Tunnelling Journal

A first for the US

A new water mist firefighting system in New York's Hugh L Carey Tunnel is the first ever to be installed in a US road tunnel.

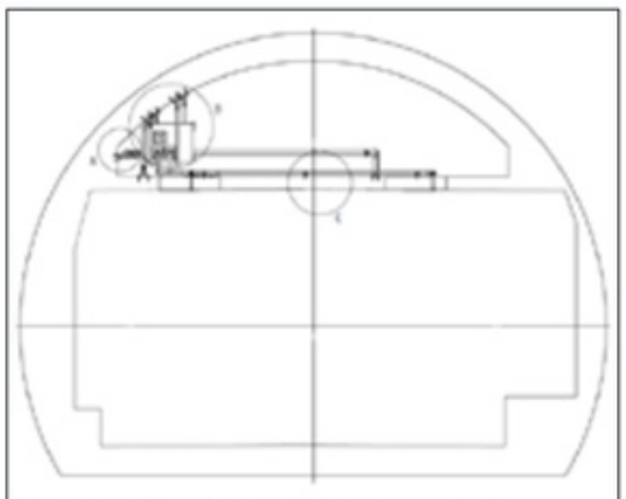
Every day more than 50,000 vehicles travel through the twin tubes of the Hugh L Carey Tunnel in New York. Formerly knowns as the Brooklyn-Battery Tunnel, it connects Red Hook in Brooklyn with Battery Park in Manhattan, running for 2.8km under the mouth of the East River.

Open to traffic in 1950, after a 10-year build programme that was interrupted by World War II, the twin tunnels needed serious rehabilitation after Storm Sandy flooded them in 2012. Their latest upgrade involves the rehabilitation of the tunnels' ventilation system and the installation of a high-pressure water mist system.

Tim Usner, Fogtec's project manager, conducted the entire project remotely, thanks to the constraints of the Covid-19 pandemic.

This is an unusual project for several reasons. It will see the first water mist system ever to be installed in a road tunnel in the US. Tunnel owner MTA Bridges and Tunnels (also known as Triborough Bridge & Tunnel Authority, TBTA) calls it a prototype installation; it runs for only one-third of the tunnel's length from the Brooklyn end. And the COVID-19 pandemic has meant that the relationship between Fogtec, which designed the water mist system and supplied the components, and its client, a main design-build contractor from New York (who did not want to be named), has been a purely virtual one

"I have been working on the project for one-and-a-half years, but I have never visited it," says Fogtec project manager Tim Usner. "This wouldn't have been possible 15 years ago, but digital technology means that nowadays it works."



The owner wanted all the water mist system to be retrofitted within the tunnel's air duct above the ceiling.

There was the possibility that Fogtec technicians might visit the project in September this year, since Fogtec will be responsible for commissioning. But equally likely was the prospect that the main contractor's technicians would use augmented reality (AR) glasses, with their Fogtec colleagues talking them through the process from Germany.

Why water mist?

Installing a water mist system in the Hugh L Carey Tunnel – which was renamed after a New York governor in 2012 – makes sense here for two main reasons, explains Usner. First, the mist will cool down the exhaust gases that would be drawn out through the tunnel's fans in the case of a fire.

"Some of the major components of the jet fans are not stable at high temperatures," says Usner. "Rather than having to replace those components, or even the whole fans, a better solution is to cool down the gases and reduce the fire load."

