



Technical Memorandum

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Project: GPC6, C2012668-02 Task Order #39 Dallas
CBD Second Light Rail Alignment
(D2 Subway)

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Subject: **FINAL DRAFT** Technical Memorandum No. 14 – **REVIEW**
DART Internal Memorandum dated August 24, from Tad Heimburger titled “Lessons Learned on Tunnel Drainage”

Revision: A

Introduction

The subject memorandum expresses a concern about clogging of pipes intended to drain groundwater from the limestone formation prevailing along the DART Dallas CBD Second Light Rail Alignment (D2 Subway), and previously experienced difficulties in remediating this issue with piping embedded in concrete.

Clarification

Incipience of Water in Tunnels and Underground Structures

Water ingress in tunnels can be categorized according to its source as described below. This differentiation is essential in the determination of its composition, rate of inflow and, its management.

A. Internal Sources

These include water from within the structure’s boundaries such as the lining of a tunnel or the exterior walls and slabs of an underground station. Ingress in this case may comprise excess rainwater flowing in from the portals and water from washing activities and fire-fighting activities within the tunnel. Water of this nature would have some level of contamination in the

case of rainwater flowing in from an urban environment, but would otherwise be chemically plain.

Disposal of water in this category is carried out by means of an undertrack drainage pipe with catch basins placed generally at 100 feet spacing along the low-lying trough. Water thus collected is conveyed by means of transverse pipes to a main pipe running along the center of the structure, as shown in Figure 1. The piping system is completely embedded in the structural slabs and can be adequately maintained or unclogged through the catch basins along the undertrack pipes and cleanout handholes placed along the main center pipe. Clogging of this system is caused by debris and its maintenance can be performed by common pipe cleanout procedures accessing the system through the provided cleanouts.

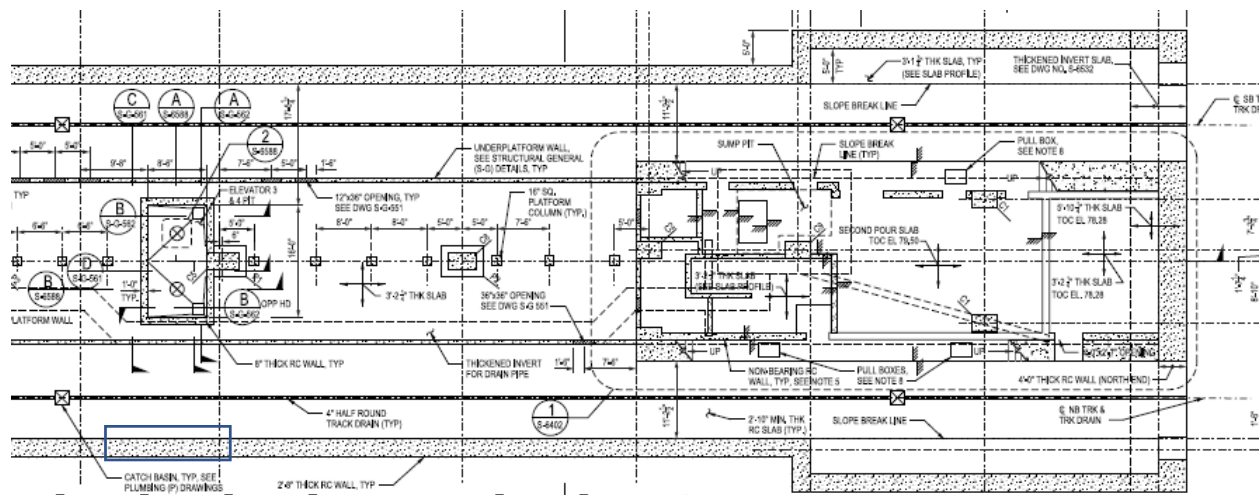


FIGURE 1: TYPICAL LAYOUT of INTERNAL WATER DRAINAGE SYSTEM in STATION

B. External Source

This comprises unintentional or intentional intrusion of groundwater through the tunnel / underground structure's outer boundary (tunnel linings, or roof, invert and walls of box sections). Common contaminants in groundwater may come from environmental seepage such as hydrocarbons, but would also from dissolved minerals. The calcareous limestone through which the D2 Subway will be constructed is susceptible to dissolution by groundwater, and the dissolved calcium carbonate can be subsequently precipitated if there are changes in groundwater pH or temperature. This precipitation can result in clogging of drain pipes.

