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APM Tunnel Extension for the Maynard H. Jackson Terminal at Hartsfield-Jackson Atlanta International Airport

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ABSTRACT: Hartsfield-Jackson Atlanta International Airport underwent a $1.2 billion dollar expansion project centered on the construction of the new Maynard H. Jackson International Terminal. Since completion, all international operations have transferred to the new terminal. The new International Terminal has its own pick-up and drop-off access, baggage claim and check-in facilities; as well as parking facilities. Passenger access between the new International Terminal and the domestic airport facilities is primarily via underground Automated People Mover (APM) trains.

Prior to the current expansion, the APM tunnel terminated at Concourse E, which previously served all international flights. The new International Terminal is located approximately ½-mile from the terminus of the existing APM tunnel. A cut-and-cover method was selected for the construction of the APM tunnel extension to allow the construction team to best address unknowns and potential obstructions. This paper presents the challenges posed by the extension of the APM Tunnel and the construction techniques selected to most-efficiently overcome these challenges.

INTRODUCTION, GEOLOGIC SETTING AND SITE PROFILE

The construction of the APM extension required an excavation support system for a 450-ft long, 55-ft deep excavation across Taxiway Dixie and a 900-ft long, 30-ft deep excavation beneath the basement of existing Concourse E. The excavation under Concourse E required both excavation support and support of the existing columns over the proposed excavation zone.

The airport facilities are located within the Piedmont Physiographic Province of Georgia. The general geologic profile typically includes residual soils as a result of in-place physical and chemical weathering of the parent bedrock (igneous and metamorphic bedrock).

The soils vary from highly-weathered, fine-grained to less-weathered, predominantly coarse-grained (often exhibiting the relic structure of the parent rock). There is often a transitional intermediate geo-material between residual soil and the parent rock, locally referred to as partially weathered rock (PWR) and defined as residual soil with standard penetration test results (SPT N-value) of at least 100 blows per foot. Alluvial deposits (typically relatively thin) may be encountered over the residual materials.

The excavation required for the new APM tunnel exposed up to 50-ft of fill. Some alluvium was encountered below smaller fill thicknesses. Typically, residual soils were encountered below the fill transitioning to PWR typically within the depth of excavation. Bedrock was encountered at a depth range of 50-ft to 100-ft. The depth and quality of the fill material, as well as the variability of residual soil, PWR, and rock elevation and thickness was a significant factor in the selection of the excavation method. Profiles of the subsurface conditions the excavation along Taxiway Dixie and under Concourse E are shown in Figures 1 and 2 respectively.

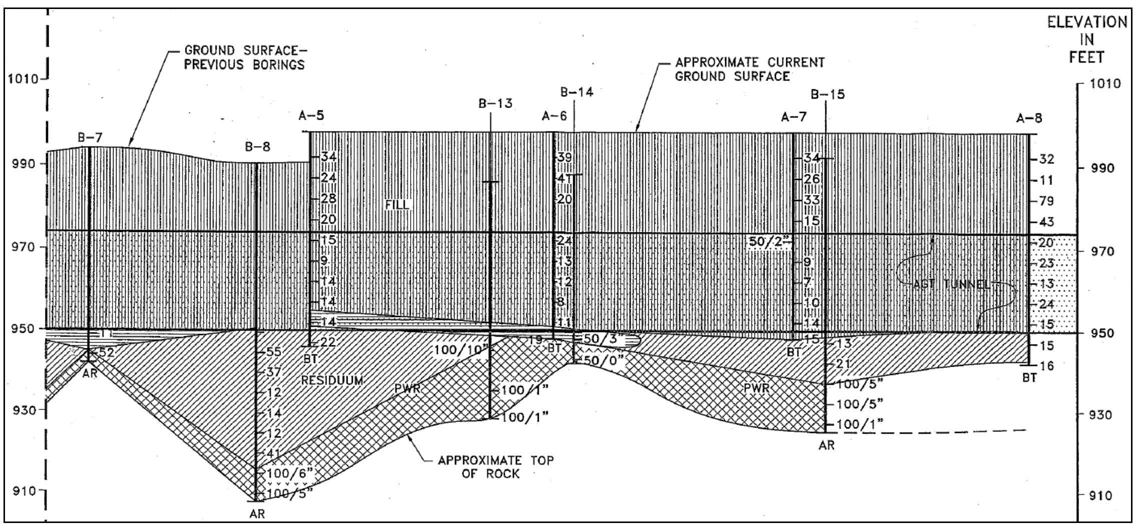

FIG. 1. Subsurface Profile Near Taxiway Dixie

SUPPORT OF TAXIWAY DIXIE

While excavating across the taxiway, construction time was critical because the extension of the APM tunnel required the temporary closure of Taxiway Dixie, adding almost 13 minutes to every arriving and departing international flight. The scope of support required for the excavation is shown in Figure 3.