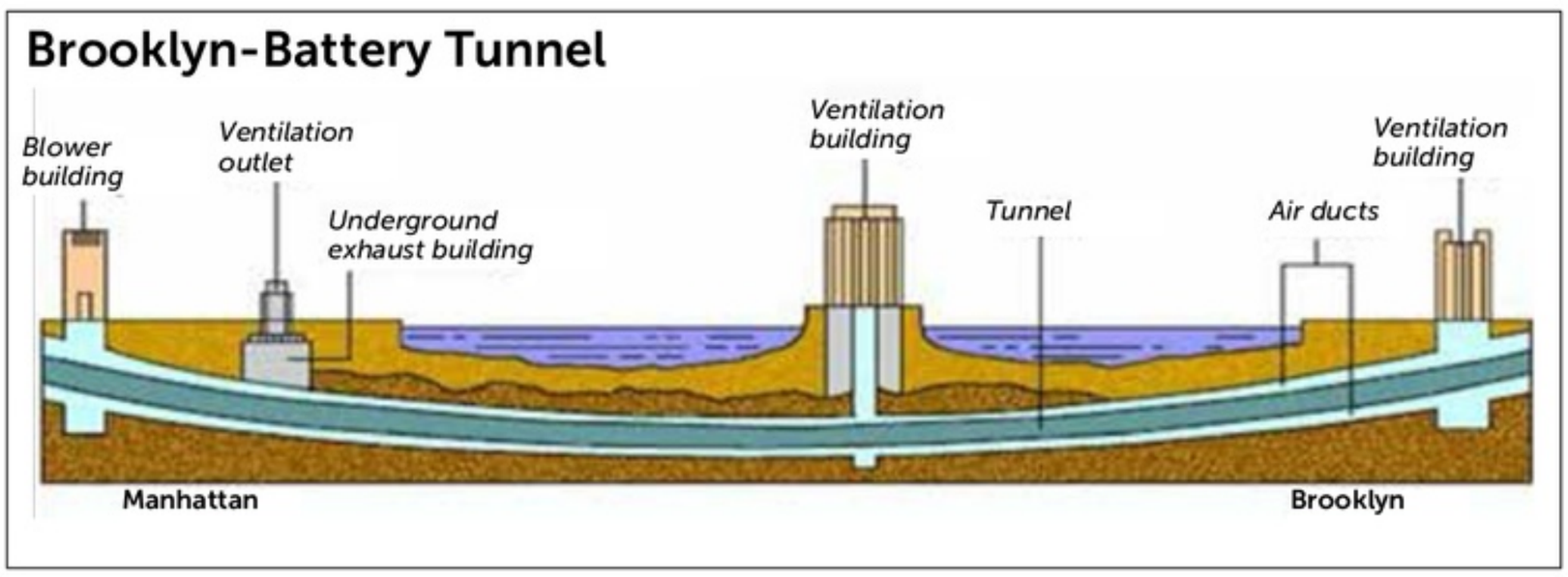
The second reason to use a water mist system is to get the tunnel back into operation as quickly as possible. This is a tolled tunnel, but financial losses when a fire stops traffic flows are not limited to missed tolls. There is also a cost to local businesses and people of journeys delayed or arrested.

The tunnel's ventilation system is fully transverse, which means that it has separate ducts for the exhaust air and the fresh air (see diagram). For the Hugh L Carey Tunnel, exhaust air is drawn into a duct above the ceiling of the tunnel, while fresh air is blown in through a duct beneath its floor (cross section, below left). Transverse systems are less often chosen due to the additional cost they incur, although there are several older tunnels in the US that have them.

The evidence of this expensive ventilation system is clearly visible at the surface. The most imposing element is an octagonal ventilation building situated on Governor's Island, halfway across the river. On the Brooklyn side there is another ventilation building, which has found fame in the Men in Black film as their headquarters building. And there are ventilation and blower buildings on the Manhattan side.

Although fixed fire fighting systems (FFFS) were installed in US tunnels in the 1950s,

Cross section through the Hugh L Carey tunnel (originally the Brooklyn-Battery Bridge) showing its extensive ventilation system.



there was a hiatus in their use until relatively recently. A 2020 report published by the Federal Highways Authority lists 57 tunnels of which seven have FFFS, and all of these are deluge systems (see box, p38, for more details).

There were a few reasons why water mist made more sense than a sprinkler or deluge system for the Hugh L Carey tunnel, according to Usner. They take up less space and are hence easier to retrofit within existing ducts; they also require less water compared to a deluge system and hence produce less water in the tunnel. Using a system with a higher water flow rate would likely have required the drainage system for the tunnels to be updated – which would have added more cost and disruption to drivers.

It should be noted that the tunnel's passive fire safety system had already been upgraded during the tunnels post-Storm Sandy rehabilitation. Design-build contractor Tully Construction, which delivered the $283m restoration and improvement contract, installed Promat T 22mm fire protection boards to the ceiling of the tunnel to meet requirements of National Fire Protection Association (NFPA) standard NFPA 502 (the 2011 version).

Full-scale fire tests

One of the assurances required by operator TBTA, before the water mist system could be installed was full-scale fire tests. These are costly and time-consuming. Usner reckons they could take six months to prepare for and the cost to conduct them runs into six digits.

