion 9 that the luffing jib was spinning in the wind, its lift cable and hook striking the building.

Tower cranes are specifically designed to spin freely in the wind in a process known as "weathervaning." It is a natural procedure that lets the crane spin with the wind, instead of resisting it, when locked in a static position. Spinning relieves the crane of excessive pressure that might lead to structural damage from wind stress. The problem here was that the lift cable was extended too far, which enabled the cable and hook to strike the building. Fortunately for us, by the time of my arrival as the Citywide Tour Commander that night, the wind had died down and the crane had stopped spinning. This enabled us to concentrate on mitigating the damage already inflicted while monitoring and planning next steps if it started up again. Even without the crane spinning and creating new damage, there were still loose pieces of debris on the building and on the crane tie-backs that were in danger of falling. Units secured all loose debris on the building that they could safely reach. Professional construction riggers were ultimately used to secure debris hanging on the crane tie-backs, as we could only monitor these pieces in the interim.

Sections are pinned or bolted together; this section is pinned.

While units conducted these operational tactics, Division 1 Deputy Chief Mastandrea had transmitted a signal 10-60, bringing additional resources to the scene above the currently assigned major technical rescue response matrix. Dispatch was requested to have responded agency representatives report to the location of the command post. Some of those responding—such as the New York City Police Department (NYPD), NYC Department of Buildings (DOB), New York City Emergency Management (NYCEM) and utility supervisors—would be familiar with this. Others—such as the building manager, building engineer, crane company and construction managers—would not. As contact information was gathered from units operating in the building, calls were made to have the construction and building representatives respond. It was critical that a crane operator arrive to retract and secure the cable and hook that had caused the damage. Weather updates were requested from the Fire Department Operations Center (FDOC) to find out whether an uptick in wind was anticipated.

Directions were given via the dispatcher to have MTA buses rerouted from the area and have subway stations in the affected area bypassed. Even though MTA buses would be prevented entry by FDNY and NYPD members, operators would still need notification in order to plan accordingly. Having the subway stations bypassed would prevent more civilians from exiting the stations in the hazard area.

Two and a half hours into the operation, the crane operator arrived on scene. Within 30 minutes, he had retracted and secured the crane cable so it could not cause any more damage. Before his arrival, we had discussed with other supervisory construction personnel who had arrived how to bring this operation to a conclusion. They had assured us that they had multiple workers coming in who were certified riggers and would be able to secure all of the debris on the building and crane mast we could not reach. As we finished up our searches in the exclusion area, construction workers did arrive on scene; they began to secure debris, starting at the 85th floor and working down. Just past six hours into the incident, they reached the 68th floor, and we went "probably will hold." Coming up on nine hours into the operation, all debris and floors had been thoroughly searched and secured, and we went "under control." A watch-line was established, the exclusion zone was contracted to just the immediate area and we would maintain a presence for days afterward.

Crane incidents are low-frequency, high-risk events, but they are always possible with the abundance of construction taking place in NYC. Just look up at the skyline in Manhattan and Northern Brooklyn, and you will see multiple cranes in operation. Although this article deals with a tower crane incident, we have also had failures of crawler cranes that could be just as dangerous and difficult. Each incident brings its own unique challenges, some similar to those addressed in this one. Ten years previously—to the day—during "Superstorm Sandy," a tower crane collapsed in this exact area. At that time, Division Chief John Hodgens and Manhattan Borough Commander John Sudnik were on scene when I arrived for relief as a bat-

Tie-backs such as these are used to connect the tower crane to the building, giving the crane structural support. They are heavy I-beams bolted into position. In this incident, some loose debris from the building ended up hanging on the tie-backs where they extended outside the building. Construction riggers were able to remove the debris when they arrived.

talion chief. As the Command Chief during this current incident, I again met up with now Assistant Chief Hodgens, this time for a 10-year reunion. Although it is not common, you may find yourself operating at your own crane incidents on more than one occasion. I hope what was presented in this article will help.

**Lessons Learned Reinforced**

The FDNY operates with a tiered response based on information and conditions encountered. This response progressed from the minor to major technical rescue matrix, then—upon the arrival of Deputy Chief Mastandrea—to the signal 10-60 (major emergency response). This enables the Incident Commander (IC) to bring preplanned, needed resources to the scene—based on the hazard presented—without requesting specific units. Individual resources, victim removal groups, additional rescue task forces and additional alarms all can be special-called as needed above the signals 10-60/10-60 code 1, as they were at this incident.

