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Jacking Pits in Boston's Central Artery Project

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JACKING PITS IN BOSTON'S CENTRAL ARTERY PROJECT

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ABSTRACT

The jacking of the largest concrete tunnels ever built in the United States required the construction of jacking pits of unusual dimensions and requirements.

The location of the pits posed the additional challenge of difficult ground conditions, since the bottom of the pits was in the Boston blue clay.

The pits had to have an unsupported span of over 40 feet to accommodate the dimensions of the tunnel, have a solid base to carry the weight of the sections being built and provide lateral resistance to the thrust of the jacks.

Treviicos met those challenges by constructing a four feet thick, post-tensioned slurry walls capable of spanning 55 feet without intermediate support and by creating a thirty feet thick jet grouted mass below the sub-grade which had the double function of contrasting the wall at its toe as well as providing a more competent foundation for the jacking operation.

INTRODUCTION

The "Big Dig", Boston's replacement of its elevated Central Artery with an underground structure, is not only the largest urban transportation project ever built, but also one of the most difficult.

The project's objective was to alleviate the traffic congestion in the downtown area by increasing the number of traffic lanes, reducing the access point and by diverting traffic coming from the South and directed to the airport through a new tunnel under the Boston inner harbor, under Fort Point Channel and under nine active railroad tracks.

While all of those crossing presented great challenges, the tunnel under the Amtrak lines was particularly difficult since it had to be built with only 20 feet of cover without taking out of service any of the tracks bringing commuters to South Station, the City's busiest rail terminal.

Add to this the difficult geological conditions, the presence of utilities and obstructions and the size of the tunnels to be built and it is easy to believe that this particular contract ranks among the most challenging ones in a project which will be remembered for years to come as a true test of the ingenuity and professionalism of the American construction industry.

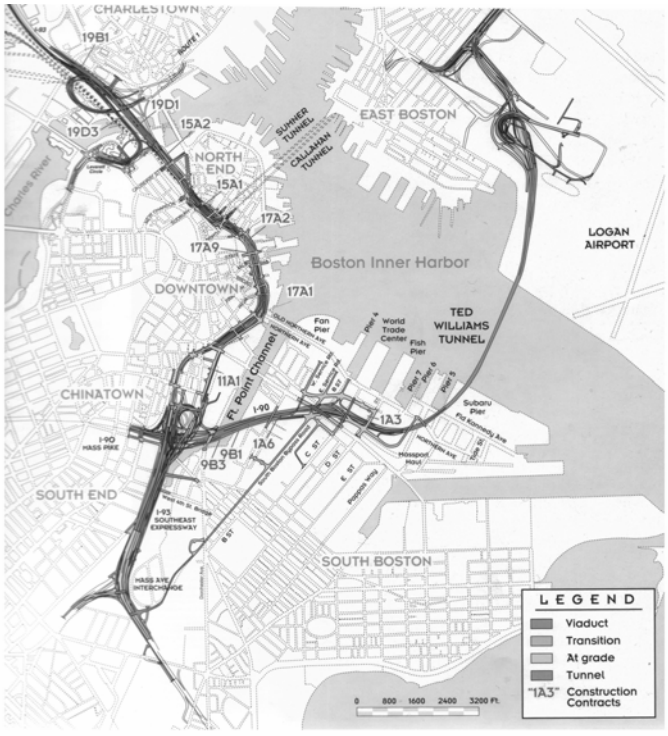

Fig. 1. Central Artery/Tunnel Project General Map

METHODOLOGY

Three tunnels had to be built, all 78 feet wide by 38 feet high, the 150 feet long ramp section, the 260 feet long westbound tunnel and the 380 feet long eastbound one collectively known as the South Bay Interchange.
After careful study of the geology and of Amtrak's requirements, the chosen method was to jack the tunnels under the tracks, a feat never attempted in North America for boxes of those dimensions. Soil freezing was the method chosen to stabilize the ground through which the boxes had to be jacked and appropriate precautions were taken to compensate for the expansion of the frozen soil. In such a manner the tracks could be protected from collapses during excavation and from heave during the freezing procedure.