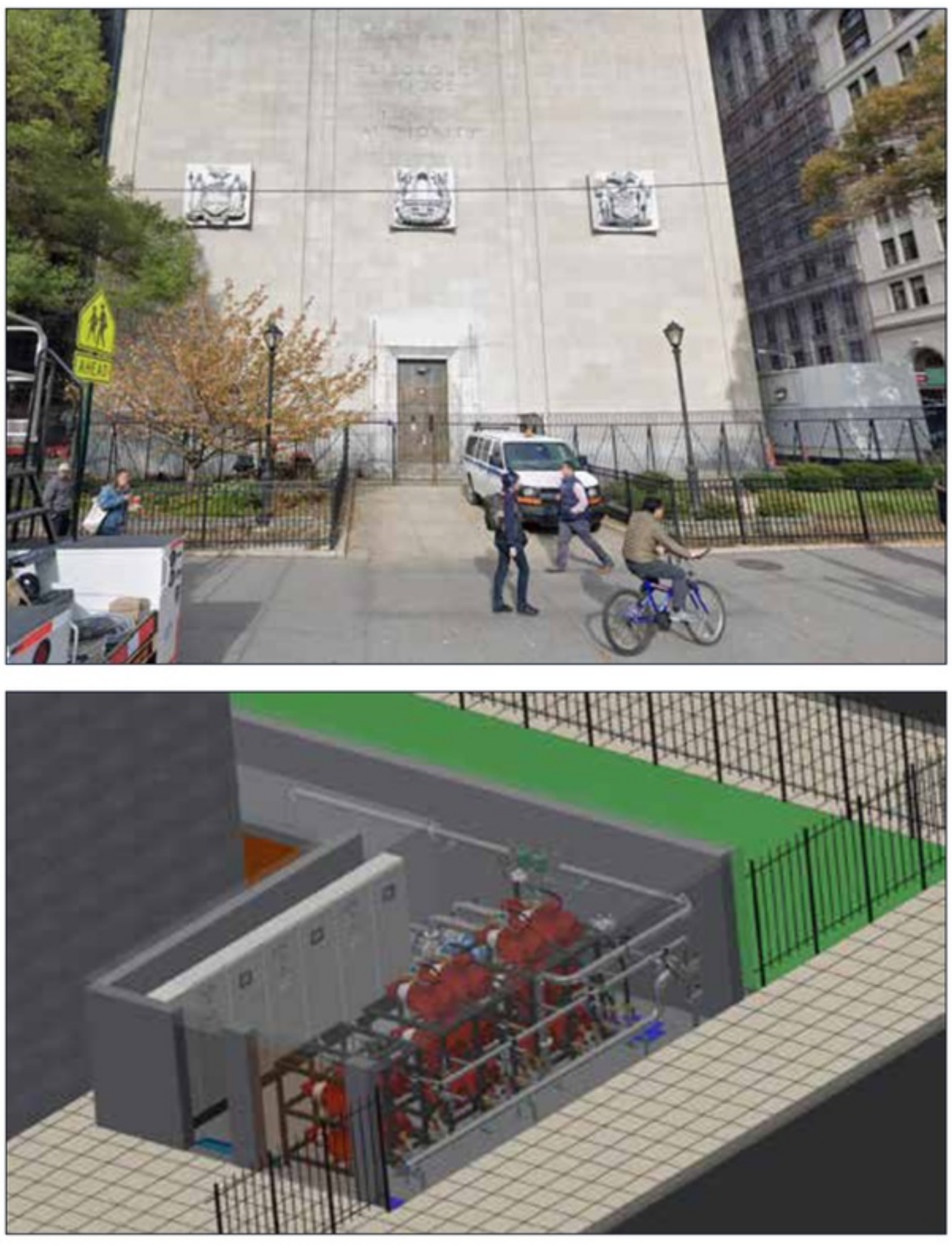
Fortunately, Fogtec already has a wealth of fire test data, gathered over years of full-scale tests for projects around the world. The water mist system had to be installed entirely within the air duct above the ceiling of the tunnel, with only the nozzles protruding into the tunnel space. Most of these nozzles were fitted through existing exhaust vents and, as luck would have it, the spacings of these vents were almost identical to those for existing fire test data that Fogtec owned.

Fogtec employed a third-party checker to confirm that the data was compatible with the geometry of the Hugh L Carey tunnel, with the resulting report submitted to TBTA, and accepted. The main contractor also carried out a spray test before the system was accepted, using the ventilation in emergency mode with air speeds of up to 3m per second and checking what happened to the spray; barely any water mist was sucked into the air duct.

COVID-imposed travel restrictions also required a new approach to the factory acceptance process, which normally would have involved representatives from the main contractor, the consultants and the owner spending a week at Fogtec's factory in Cologne, Germany. Instead, the acceptance tests were watched remotely via video.

"We had cameras all over the place, and there were some initial challenges in getting the sound right. I felt like a film director," confesses Usner. This was Fogtec's first ever remote factory acceptance, but other parts of the business soon followed suit.

Once the components reached site – a process that thankfully was not delayed by Covid, although that had



The pump room had to be squeezed into the area around the tunnel's ventilation building on the Brooklyn side, which found fame in the Men in Black film as their headquarters building.

been a concern – the main contractor installed everything. It is not unusual for Fogtec to provide design drawings and the components, while the main contractor installs the system, says Usner, but in the past there has always been a need to visit site to provide training or advice. But here again, everything worked remotely.

