CUT-AND-COVER TUNNELING

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STATE OF THE ART

Methods and techniques currently used in cut-and-cover tunnel construction have evolved under the influence of environmental factors at the work site. Though this type of construction may be carried out in a suburban area, it is more likely to be associated with an urban surrounding where constraints are more prevalent than in open areas. The complexity of the area (narrow confined streets, large buildings, and heavy traffic, both vehicular and pedestrian) contributes to the decision to place facilities below ground. Construction economy dictates that the structure be placed as close to the surface as possible because the cost of cut-and-cover construction increases rapidly with depth.

The following operations are usually performed sequentially on a cut-and-cover construction project: relocate utilities, underpin adjacent structures, dewater where required, install ground-support system, excavate street surface, place temporary street decking, continue excavation below street, construct structure, restore utilities, remove temporary street decks, and repave street.

1. Relocate utilities. Most urban streets contain sewers, water lines, gas lines, and electrical and telephone ducts that must be continually maintained during construction. Major streets often carry the main lines of these utilities. Smaller lines are usually maintained in place during construction, supported below street decking. Heavy sewers and utility manholes may be temporarily replaced by lighter facilities, to be restored after construction. Gas lines and large water mains must sometimes be temporarily or permanently relocated for reasons of safety.

2. Underpin adjacent structures. Requirement for underpinning depends on the value and proximity of an adjacent structure, condition and design of existing foundation, type of ground-support system used, and nature of the soil. Properly designed and installed, ground-support systems prevent excessive ground movement and reduce underpinning requirements. Underpinning may involve hand-excavated pits or caissons, pile clusters jacked below spread footings, or small-diameter friction piles drilled down through the footing. On smaller buildings, temporary support measures such as pile pickup or jacking piers for support walls may be employed to prevent uneven settlement.

3. Dewater where required. If groundwater flow is small, trenching and sumping ahead of excavation may suffice. Dewatering equipment, where required, should be installed and activated prior to excavation. For shallow excavation, a system of well point is usually the most economical. For deeper excavations, eductors may be used for relatively light flows and deep wells for heavier flows.

4. Place temporary street decking. Street decking usually consists of structural steel beams across the width of cut, resting on the ground-support walls. For wide structures, intermediate support piles may be required. Removable timber mats placed on the beams form the temporary deck. Traffic must be restricted during placing and removal of the deck. Wide decking is usually placed sequentially on one side of the street while limited traffic is permitted on the other side. Traffic is then diverted to the completed deck while decking of the second side takes place. The procedure is reversed during decking removal. Some decking operations may have to be done on weekends to minimize disturbance. Access to adjacent buildings for pedestrian and emergency vehicles must be maintained. When cut-and-cover structures are located in less congested areas, there often is sufficient room for detouring traffic and thereby eliminating the requirement for temporary decking.

5. Install ground-support system. Though many ground-support systems have been developed, soldier piles and lagging are probably still the most widely used. Good workmanship and careful procedure must be followed to prevent ground movement and subsequent settlement of adjacent structures, utilities, and pavements. Because of the environmental disturbance of pile-driver noise and vibration, vertical soldier beams are now usually placed in predrilled holes. Lagging is placed between the piles as the excavation and bracing proceeds.

Sheet piling has traditionally been used in wet running ground, but the noise of pile driving now restricts its use in urban areas. Cast-in-slurry concrete diaphragm walls, though more expensive than sheeting, have been used in a number of projects including several subway stations in San Francisco and Washington, D.C. These walls not only reduce the need for underpinning but are structurally capable of being incorporated in the completed structure.

6. Excavate below street level. Bracing of the ground-support wall is usually by horizontal steel wales and struts

Excavation bracing for subway station.

placed concurrent with excavation. Struts are usually on the same spacing and in vertical plane with deck beams for ease of lowering materials and raising excavated soil. Earth-anchored tiebacks are gaining in popularity for foundation walls, but have not been used much for cut-and-cover work.

Excavation and backfilling operations are governed by environmental considerations. Urban restrictions preclude the use of large scraper equipment so effective on highway projects. Small dozers, backhoes, front-end loaders, and crane-mounted clamshells are inherently expensive. The first excavation pass, to expose utilities and place decking, is usually loaded by front-end loader or backhoe into dump trucks.

Below the deck, digging is done by dozer or front-end loader, which transports the soil to central areas where it is usually lifted to the surface by a large clamshell and loaded into dump trucks. Where the soil does not contain much clay, conveyors are an attractive alternate for lifting.

Costs can frequently be saved by using the permanent steel frame of a structure as temporary bracing.

FUTURE RESEARCH

Environmental, Social, and Economic Impacts

Most future improvement for cut-and-cover work will involve ways to minimize environmental, social, and economic impacts. There has been a growing awareness that construction cost alone is not the only factor to be considered. Though not easily assessed, delays to commuters, interruption of normal business activities, and loss of local business income and tenants are all affected by the construction methods employed. Noise and dust ordinances have already had an impact on construction methods and costs.

The time of exposure is the single most important factor of social and economic losses. To reduce the exposure at street level, major alternate construction sequences are being investigated. Placing a permanent street deck in lieu of temporary decking eliminates the need for the disruptive period of decking removal. It also reduces the problems of maintaining traffic on a less than ideal deck surface cluttered with construction equipment. Subsequent excavation, bracing, concrete, and backfill below the street must be performed from side ramps or shafts without the benefit of removable decking. New techniques need to be developed to keep these operations from becoming overly expensive.

Ground Support

A new type of ground support has been developed in Europe and is being studied by the U.S. Department of Transportation. Precast panels are placed in a slurry trench to form a continuous ground-support wall that can be used also as part of the permanent structure. It has the following advantages: Concrete quality control is better; panels can be delivered with waterproofing on the outside; the inside has an architectural finish; and bearing plates, keys, dowels, and recesses can be included in the casting. This system would combine well with a permanent street deck.

Street Decking

Development of precast panel street decking will also be required for a permanent deck installation, for the placing and curing of cast-in-place concrete slabs would negate the purpose of minimal disruption.

Utilities

Utilities, as always, remain a problem. There are two possible methods of handling maintenance of utilities. The first is to provide before main excavation twin utility tunnels (utilidors), one on either side of the street. All utilities (with the exception of gas lines) serving local buildings would share these tunnels. This would leave the center of the street clear and would permit the precast structural roof to serve as a street deck, placed with minimum encumbrances. The second method is to support utilities below a permanent street deck and to place a second structural slab below the utilities, providing in effect a utilidor above the roof. Such methods have been used in other countries, but have not gained wide acceptance in the United States.

Other Areas

Other areas for future research include ground consolidation methods to reduce dewatering and ground support requirements. Transportation of excavated soil by hydraulic or pneumatic pipelines could be investigated as an alternate to lifting by clamshell or conveyors.