



## ROCK SLOPE STABILIZATION

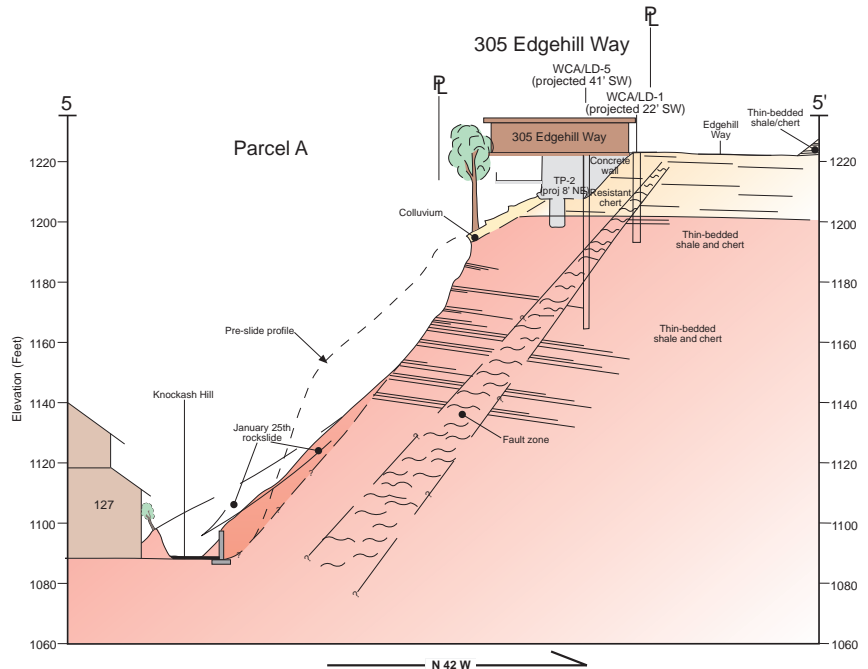
KNOCKASH HILL PROJECT  
SAN FRANCISCO, CALIFORNIA

### PROJECT DESCRIPTION

Knockash Hill is a prominent bedrock ridge situated in the West Portal District of San Francisco. During the early part of this century, the chert and shale bedrock was quarried and used throughout the City as roadway baserock and engineered fill. The quarry operation created steep, unstable slopes. The tops of the quarry walls were excavated to the property lines with uphill residential parcels, placing nearby residential structures in jeopardy.

In 1992-1993, construction was begun on a new residential development near the base of the steep quarry walls. Numerous small-scale rock falls have issued from the quarry walls and have placed the homeowners at risk. Early attempts to stabilize the quarry walls have met with little success. In January of 1997, a large section of the quarry wall failed and resulted in a rockslide that prompted the City to evacuate the homes above and below the failed portion of the quarry wall.

### Engineering Geologic Cross Section



### ENGINEERING SOLUTION

Engineering and geological investigations were carried out by Cotton, Shires and Associates, Inc. geotechnical staff in order to characterize the surface and subsurface geologic framework of the rockslides and to determine engineering parameters of the rock materials. The stabilization design includes a series of reinforced concrete "belts" with tiebacks that run horizontally across the slope. The belts are designed to act as an integrated system and to anchor the slope, increasing the factor of safety against failure to 1.5 for both shallow- and deep-seated failures, plus they have gutters built into them to catch small-scale rock raveling and channel surface water off the rock slope. In addition, they anchor the wire mesh that covers the slope. The belts are spaced approximately 20 to 35 feet apart (vertically) and are held in place by multi-strand, double corrosion protected tieback anchors. Tieback lengths are up to 75 feet with lock off loads of 200 kips each. The total of 99 belt tieback anchors and approximately 1,200 linear feet of concrete belt structures are included in the stabilization plan. The estimated cost of slope stabilization is approximately \$2 million. Structural Engineering was provided by Carl Chan, and Soil Engineering Construction was selected as the General Contractor to complete the construction.