In the former case, water intrusion may be due to waterproofing failures. This type of inflow is sporadic and in small quantities manifested as seepage through cracks in the liner or wetness in some areas of the liner. In the current practice of waterproofing, provisions are made to isolate the areas of water seepage and to mitigate such seepage by grouting through pre-installed

grouting pipes, thus limiting the duration and quantity of water inflow. Nonetheless, it is good practice to convey any seepage water through appropriately located troughs, as shown in **Figure 2**, to the internal drainage system. As the quantity and duration of such flows are small, they would not cause a serious precipitation and clogging of pipes during the design life of the facility, if cleanouts are provided and properly maintained.

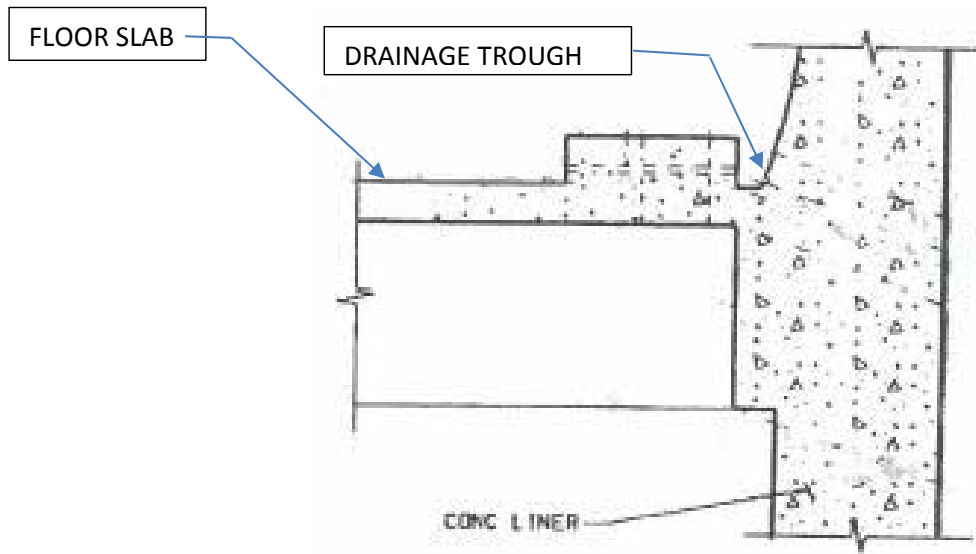


FIGURE 2: TYPICAL DETAIL of DRAINAGE TROUGH for INTERNAL WATER DRAINAGE

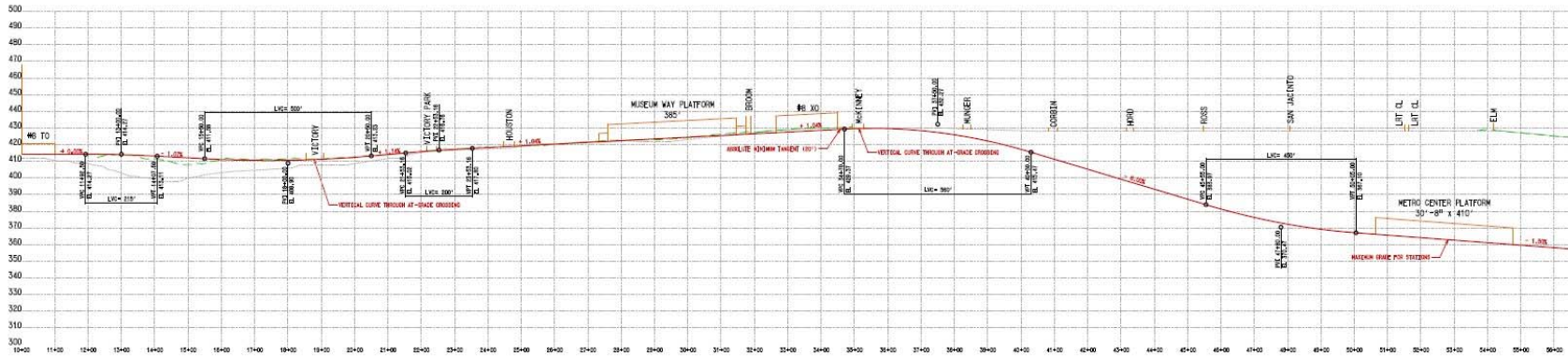
The latter is the case of pre-engineered groundwater collection systems implemented in conjunction with waterproofing. As opposed to completely waterproofing underground structures, draining groundwater from the rock surrounding a tunnel or station cavern is a method commonly used for reducing the external loads due to high water pressures acting on these structures. As such, it is commonly implemented in deep underground structures where the high hydrostatic pressure would otherwise require designing excessively heavy structural liners, walls and slabs. Such a pressure relief system requires continual maintenance of the groundwater drainage system that must be accessible for such activities, and