



## *Stabilization of a reactivated landslide near Wagon Mound on Interstate 25*

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# STABILIZATION OF A REACTIVATED LANDSLIDE NEAR WAGON MOUND ON INTERSTATE 25

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## INTRODUCTION

Wagon Mound lies in north central New Mexico. The surrounding area is characterized by large volcanic buttes and lava flows that terminate in bluffs west of Interstate Highway 25 near a dry lake bed. Interstate 25 skirts the edge of a basalt-capped mesa whose perimeter is composed of landslide debris. One problem that arose during construction of the highway was a landslide condition which developed during excavation on the north end of the project. On February 4, 1970, during the final stages of excavation between stations 1 1306 and 1317, an ancient landslide was reactivated and movement and crack-ing were noted. On February 10, as the excavation continued, a small perched groundwater reservoir was breached and an estimated 10,000 gallons of water were released.

## INITIAL STUDY AND RECOMMENDATIONS

Personnel of the Materials and Testing Laboratory were informed of the problem and began to determine a solution. The cut slope as designed was to have had a 12 ft level bench at the ditch line and four additional benches 15 ft wide and 25 ft high with the intervening slopes cut on a 0.5:1 ratio. On February 10, the cut slope was at its designed section and almost to grade. Exposed in the benched cut are Cretaceous rocks, primarily interbedded limestones and shales of the Fort Hays Limestone and the dark, fissile Carlile Shale near the bottom. A slumped, disoriented slab of basalt overlying a paleosol and several feet of sandy clay cap the interbedded limestones and shales.

The initial slide movement was about 1.5 in. every 24 hours. The main surface of rupture and movement was along a 6 to 12 in. bed of saturated montmorillonitic clay about 20 ft above grade. The crown of the slide was marked by a continuous arcuate crack, as much as 2 ft wide, near the periphery

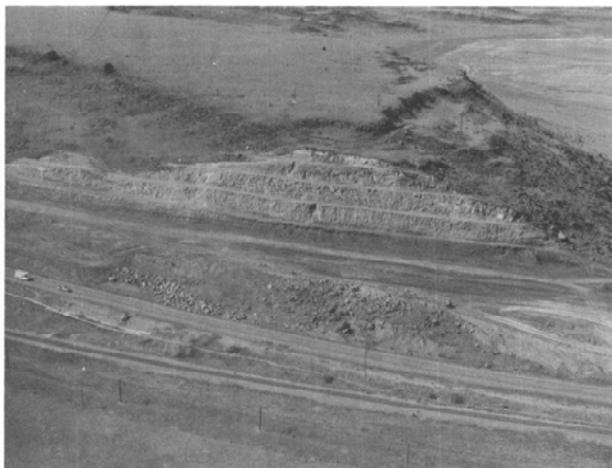


Figure 1. Failed slope, February, 1970, looking west.

of the basalt mesa. The crack was about 1000 ft long and several antithetic faults or slip surfaces were observed in the fact of the cut.

Two bore holes were drilled in the face of the cut below and up through the slip surface to determine whether any water remained on the slide. Cross sections were made of the existing slope and superimposed on cross sections of the original slope, and an aerial photo study was completed.

The analysis of this failure showed the slide to be a slip circle or a rotational type failure. The rupture surface was a circular arc intersecting the large crack at the crown of the slide and the montmorillonite bed at the face of the cut. The center of rotation was located at the intersection of the perpendicular bisector of the arc and a line drawn perpendicular to the failure slope at the head of the slide. The average shearing resistance along the failed surface was computed and several trial solutions were devised using slope flattening and head removal.

The redesign recommendation called for a 1.5:1 cut slope above the lower bench, a 65 ft bench about 80 ft above ditch line elevation and a 1:1 slope above the 65 ft bench. This required an additional 93,000 yd<sup>3</sup> of loose rock excavation which was to be utilized for plating the old lake bed a short distance north. It was recommended that another antithetic slide, which was resting against the north end of this slide mass, be decapitated in order to avoid failure in the upper cut slope. This required an additional 22,000 yd<sup>3</sup> of rock excavation, also to be utilized as fill for the lake bed. Upon completion of excavation any large cracks remaining were to be sealed with clay soil in the upper part of the cut. This soil was to be compacted and bladed to drain.

Construction resumed in the slide area on April 17, 1970, to bring the cut to grade and construct the remedial slope design. During excavation a high-angle fault (10-15 degrees from vertical) developed along the outer edge of the proposed 65 ft bench and additional movement occurred in the upper area of the slide. This fault was approximately 300 ft long and 2 ft wide at the surface. The middle slope was flattened from 1.5:1 to 1.85:1, reducing the bench width from 65 to 45 ft. This required an additional 22,000 yd<sup>3</sup> of excavation. Upon completion of excavation several large cracks remained across the 45 ft bench. An attempt to close these cracks was made by loosely blading a clay soil across the bench. The final slope construction was completed about June 15, 1970, and no signs of distress or instability were noted until May, 1972.

## RENEWED FAILURE AND FURTHER INVESTIGATION

In May, 1972, a small slide occurred about mid-slope as a shallow slip circle or piping type failure antithetic to the main slide mass and insignificant other than from an aesthetic view. In October, 1972, following heavy precipitation during the summer months, another more significant slide occurred near the south end of the slope.

