WORLD TUNNELLING

# POTENTIAL FAILURE TURNED TO SUCCESS IN PORT AUTHORITY PROJECT

Success can be the product of a near failure. The Port Authority of NY & NJ can certainly attest that pursuing a successful solution to counter a collision with failure has been very rewarding. It all took place at its Downtown PATH Restoration Program at Exchange Place Station, Jersey City, New Jersey. Here, the Port Authority met a set of challenging excavation conditions that were required for constructing underground crossovers and lengthening the station's existing platforms, and which involved a radical change of procedures when the initial plan was proving inadequate for the conditions experienced.

Some readers already know that the restoration project at Exchange Place Station is linked directly to the tragic event that took place on September 11, 2001 (9-11) at the World Trade Center, New York City. For those who do not know, here is some background. PATH (Port Authority Trans-Hudson) is a subsidiary of the Port Authority of NY & NJ that is responsible in maintaining and operating the Hudson River underground mass transit system that links New Jersey to New York City. Daily, 210,000 people use the PATH services.

One of the main train services operating until the 9-11 incident was on the east-/west-bound lines, designated E and F, which directly connect the WTC (World Trade Center) Station with the Exchange Place Station. With the WTC Station located directly under the twin towers, it was all but obliterated on 9-11 and during subsequent site clearance activities. Another serious problem incurred in the two Hudson River tunnels with the inflow of water and debris. This inflow was mostly attributed to the fire-fighting seawater runoff, which was pumped from the Hudson River, and the building materials cleanup held at the WTC site. In any event, this necessitated the complete renovation of the tunnels, including the replacement of all mechanicals.

Before 9-11, the WTC Station daily served 65,000 New Jersey commuters so its interruption has had a major impact on the people who depended on this PATH service. The Port Authority wasted no time rising to the challenge of rebuilding and improving this important Lower Manhattan–New Jersey commuter service. By December, 2001, it allocated US$544 million for the construction of a new temporary PATH station at the WTC site, the complete renovation of tunnels E and F and the renovation and new construction in and adjacent to the Exchange Place Station.

A contract for $300 million was let in January, 2002, to a partnership of Yonkers Contracting Inc., Tully Construction, and J. Pegno Construction. This unique contract called for a net cost plus the contractor's fee. Therefore, the contract was let to the bidder with the lowest fee, which was $16,711,000. The next lowest fee bid was for $23,750,000.

*Jim Brady (left) showing construction leader team a profile he made of the Port Authority tunnel section to give a better understanding of the complex design involved*

## Completion date set

Considering the urgency in reopening this vital PATH service as quickly as possible, the Port Authority targeted June 2003 as the completion date for the Exchange Place Station's renovation and the addition of the new crossovers and turnout tracks, west of the station. The crossover and turnout tracks enable the trains to enter the station and then depart from the same platform. Additionally, the two platforms are being lengthened from a 7-car to a 10-car capacity. One immediate reason for the turnout and crossovers is for getting the Exchange Place Station not only completed but operational by the targeted June construction-completion date. With the station and crossovers operational, this PATH line will serve Lower Manhattan-bound commuters by connecting them to ferry services, whilst the temporary WTC Station is still under construction and the corresponding tunnels E and F are being rehabilitated. The construction of the temporary WTC Station is expected to be completed by year's end. Concurrent to all these activities, the Port Authority is designing a permanent WTC Station.

## Precious little time

It followed that getting this important PATH line back into operation quickly was crucial not only from a political view or because of the 65,000 commuters who directly depend on these PATH services but for the Port Authority to demonstrate its ability to successfully meet the adverse conditions caused on 9-11. With this in mind, here is an account of how the Port Authority quickly solved a problematic set of circumstances that threatened the targeted completion date for bringing the Exchange Place Station operational again. Pointedly, the problem occurred because of the excavating method chosen for constructing the crossovers and lengthening the platform areas.

The contract specified the new crossovers and lengthening of the platform areas be excavated by drill and blast. This appeared to be the logical choice since the rock to be excavated is Manhattan Schist (a mica-schist), which on some past NYC

*Beginning of tunnel excavation*

tunnel construction projects has been known to be substantially hard.

The use of a roadheader was never seriously considered at this point, for the consensus was this type of equipment would not be effective in such "hard rock" conditions. Aside from a roadheader there is precious little available in high-production excavation equipment that can excavate intact rock, especially under the complex set of excavation conditions found here. Therefore, the Port Authority and its design engineers concluded the practical choice was to use drill and blast.

