Big Accomplishments at the Big Dig

Nicholson Construction Company Completes 12 Major Projects for the CA/T

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Boston's Central Artery/Tunnel Project (CA/T), also known as "The Big Dig," is considered the most complex and technologically challenging engineering and construction endeavor in American history. For Nicholson Construction Company, the enormous scope of the Big Dig created enormous challenges and opportunities. Nicholson was involved with twelve major CA/T projects.

The company's extensive involvement included the installation of over 450,000 sq ft of concrete diaphragm (slurry) walls, more than 700,000 sq ft of soil mix walls, an additional 570,000 cu yd of soil mixing and the installation of about 6800 anchors. In addition, jet grouting technologies were applied to about one half of the contracts to provide cost-effective and permanent ground improvement.

Barge-mounted soil-mixing rig working at the Fort Point Channel.

The innovative technology that was implemented in the CA/T project can be summarized into the following categories:

- ***Jet Grouting***, the injection at very high pressure of specially formulated cement grout into the ground to improve its strength and reduce the permeability, is increasingly chosen for underpinning and excavation in tight places.
- ***Diaphragm Walls***, or slurry walls, are basically deep trenches excavated in the soil into which reinforced concrete is placed. It is slurry wall construction that made the whole CA/T possible, providing a rigid work area for excavation and supporting the existing highway structure.
- ***Tieback Anchors***, providing tension support, limit movement from subsequent excavation by providing a pre-loaded condition to the underlying ground. Ground anchor systems were installed throughout the CA/T project as reliable and cost-effective alternatives to conventional retaining walls.
- ***Deep Soil Mixing***, or the formation of consolidated soil columns through mechanically fracturing soil while simultaneously mixing with cementing agents, allows for permanent improvement of the foundation bearing capacity. The work at CA/T created cemented foundations to

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resist vertical and lateral loads of tunnel structures.

Mixing It Up in the Fort Point Channel

One of the most demanding "Big Dig" projects was the Fort Point Channel (C09A7) crossing. Massive highway ramps and tunnels had to be built in unusually soft and weak soil in an urban congested area. The area is bounded by the Channel, but also by Boston's commuter and Amtrak rail systems, the U.S. Postal Service distribution center and Gillette world headquarters. Before construction began, the soft ground along the Channel edges needed to be stabilized, and this was accomplished by a joint venture led by Nicholson to perform deep soil mixing and jet grouting. The scale of deep soil mixing required by the project was unprecedented – over 530,000 cu yd of soil. In areas too difficult to reach with mixing equipment, approximately 45,000 cu yd of jet grouting was used. More than 300,000 tons of cementitious material was required and installed to a depth of 130 feet. Today, this work at the CA/T is recognized as the largest deep soil-mixing project in the U.S.

As an adjunct to this project, the stabilization of soils around the Broadway Bridge (C09A8) was also performed by Nicholson. The bridge crosses the Fort Point Channel and is underlain by the same deep layers of weak and soft soils. 40,000 cu yd of soil mixing and 13,000 cu yd of jet grouting for global stability and tunnel face stabilization was accomplished.

Partially excavated Casting Basin looking west toward the Fort Point Channel.

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In the same Fort Point Channel area but under separate contract (C09B1), 135 ground anchors with working loads of up to 150 kips were installed. The anchors, installed on nine different levels, secured a soldier-pile and lagging wall over an 80-foot deep excavation in Boston Blue Clay. This deep wall connected the soil mixed section (C09A7) with an adjacent frozen wall at the exit side of a huge jacked tunnel.

The C09B3 Casting Basin was constructed as an excavation support system for the concrete elements that formed the sunken tunnel crossing of the Fort Point Channel. The excavation served as the dry casting dock for all the sunken tube sections and the conventional cut-and-cover tunnel built inside. A redesign was facilitated for this slurry wall, which resulted in the use of fewer anchors of a higher capacity. The slurry wall consisted of approximately 193,500 sq ft. The structure was 3-feet thick and was dug to a maximum depth of 95 feet. About 1500 high-capacity anchors were utilized as the primary means of lateral support. The anchors ranged in length from 70 to 150 feet.

Leading the Way to the Airport: The I-90 Extension

In addition to the casting basin, another important dimension of the CA/T project was the complete design/build support of excavation for the Ted Williams Tunnel section of CA/T, adjacent to Logan Airport, known as Bird Island Flats (C07A1). The largest soil-mixed retaining wall in the U.S., 400,000 sq ft of soil-mixed wall with wide flange beams on 4-foot centers and 3 to 5 rows of tieback anchorswere installed. A total of 3,400 anchors were installed with working loads ranging from 150 kips in clay to 420 kips in glacial soils. To strengthen the marine clays against deep global movements, 45,000 linear feet of jet grout columns, and 400,000 sq ft of soil

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70 ft deep excavation for Logan Airport approach to the Ted Williams Tunnel – C07A1 Bird Island Flats.

mixed wall buttress elements were installed with a minimum compressive strength of 300 psi.

