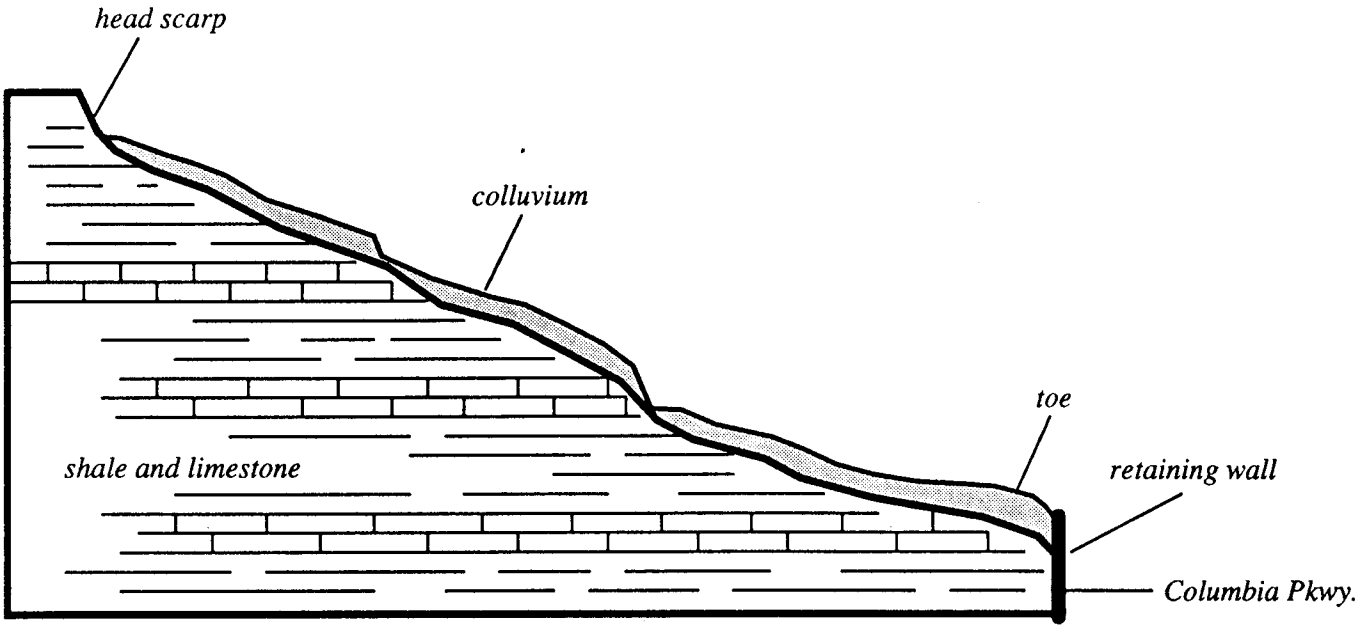

FIGURE 3.—Cross section through a typical thin colluvium landslide along the Ohio River valley. Bedrock is predominantly shale with limestone interbeds, and the landslide slip surface coincides with the bedrock-colluvium contact.

material was shale and clay dumped along the slope during 19th-century quarrying operations. Cost of removal was $31,000. Also in 1975, six landslides occurred along the hillside east of Kemper Lane. About 5,000 cubic yards of soil was removed from behind the retaining wall, at a cost of $19,000. A review of files revealed that in 1973 a large amount of soil slid over the retaining wall, blocking the westbound lane of Columbia Parkway in several places. Sliding was caused by heavy rains that occurred between February and May 1973. The costs to remove the debris along the parkway were:

Bains to Kemper	$8,325
Kemper to Taft	$1,930
East of Torrence Pkwy.	$2,352
At Wortman	$4,754

Landslides above Columbia Parkway will continue to occur, and the rate of sliding at any given time will be related to rainfall. The conditions most conducive to landsliding will be heavy rain storms during early spring, after the spring thaw but before trees had leafed out.

