Maintenance of Utilities

During

Metro Rail Construction

Prepared by

The Southern California Rapid Transit District

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INTRODUCTION

The 18.6-mile starter line of the Southern California Rapid Transit District Metro Rail Project is expected to help solve the increasing transportation problems of Los Angeles' high-density urban center -- the Regional Core. With the exception of the Yard and Shops near Union Station, the entire starter line will be underground. The track will be in twin tunnels constructed by tunnel boring machines and finished with precast concrete tunnel liners. Stations, essentially buried concrete box structures, will be constructed by the cut-and-cover method. They will typically have two levels: the lower platform level will provide access to the trains and the upper mezzanine level will contain ticketing equipment and will be connected by escalators to the entrances on the surface. In addition, stations will house mechanical, electrical, heating, and ventilation equipment required for the operation of the system.

Metro Rail stations are designed to provide sufficient cover above the roof slab to accommodate the subsurface utilities. To the extent allowed by the constraints of each station site, station locations have been selected to minimize the utility disruption.

A critical part of project design is to ensure that:

1. The utilities in the transit corridor are properly protected during construction;

2. The essential service provided by the utilities is maintained; and

3. Utility relocation or reconfiguration does not delay the project.

To achieve these goals, the design for each Metro Rail station will include a comprehensive program that identifies all utilities in a construction area and defines a plan of action for accommodating each facility. Consequently, when the transit contractor begins his work, some utilities may be taken from service or rerouted clear of the site. It is anticipated that a large number of utilities will remain in place and these, therefore, must be considered an integral part of project construction.

This report outlines typical rapid transit excavation and construction methods to provide a clear understanding of the feasible options for maintaining utility service and protecting the utilities during the construction period. Illustrations and construction photographs from other recent transit

projects are included at the end of the report to illustrate construction techniques and the alternative methods used to support the utility facilities.

UTILITY HANDLING DURING CONSTRUCTION

The majority of the utility impacts produced by the Metro Rail Project will occur in the vicinity of the cut-and-cover station sites. The following sequence is typical for cut-and-cover transit construction in areas where the site boundaries are constrained (i.e., in city streets):

1. Existing utility facilities are located and marked and, at certain critical locations, may be exposed and re-arranged.

2. The excavation support system is installed. Simultaneously, some utilities may be rearranged to accommodate transit construction.

3. Street pavement is removed and the utilities are exposed. The deck beams are placed and utility support structures are attached to them.

4. Temporary decking is installed and the street reopened for use.

5. The site is excavated and the reinforced concrete shell of the station is constructed.

6. Backfill is placed over the station up to the utility zone.

7. Utility supports are removed and the utilities are reinstalled in the ground.

8. The deck structure is removed and final adjustments are made to utilities and service connections.

9. The pavement is restored and the street reopened to public use.

10. Transit construction continues to completion in off-street areas.

Soldier Piling

The first step in cut-and-cover station construction is to locate all existing utilities in the area where the excavation support structures will be installed. This is done by digging exploratory trenches in those areas where the sub-

surface facilities are known to exist and by potholing to locate the many service connections to buildings located adjacent to the site. Next, soldier pile locations are chosen. Pile separation is typically six-to-eight feet, but spacing is varied so that conflicts with utilities are avoided to the maximum extent possible. Beginning at one end of a pile line, holes for the soldier piles are predrilled at the selected locations with an oversized auger to an elevation below the base slab of the transit structure. A typical auger size is 24 inches in diameter. Pile installation closely follows behind the drilling operation, the bottom of the pile being set in concrete to provide a firm anchorage. The process is then repeated along the other pile lines.

The limited space between the pile line and the buildings may be utilized for rearrangement of facilities that cannot be supported in place. Figures 1 and 2 graphically represent the soldier piling operation. Photographs of utility rearrangement and soldier piling are shown on Figures 3, 4, and 5.

Decking and Utility Supports

When soldier piles are in place on both sides of the station, a temporary surface known as decking is constructed over the cut-and-cover site at an elevation close to that of the existing street. The decking has several important functions. It provides a staging area for the contractor and his equipment and a temporary means for vehicles and pedestrians to continue over the area. Below the surface, the deck structure provides a means of supporting utilities in place while construction continues beneath.

Generally, street pavement and the subsoil are excavated in increments while transverse steel beams are installed between the pile lines to provide support for the decking. (See Figures 6, 7, and 8.) When a substantial deck area is in place, excavation continues until the subsurface utilities are exposed. Support facilities are then placed around the utilities and are attached to the deck structure. It may be necessary to dig trenches to expose the deeper utilities in order to install their support structures.

Because the decking and utility supports are interrelated, it is usually the contractor's responsibility to design the supports based on standards specified by the utility owners. Close coordination and cooperation is needed between the transit contractor and the utility owners so that construction continues in a timely manner. It is important that the utility owners monitor the support installation so that the work is done safely and without damaging the facilities. (Figures 9, 10, and 11).

As no two sites are the same and because the depth, condition, and location of some utilities may not be known until they are exposed, support structures are generally unique to each particular situation. As a result, much of the support system is field fabricated. Adequacy of the supports is ensured by specifying requirements for spacing, materials, capacity, and rigidity and by using standard drawings showing approved support methods for each type of utility. Where utilities are relatively new, it is often practical to support them completely in place with little modification. Examples would be pressurized and nonpressurized pipe systems using continuous steel pipe or rubber gasket pipe joints, and concrete-encased duct systems where the concrete is in good condition. In cases where utilities are old and have deteriorated, they may be unsuitable for supporting in place without some form of strengthening. Nonpressurized pipe systems, tile ducts, and concrete-encased ducts may be encased with heavy boards or plywood and banded. For the older pipe systems having rigid joint packing, such as mortar or lead, the complete facility must be replaced with an appropriate material that may then be supported. Such replacements may be suitable for reburial or may serve for the construction phase only. For deteriorated conduit systems, an alternative is to remove the concrete and conduits and support the cables in a tray or re-encase them using split plastic duct that is later encased in concrete during the street restoration phase.

In most cases, the stresses produced in a utility by overlying soil, pavement, and traffic loads are much greater than the stresses that result when the facility is suspended from a suitably designed support system. Thus, provided proper care is exercised in the exposure, support, and reburial, the utilities have adequate strength to be supported in place. However, support does place utilities at some risk for the duration of construction, especially during those phases of the work when construction machinery is operating nearby. This danger can be reduced by building additional protection into the support structure of critical facilities. By also establishing controlled procedures for exposure, handling, and reburial of utilities and including such procedures in the contract documents, the work may be safely and promptly performed.

Figures 12 through 16 show a variety of utilities supported in place during rapid transit construction.

It should be noted that there are areas of construction where decking is not needed above the excavation (Figure 17). Here, tie-backs may be used to resist lateral earth loads on the soldier piles. This method is suitable for off-street station entrances and vent shafts.

Stations

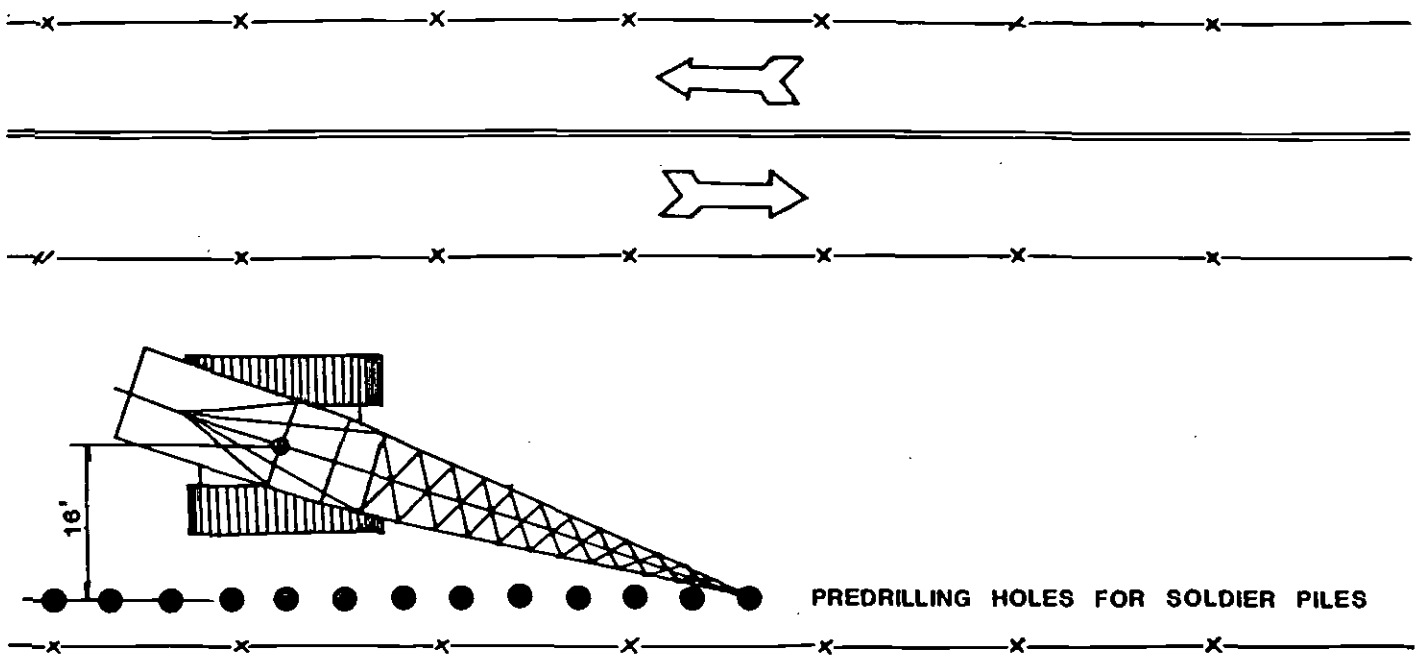
When the decking is in place and the utilities are supported, excavation proceeds rapidly using heavy earthmoving equipment operating beneath the deck (Figure 18). The deck is constructed of panels that are easily removed to create an opening for spoil removal and materials delivery. As excavation proceeds, transverse steel beams are installed at various depths to brace the soldier piles against lateral earth thrust (Figures 19 and 20). With the excavation complete, construction proceeds with little effect on the utilities supported above (Figure 21). Station construction may commence whenever excavation in an area is complete. Frequently, work on a portion of the station structure will begin while the excavation continues elsewhere.

