

ENGINEERING

Excavating Mountain Developments

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Development in the mountain communities has been seemingly boundless in the last 20 years. We've seen whole cities develop around ski resorts and in the Denver foothills. However, as growth continues, many of the 'good sites' in the mountain communities are gone. What remain are significantly sloped sites or, as land values continue to escalate, tight sites with hard-to-meet space requirements. These sites make construction tricky, because the space isn't available to make normal sloped excavations. CTL | Thompson has been assisting with design of these tricky excavations for many years through the use of shored or braced excavations.

In the past, shored or braced excavations were used primarily for major inner city projects where existing buildings and utilities made sloped excavations virtually impossible. But as development has expanded and land values increased, more and more sites need to take advantage of the technology.

As demand has grown, knowledge about the systems has followed. Better analytic methods for designers like CTL | Thompson are now available and contractors have more effective installation equipment. Below I have described the technologies used to compensate for a tight or sloped development site. A geotechnical engineer and contractor can analyze the best remedy to mitigate site problems, but builders and contractors should be aware of the options that now exist for tricky excavations.

• **Tieback Anchors.** Tieback anchors were first used in temporary construction shoring. In this technique, the contractor installs driven piles – anchors – at about 8 feet on center and then excavates down to the top level of anchors. Anchor holes are drilled into the embankment, and a cable is grouted into the hole and attached to the piles. When the anchors are pulled and locked off, future deflections of the wall are relatively limited. Wood shoring extends from pile to pile and is

installed from the top down as the excavation proceeds. Foundation walls and floors are then installed inside the temporary shoring. When construction of the permanent walls is complete, the space between the wall and shoring is backfilled.

Additionally, earth anchors can be part of the permanent foundation walls, reducing construction time and limiting backfill problems. A very effective technique, but one that can be a problem if the site is obstructed by buried utilities or other structures. In this case of an adjacent landowner, an easement may be required as well.

• **Cantilever Drilled Pier Walls.** If tieback anchors can't be used because of obstruction, a cantilevered pier wall is often used. This type of wall has been extensively used on the T-Rex project. In fact, you can see a standing example on the work being done on I-25 in the Washington Park neighborhood. Piers are drilled side by side extending below the planned excavation so that the "wall" created by the piers does not tip over as excavation proceeds. The system is most efficient when permanent anchors can be included to reduce the length of pier embedment below the planned excavation. However, when an easement cannot be obtained from the adjacent landowner, a pier wall without tiebacks is a good alternative. This system is also attractive in urban areas, as it eliminates backfill. A variety of finish methods are available.

• **Soil Nail and Mechanically Stabilized Earth (MSE) Systems.** Soil nails and MSE walls are similar in that they result in a block of soil that is reinforced and resists movement of the excavation face. Soil nails are installed in a process similar to anchors, but consist of steel rods grouted into the holes. There is no tension applied to the rods.

MSE walls are typically constructed by placing a plastic grid or fabric between layers of granular fill. When excavation is completed, then the MSE system builds the wall up to the desired level. The MSE approach is usually

very economical but requires extra room outside a building in order to slope the excavation and construct the backfill to interact with the reinforcing grid or fabric. The other systems allow top down construction and less site disturbance.

Whichever system is best for your site, it will be installed by design/build specialty contractors in close coordination with the geotechnical and structural engineers to achieve the overall project needs.

Our most recent project was to develop a deep parking structure at the base of Little Nell in Aspen. We completed design and observed construction of two similar structures; one at the base of Aspen Highlands (which used temporary shoring with tieback anchors) and the Timbers Club project at Snowmass, completed with a permanent anchored wall. At the Timbers project, tiebacks, soil nails, and a continuous pier wall were each used successfully in different parts of the same excavation.

It is not just the mountain resorts that face excavation difficulties. An apartment project in Boulder was constructed with a continuous



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Mountain construction requires extensive shoring.

drilled pier wall because of easement restrictions. Similarly, it is not confined to commercial sites. We have two residential projects under construction in the foothills just west of Denver where permanent soil nail walls and MSE walls are incorporated into the site design because slope conditions do not permit traditional excavations.

All of these projects were possible because of availability of construction equipment and techniques, and advances in engineering analysis. Relatively undevelopable land could be modified resulting in high quality projects with minimal impact to surrounding properties.