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Rehabilitation of Amtrak Baltimore and Potomac Railroad Tunnel in Baltimore, Maryland

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Rehabilitation of the National Railroad Passenger Corporation (Amtrak) Baltimore and Potomac (B&P) Railroad Tunnel in Baltimore, Maryland, built between 1871 and 1873, was undertaken by Amtrak and funded by the Northeast Corridor Improvement Project (NECIP). Planning of the project was undertaken jointly by Amtrak, FRA, and De Leuw, Cather/Parsons and Associates (DCP). Construction management services were provided by DCP. The tunnel rehabilitation effort, planned improvements, and problems encountered and action taken to overcome them are described. The double-track tunnel is a vital link in the Washington to New York freight and passenger main line and its deteriorated condition made its rehabilitation a primary goal of NECIP. After field inspections and engineering analyses were completed, the repairs agreed on were to (a) rehabilitate the existing invert, (b) repair the tunnel lining, (c) rebuild the gunite casing of the arch and walls, (d) install 140-lb continuous welded rail, (e) install a new gantlet track, (f) grout the invert, and (g) clean and improve the drainage system. The work was designed to be accomplished by contractor forces and Amtrak employees. To date three new sumps have been installed. Work on one track has been completed and work on the second track was scheduled to begin early in 1983.

The Baltimore and Potomac (B&P) railroad tunnel is located immediately south of the Baltimore passenger station and is within the heavily used Washington to New York passenger and freight main line known as the Northeast Rail Corridor. In 1980 a major rehabilitation of the tunnel was undertaken by the National Railroad Passenger Corporation (Amtrak) and funded by the Northeast Corridor Improvement Project (NECIP). Planning of the project was undertaken jointly by Amtrak, FRA, and De Leuw, Cather/Parsons and Associates (DCP). Construction management services were provided by DCP.

INTRODUCTION

The B&P Tunnel was built in 1871-1873 at a cost of about $2.3 million. Constructed in three sections, it spans a distance of 6,948 ft and has an inside height of 22 ft and a width of 27 ft (with slight variance at curves) to accommodate two tracks (Figure 1). The north section (approximately 1,150-ft long) is known as the John Street Tunnel; the center section (approximately 3,650-ft long) is known as the Wilson Street Tunnel; and the southern section (approximately 2,200-ft long) is called the Gilmor Street Tunnel. The largest gap between sections (approximately 300 ft) is between the Wilson and Gilmor Street Tunnels. The ruling grade is 1.34 percent through the Wilson and John Street Tunnels.

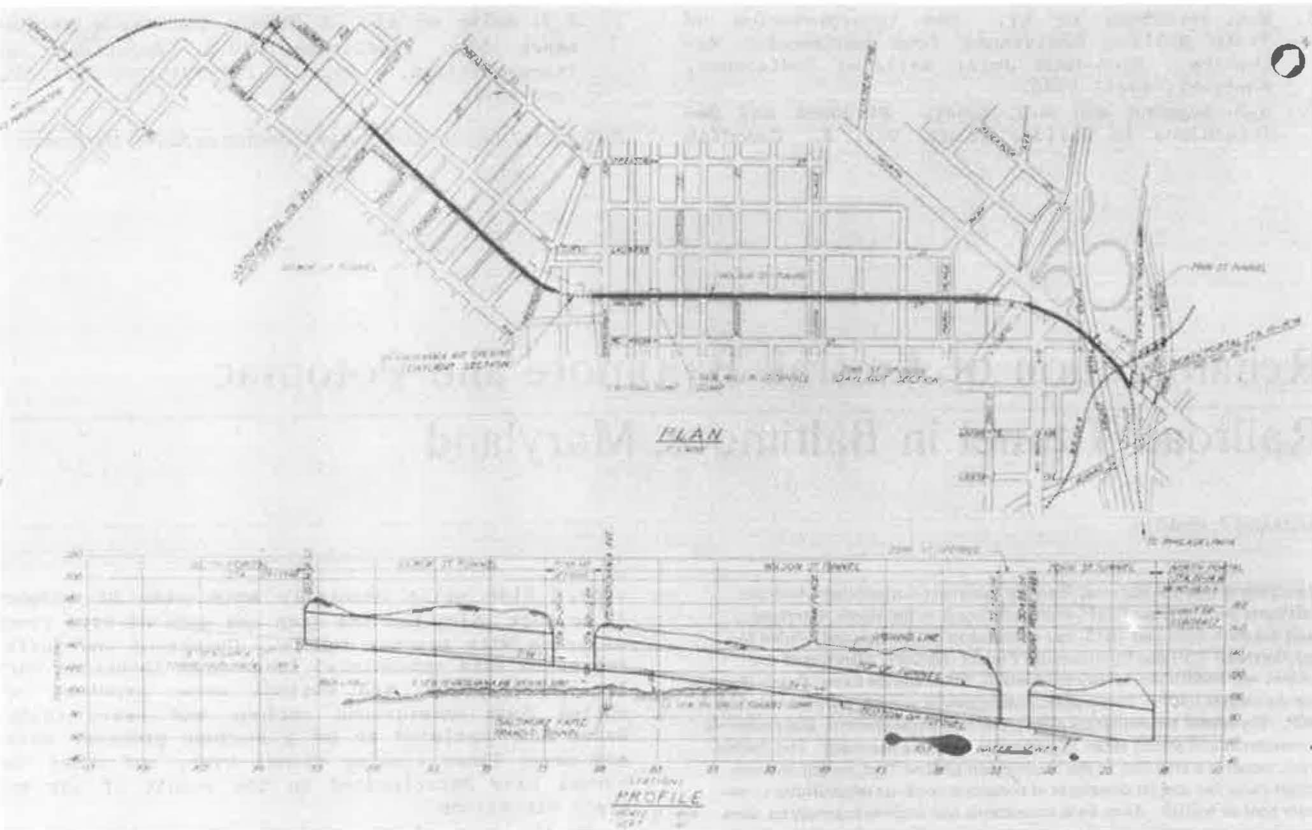
Original construction was cut and cover, except for a 1,057-ft section that required boring through rock. Side walls generally were made of masonry 4- to 6-ft thick and the arch was made of five rings of brick with masonry rubble. Quicksand and shifting earth were encountered in several locations during construction, and serious water problems resulted from underground springs and heavy rains. Water has continued to be a serious problem; water and sewer lines running along, over, and under the tunnel have deteriorated as the result of age and train vibrations.