pumping and disposal of the water draining from an engineered collection system; therefore, the life-cycle cost of operating and maintaining this system over design service life of the structure should be weighed against the capital cost of constructing fully waterproofed structures designed to resist full hydrostatic pressures.



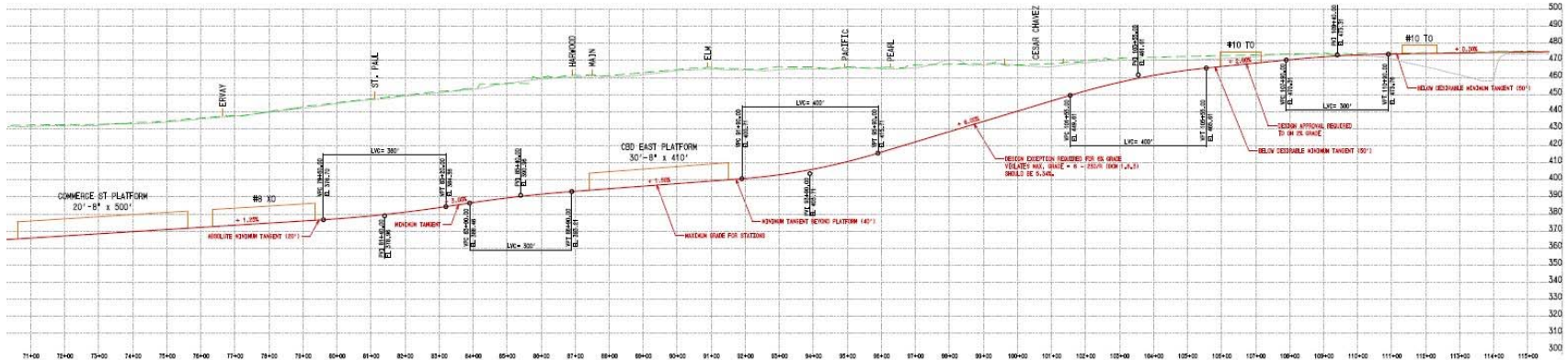
Application to D2 Subway

The life-cycle cost assessment should be performed and different (drained or undrained) structures analyzed, after the alignment and related underground structure locations become finalized and agreed upon (usually before 30% design completion). This analysis should account for the current experiences of DART maintenance and operation personnel with the existing system currently installed in DART existing stations and tunnels (Cityplace Station). With the current D2 Subway alignment profile shown in Figure 3 a maximum groundwater head of approximately 56 feet occurs at the Metro Center station, which could be constructed either as a mined cavern or a cut-and-cover station boxes. There, the groundwater head is not excessive, and may not warrant complex drainage system installation, and further continual maintenance costs, to relieve initial capital investment of somewhat heavier structural element installation. However, the final cost-benefit analysis (taking place after the alignment and third-party impacts are finalized) would provide definitive qualitative and quantitative evaluation and include operational and economic assessment of both drained and undrained systems. Only after this analysis the underground stations and tunnel configuration would be finally recommended.