The concrete invert slab of the station is generally poured in panels that are the full width of the structure and some 30 to 50 feet in length. The outside walls are formed directly against the soldier piles and lagging and, as sections of the structure are complete, the transverse steel beams are removed (Figure 22). Station entrances are generally outside public rights-of-way. Though few utilites are encountered in entrance areas, those that do exist must be completely relocated clear of the site (Figures 23, 24, and 25).

Backfilling and Street Restoration

When the station shell is complete, backfill material is placed and compacted in layers beneath the deck structure to the highest elevation practical using large rollers. Above this elevation, sections of the decking must be removed to allow backfilling to progress. Material is carefully tamped around the supported utility structures (Figure 27) and any new facilities are installed in trenches cut into the new backfill in the normal manner. Hangers and other support structures are disconnected from the deck structure and removed whenever the utilities are safely supported by the soil.

When the completion of the work allows, the transverse deck beams are removed and the soldier piles are exposed and cut off some feet below the final street grade (Figure 26). Concurrent with these latter stages of restoration, permanent utility services will be connected and manholes, sidewalk vaults, meters, and valves will be rebuilt at their proper locations (Figures 27 and 28). The final step is the installation of street pavement and sidewalks, at which time storm drain inlets are completed, covers for manholes, vaults and valve boxes are set to grade, and permanent street lighting, signals, and signage are installed.