By the turn of the century rail traffic through Baltimore had become so great that the Pennsylvania Railroad gave serious consideration to ways of relieving the congestion. The problem was compounded because evolving railroad technology had produced larger and higher locomotives and cars that required greater clearance. The floor of the tunnel was lowered approximately 2.5 ft in 1916-1917 to accommodate larger trains. The track was reconstructed on block ties fastened directly to a new concrete invert, and drainage was provided by a 10-in. pipe embedded in the invert in the center of each track with drop inlets at 100-ft intervals. The base of the walls was chipped away to improve horizontal clearance, with the result that the original wall thickness of 4 to 6 ft was reduced to a thickness of 1 ft 10 in. in some locations.

By 1923 the tunnel had become so badly damaged by constant leaks and locomotive exhaust blasts that lining repair became a continuing operation. The tunnel was subsequently closed to train operations on at least two occasions because of flooding. Major renovations were performed in 1935-1936 to install an oilostatic power line and catenary for electrification and in 1959 to improve clearance and install a gantlet track for freight trains.

As early as 1915 the Pennsylvania Railroad considered building new tunnels parallel to the existing Union and B&P Tunnels to provide additional capacity and alleviate traffic congestion. By 1928 railroad authorities were characterizing Baltimore as the bottle neck of north-south rail traffic. Debate on this subject continued for many years and, during the early stages of planning for NECIP, consideration was given to either outright replacement of the present B&P Tunnel or the construction of a parallel tunnel. The cost of building a new tunnel, estimated to be $200 million in 1974 dollars, when ranked against NECIP requirements and funds available and when coupled with the possibility that con-

Figure 1. Plan and profile of B&P Tunnel, Baltimore, Md.



gestion could be eased by the rerouting of trains, led to the decision that the B&P Tunnel would be repaired rather than replaced.

The repairs finally agreed on were to (a) rehabilitate the existing invert, (b) repair the tunnel lining, (c) rebuild the gunite casing of the arch and walls, (d) install 140-lb continuous welded rail, (e) install a new gantlet track, (f) grout the invert, and (g) clean and improve the drainage system.

WATER INFILTRATION AND DRAINAGE PROBLEMS

Water infiltration and drainage problems have contributed to deterioration of the B&P Tunnel and have created the need for extensive maintenance of its walls, arch, and floor structure. Along with natural ground water (a factor ever since completion of the tunnel) urban storm and sanitary sewerage and potable water line breaks have plagued the tunnel.

As NECIP planning progressed, because of the severity of the water problem, priority was given to improving the drainage system. The original center track drains had long ago lost their effectiveness in handling floor surface water. The planners determined that before installation of a new invert an improved drainage system must be in place. The key elements of this new system were large impoundment chambers or sumps constructed at critical water collection points, additional weep holes in the tunnel walls, and troughs to collect and convey the drainage to the collection sumps. The sumps were located under the tracks at the south portal to cut off the entrance of outside water at Pennsylvania Avenue to supplement an original pumping chamber, and in the Wilson Street Tunnel just short of the rock line intersection with the tunnel invert. Water from the sumps is pumped to the city storm sewers.