Update Figure 3 with the latest Track Profile.



(a) At Metro-Center Station



(b) At Commerce Street and CBD East Station

FIGURE 3: DART D2 SUBWAY PROFILE

Further, as noted above and illustrated in the figures below, the depth of the stations might not warrant the provision of a groundwater drainage system, and these structures would be fully waterproofed (as noted in the 10% submission of the D2 Tunnel Design, Figures 4 and 5).

Update to 20%

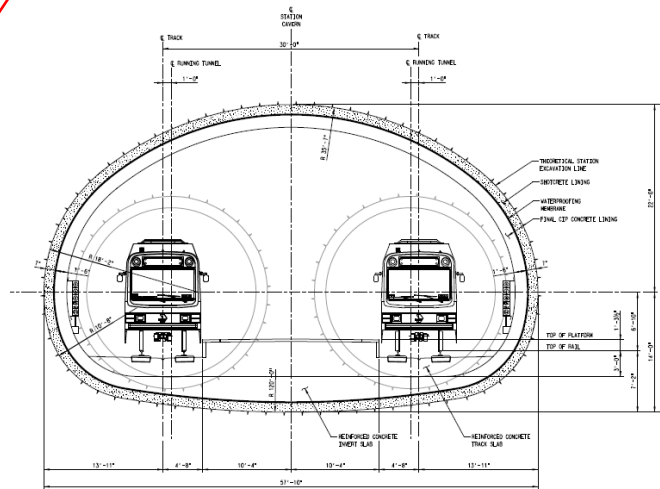


FIGURE 4: MINED CAVERN STATION

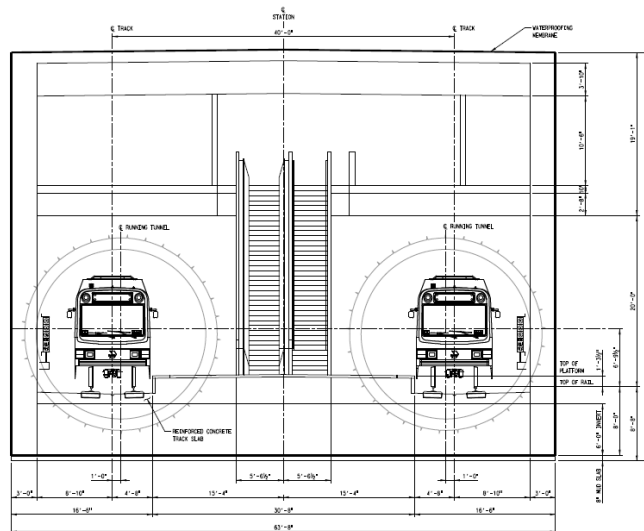


FIGURE 5: CUT-AND-COVER BOX STATION



Conclusion

The exclusion of groundwater drainage from the Dallas CBD Second Light Rail tunnel and stations along the currently selected alignment might obviate the concern of clogging expressed in the subject memorandum. At 30% design submittal, after the alignment and underground structures locations are finalized, life-cycle cost assessment of both drained and undrained systems should be undertaken and ground water management system finally recommended.

Groundwater pressure relief systems have been successfully used in the Washington DC's WMATA tunnels, and are also being implemented in the underground stations of New York City's East Side Access project. To avert problems of mineral deposition clogging, these systems have been designed with submerged drainpipes to prevent precipitation.

Should a drained tunnel and/or station cavern be selected as a viable option for the D2 Subway, considering the probable high calcium concentrations in groundwater along the its alignment, appropriate design of the drainage system, such as completely submerged piping to prevent calcification, with due consideration of accessibility for maintenance of such system, including surface mounting of the drain pipes will be implemented. The pressure relief system's piping will be segregated from the internal drainage plumbing.