MASS MOVEMENT BELOW THE PARKWAY

The entire hillside below Columbia Parkway is actively creeping downslope. When the rate of movement within a given area differs sufficiently from the adjacent area, scarps, cracks, and other landslide features develop and the area is referred to as a landslide. Sidewalks and curbs may be offset, and buried utility lines may rupture due to the effects of landsliding. Deep-seated active and inactive landslides occur on the hillside below Columbia Parkway and are almost continuous from Bains to Torrence Parkway. The landslides are elongated, with their long dimension running perpendicular to the hillsides. The head scarps of the landslides occur within 6 to 10 feet of the roadway, in some places cutting through several feet of roadway if not through the roadway entirely. Within the pavement, the head scarps are easily distinguished by extensive cracking, settlement, and warping of the pavement. Head scarps on the downhill side of the pavement are not as easily distinguished because of vegetation and the effects of weathering. The slip surfaces of the landslides presumably occur along the soil-rock interface, which is typically more than 15 feet deep. The toes of landslides occur along the north side of the Conrail tracks and in some instances extend downhill as far as Eastern Avenue.

Maintaining the integrity of the eastbound lanes of Columbia Parkway has been a long-term problem. The rate of movement, as determined by the amount of vertical displacement within the pavement, is on the order of several inches per year. In order to insure a smooth ride, asphalt overlays must be placed at least twice a year in areas most affected by landsliding. As is the case for landslides above the parkway, the rate of sliding at any given time is directly related to precipitation.

IMPROVING COLUMBIA PARKWAY

Columbia Parkway is currently being widened and improved between Bains and Beechmont Avenue. The improvement is being performed in three sections: Bains to Torrence Parkway, Torrence to Tusculum, and Tusculum to Beechmont.

In 1976, the section of Columbia Parkway between Torrence Parkway and Delta was widened by adding approximately 8 feet onto the south side of the roadway. Retaining walls consisting of 36-inch-diameter concrete piers, socketed into bedrock, were required in several places. Sections of the roadway between Torrence and Delta that are not supported by a pier wall are affected by soil creep. This movement has caused up to 5 inches of settlement along the southern curb line and opening of joints in the eastbound lane. The City of Cincinnati will improve this section in the fall of 1992 by rehabilitating and resurfacing the existing pavement, installing pier walls, and underpinning sections of the existing barrier walls.

In October 1990, the State of Ohio began construction on the improvement of Columbia Parkway from Tusculum to

Beechmont Avenue. This project was completed in the spring of 1992. In October 1991, the State began construction on the improvement of Columbia Parkway from Bains to Torrence; this project is expected to be completed by the spring of 1993. The Tusculum to Beechmont and the Bains to Torrence projects involve widening the existing traffic lanes, rehabilitation and resurfacing of the existing pavement, resurfacing and strengthening or replacement of uphill retaining walls, and other safety upgrades. The existing reinforced concrete retaining walls along the uphill side of Columbia Parkway between Tusculum and Beechmont were resurfaced with 8 inches of reinforced concrete. The top of the wall was raised slightly and a safety barrier was incorporated into the wall along the roadway. The retaining walls were also strengthened using tiebacks to prevent the kind of sudden wall failures that have occurred in the past. All existing uphill retaining walls between Bains and Kemper will be strengthened, refaced, and tied back with grouted rock anchors. Existing uphill walls between Kemper Lane and Torrence Court will also be strengthened or replaced. Several new walls will be built in areas where there are none.

Because of continuing sliding beneath the parkway and the need to further widen the roadway, the downhill side of the pavement along 5.2 miles of Columbia Parkway will be stabilized using 3.2 miles of drilled pier walls. A pier wall is an earth-retaining structure consisting of a row of individually drilled piers socketed into stable bedrock. The piers are constructed so that they penetrate the unstable soils and develop resistance to the lateral loads in the underlying bedrock. In many cases, the depth to bedrock is such that tiebacks with grouted rock anchors are necessary to support