Raymond E. Sandiford, P.E, Chief Geotechnical Engineer and Thomas J. Groark, P.E, Engineer of Construction – PATH, are two of many people from the Port Authority who are directly involved with this project. They led. Sandiford was responsible for the design contract and geotechnical evaluations, thus he worked closely with the project designer, Golder Associates. Golder designed the project and included a NATM-like pre-support/final support system that included installing rock bolts, grouting of existing tunnel linings and concrete placement at existing tunnel sections. Advancement of the crossover tunnel excavations was to be made not exceeding 3m (10ft) rounds, fully completing the pre-support of the excavated round before starting the next round. The inverts of the new crossover tunnels are up to 18m (60ft) wide yet the tunnel ceiling heights do not exceed 10.6m (35ft). Here, pre-stressed rock bolts, lattice girders and shotcrete were installed at appointed rounds for optimum support. The rock cover left after excavation was also as little as 10.6m (35ft).

Once the design was completed, Groark assumed all construction responsibilities. Even so, Groark and Sandiford worked closely together from the beginning of construction. One of the first actions to be carried out concerning the excavation programme was to make three test blasts. Unfortunately, the results of these tests were very poor. One of the main problems was sizable overbreak leaving gaping areas that were far beyond the prescribed geometric excavation design. These overbreaks suggested huge quantities of shotcrete would be required to bring the tunnel into the specified form and measurement, and much time would be needed to do so. Additional time and costs, with the emphasis placed on time, are what the Port Authority could ill afford. Overbreak also meant an expanded mucking-out programme.

## *Finding a Plan-B*

Sandiford attributed the overbreak phenomena to excess foliation. The hot gases would advance between the foliations at high velocities thereby exploding them apart. Also, acceptably precise control with hand-held jack hammers was impossible. However, the problem was not limited to geotechnical conditions. The tunnelling was to be carried out directly under high-rise buildings and the State of New Jersey has very strict parameters to follow when drilling and blasting under such conditions. Quickly, Groark re-evaluated the drill and blast programme, taking the "new" set of conditions under careful consideration. Either the drill and blast programme would have to be substantially modified or a Plan-B would have to be made if this project were to stay on schedule.

By June of 2002 it was decided outside expertise was needed to find a quick and feasible solution to the problem. "Jim Brady [BU Corp, Inc., Charleston, SC] was a logical choice to evaluate our concerns on the schedule. I met him years ago on a WMATA [Washington Metro Transit Authority] tunnel project in Washington, D.C. We both were involved in the project and it is here that he gained my respect for his professionalism and competence. My decision was to bring him in for a complete evaluation of the problem," said Groark.

Brady already had a good understanding of the project for in its planning stages he acted as a consultant for Golder Associates. He assisted in projecting the contractor's cost, the constructability and in the scheduling.

Actually, it was Golder who called Brady back for consultation with Groark's blessing. He started under Golder but later was placed under the construction contract, working closely with Groark. Golder and Brady specifically were assigned the task of presenting the Port Authority with a plan that could ensure the project staying on schedule. Once Brady evaluated the state of the excavation programme, he reported back; essentially the project is beset with serious problems because of the chosen excavation method, and it cannot be improved sufficiently to overcome the set of problems being incurred and still meet the completion date. Not an encouraging report, especially with no Plan-B ready to execute.

Brady was not discouraged, however, and after re-reviewing the geotechnical report, rock properties and the foliation, he thought that a roadheader might be the solution to the problem. Brady is not an expert on roadheader applications so he turned to those, outside the project, who were. It quickly became apparent that a roadheader was feasible. "I recommended we try a roadheader. I felt the geology was such that a roadheader could get this project back on track," explained Brady. Groark decided to go with the recommendation but it was not an easy decision for him to make. "I went with the recommendation because it was Brady who made it. I not only was committing up to $250,000 of the Port Authority's funds to try this excavating method but my professional reputation was on the line," said Groark.

Once decided, a team headed by Brady was appointed to find a roadheader that would be available immediately. A used one in questionable condition was located and quickly moved to the project. It worked! It was eating rock! However, it proved to be unreliable and underpowered and a second roadheader was brought in from the Alpine Equipment Company. The model roadheader was the Alpine ABM

*The Voest Alpine AM 75 used on the project prior to delivery on site*

330. The machine was rented by the Port Authority and proved to be better than the first. Unfortunately, Brady said, they also experienced some availability problems with it. "I could see that we were not going to stay on schedule with this one machine. When it worked, it did give us good production but it was not sufficient for keeping this project on schedule. I decided we needed another roadheader," he says.

This time, he turned to Austria's Voest Alpine for help. Brady had a Voest Alpine AM 75 roadheader on the project only one week after his ordering it. This was despite the modifications and adjustments required for mining in the mica-schist.

Even though this roadheader proved to be reliable, according to Brady, he concluded a third one was needed for ensuring acceptable daily excavation-production schedules. Brady says, the logical choice for the third roadheader was another Voest Alpine. This time, a model AM 50 was delivered from the company's plant in Austria to the project in a record time of only four weeks after ordering it.