A soldier pile and lagging wall with tiebacks was planned to support this portion of the excavation. Approximately 100 soldier piles and over 200 tiebacks were installed in the wall under the taxiway. More than half the soldier piles were battered which was an alternate approach from the original design. A profile of the original support scheme is shown in Figure 4.

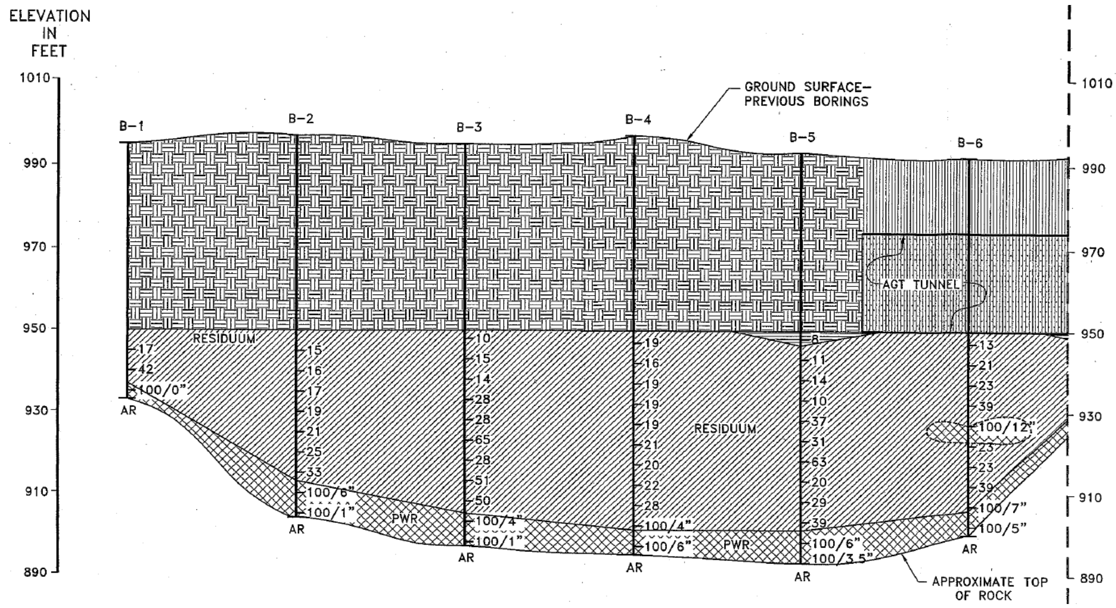

FIG. 2. Subsurface Profile Under Concourse E