Assigned on the initial response, incoming EMS units may not be monitoring our frequencies and might therefore be unaware of the immediate establishment of a hazard area due to falling debris. The Incident Commander should ensure that this information is relayed to incoming EMS units via our dispatchers. The IC app on the iPad will show which EMS units are assigned to the Box. Incoming additional units should be directed on any special response patterns, and responding officers should enquire of the dispatcher if not so directed.

Large buildings and construction sites might have multiple entrances, sometimes on completely different streets. Those entrances farthest from the hazard should be utilized and all units informed.

Public transportation agencies must be notified to bypass the exclusion area so they can redirect and plan accordingly. Otherwise, we might have buses sitting at the perimeters without direction from their management, and civilians exiting subway stations in the exclusion area. The Transit Liaison Officer (TLO) stationed at the control center is a great resource for gaining information and relaying requests directly. Ultimately, these requests should be relayed and confirmed by our dispatchers over our frequencies.

Structural collapse is designated as an FDNY Single Command in the Citywide Incident Management System (CIMS). Incidents such as this require the response of multiple agencies. The location of the command post must be established and transmitted to responding agencies and units. Due to the extended timeframe of these events, the lobby of a nearby building should be considered if available, as It can provide lighting, shelter from the weather and access to other facilities.

Electronic devices such as the iPad might not work in rain or in extreme heat or cold. The weather during this incident was cold and windy, with a constant steady rain. Until the command post was moved under shelter,

Glass and metal debris lie in the street. It is imperative that an exclusion area be established quickly.

the iPad and clipboards were not able to be used properly. When the Field Communications Unit arrived and set up their command board, we used grease pencils to update it. A good alternative during inclement weather is to keep a clipboard or at least some rain paper with you, as well as a pencil or grease pencil.

Utility representatives should be special-called and held at the command post. Falling debris can damage utilities, especially when impacting at street level, where they pass underground.

Establishment of sectors enables the IC to define areas of task responsibility and command in order to make the incident more manageable. At this incident, the sectors encompassed streets and were identified by the street on which units operated. The map applications on the iPad were extremely helpful in identifying building addresses in these sectors for assignment of units in a systematic pattern.

If available, interior elevators are preferable to an exterior construction elevator.

Holidays, weekends and nights are times when it may prove difficult to contact required construction and building personnel. When a building reaches 75 feet, a site safety manager is required during construction hours. A fireguard is then required until midnight, and a watchman at all other times. Construction and building personnel information may also be posted on site or available in the FDNY First Responder Gang Box. One of the first-alarm ladder company officers served on the Division 3 Mega High Rise Task Force, and upon his arrival, he informed the IC that he had contacted the Fire Safety Director via his cell phone. He informed him that construction personnel were on their way. During routine building inspection, local units that will be responding to these sites can also gather contact information. Many times, construction personnel have the contact information for other trades employed alongside them. At this incident, a glazier on site had the contact information for other trades.

If evacuation becomes necessary, NYCEM should establish sites for relocating occupants. Local schools and churches can also be a short- or long-term possibility while plans are being developed.

When managing large-scale incidents that involve multiple agencies, communication can sometimes become difficult. Unfamiliarity with proper terminology, industry jargon and slang used by agency representatives can make it difficult to understand what is being communicated. If unsure, the IC must keep asking questions for clarification. ■

This photo shows the tower crane during the incident. The jib is pointed upward, indicating that it is a luffing jib. The tie-backs are visible, extending from the building to the tower crane, and pieces of debris can be seen hanging on them.

**Tower Crane Terminology**

Base—A reinforced concrete pad or grillage, constructed on site, to which the mast/tower is connected. The mast/tower can also be welded or bolted to a steel base structure, the existing building or a cantilever structure.

Mast/tower—The vertical steel framework made of individual sections bolted or pinned together that the crane superstructure rotates on and are added as required to get to the desired height.

Operator's cab—Where the crane operator controls the crane's operation. To access the cab, the operator must climb a ladder in the mast/tower from ground level, or access a catwalk higher in the building and climb a shorter distance via the mast/tower ladder.

Jib—As related to a tower crane, the fixed or luffing structure that supports the load. A similar and more familiar term might be "boom," which is used for a crawler crane. A boom moves up and down, similar to a luffing jib. Construction personnel may refer to all of the various jibs as simply "the jib."

A hammerhead tower crane has a long horizontal jib that cannot move up or down. It has a trolley system built into it to move the location of the cable and hook for lifting and moving loads.

A luffing jib tower crane has the capability to move the jib up and down to lift and move loads.

Counter jib—The jib opposite the working jib used to offset the weight being lifted. Concrete slabs can be added to act as counterweights.

Tie-backs—steel components that provide additional stability to the mast/tower by connecting it to the building at different floor levels.