Fogtec had to think carefully about the system during design, as all the materials had to pass through square hatches around 1.5m in size in the tunnel ceiling. Some flexibility was built into the design, with standard set ups that could be modified to fit round what was already there. One clever detail was the Fogtec's idea of using flexible stainless steel hoses, normally used in building systems, to connect the nozzles to the main water supply pipes.

One of the biggest design challenge, says Usner, was fitting the equipment for the pump room into the space designated for it, which was a small area at the base of the 'Men in Black' ventilation building. "Typically, with a new tunnel you have plenty of space for the pump room, but here there were only centimetres to spare," says Usner. "Obviously in Downtown New York, space is at a premium."

New York City regulations also required that the pumps be tested for noise, which was a first for Fogtec. The manufacturer had to run tests at different frequencies, recording and measuring the noise levels to be submitted for approval to the authorities.

Fogtec's system allows remote and frequent testing of the section valves, without having to spray any water into the tunnel. This means that the operators can check the functionality of the valves without having to go into the exhaust air duct. This raises the availability of the system and reduces maintenance costs.

As the tunnel is only partly covered with a water mist system for the time being, it would be possible to extend the system for the entire tunnel length with a FOGTEC system, without the need for more pumps. A deluge or sprinkler FFFS systems would require more pump rooms – possibly three to serve the whole length of the tunnel.

Perhaps when this prototype system has been put through its paces, there may be a will to extend it in this tunnel and use it in other New York tunnels, or even in other US tunnels. As for the new, remote working regime which Fogtec and the main contractor were forced to adopt, this could prove useful in future contracts, says Usner, where Fogtec is again providing the design and the components for others to install.

"Now that we've seen it works, it would lead to cost savings and time savings," says Usner. "This was the first time for us doing it completely remotely. We did not know what to expect, or how it would work. But communication and the way we worked together has gone really well."

Are more Fixed Fire Fighting Systems coming to US road tunnels?

While fixed fire fighting systems (FFFS) in road tunnels are common practice in Australia and Japan, this hasn't been the case elsewhere. Over the past 20 years, they have been installed in some European tunnels and now we are seeing their installation in new US tunnels. The US's Federal Highway Administration (FHWA) is currently developing guidance on how to integrate the design of FFFS and emergency ventilation systems.

FFFS were first installed in the US in the 1950s. However, their use did not become widespread – reportedly due to problems with tunnel fire tests conducted in the Swiss Ofenegg Tunnel, where human error led to accidents.

All those recently constructed road tunnels in the US that do have FFFS have deluge systems (larger drops, lower pressure) rather than water mist systems (tiny droplets, high pressure), like that being installed at the Hugh F Carey Tunnel. In Europe, most recent installations are water mist. Deluge systems aim to cool the core of the fire with their larger systems whereas water mist systems add additional cooling effects to the ceiling and walls. Neither system aims to extinguish the fire but to keep the heat release rate low and control the fire until a fire brigade can extinguish it.

When selecting a FFFS, experts have to look at the space available for retrofit and water supply, as well as the likely fire loads. Many of the older road tunnels in the US have transverse ventilation systems, like the Hugh L Carey Tunnel, which means that FFFS could be installed within the exhaust ducts above the main tunnel space – or within the tunnel itself. Guidance on the use of FFFS in road tunnels has changed over the years. The world road association PIARC was against sprinkler systems originally because it said they could lead to dangerous steam and smoke, but in 2008 it published a guidance document, updated in 2016 to recommend the use of FFFS.

In the US, the National Fire Protection Association (NFPA) has also changed its stance. In the latest edition of NFPA 502 Standard for Road Runnels, Bridges and Other Limited Access Highways, published in 2016, FFFS are covered in detail.

One of the controversial elements of the latest NFPA 502 guidance is that it says that it may be possible to reduce the requirement for fixed fire protection, such as boards, and ventilation requirements in the light of FFFS systems. Opponents, such as manufacturers of fire protection boards, say that FFFS can fail so passive protection should not be reduced, because it preserves structural integrity.

FHWA reports:

Fixed Fire Fighting and Emergency Ventilation Systems for Highway Tunnels – Workshop Report
https://www.fhwa.dot.gov/bridge/tunnel/pubs/nhi09010/hif20060.pdf

Fixed Fire Fighting and Emergency Ventilation Systems for Highway Tunnels – Literature Survey and Synthesis
https://www.fhwa.dot.gov/bridge/tunnel/pubs/nhi09010/fixed_firefighting.pdf