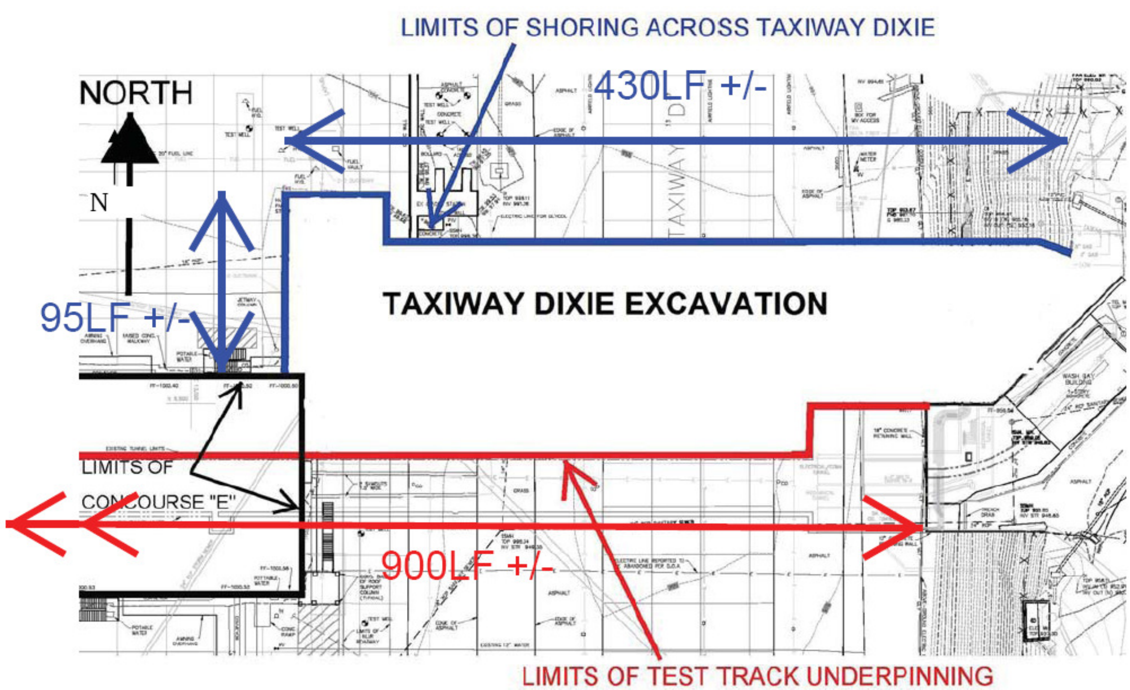

FIG. 3. Location of Excavation and Required Shoring for Taxiway Dixie

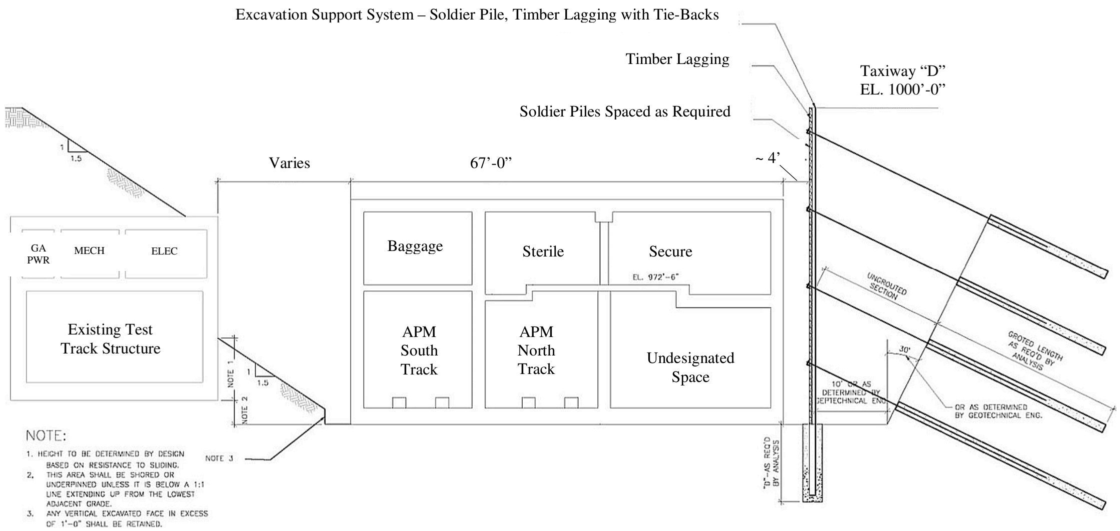

FIG 4. Typical Excavation Support System Section

Features of the original plan include top-of-shoring at the taxiway elevation with future demolition during backfill resulting in cutoff of the shoring 10-ft below finished grade, a costly procedure due to the depth of cutoff required.