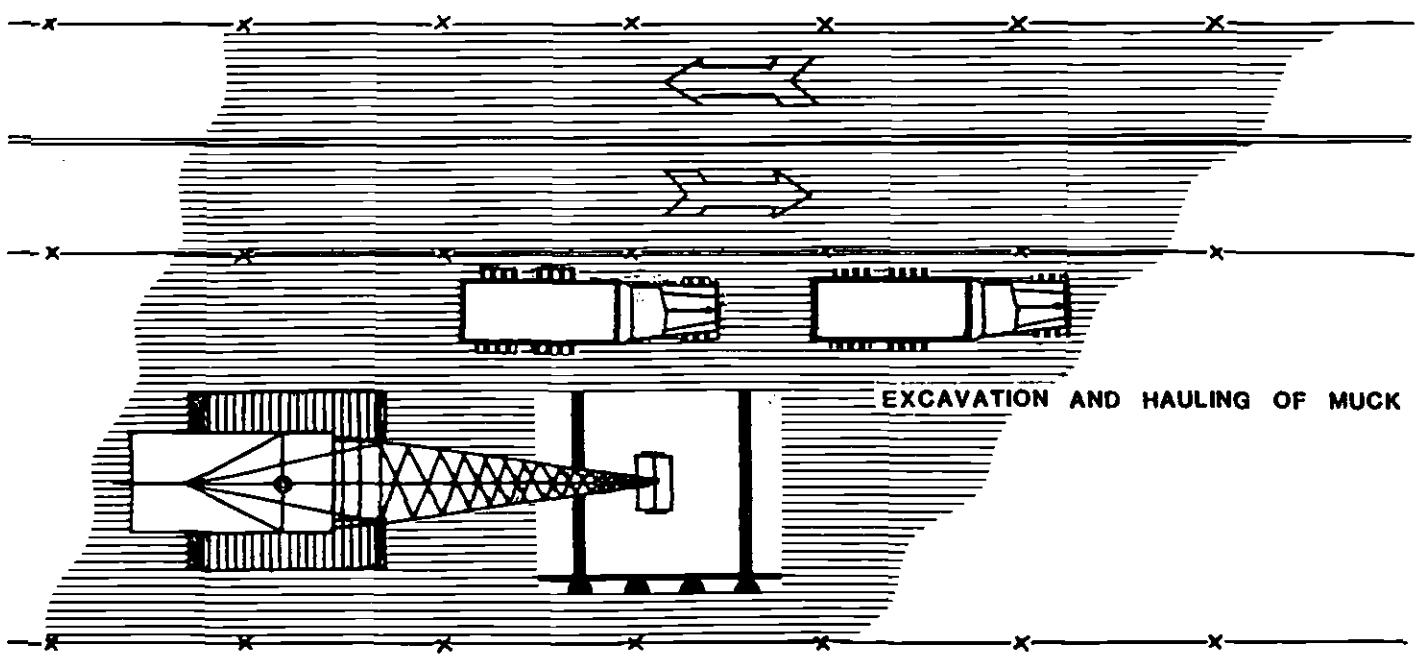


FIGURE 1
CONTRACTOR'S SURFACE OPERATIONS

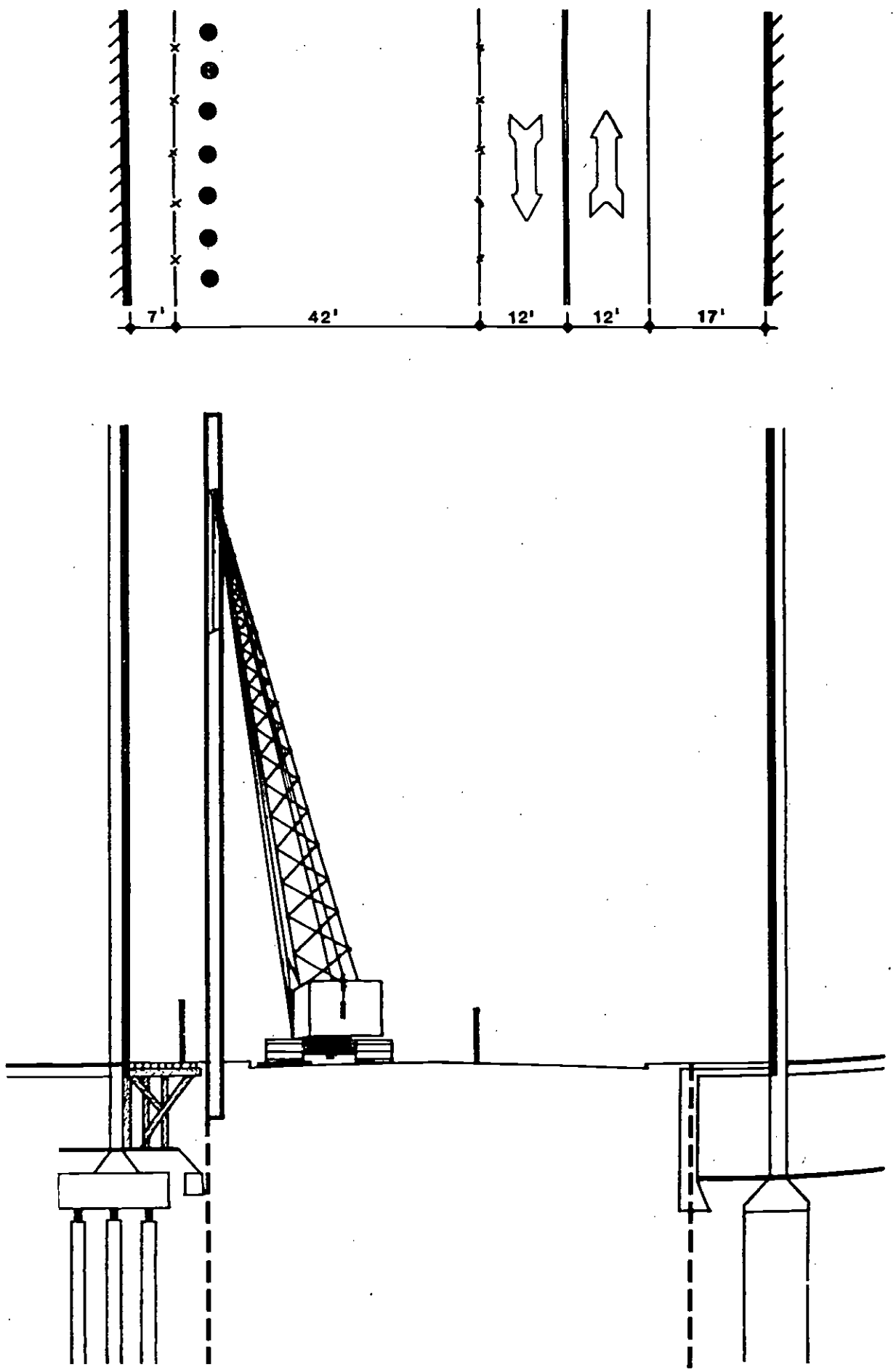


FIGURE 2
SOLDIER PILE INSTALLATION

FIGURE 3
LOCATING AND REARRANGING UTILITIES AT THE CONSTRUCTION SITE

FIGURE 4
SOLDIER PILES AROUND FUTURE STATION PERIMETER

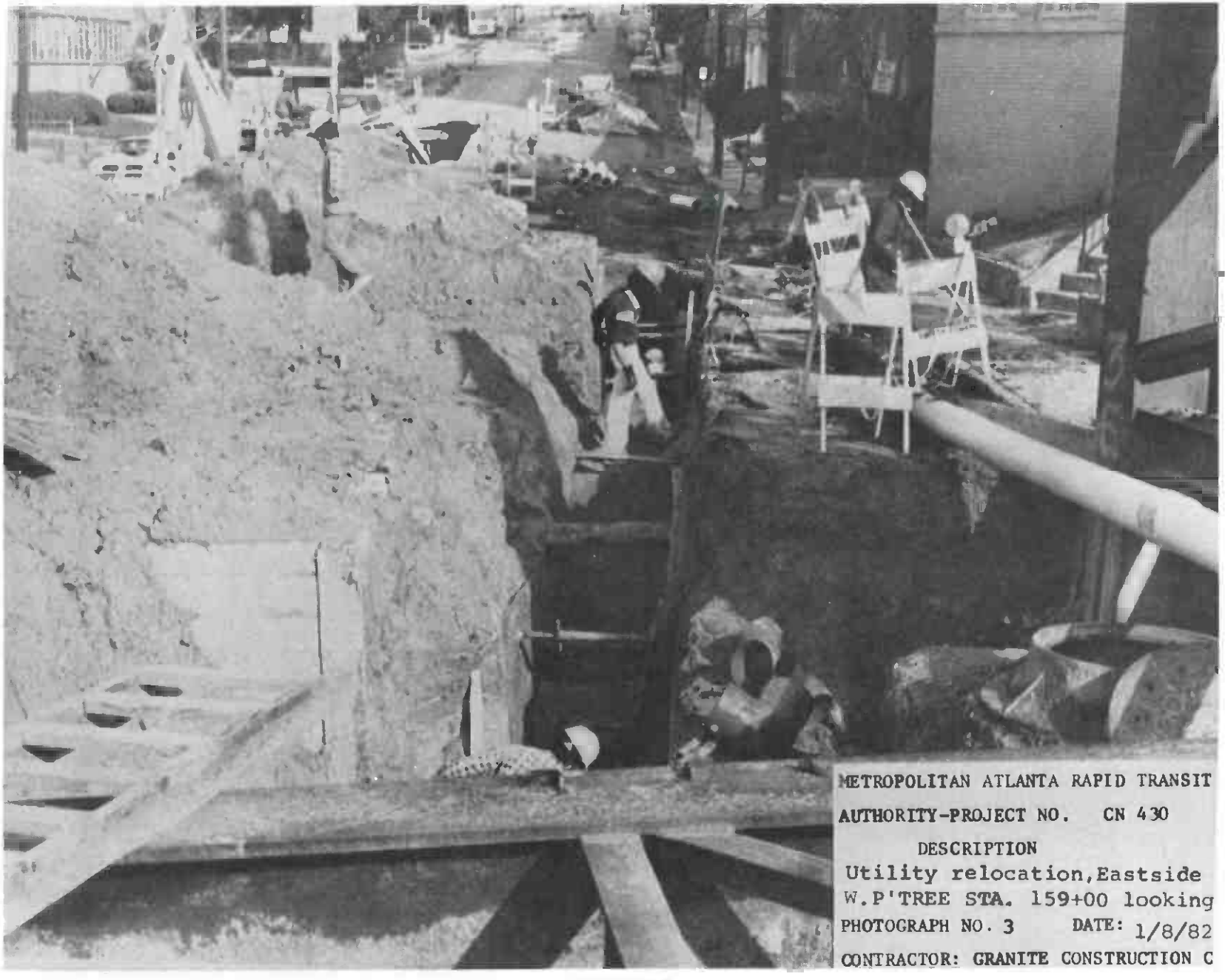


FIGURE 5
SPACE BETWEEN SOLDIER PILES AND EXISTING BUILDING IS USED FOR REARRANGEMENT OF UTILITIES

FIGURE 6
DECKING PREPARATION: REMOVAL OF STREET PAVEMENT AND