Hundreds of pipes were driven into the ground on a tight pattern between the tracks on the alignment of the proposed tunnels and brine at 30 degrees below zero was circulated through the pipes to create a block of frozen ground.

Fig. 2. Soil Freezing

While this operation was progressing, jacking pits needed to be built in which the tunnel section could be built and from which they could be launched.

While a road header started mining the frozen soil ahead of the sections, two set of jacks started pushing them forward three feet at a time. The frozen spoil was removed by a loader, put in akip pan and lifted to the surface by a crane.

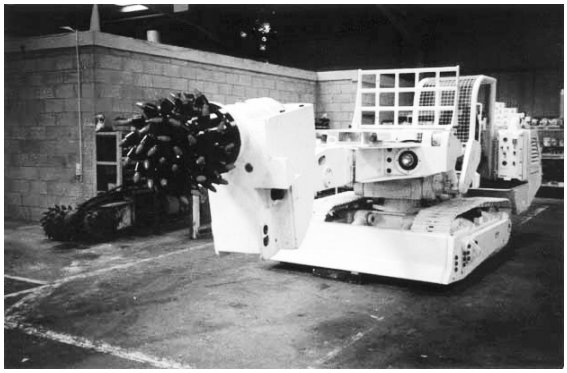

Fig. 3. One type of Road Header

DESIGN OF THE JACKING PITS

The General contractor, a joint venture of Slattery, J. F. White, Interbeton and Perini, Was faced with the problem of constructing the jacking pits with a strict set of requirements:

- They had to be big enough to accommodate a full section of the tunnel and the jacking equipment.
- The bottom of the pits had to carry the weight of the concrete bottom slab, of the tunnel sections and of the jacking apparatus, had to resist uplift pressure during excavation as well as act as bottom brace for the side walls of the pits.
- The back walls had to resist the thrust of the 50 hydraulic jacks pushing forward the 17,000 tons tunnel sections.
- The front wall had to accommodate an opening of the size of the tunnel sections
- The side walls had to have a 40 feet unsupported span to accommodate the sliding tunnel sections.

Treviicos was the specialty subcontractor hired to do the job and, with the help of Weidlinger Associates, it developed a value-engineering proposal which satisfied all of the requirements of the General Contractor. It utilized four feet thick, post-tensioned slurry walls on three sides and three foot thick regular slurry wall on the side to be breached.
By using high stress tendons, draped to a profile determined by the bending moment diagram, triangular space frames as the upper support and the jet grouted mass as the bottom brace, the pits could be excavated to sub-grade with an unsupported span of 55 feet.

The slurry walls were 83 feet deep and the jet grouted bottom slab extended approximately 25 feet from sub-grade to the bottom of the wall.