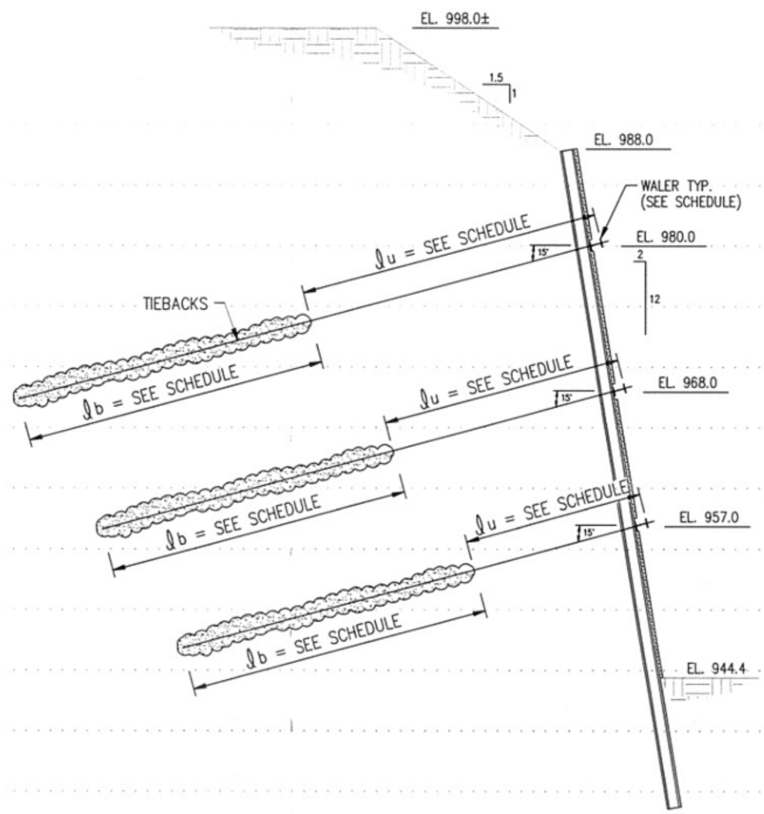

FIG 5. Alternate Excavation Support System Section

The alternate approach for shoring included installing shoring, where possible, with a top-elevation 10-ft below finished grade to eliminate the need for shoring cutoff but included some demolition of the existing taziway before completion of the work. Additoinally, the soldier piles were installed on a 10-degree batter to reduce earth pressures to allow for the use of smaller piles, fewer tiebacks and less pile-toe penetration below the bottom of the excavation. A schematic of the alternate approach is shown in Figure 5. A photo of the completed work is shown on Figure 6.

FIG 6. Completed Excavation Support of Taxiway Dixie

Additionally, analysis indicated a possible sliding failure of the existing test track paralleling the excavation opposite Taxiway Dixie (see Figure 4). Underpinning pits were constructed around any exposed columns supporting the test track to mitigate the possible sliding failure (shown on Figure 7).

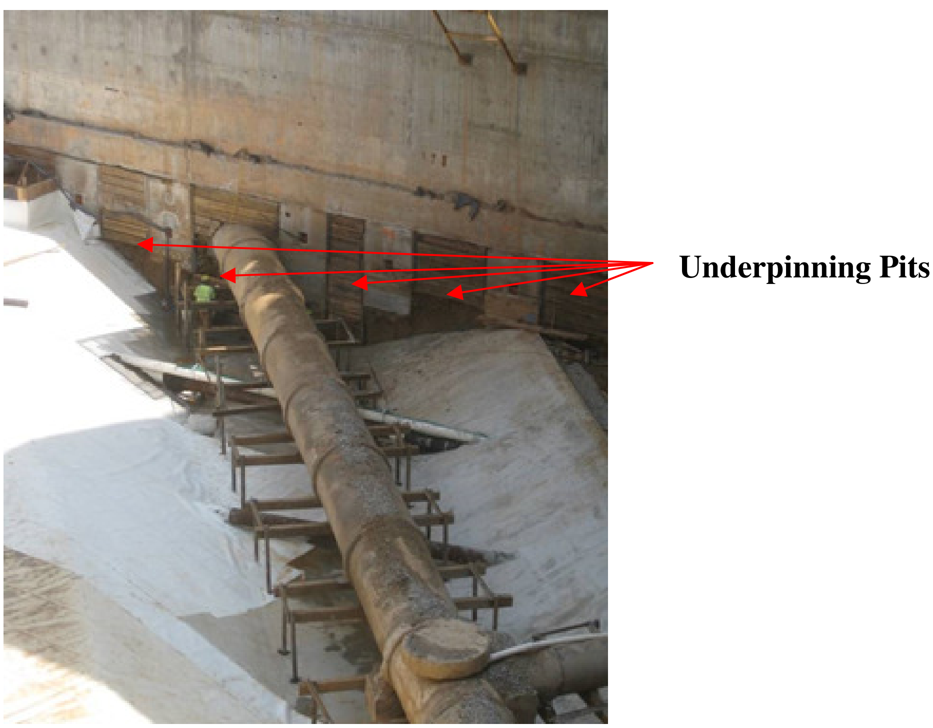

FIG 7. Supporting Existing Test Track (see Figure 4)

EXCAVATION BELOW CONCOURSE E

The challenges of excavating underneath Concourse E included the exposure and underpinning of much of the existing deep foundations. The original structure support consisted of Auger Pressure Grouted (APG) Piles that were installed in the early 1990's.

The work was performed in low-headroom conditions with limited access below Concourse E, which remained active during the work. Planned bottom-of-excavation was about 35-ft below the concourse basement slab (55-ft below the tarmac apron). Existing structure movement tolerances were planned to be 1/4-in. An overview of the excavation support requirements is shown on Figure 8 and a profile of the original support scheme is shown on Figure 9.