INSTALLATION OF STEEL BEAMS

FIGURE 7
DECKED STREET WITH TEMPORARY SIGNALS

FIGURE 8
DECKING SERVES AS TEMPORARY ROADWAY AND STAGING AREA FOR
CONTRACTOR'S EQUIPMENT AND MATERIALS

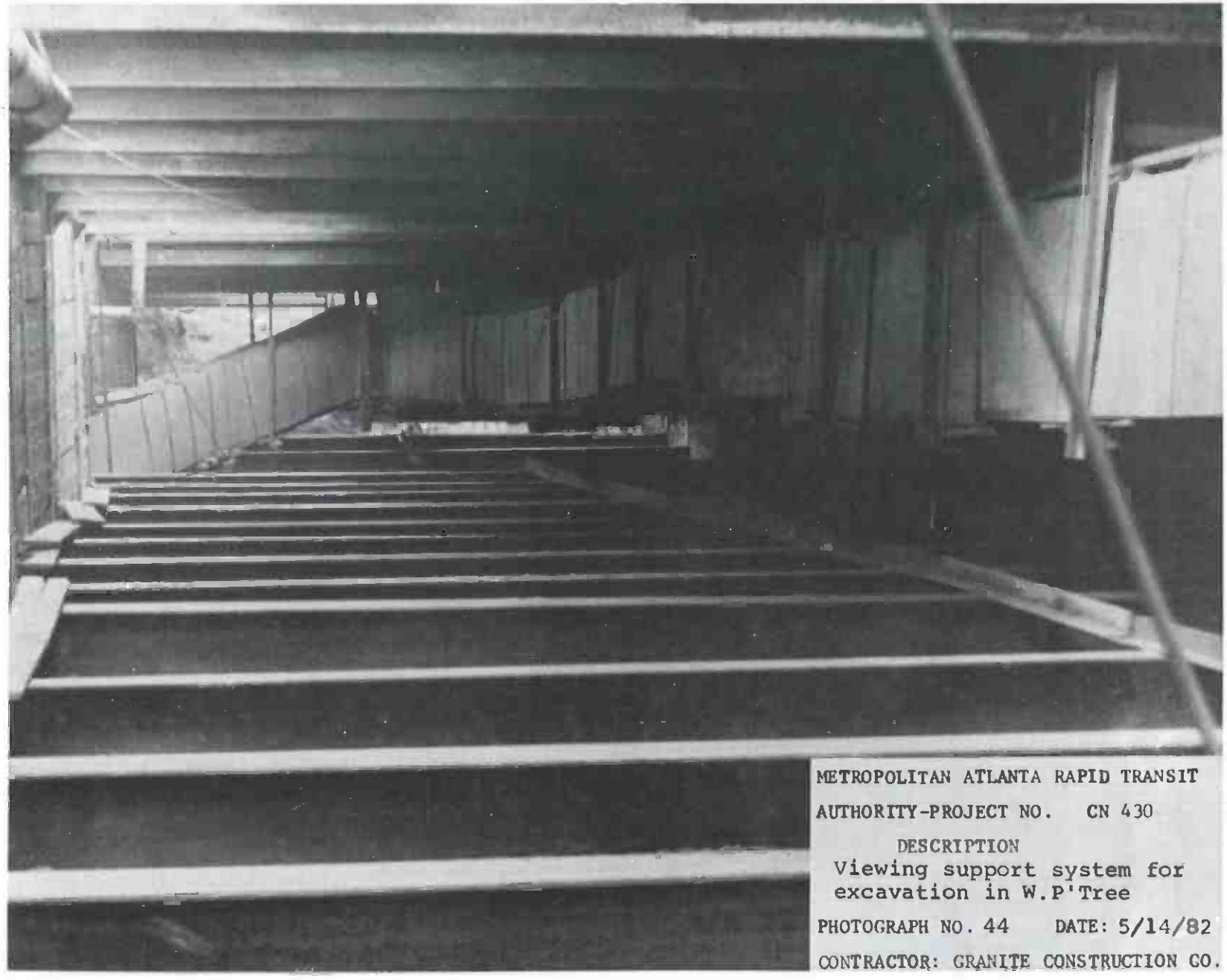


FIGURE 9
UTILITY SUPPORTS

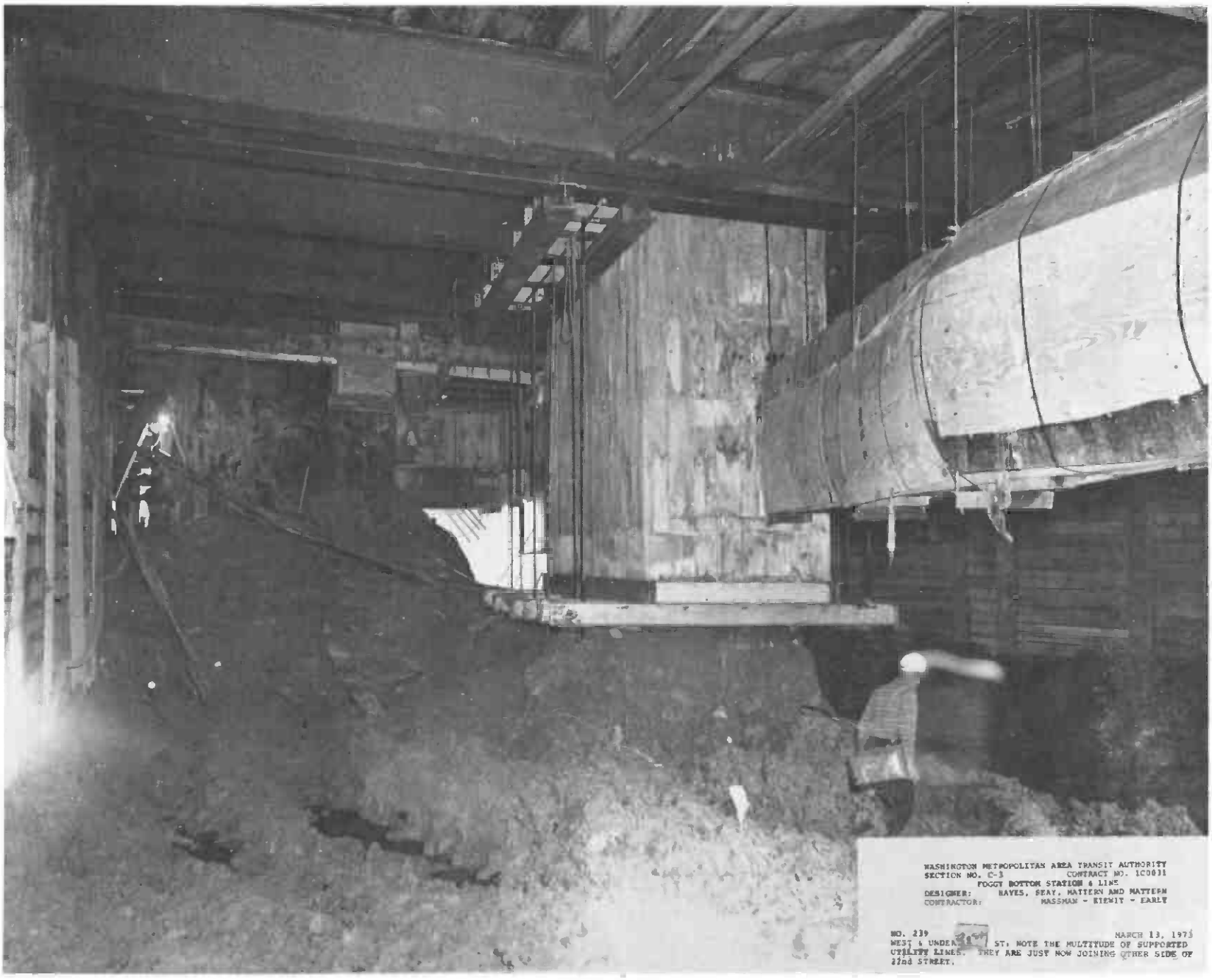


FIGURE 10
EACH UTILITY SUPPORT IS UNIQUE; IT IS THE CONTRACTOR'S RESPONSIBILITY TO DESIGN THEM

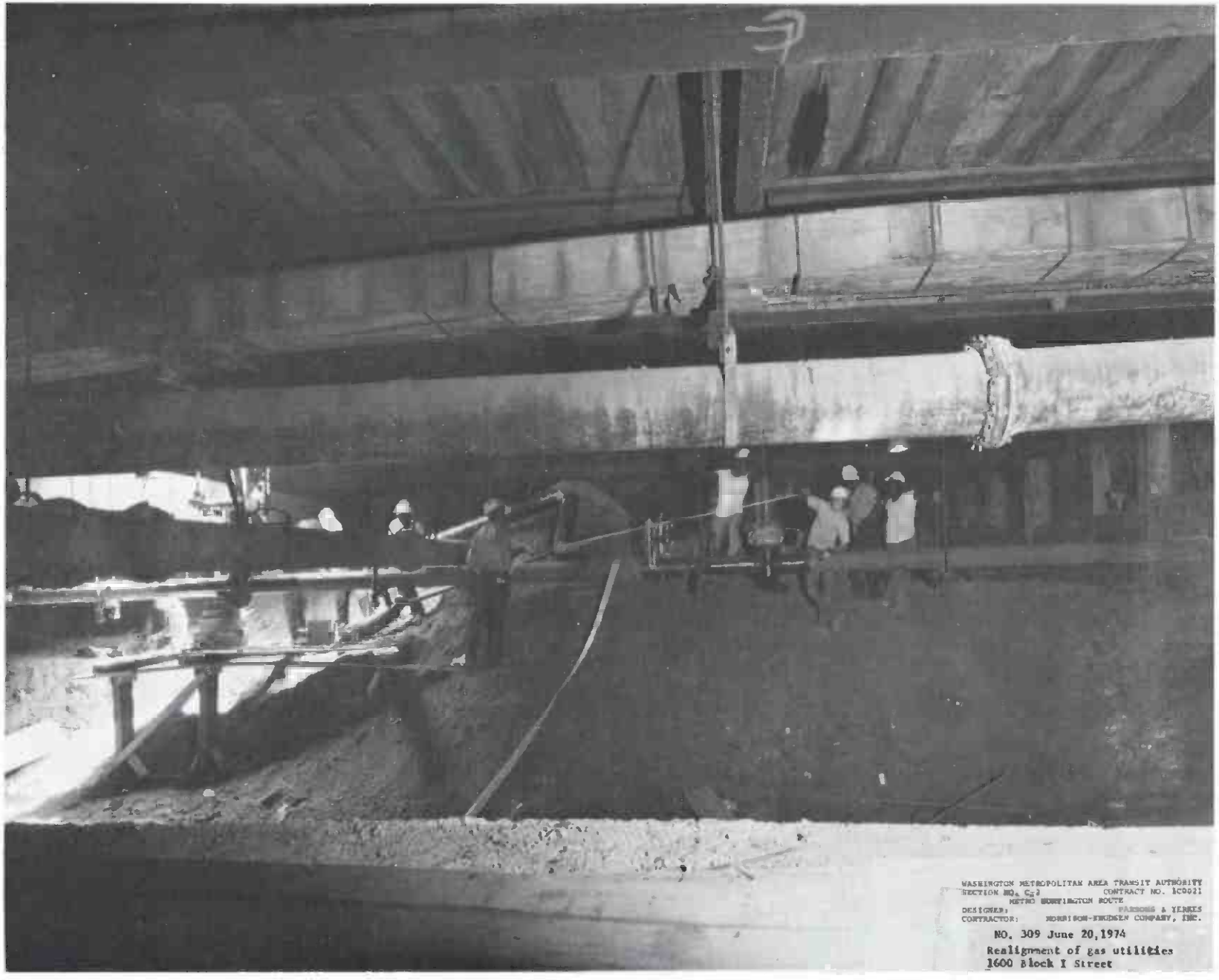


FIGURE 11
