

The plate pile slope stabilization method consists of the installation of vertical steel reinforcing elements in a natural or man made slope for the purpose of increasing the Factor of Safety against a landslide failure. Plate piles can be used to stabilize active landslides as well as creeping slopes. The sliding or creeping soil mass is resisted by a ¼-inch thick 12-inch wide steel plate welded to the upper half of a 6 foot long steel 2 ½" x 2 ½" x ¼" angle. The plate piles are spaced at 4 feet on center parallel to the slope and staggered in rows 8 feet apart perpendicular to the slope. The plate pile method is designed to stabilize creeping unstable slopes where the soil conditions consist of an upper three to six foot thick zone of soil that has degraded due to weathering, shrink-swell or saturation. The plate piles form a barrier where the soil arches between the plates and limits downslope movement. The steel is galvanized to provide long term protection against corrosion. The plate piles are driven into the slope using a small vibratory hammer to a depth of 12 inches below the slope surface so that they are not visible when the installation is completed.

The plate pile innovation provides a low cost method for stabilizing slopes where few options previously existed. In the past shallow slides have been considered a maintenance problem and largely ignored by common slope stabilization and repair methods where vegetation was used as the primary defense against shallow slides. The annual cost of repairing shallow slides is a very significant problem faced by homeowners and large property owners such as public utilities. The commonly used method of repair is to wait until the summer and remove the slide debris, cut benches into the hillside and place compacted fill to restore the slope. Because of the size of earthmoving and compaction equipment the volume of excavation is usually much greater than the slide zone. The cost of the "remove and replace" method is about \$30 per square foot of slope surface. The plate pile method stabilizes the slope in-place with minimal earthwork required. The work can be accomplished with a small excavator adapted with a driving hammer and one laborer. The installation cost ranges between \$5 and \$10 per square foot of slope surface repaired.

The plate pile method was developed at the Blackhawk Geologic Hazard Abatement District (GHAD) where an extensive testing program has been conducted. The GHAD, a quasi-government agency, contracted Kleinfelder as the General Manager, to repair and prevent landslides in a district where unstable slopes are prevalent. The GHAD under Kleinfelder management established a program to study and develop new, less costly methods for stabilizing slopes. General Manager, Richard Short, invented the plate pile concept after dealing with a storm on December 15, 2002 that resulted in 60 shallow landslides throughout the District. Short subjected the concept to a rigorous technical scrutiny bringing in U.C. Berkeley Professors Nick Sitar and Jonathan Bray as peer reviewers and developing a full scale testing program followed by three dimensional finite element modeling. The plate pile method proved a simple, but sound technology for solving the shallow landslide problem.

Although very new, the plate pile method has been utilized on several projects with over 11,000 elements in the ground. The Santa Rosa commercial site is an example project where a chronic slope stability problem developed resulting in 17 shallow slides over a period of five years. The slopes were stabilized using 10,000 plate piles which effectively arrested the problem. The cost savings to the owner amounted to \$3.5 million. During the winter storms in California over the past two years hundreds of shallow slides have occurred on the shoulders of highways and rural roads and behind residential properties. In one typical project, a 3,500 square foot slide was repaired in one day at a cost of \$15,000. The slide was located on a steep slope on City property directly behind a residence where a conventional remove and replace solution is estimated to cost \$100,000. Currently, a plate pile solution is planned for a Caltrans freeway interchange along Highway 5 in Northern California where the on and off ramp slopes are creeping and failing. The potential cost savings is \$2,500,000 and the safety risk is significantly reduced by eliminating the need for deep excavations alongside a major freeway in operation.

The danger associated with fast moving shallow debris flows or mud flows is very real as evidenced by the La Conchita Landslide near Santa Barbara, California in 2005 and Mill Valley Landslide in Marin County, California in 2006 California where a total of 11 lives were lost. The plate pile method holds promise as a tool for stabilizing potential debris flow source areas. The U.S.G.S. uses laser scanning mapping techniques to create topographic images that can highlight debris flow susceptible slopes. Combining the debris flow susceptibility maps with the locations of residential or lifeline structures will identify slopes that could be stabilized to prevent life threatening debris or mudflows.