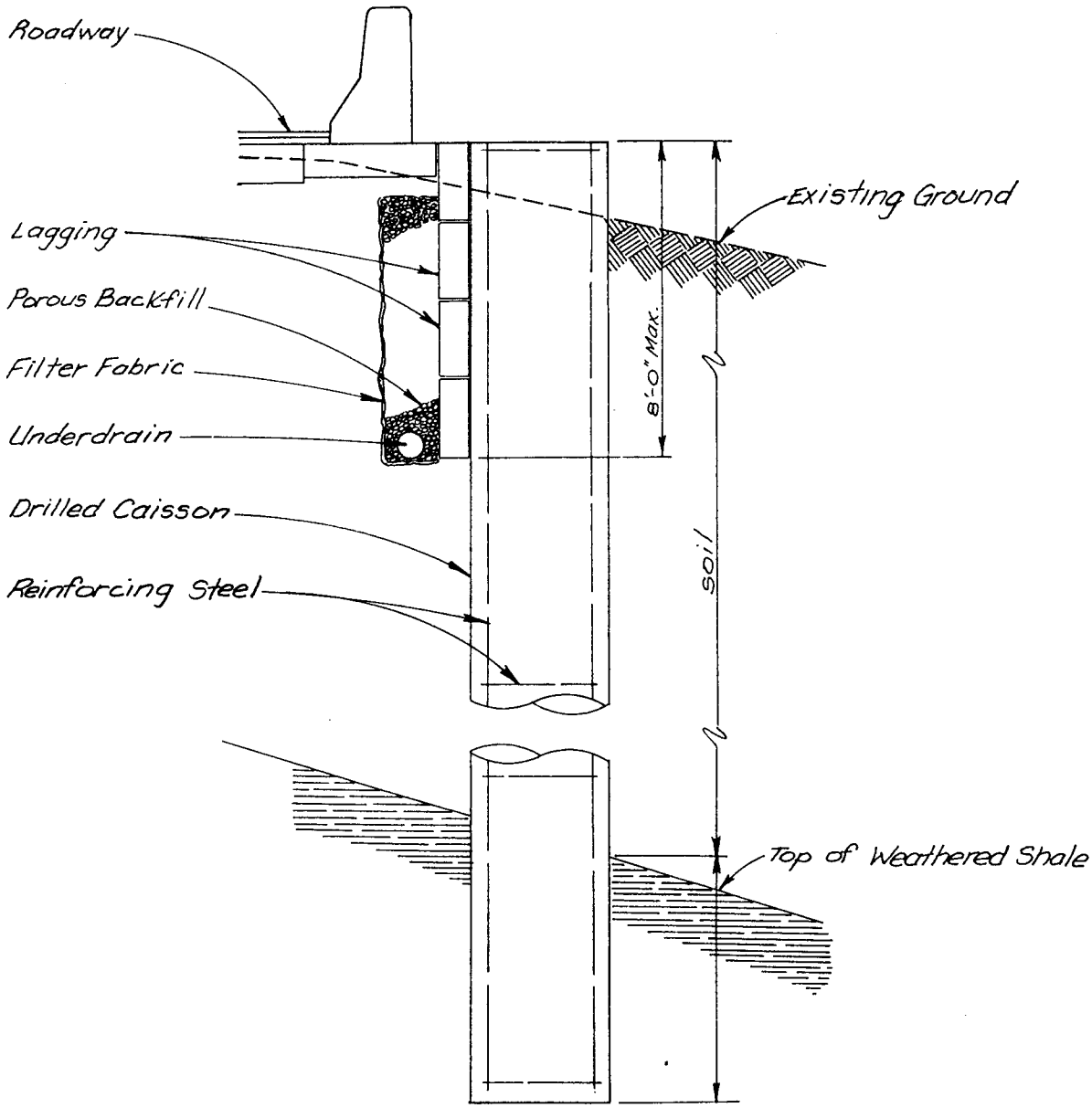

FIGURE 4.—Design of a typical cantilevered pier wall used to support potentially unstable slopes in the Cincinnati area. Pier walls are constructed by drilling large diameter holes into bedrock, which are in turn filled with reinforced concrete. When completed, each pier acts as a lever to prevent the colluvium from moving downslope.

