Circular pumping station Massachusetts Bay (USA)

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2. Circular Pumping Station Massachusetts Bay (USA)

Client:	*Massachusetts Water Resources Authority*
General Contractor:	*Daniel O'Connell's Sons*
Diaphragm Wall Contractor:	*ICOS Corporation of America*
Project Designer:	*Metcalf & Eddy*
Diaphragm Wall Consultant:	*Mueser Rutledge Consulting Engineers*
Depth of Diaphragm Wall:	*33 meters*
Depth of Excavation:	*25 meters*
Outer Diameter of Diaphragm Wall:	*23 meters*
Thickness of Diaphragm Wall:	*800 mm*

Introduction

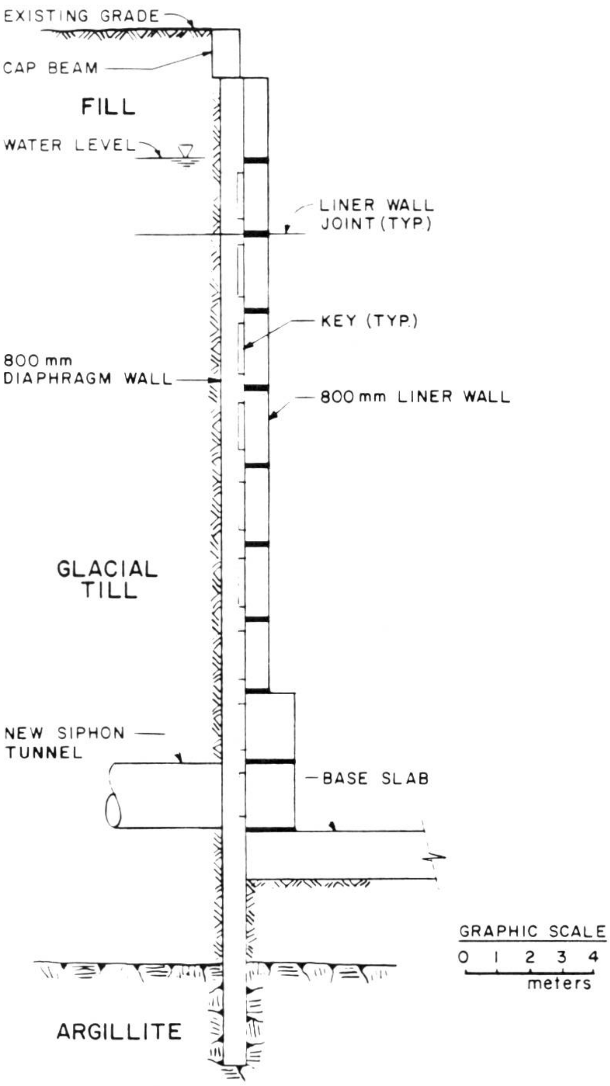
Major reconstruction of the Massachusetts Bay area sewerage treatment and conveyance systems required the construction of a large, deep pumping station adjacent to an existing operating pumping station on a tightly constrained site, through fills, dense glacial tills and rock to a depth of 25 meters. Groundwater was found about 4 meters below grade.

Description of the Design Concept

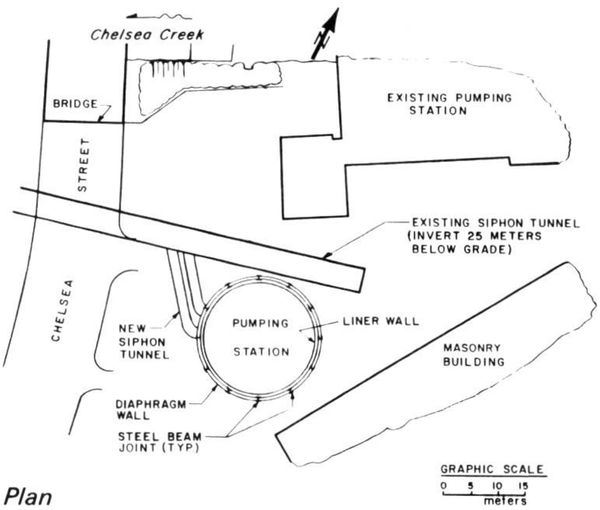
The selected design utilized an exterior 800 mm diaphragm wall as a temporary construction wall which would later serve as a portion of the permanent ground support wall of the pump station. An interior 800 mm formed concrete liner wall served as a temporary waler to support the diaphragm wall in the event unbalanced soil pressures develop or a defect or misalignment of the diaphragm wall were to occur. The liner wall, acting composite with the diaphragm wall serves as the permanent interior wall for the pump station.

The diaphragme wall was installed from grade to a minimum 3 meter embedment into the fractured argelleite bedrock. Excavation then proceeded downward to the level of the bottom of the first liner wall segment. Wall keys and reinforcing steel dowels were then prepared at the face of the diaphragm wall, a reinforcing cage was installed and formwork placed for the interior liner wall. High strength concrete was then placed in quadrants in order to minimize shrinkage cracking. Upon development of adequate liner wall concrete strength, the forms were removed an the excavation proceeded downward, as described, until the base slab was constructed. Interior dewatering was handled by local sumps and small pumps.