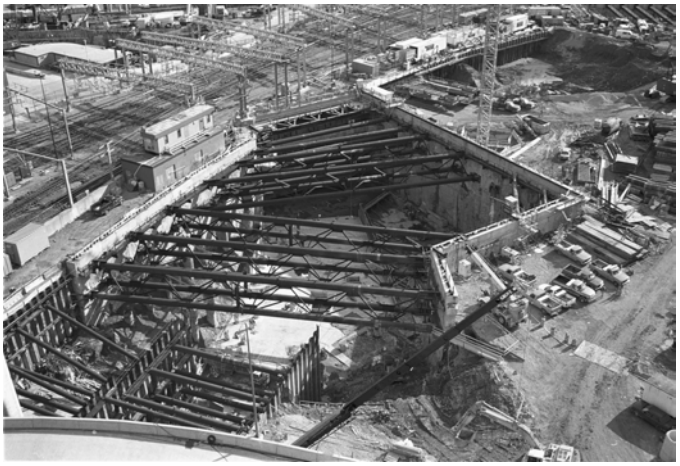

Fig. 4. Site View

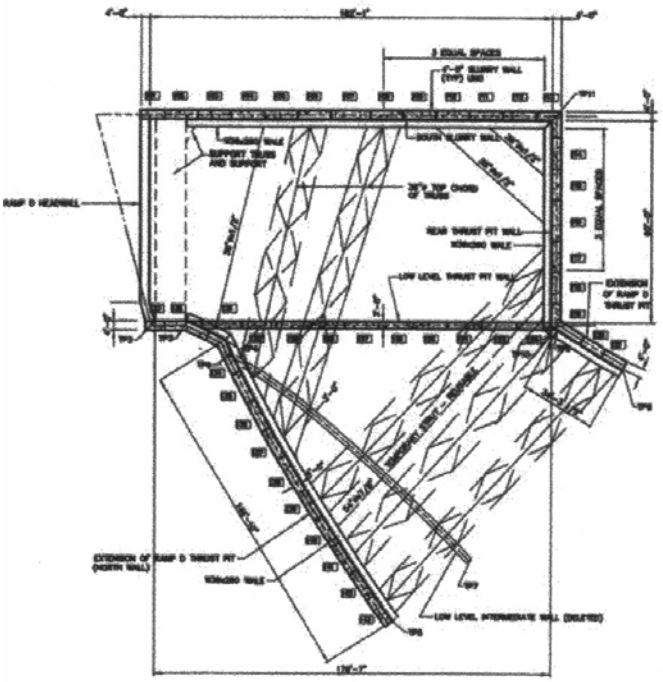

Fig. 5. Ramp"D" Jacking Pit

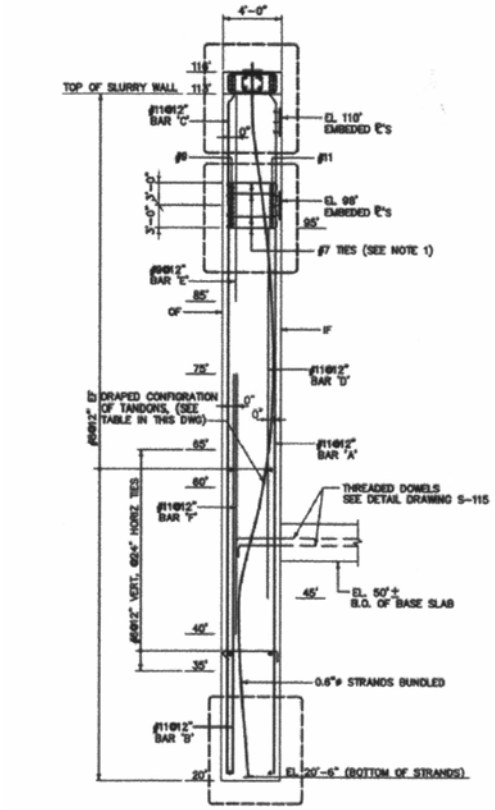

Fig. 6. Ramp"D" Jacking Pit

CONSTRUCTION

A combination of mechanical clamshells, manufactured by Tecnosoil, and hydraulic ones, manufactured by Soilmec, excavated the slurry walls, while the jet grouting work was done by Soilmec equipment consisting of:

- CM-40J drill rig
- EC-30 leader and power pack mounted on a Link-Belt 128
- 7T-450H pressure pumps (three units)
- GM-14 mixing plants (two units)

Fig. 7. Soilmec CM-40J Drill Rig performing Jet Grouting

Fig. 8. Soilmec SM-870 with a BH-12 Hydraulic Clamshell

Fig. 9. BR Clamshell

Fig. 10. Soilmec Soil Mixing Plant

The combination of innovative design and specialized construction techniques was the key to provide a solution which was both safe and cost effective for the construction of this complicated portion of the jacked tunnels.

Fig. 11. Completed West Bound Tunnel Jacking Pit

CONCLUSION