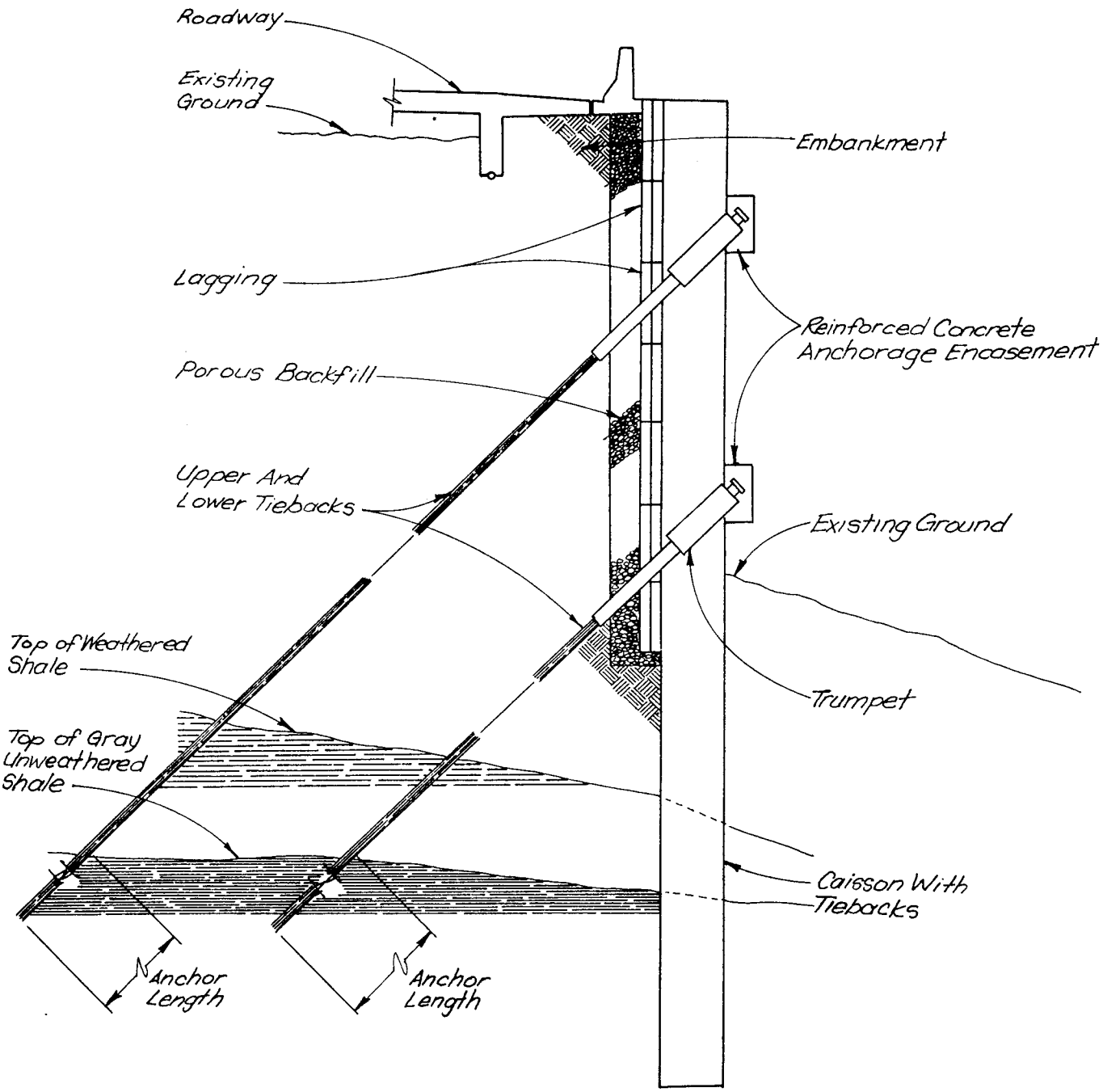

FIGURE 5.—Design of a typical tied-back pier wall. Tied-back pier walls are similar to cantilevered pier walls, but resistance to sliding is increased by adding steel tiebacks anchored in stable shale bedrock.

the tops of the piers. Figures 4 and 5 show typical details of a cantilevered and tied-back drilled pier. The diameter of the piers on Columbia Parkway projects ranges from 30 to 48 inches, and the length ranges from 15 to 55 feet. The bedrock sockets range from 5 to 18 feet deep, and the total number of individual piers to be installed is 2,526. Estimated cost of the project is $25 million, or about $5 million per mile. While these projects will stabilize the parkway, they will neither eliminate landsliding below the pier walls nor reduce the occurrence of landslides above the parkway.

As we travel east along Columbia Parkway, observe the barren areas along the uphill side of the roadway, where soil has slid over the wall. Along the downhill side of the roadway, pier-wall construction should still be in progress. It may be possible to pull off the road to inspect and discuss the construction of pier walls (Stop #1). If not, we will stop at McCollough Avenue off Eastern Avenue to inspect an existing pier wall (Stop #3).