UTILITY OWNERS WORKING CLOSELY WITH CONTRACTOR TO ENSURE SAFETY AND EXPEDIENCY

FIGURE 12
PIPES AND CONDUITS SUPPORTED BY HANGERS ATTACHED TO STREET DECKING

FIGURE 13
TEMPORARY METAL PIPE SUPPORTING STORM DRAINAGE; CAST-IN-PLACE CONCRETE MANHOLES AND CONCRETE ENCASED DUCTS ARE SUPPORTED IN PLACE

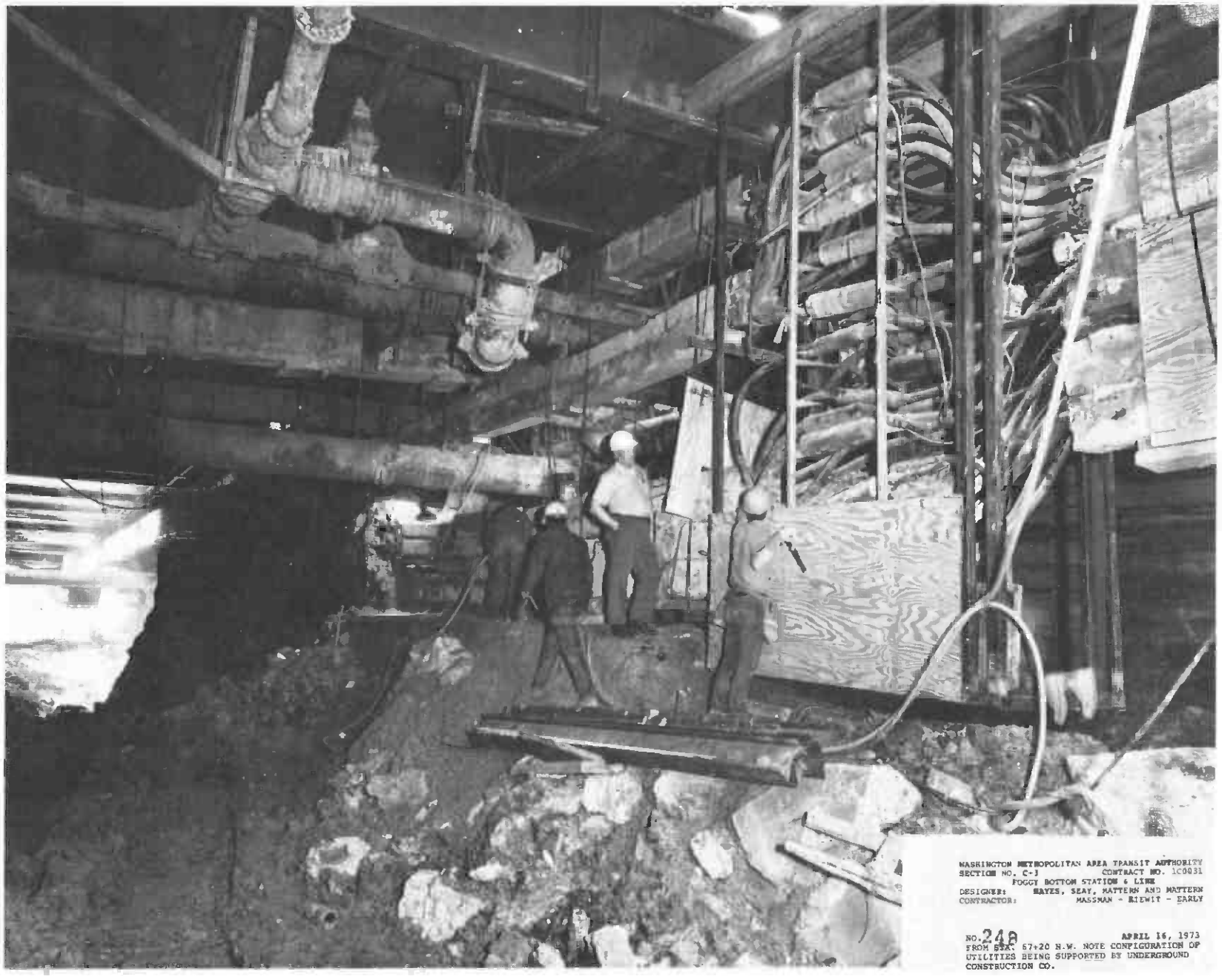


FIGURE 14
TEMPORARY STEEL AND PLYWOOD CAGE SUPPORTS A MANHOLE IN POOR CONDITIONS

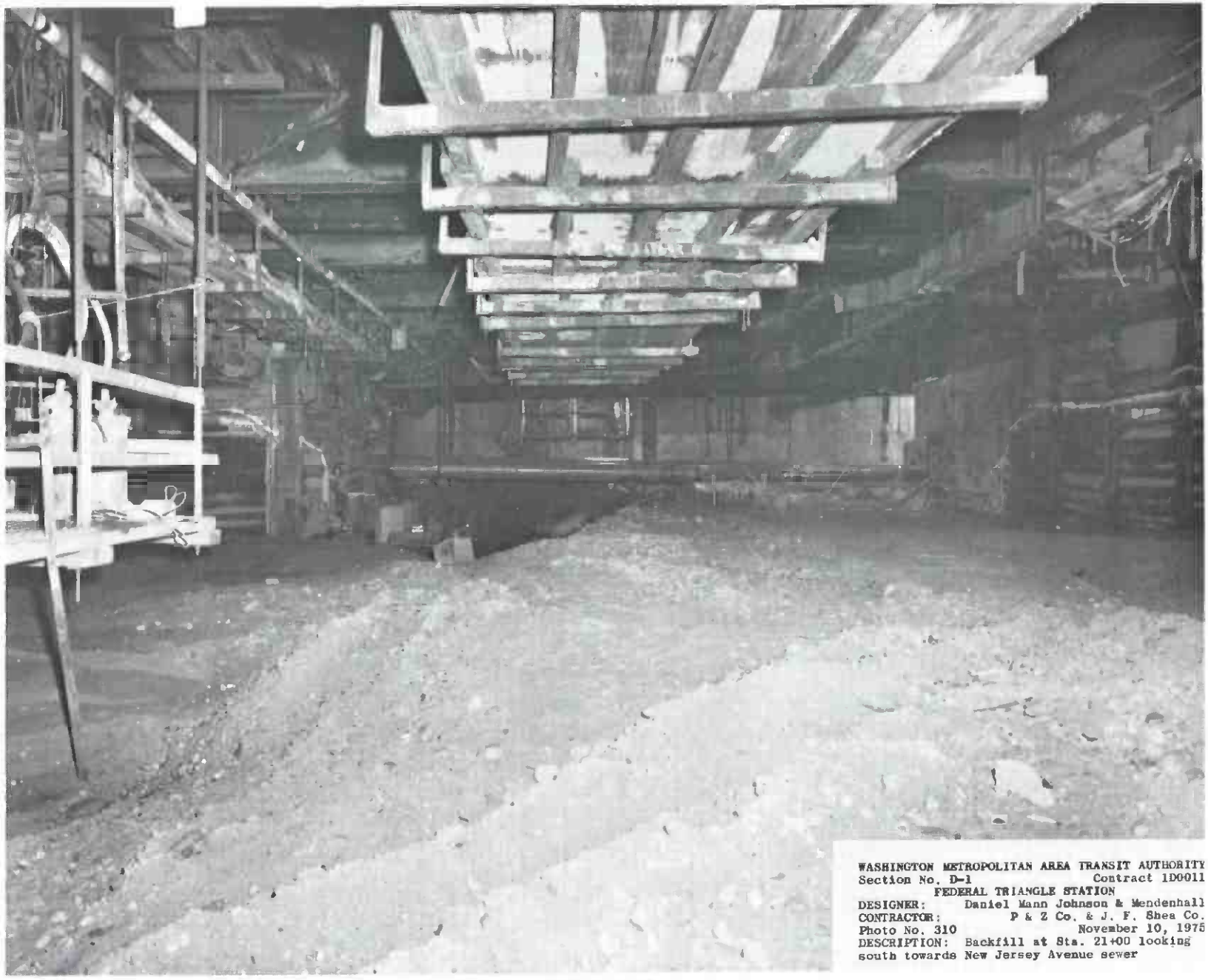


FIGURE 15
POWER AND COMMUNICATIONS CABLES SUPPORTED BY:

1) CONCRETE ENCASED DUCT BANK
2) TEMPORARY TIMBER AFTER REMOVAL OF DUCT AND ENCASEMENT
3) ENCLOSED RACKS

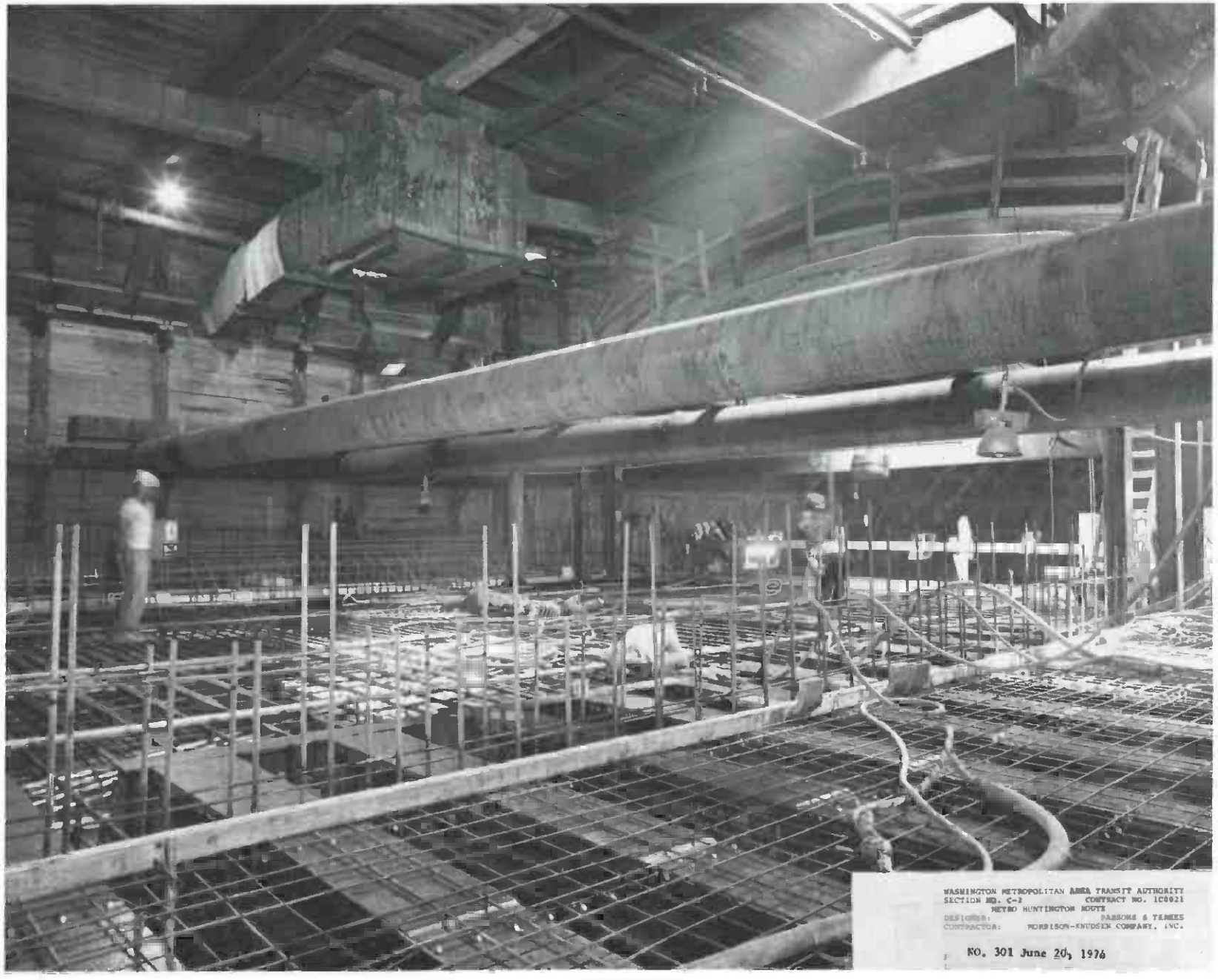


FIGURE 16
DECKING BOUND INTO PANELS IS REMOVABLE FOR ACCESS TO CONSTRUCTION AND SUPPORTED UTILITIES

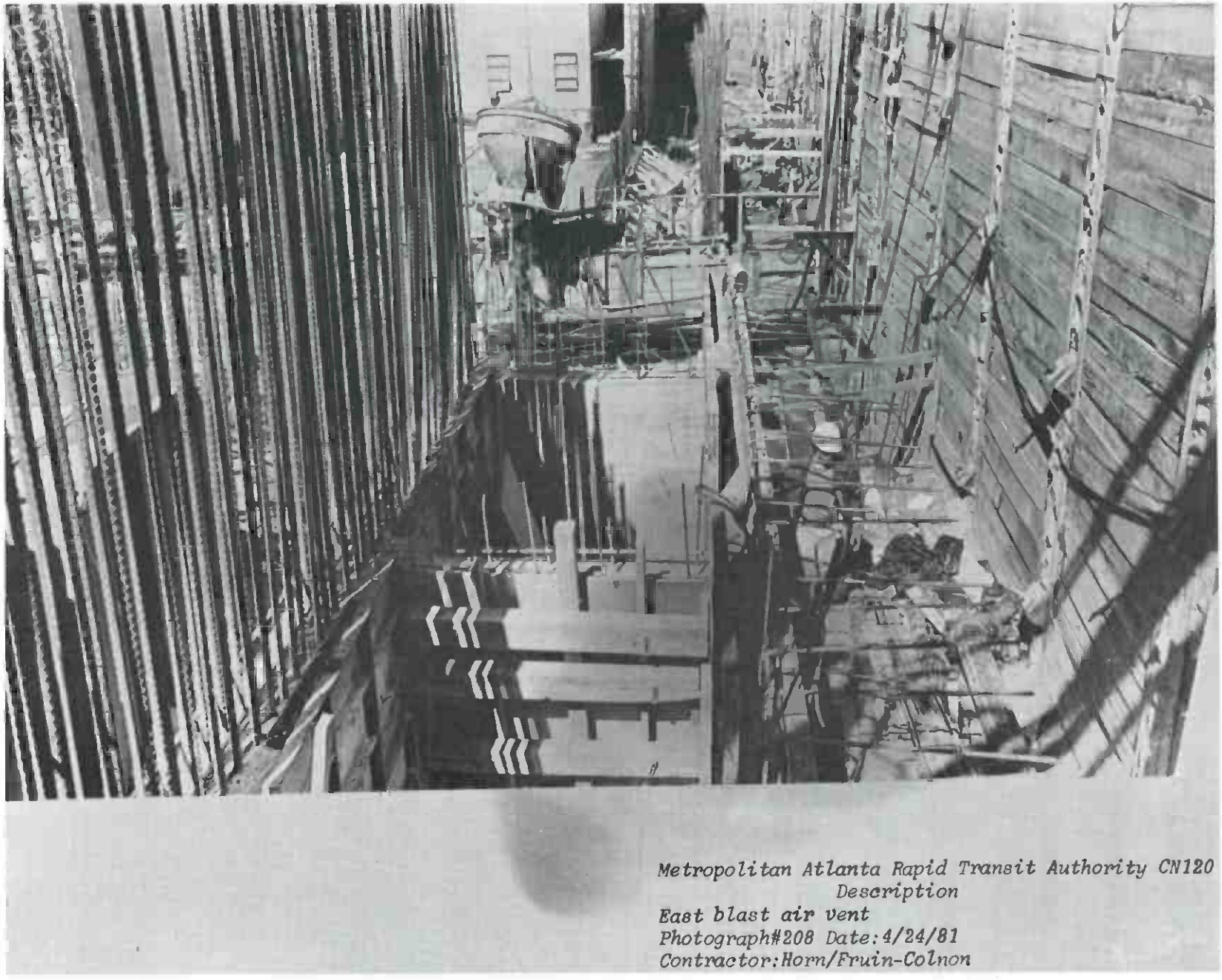


FIGURE 17
TIE-BACKS RESIST LATERAL EARTH LOADS ON SOLDIER PILES
WHERE DECKING IS NOT NEEDED

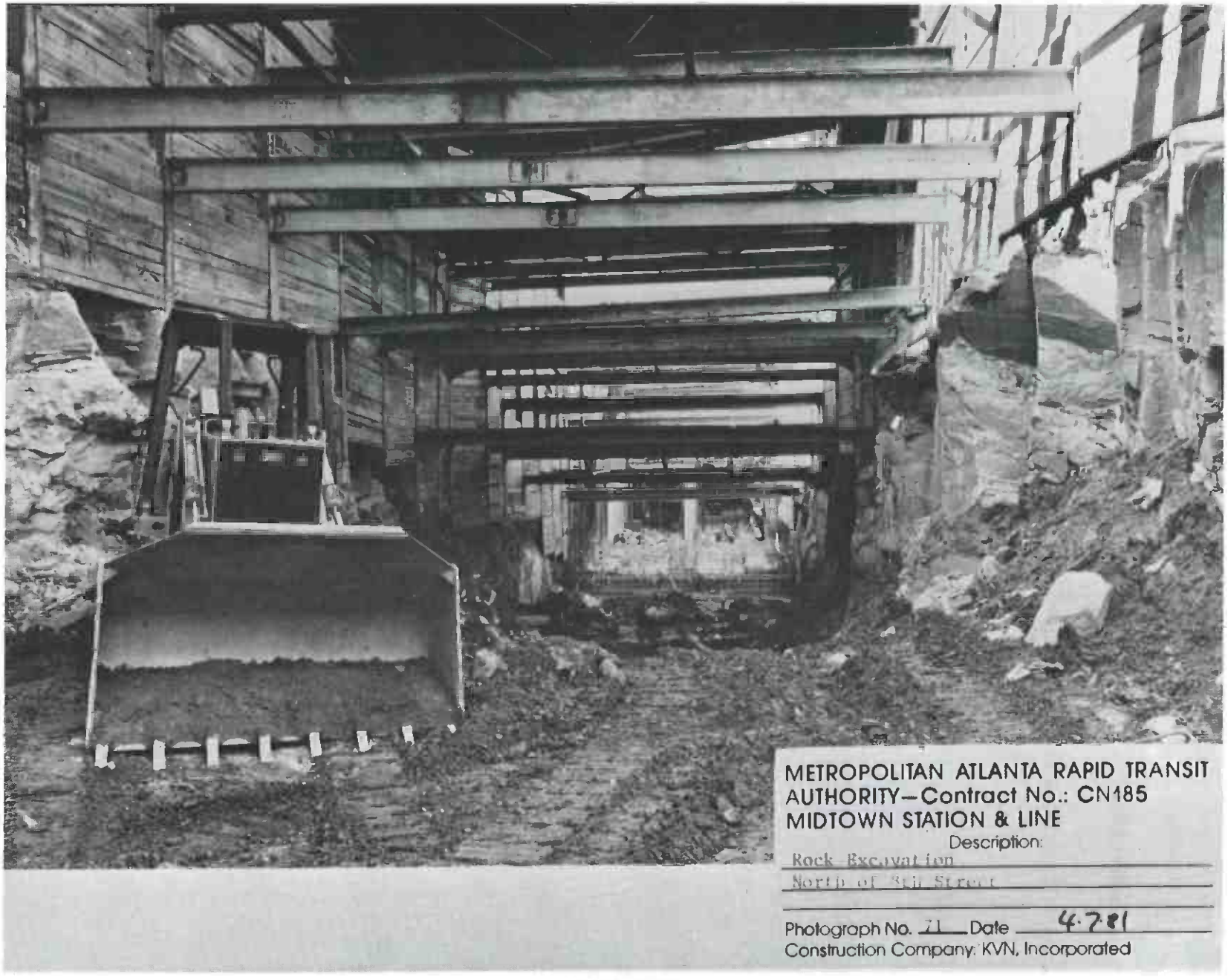


FIGURE 18
EXCAVATION BENEATH THE DECKING WITH HEAVY EARTH-MOVING EQUIPMENT