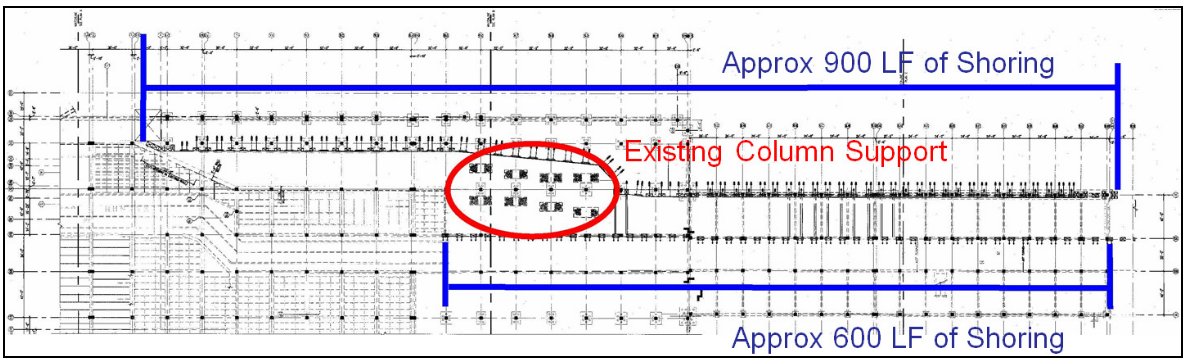

FIG 8. Overview of Excavation Support Requriements Below Concourse E

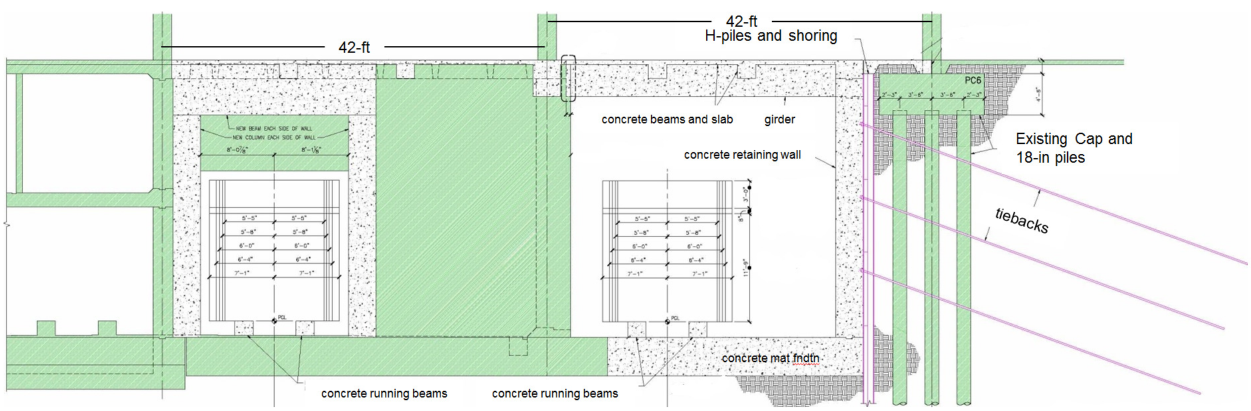

FIG 9. Profile of Original Support Scheme Below Concourse E

A plan view of two sections of excavation support is shown on Figure 10. The proposed shoring configurations in these two sections would have required eight existing columns to be exposed and supported, which would be both complex and expensive. The alternate support scheme (Figure 11) used a combined approach of soldier pile and lagging wall with tiebacks as per the original along with hand-dug underpinning pits around the majority of the nine existing columns to minimize the number of exposed columns requiring support.