Under contract to Amtrak, the Mergentime Corporation began the $2-million invert grouting and drainage control project in the B&P Tunnel in March 1981. The objective was to upgrade the drainage system and solidify any existing underslab erosion. The contractor used special equipment developed for the job to drill weep holes in the tunnel's rock walls, pressure grout voids under the invert, and install sumps, pumps, and drainage pipe. This work was completed in 1982. All work was done under traffic, usually with periods of 8 to 12 hr of track outage per day.

TRACK AND INVERT IMPROVEMENTS

Although the granite walls and brick arch were judged by NECIP engineers to be generally in fair to good condition and required only occasional spot repair or strengthening, improvement of the invert and track structure was concluded to be essential to the restoration of operating safety and structural integrity. During the last 25 years most of the block ties from 1916 had been replaced by long ties and a thin veneer of ballast as the top concrete slab and wood blocks deteriorated. Drainage flow was on the surface because the center drain system had long since ceased to function as designed.

The renewal plan encompassed the placing of a new wood crosstie track structure on either a totally new concrete slab invert or shaved-down parent slab and then encasing it in concrete (Figure 2).

Because disturbance to the parent slab and underlying soil had to be kept to a minimum the existing slab was to be replaced only when test cores showed

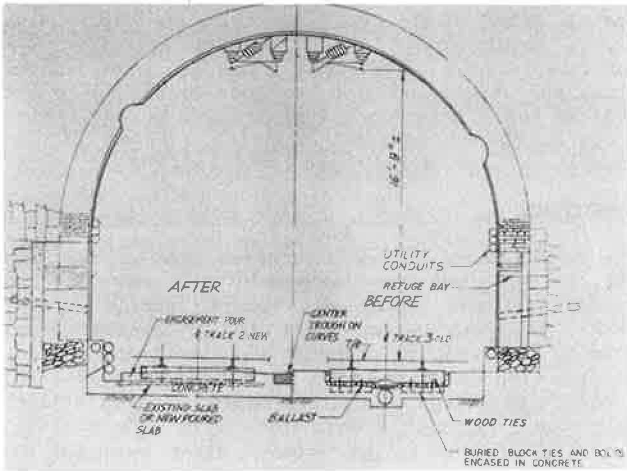


Figure 2. Cross section of B&P Tunnel; proposed track structure cross section on right.

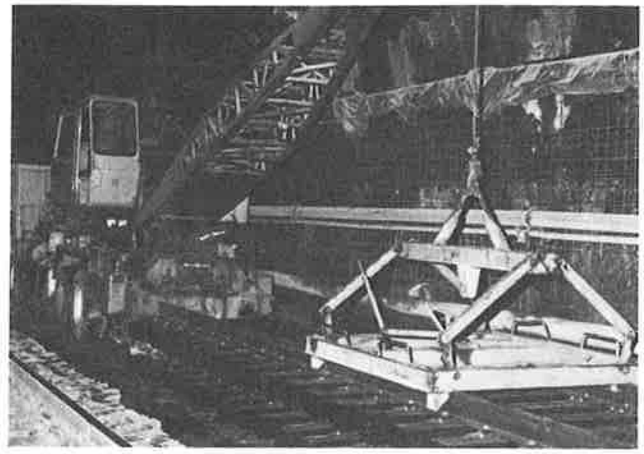


Figure 3. Placement of track panels on track 2.

concrete of either insufficient depth or strength. As designed, approximately 25 percent of the whole slab was to be replaced. The new cross section has drainage troughs to collect and transport infiltrating water to the sumps. Amtrak awarded the Mergentime Corporation a contract for this work in October 1981. The track was placed out of service in March 1982 and single track operation was in effect until completion of work. The work was expected to be completed in 90 days.

Several factors affected both progress and methods of construction from the outset of this phase of work. Several as-built plans used as important planning references were found to be inaccurate. Both the extent of foundation variations and the presence of additional block ties in the parent slab required field changes to the initial engineering plans. The block tie problem required additional removal of parent invert slabs and the foundation problem influenced the method by which the removal could be accomplished. This, in turn, reduced the initially projected rate of slab removal and replacement considerably.

Construction progressed through the Gilmor Street Tunnel into the Wilson Street Tunnel once plans were revised. Water removal, both from ground and external sources, continued to be toublesome. The work procedure generally consisted of the following steps:

1. Removal of the track,
2. Breaking up and removal of the slab,
3. Removal of material at the openings with cranes and buckets from overhead,
4. Preparation of the area for new foundation slab,
5. Pouring of new slab with pumped-in concrete,
6. Shaving off of existing slab where necessary by air guns and a scarifier mounted on a patrol grader,
7. Preparation of the scarified invert and the newly poured parent slab for the track structure placement with reinforcing mesh placed on the invert,
8. Placement of track panels (Figure 3),
9. Lining and grading of track panels,
10. Forming and shimming for the encasement pour,
11. Placing of the encasement concrete using on-track equipment, and
12. Pouring the curb.