Once all three roadheaders were on the job, daily production was sufficient to bring the excavation programme to within specified time schedules. Noteworthy, however, is that machine performance was not based only on the quantity of the rock excavated per unit of time but how well the machine could cope with the excavation of the complex geometric spaces specified. Brady said the best machine for this challenge was the Voest Alpine AM 50. As to the total quantity of rock excavated, the AM 75 roadheader was clearly first, he says. Nevertheless, it was the AM 50 roadheader that was still in action after the other two were pulled from the project as excavation activities were winding down. "We kept the AM 50 longer to do the final excavation because it was more manoeuvrable and versatile," he said.

Whilst there was a very good team effort between The Port Authority, Golder Associates and Yonkers Contracting Co., Tully Construction, and J. Pegno Construction the success of this excavation project would not have been possible without the outside expertise of many companies and individuals. To mention some, there are: David R. Klug & Associates, GCS, Llc. and Dr. G. Sauer Corporation.

According to Groark, David Klug was instrumental in getting the 95 lattice girders built on time so a delivery-delay would not hinder the excavation advancement. Klug is well-known for his library of expert companies/people. Contractors and owners often rely on him for his connecting them with experts who can help solve their problems. He did more than just point the Port Authority to Sauer; he acted as coordinator between Sauer and American Commercial.

In this situation, there was a problem associated with the fabricating of the girders and it was concluded that outside expertise (Sauer) was needed to resolve it. Golder Associates designed the excavation and support systems with no appreciable problems encountered. American Commercial, the company assigned to fabricate the girders, needed help in making up shop drawings for the complex system of lattice girders required for the support phase of the project. The challenge was, consequently, to take the complex-designed excavation spaces and translate them into the correct size and shape of each lattice girder.

Klug recommended Dr. G. Sauer Corporation, an engineering company specialising in soft ground and mixed face tunnelling. Fortunately the company was under a design contract with the Port Authority so this contract was simply expanded to include this consultation.

Sauer's Kurt Egger, VP Operations, is quick to point out his company did not have to make any design corrections. "The design by Golder was solid; all we had to do was bridge a wide gap between Golder's design and the fabricator's requirements for detailed shop drawings. We started with three-dimensionals and cross-sections for greater detailing of the excavation, shotcrete application and lattice girder curvatures. Essentially, we detailed the whole scheme with 185 drawings that gave the fabricator at least 95 percent of what he needed in a shop drawing. He only had to add some details to our drawings for making them shop drawings. We were able to complete all 185 certified

*Tunnel views giving a further idea of the geometric complexity of the work to be carried out*

*Some of the lattice girders specially designed for the project*

drawings between May 1st [2002] and September 4th," says Egger.

The shotcreting on this project was particularly challenging because of the irregular surfaces involved. Unlike typical tunnel surfaces that usually have a single-direction curve, here the surface's curves are not easily described and only can be interpreted through geometric values. All shotcrete was applied using a hand-held nozzle. Only wet shotcrete was used and since the shotcrete was part of the primary support system, as well as the final lining, steel fibres were added to the mix. There are very few nozzle people that are apt enough to bring about quality results at such a challenging shotcrete project. Fortunately, George Yoggy of GCS, Llc., was available to not only help plan the shotcrete-application programme, recommend shotcrete applicators and recommend the equipment, but he periodically visited the site for troubleshooting problems and helped assure high quality end-results. Yoggy is not only a shotcrete-applications consultant but represents companies such as MBT (Master Builders Technologies). MBT supplied the admixtures and shotcrete equipment here.

There were other outstanding people on the project. Most of them came here by Brady's choosing. He brought in people from around the country who were expert in various fields of underground construction. Most of them are on the sun-setting side of their life. Brady says kiddingly, "You can't teach an old dog new tricks, so I went out and found me some tricky old dogs. That is, they are all expert, but still receptive to learn when necessary."

Nevertheless, the hats must really come off for the Port Authority. Often, government agencies are known as layers of bureaucrats where very little meaningful gets accomplished. There are incidents when this reputation is well-earned. That is not so here on this construction project. It is the Port Authority that has led the way and when faced with possible failure of this project, tried again by daring to try an excavation method yet not proven here in the Greater New York City area. Instead of trying to improve the drill and blast method, which was almost guaranteed to fail, they decided, quickly, to make a change. Groark summed it up this way, "This project with its significance tied to 9-11 was bigger than all of us [put together].

*Shotcrete application over lattice girders*

We were all going down with the drill and blast method but instead we drastically modified [the excavation] methods and stuck it out here, for we remembered 9-11." And, so now is the sweet hour of success. The project will be completed by the deadline and the temporary WTC Station might even be completed before the targeted year's end.

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