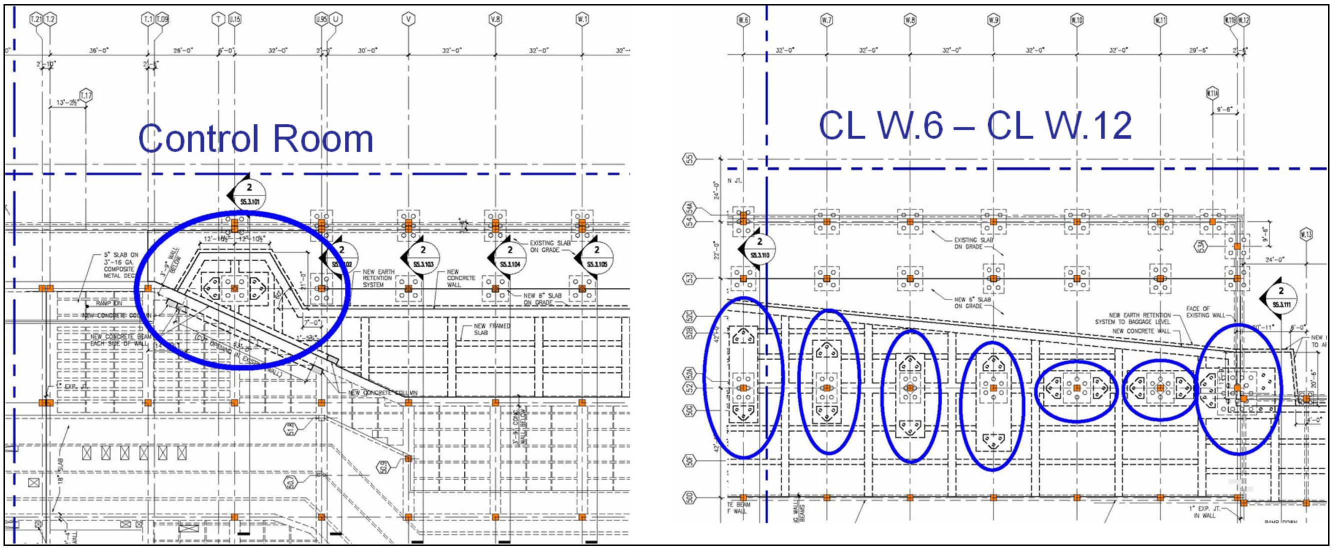

FIG 10. Plan of Original Support Scheme Below Concourse E

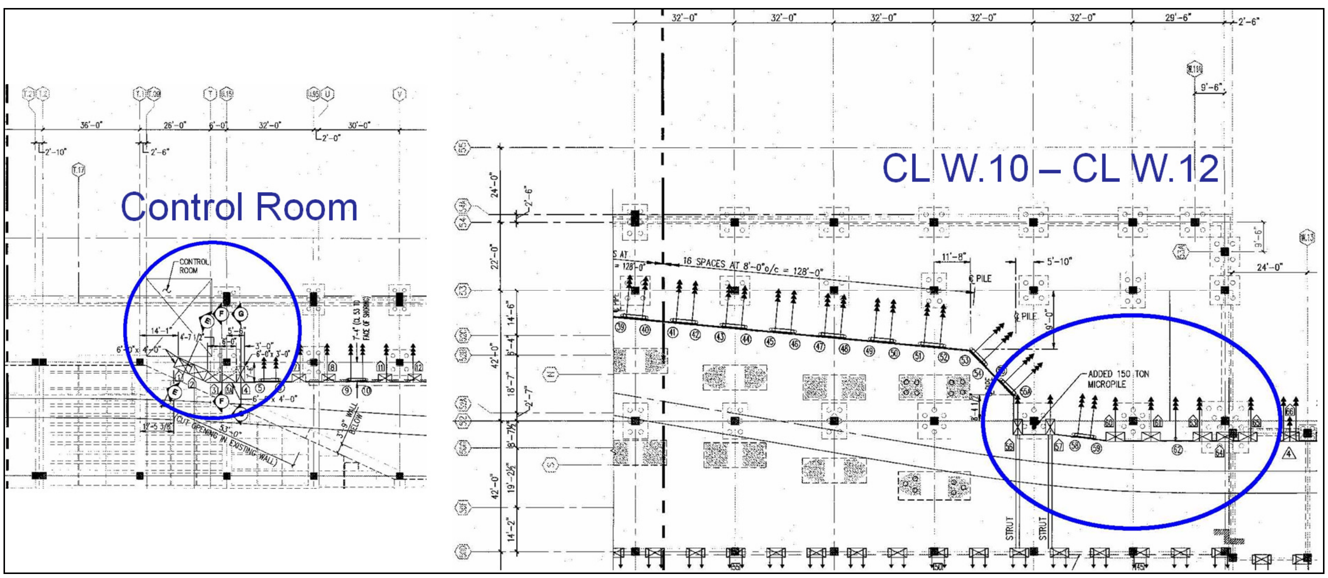

FIG 11. Plan of Alternate Support Scheme Below Concourse E

Additional details of the underpinning pits around the existing columns are shown on Figure 12. The approach utilized the pits in conjunction with tie-backs to support the columns. Shotcrete was applied to protect the existing auger-cast piles exposed during the excavation. Additionally, steel pipe piles with walers and tie-backs were installed where the bays between the existing columns were particularly long. The new support system includes over 100 hand dug underpinning piers as deep as 50-ft, approximately 40 soldier piles and over 400 tiebacks. Figure 13 includes two photos showing pit-excavation and concrete-backfilling. Figure 14 shows the resulting combined support system under Concourse E while Figure 15 shows exposed pits supporting the column where the support under the concourse met the support of Taxiway Dixie.