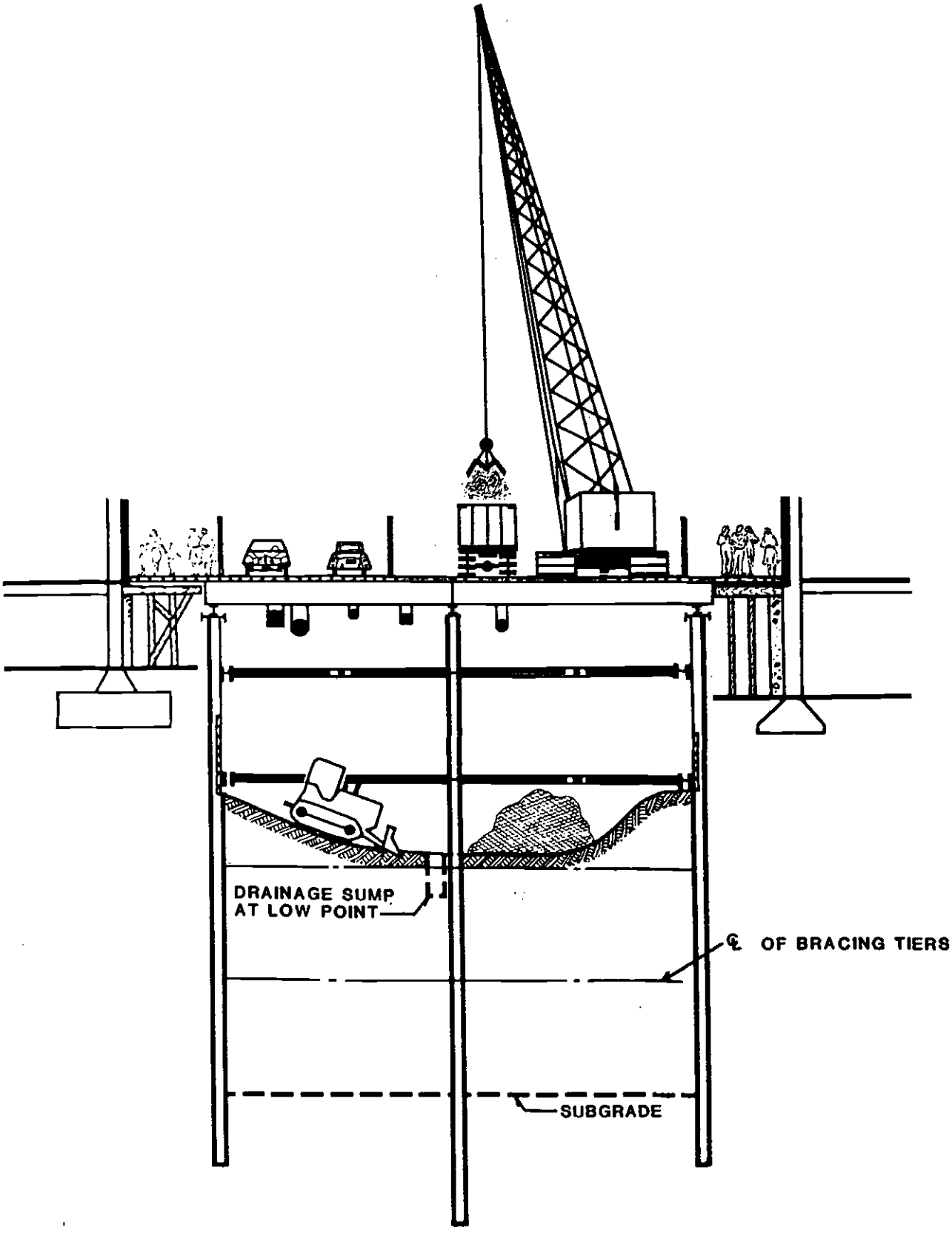


FIGURE 19
EXCAVATION AND BRACING

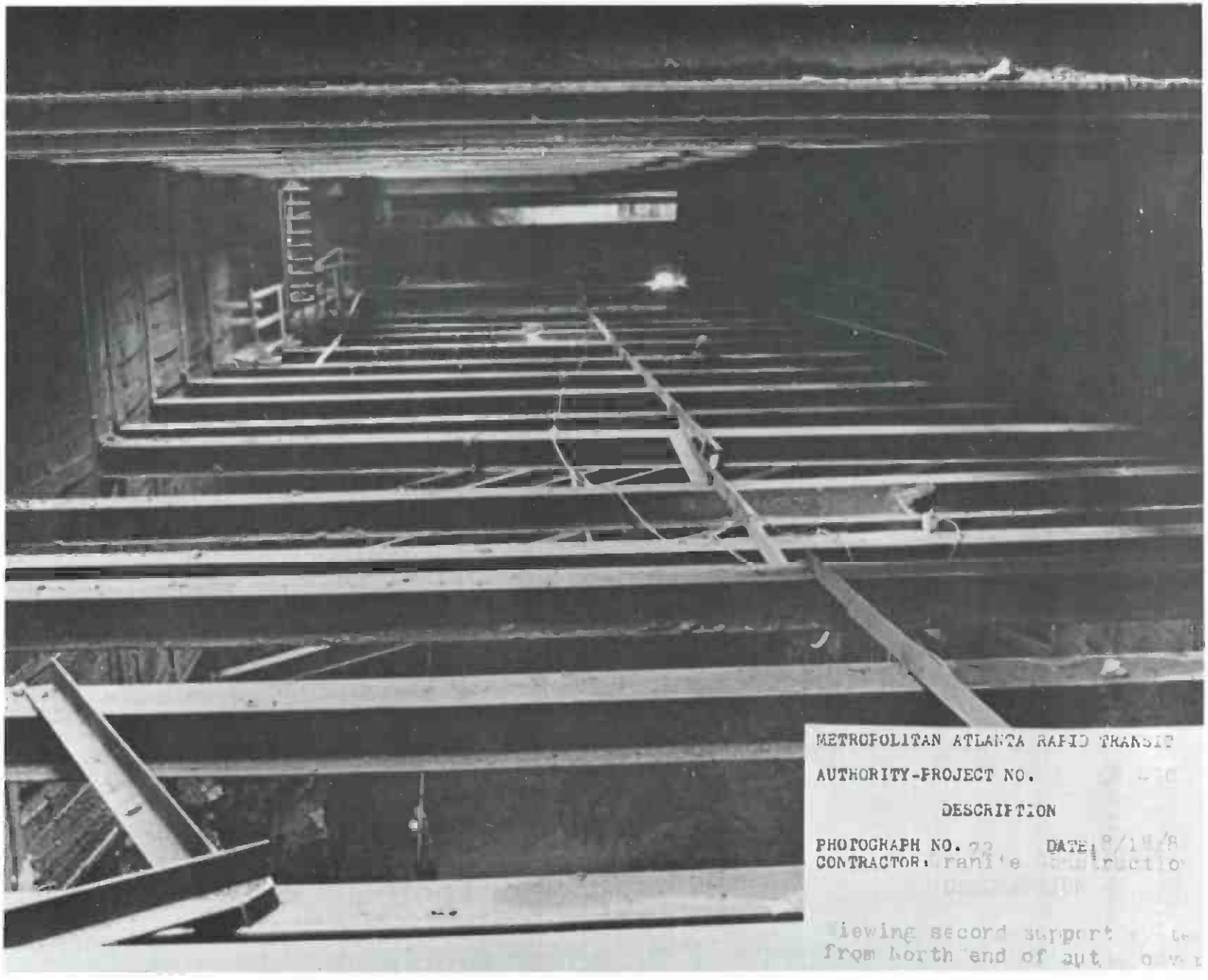


FIGURE 20
AS THE DEPTH OF EXCAVATION INCREASES, ADDITIONAL LAYERS OF BEAMS ARE INSTALLED TO BRACE THE SOLDIER PILES

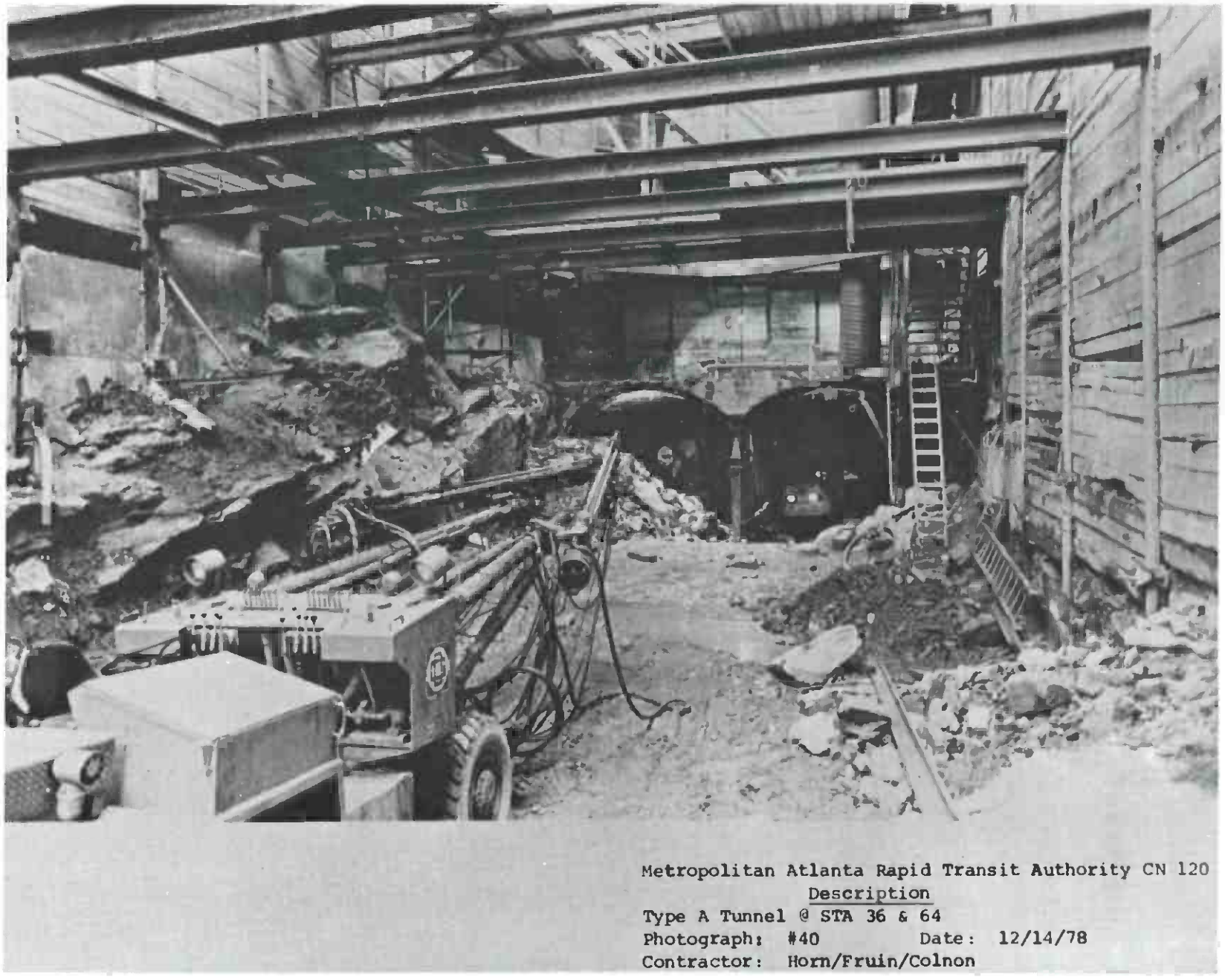


FIGURE 21
WHEN EXCAVATION IS COMPLETE, TRANSIT CONSTRUCTION PROCEEDS WITH LITTLE EFFECT ON THE UTILITY FACILITIES SUPPORTED ABOVE

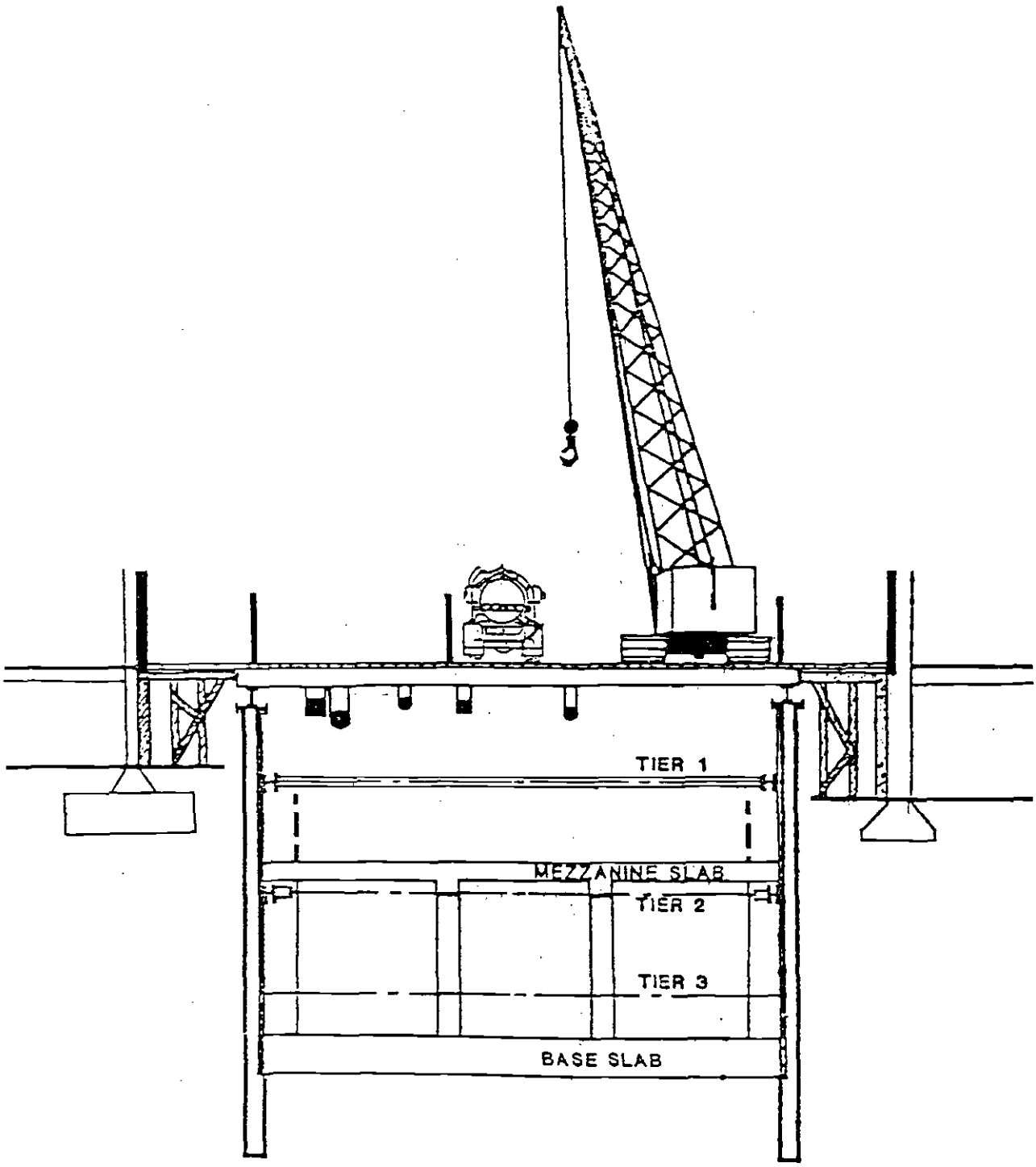
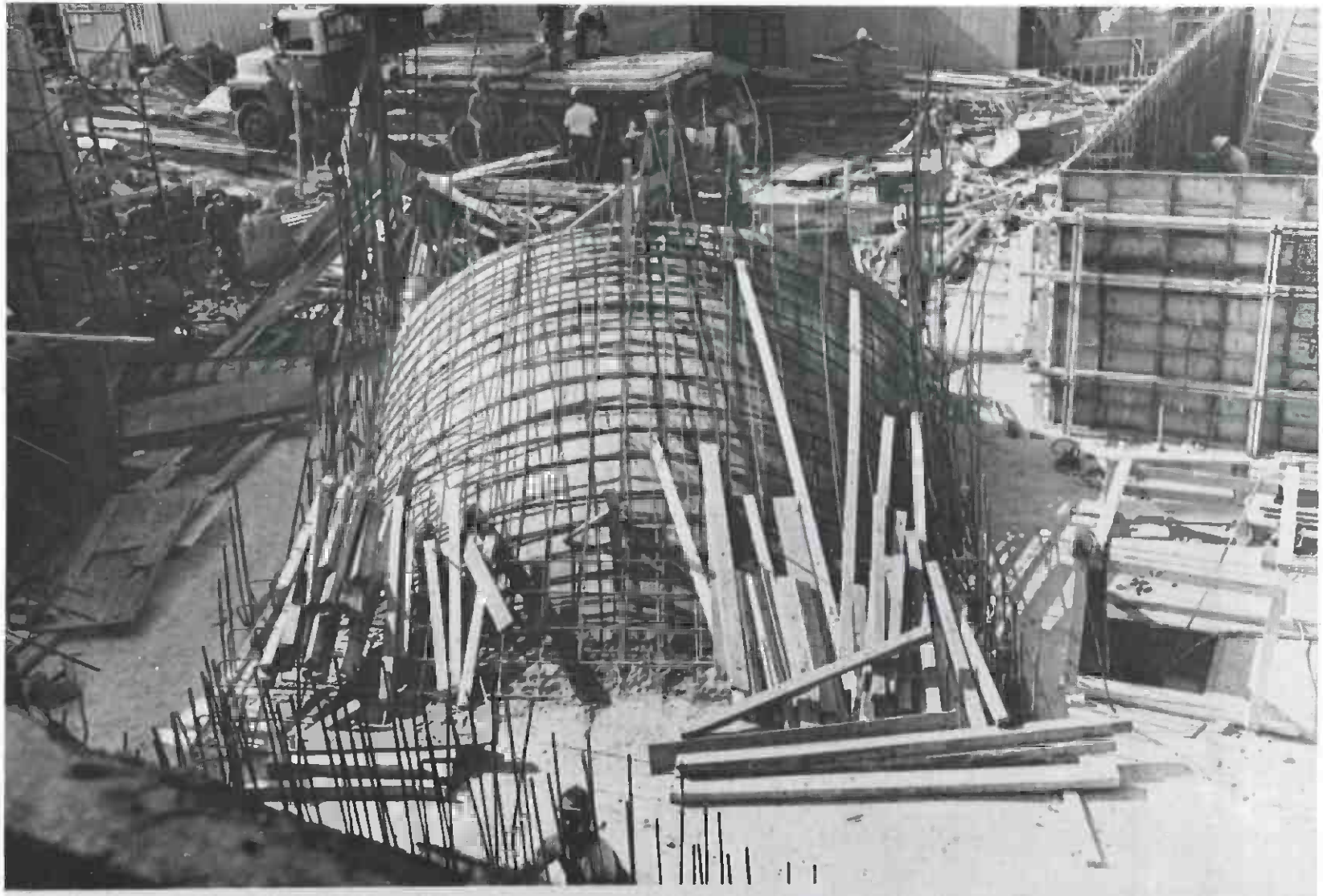