As the demolition work progressed concern and respect were shown for the age and unpredictability of the tunnel structure action, particularly reaction to the construction disturbance. Although precautions, including such methods as strutting at the base during slab removal, were taken to maintain stability as the work progressed, a severe wall displacement occurred in May 1982 in the Wilson Street Tunnel. The tunnel wall on the track 2 side in the vicinity of the soil-rock transition area moved inward more than 5.5 in. within a few hours. The wall moved as a unit, although some horizontal cracking was experienced. Both short- and long-term actions were taken to arrest the movement and determine a permanent fix that would stabilize the wall and prevent future movement.

Immediate actions taken included the installation of rakers and struts (diagonal and horizontal steel beam braces) and expansion of the extensometer measurement program to detect wall movement. Subsequently, programs to determine foundation and subsurface conditions were initiated.

The presence of heavy water infiltration from the tunnel crown and subsidence areas at the street level above the fault established the possibility that underground utility leaks were contributing to the displacement forces behind the wall. Three brick row houses along the street above the tunnel, where cracks had developed in the foundations, were evacuated and subsequently condemned. Investigation of the quality of the infiltrating water indicated that it was probably potable, and subsequent reduction of pressure in an adjacent 30-in. main provided an immediate reduction of the volume of infiltration.

In the meantime, engineering analysis deemed that the portion of buckled wall should be restrained permanently. A tieback system to restrain the wall was designed by DCP and installed by a separate contractor. The tieback essentially consists of a reinforced concrete whaler beam, 1 ft 2 in. by 2 ft 0 in. by 132 ft long cast in place, and held by tendons spaced every 7 ft, anchored in the soil to a distance of 35 ft behind the wall. The installation procedure consisted of installing an independent track system for the machinery, drilling and augering through the wall and soil, placing and anchor grouting the cable tendons, and forming and casting in place the restraining beam (Figure 4) with the embedded tendon anchors post-stressed. The width of the beam created a clearance problem and a revised track alignment through the area had to be engineered. Fortunately, the 6-in. bulge and beam width could be negotiated within the existing envelope.

Figure 4. Casting in place of restraining beam.

This work was accomplished in about 4 weeks and invert work was resumed.

Another unscheduled problem was encountered in the John Street Tunnel where a storm sewer crossed under the invert after following its centerline for about 200 ft. Originally an old brick-lined barrel and arch, its top had been partly uncovered, probably during invert work in 1916-1917, and slabbed over. Because this structure was at a higher elevation than indicated on the plans, it was severely damaged during invert scarification. The solution was to totally uncover 30 ft that had the least cover, install a corrugated metal pipe, and encase it with concrete. The job would have been simple except that work had to be done in the 6-ft area between tracks without interruption to traffic on track 3. Extreme caution was exercised and the work was completed successfully.

At the south portal (Fulton Junction end of the project) a different engineering approach was taken for the rehabilitation of the invert. This open but retained area with its overhead bridges was also originally constructed with block ties in slab. Over the years the block ties had been replaced with standard ties and switch timber on a thin veneer of ballast. Because two new crossovers were to be installed in this area, engineering and maintenance analyses made clear that standard well-drained ballasted track would be preferable to other slab types. Geotechnical and structural investigations confirmed that, indeed, this could be accomplished. Thus, the underlying slab was totally broken up and removed and a drainage system leading to the sumps, properly graded backfill material, filter fabric, subballast, and ballast were installed.

CONCLUSION

The rehabilitation work progressed through the summer of 1982. The track encasement was completed and welded rail was installed. Two new gantlet tracks were also installed on track 2. An agreement was subsequently reached with the city of Baltimore for condemnation and removal of the three row houses and a pledge was given of further cooperation in utility leak water control. When the track was finished conduits were installed, signal wires were pulled, signal hardware was installed, and catenary wires were adjusted. The first train passed over the new track 2 in November 1982, after 32 weeks of construction at a cost of approximately $12 million. This was 19 weeks longer than the initial schedule; however, the lessons learned will be applied to the track 3 effort, where it is hoped that future unforeseen occurrences will be minimized.

This rehabilitation work was accomplished in a hostile tunnel environment where 78 freight and passenger trains a day were operating on the adjacent live track. Up to 14 watchmen per track were needed throughout the project. The only contractor accident of note involved a Whiting car mover that was struck by a passing train; fortunately, only a minor injury to the operator occurred.

Work on track 3 was scheduled to begin in early 1983 and to be completed in July 1983. When completed the 66-year-old invert and track structure will have been upgraded and a vital link in the Northeast Corridor will have been rehabilitated as part of the NECIP's effort to improve rail operations between Washington and Boston.

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