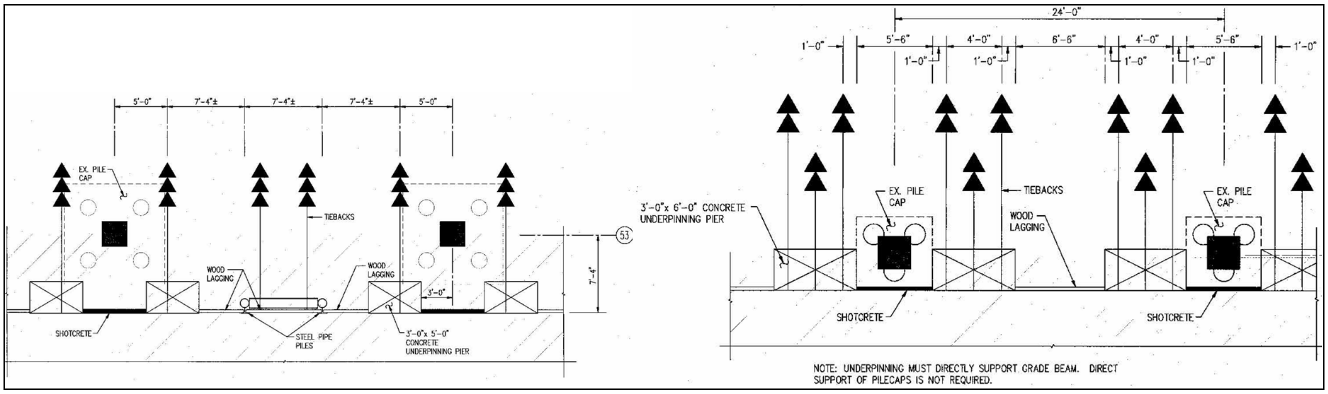

FIG 12. Plan of Tied-back Underpinning Pits and Steel Pipe Pile Support System

FIG 13. Pit Construction and Subsequent Concrete Filling

FIG 14. Completed Excavation Support System Under Concourse E

FIG 15. Exposed Underpinning Pits After Excavation

SUPPORT OF EXISTING COLUMNS

The excavation support described in the previous section left four columns founded on APG piles that conflicted with the alignment of the new train extension (see Figure 6). Figure 16 is a close-up of a portion of the profile of the original support system detailing the proposed support of existing columns exposed under Concourse E.

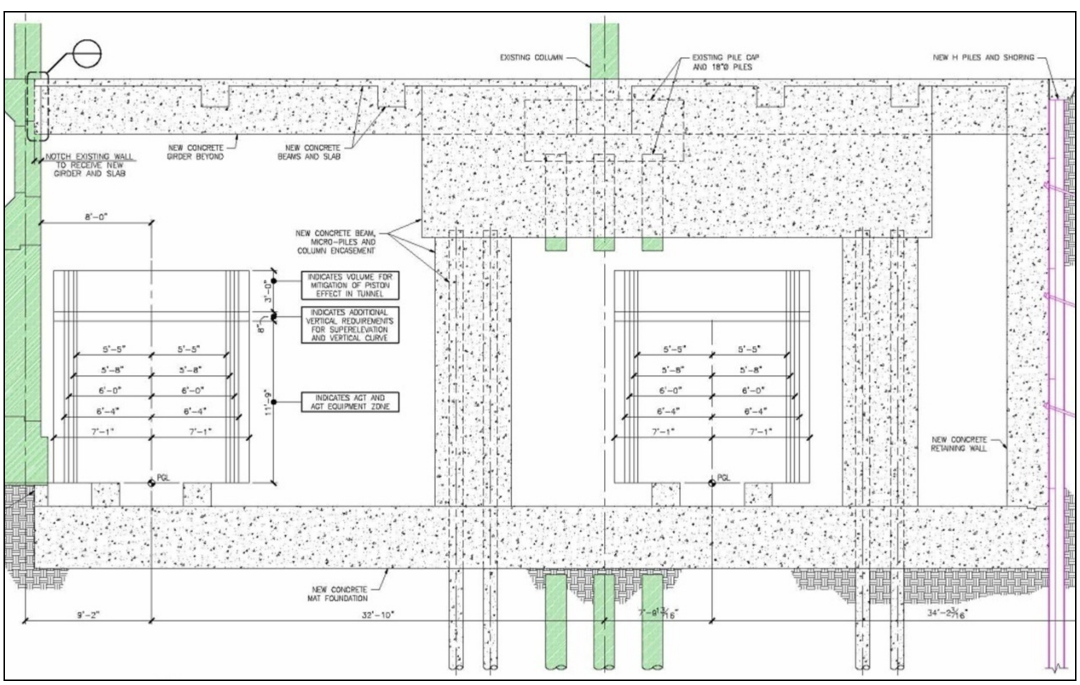

FIG 16. Portion of Original Support Profile for Columns Under Concourse E

The original concept included low-headroom (LHR) augercast piles with a 8-ft to 10-ft concrete mass transferring the column load to these new piles. Figure 17 shows a portion of the final design profile which included changing the proposed new piles to micropiles and designing a revised load transfer system consisting of a system of steel beams encased in concrete which moved the new-pile tops closer to the existing cap level. Both the change in pile-type and top-of-pile level reduced constructability issues and the associated costs due to these potential issues.