FIGURE 22
STRUCTURE INSTALLATION AND BRACING AND REMOVAL

FIGURE 23
STATION ENTRANCES ARE GENERALLY OUTSIDE PUBLIC RIGHT-OF-WAY;
UTILITIES ARE RELOCATED CLEAR OF THE SITE



Metropolitan Atlanta Rapid Transit Authority CN120
Description
Shaft backfill concrete around escalator incline
Photograph#213 Date:5/28/81
Contractor:Jorn/Fruin-Colnon

FIGURE 24
STATION ENTRANCE DESIGN ENSURES SUFFICIENT COVER FOR
UTILITIES ABOVE PUBLIC RIGHT-OF-WAY

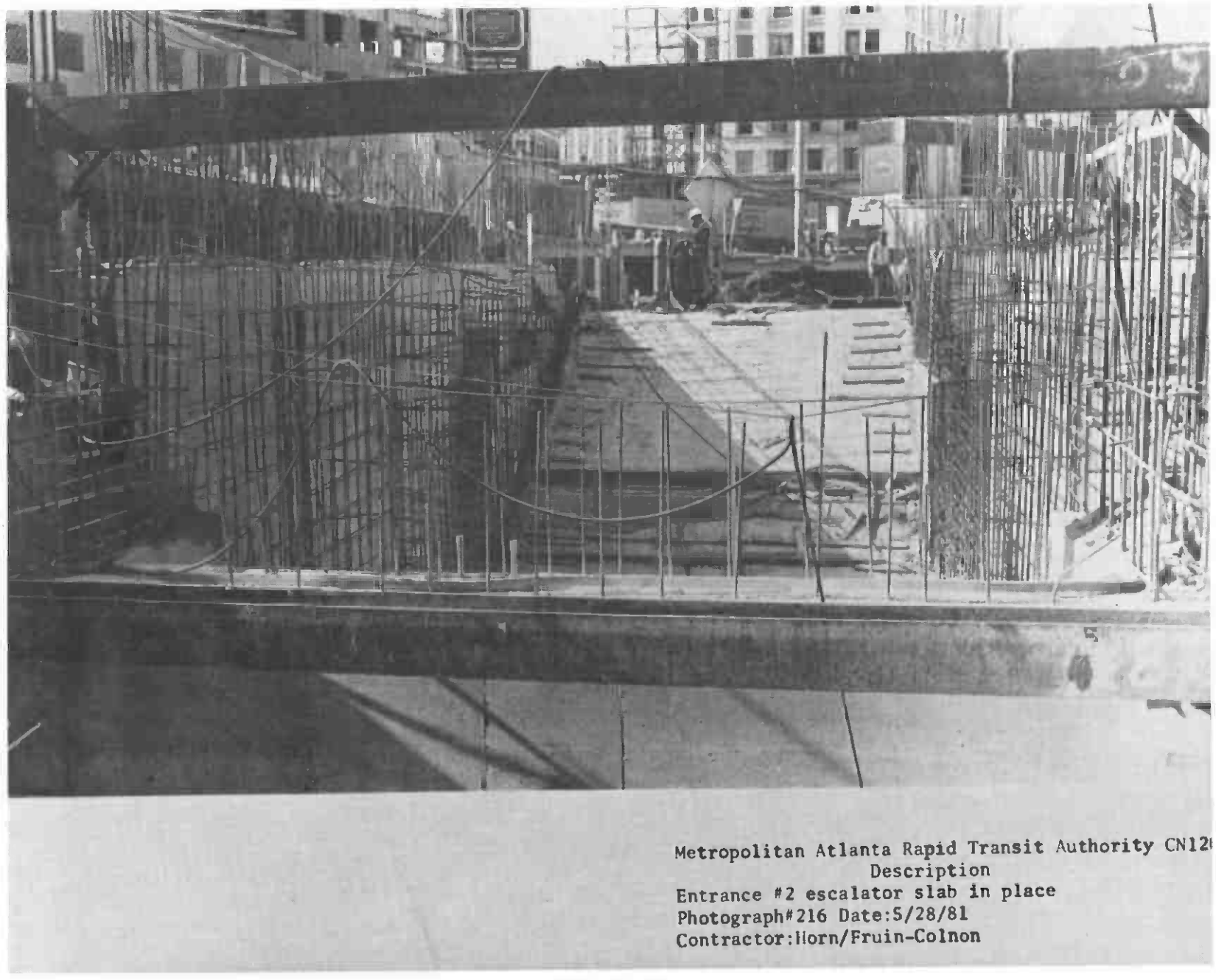


FIGURE 25
STATION ENTRANCE AT INTERMEDIATE STAGE OF CONSTRUCTION

Metropolitan Atlanta Rapid Transit Authority CN120
Description
Open cut viewed from Simpson street
Photograph#89 Date:9/3/79
Contractor:Horn/Fruin/Colnon

FIGURE 26
CUTTING AND REMOVING THE UPPER FEW FEET OF SOLDIER PILE IN PREPARATION OF STREET RESTORATION

FIGURE 27
UTILITIES SUPPORTED BY TEMPORARY BLOCKS WHILE HAND-OPERATED TAMPERS ACHIEVE PROPER COMPACTION OF THE SURROUNDING BACKFILL MATERIAL

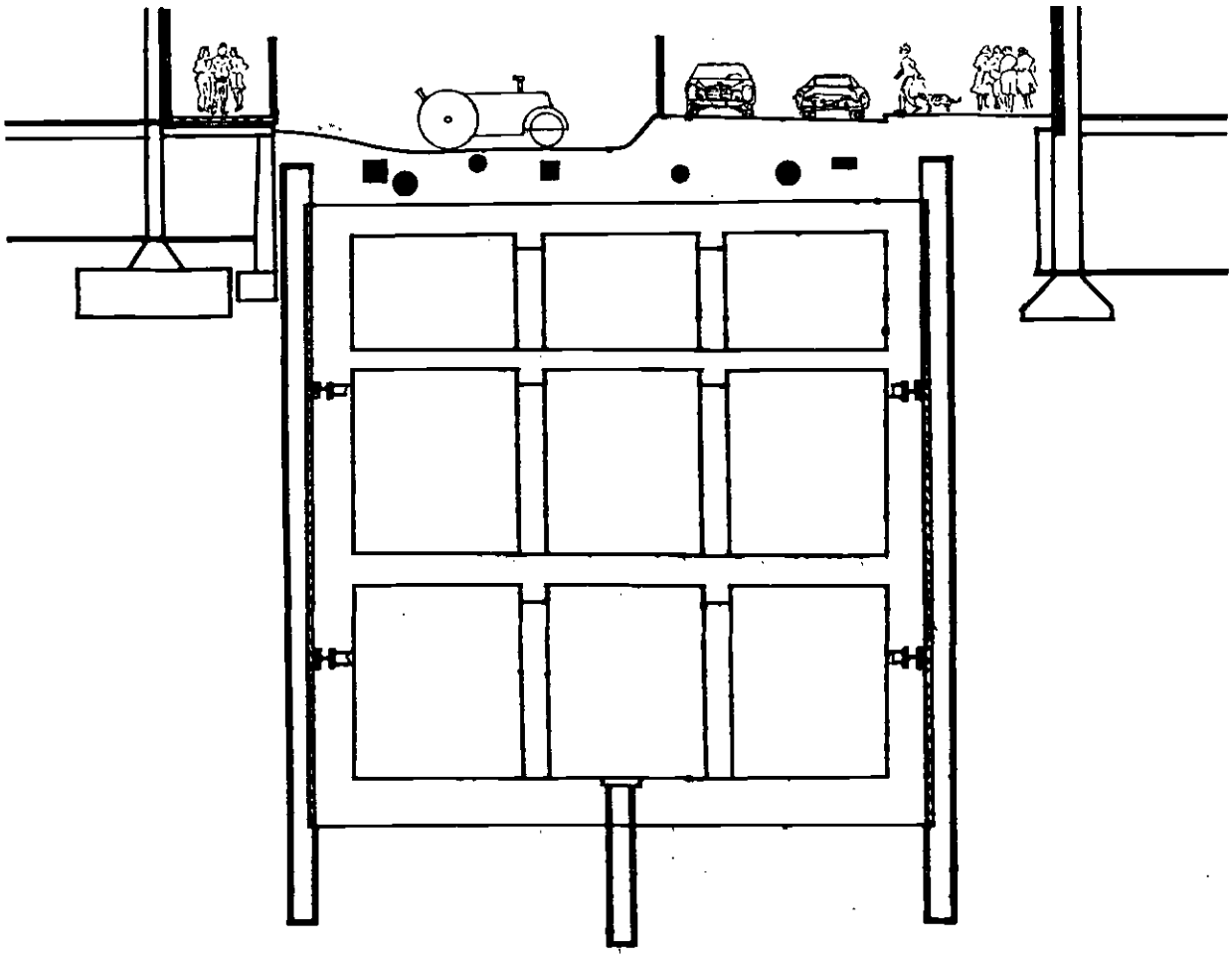


FIGURE 28
BACKFILLING AND SURFACE RESTORATION