The work for project C01A3 entailed yet another design/build excavation support system, this time for the western approach to the Ted Williams Tunnel. Complete support of the excavation was provided by 300,000 sq ft of soil mixing, 1,800 anchors and 62,000 sq ft of diaphragm wall. This project also included the installation of a 150-foot deep jet grouted cut-off by means of 97 jet grout columns with an average treatment of 100 feet per column.

First Use of Hydromill Technology

A 35,000 sq ft diaphragm wall was built by Nicholson's parent company Rodio, Inc. in the vicinity of the Quincy Market. This contract (C14C2) employed the first use of Hydromill technology on the CA/T project. The Hydromill reverse circulation diaphragm wall machine, especially modified to work in low-headroom conditions under the I-93 viaduct in downtown Boston, was capable of excavating diaphragm wall trenches through clay as well as glacial till and bedrock. The relocation of utilities made this project extremely difficult.

The Largest Highway Tunnel Vent System in the World

A total of seven ventilation buildings were built for this project, making it the largest highway tunnel vent system in the world. A new and better design was introduced for these buildings prior to installing the diaphragm wall for Vent Building #3 (C17A3).

This heavily reinforced concrete wall is 36 inches thick. A 42-foot-long soldier pile tremie concrete diaphragm wall was also installed. The total square footage for this project was 92,240 sq ft. A maximum excavation depth of 120 feet was achieved. In a joint venture with other contractors, Nicholson constructed a diaphragm wall for Vent Building #4 (C15A3), which consisted of 79,000 sq ft and was excavated to a depth of 120 feet. For Vent Building #6 (C04A3), five permanent 14-strand, double encapsulated rock anchors were installed to counteract hydrostatic uplift of the foundation slab.

Pioneering Anchor Test Program

An extensive anchor test program demonstrated the company's ability to execute significant research. This anchor test program was conducted on two different sites with anchors in fill, Boston Blue Clay and argillite. Anchors were drilled with hollow stem augers (~12) and rotary casing duplex (~30). Anchors were tested with and without post grouting using packers. Precast piles were also driven and tested. Instrumentation included vibrating wire strain gauges, vibrating wire load cells and extensometers (telltales). Approximately 80 load tests were performed on anchors using five different procedures. Several anchors were locked off and monitored for a period of one year.

Tiedown-waterproofing tests were also performed at a shop in Boston. In this case, a test setup using 4-foot concrete blocks with steel sleeves through the blocks was developed. Eight different waterproofing materials were applied outside the sleeves on "mudmats." Ten different waterproofing materials were applied inside the sleeves and around the bar or strand anchors. Water pressure of 30 psi was then applied to the bot-

The project includes the largest geotechnical investigation, testing, and monitoring program in North America.

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Nicholson's jet grouting activities at C09A7 project.

tom of the blocks and around sleeves and sides of the anchor below the sleeves. The anchors were then incrementally loaded and monitored for leaks for a minimum of 36 hours.

The Coordination of Large-Scale, Multi-Faceted Projects

This complex involvement in the Boston Central Artery/Tunnel gave the company an opportunity to employ it varied technologies and demonstrate their viability and efficacy. In many cases, the engineers facilitated a redesign that improved the original design and translated into financial savings. The massive anchor test program conducted confirms the company's commitment in performing advanced research in full partnership with Owner's Engineers. The last ten years of intense contracting activity on the CA/T project, confirmed the company's ability to manage and coordinate large-scale, complex geotechnical projects, keeping quality and safety at the top of its priorities.

Established in 1955, Nicholson Construction Company is a full-service geotechnical construction company specializing in piling, earth retention, slope stabilization, structural support, underpinning, tunneling services, and dam remediation. Nicholson offers innovative, efficient and cost-effective solutions to complex geotechnical problems throughout North America. For more information, visit their website at www.nicholson-rodio.com.■

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Big Dig Facts

- The project consists of 118 separate construction contracts, with 26 geotechnical drilling contracts.
- The old, elevated Central Artery, built in 1959, supported about 75,000 vehicles when it opened, but today it carries more than 190,000 and has an accident rate four times the national average for urban interstates.
- The underground Central Artery is expected to carry about 245,000 vehicles by 2010.
- Workers are installing more than 26,000 linear feet of steel-reinforced concrete slurry walls – the largest application of this construction technique in North America – which form the walls of the underground highway as well as the supports for the elevated highway.
- The Ted Williams Tunnel interface in East Boston between the land-based approach and the underwater portion is 90 feet below the surface of Boston Harbor, the deepest such connection in North America.
- The deepest point of the underground highway is 120 feet down, beneath the Red Line subway tunnel at Dewey Square.
- The project includes the largest geotechnical investigation, testing, and monitoring program in North America.
- The Big Dig will create more than 150 acres of new parks and open space, including 27 acres where the existing elevated highway now stands.
- The project's underground utility relocation program moved 29 miles of gas, electric, telephone, sewer, water, and other utility lines maintained by 31 separate companies.

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