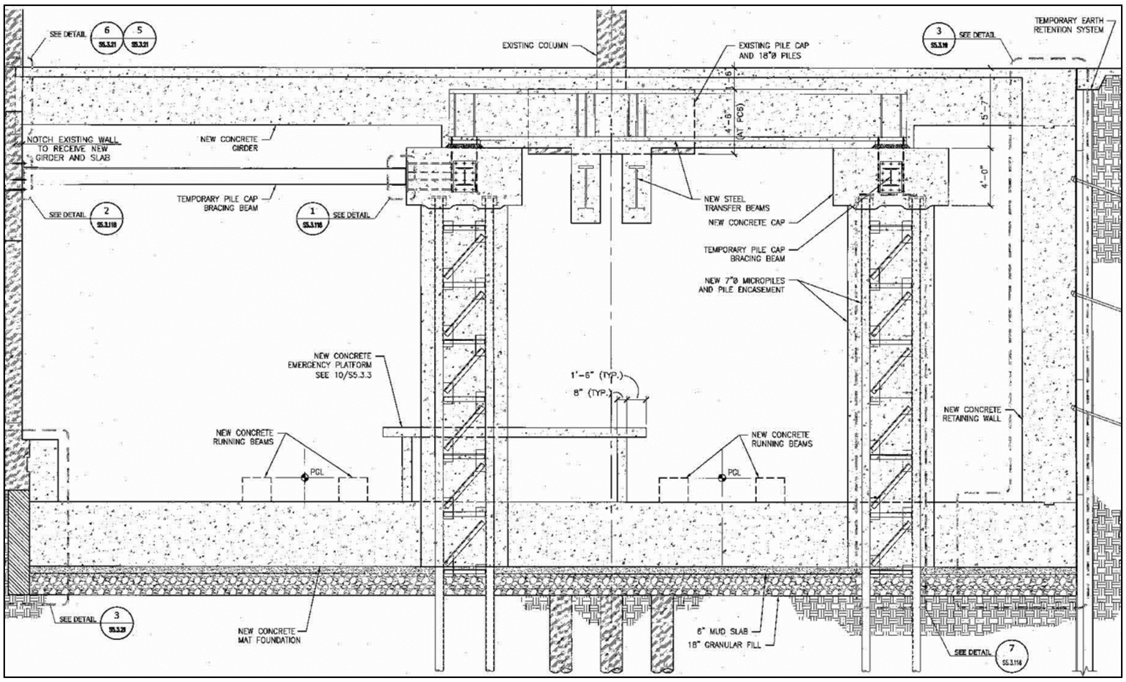

FIG 17. Portion of Alternate Support Profile for Columns Under Concourse E

Final design included 60 new micropiles, installed straddling the new train extension. Micropiles with an outside diameter of 7-in were selected to support design compressive loads of 56-tons to 150-tons (see Figure 18). The average length of the piles was 120-ft. The piles were sleeved to a depth of 40-ft below the bottom of the excavation to ensure load transfer occurred in the underlying bedrock.

FIG 18. 7-in diameter micropiles

Column loads were transferred to the micropiles and the conflicting APG piles were removed. Figure 19 shows the exposed existing APG pile which were removed along with the same view after completion of the steel load transfer system connecting the existing columns to new caps on the installed micropiles. Figure 20 is a global view of the load transfer system. The steel was eventually encased in concrete during tunnel construction. Figure 21 is a view of the completed excavation showing the existing caps, load transfer system and new micropiles.

FIG 19. Before and After View of Column Support Below Concourse E

FIG 20. Overview of Load Transfer System from Existing Columns to New Caps

SUMMARY

The cut-and-cover approach to the excavation for the APM extension was selected to allow the design and construction team to address unknowns or obstructions encountered in the variable soil profile including significant variations in the depth and quality of fill materials as well variations in the residual soils and rock underlying the fill.

The selection and inclusion of the construction team in the design evolution, particularly in the final pre-construction design phases, allowed for adjustments to the approach to further address budget and constructability concerns. In particular, this open collaboration on design and constructability allowed the team to adjust design and installation methods as work progressed during the construction phase to develop solutions to unusual challenges encountered. This allowed the team to minimize construction time and cost without compromising the functionality of the system. The APM has been successfully installed and in use as of early 2012.

The authors would like to acknowledge Stanley D. Lindsey & Associates and the Holder, Manhattan, Moody, Hunt Joint Venture who were integral in spearheading the project design-construction approach and to thank ATC Associates, Inc. and Hartsfield–Jackson Development Program for their participation.

FIG 21. Post-excavation View of Supported Columns Under Concourse E