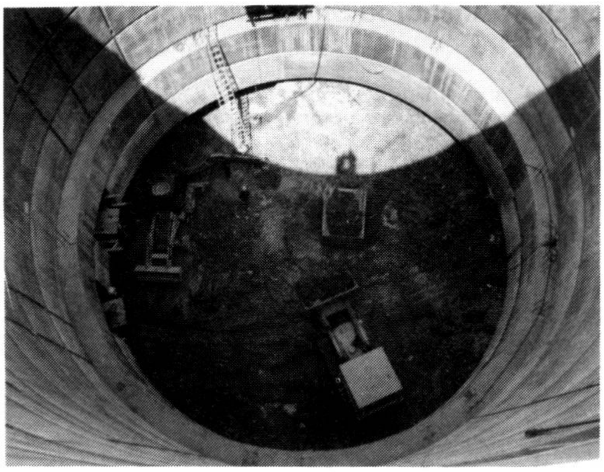
With the casting of the base slab concrete the structure is completed and secure – Finishing work required the filling ot the liner wall joints with dry packed concrete or shotcrete concrete and the installation of interior floors and walls.



Section



Plan



Excavation for base slab

Analysis of Structure

The precise behavior of the diaphragm wall/liner wall system during excavation was critical to the sequencing of the work and the magnitude of stress in the system at the end of excavation. These residual stresses would combine with the stresses which would develop after the restoration of at rest pressures.

A finite difference method was used to analyse the structure, using Winkler springs to represent the soil. The radial deformation of the composite walls is related to circumferential elastic strains of the diaphragm wall and the liner walls. A relationship between such strains was developed permitting the use of Winkler springs in lieu of circumferential strains. Soil restraint was removed from the interior of the structure mathematically, with subsequent installation of individual tiers of liner wall as supports. Previously calculated deformations (with resulting forces and moments) were incorporated into each subsequent calculation.

Two assumptions were made on the beharvior of the diaphragme walls. The first assumption, as a best case scenario, considered the diaphragm wall to be constructed with perfect joints between individual panels. Analysis indicated that under this assumptions the major support against outside soil and water forces was obtained through circumferential axial stress in the diaphragm wall, with the stresses in the liner walls of an insignificant magnitude.

The second assumption, as a worse case scenario, considered defects at each diaphragm wall joint, thus rendering the diaphragm wall incapable of developing circumferential resistance. Analysis indicated that under this assumption the annular segments of the diaphragm wall between joints bent vertically between the excavation subgrade and the previously cast liner wall above. Circumferential compressive stresses developed in the liner wall under this loading condition.

Active soil pressures were used to analyze the temporary loading conditions on the structure. It was assumed that sufficient relaxation of at-rest soil stresses occurred during diaphragm wall panel excavation to permit the temporary development of an active state of soil stress.

As a final condition the diaphragm wall/liner wall composite structure was analyzed for an incremental load representing an increase in soil pressure resulting from the long-term restoration of at-rest soil pressures. The thcikness of the composite wall was dictated by counter bouyancy considerations as well as stress considerations.

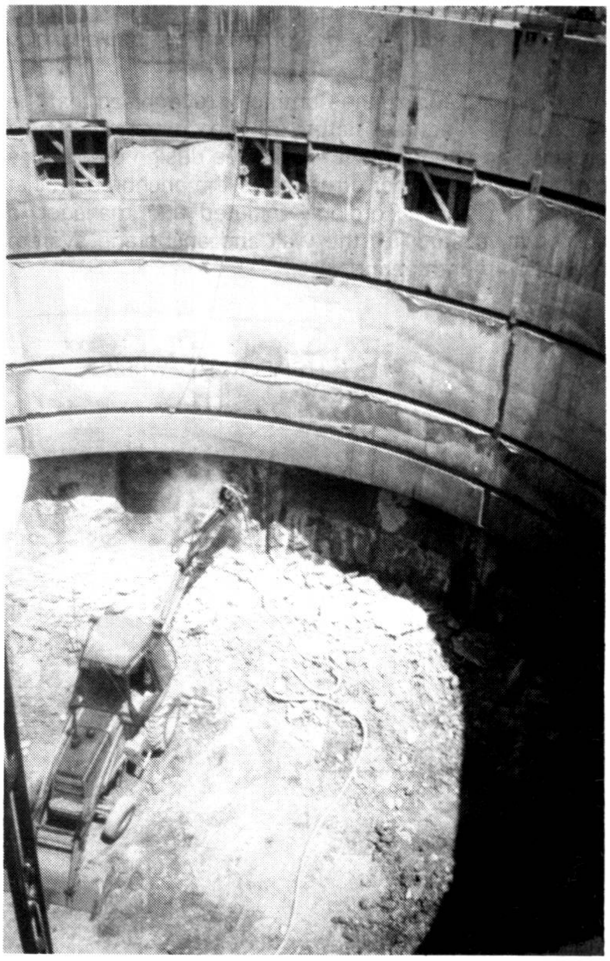
Construction

The diaphragm wall was installed without incident during a 5 month construction period. Steel H beams sections were used at the joints in lieu of the conventional joint pipe detail, thus eliminating the end pipe extraction process in a crowded site and providing a superior watertight joint.

Subsequent excavation and installation of the liner wall proceeded without incident over a 5 month period. The wall joints were observed to be better than expected. As a result the liner wall experienced circumferential compressive stresses which were insufficient to fully close transverse shrinkage cracks in the liner walls.

Instrumentation installed just outside the walls indicated insignificant lateral movements and no drawdown of the outside water table.

(G. Tamaro)



Preparation of slurry wall for casting of liner wall