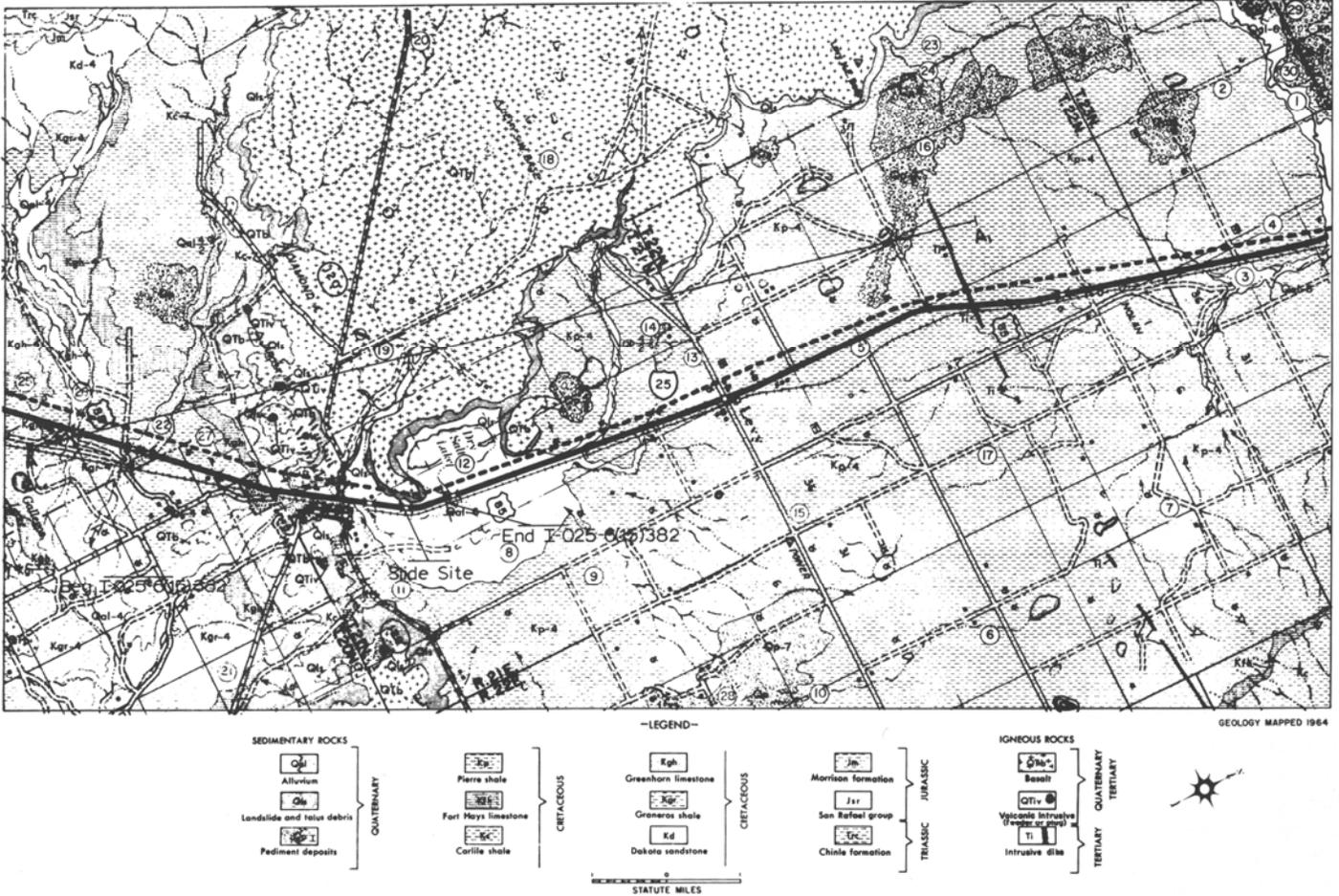


Figure 2. General geology of Wagon Mound area.

Additional subsurface investigation during January, 1973, indicated that a free draining condition still existed along the failure surface. The larger of the two antithetic slides had slumped about 10 ft at the crown in the 45 ft bench and its toe had progressed several feet across the lower bench. A test hole at the back of the 45 ft bench did not indicate that ground water was flowing through the granular materials below the basalt into the failure surface; however, a test hole above a seepage zone just above the lower bench indicated that a considerable amount of rain and snow melt was slowly percolating through the entire slide mass to the failure surface. Water apparently enters the many cracks and fissures during periods of precipitation, makes its way to the failure surface, relubricates the surface and causes additional movement. Therefore, some hydrostatic pressure exists part of the time.

Although described as a free-draining system, it is apparent that the disturbed mass will take on water faster than it releases it.

Water migrates slowly along the failure surface (montmorillonite clay layer), seeps into the slope wash on the lower bench, enters cracks in the lower bench, finds its way to another impermeable layer about 4 ft below the lower bench and appears in the face of the lower cut slope. The top of the lower bench is composed of a very competent, hard, dense black shale.

The entire slide mass is very complex, consisting of a rather large slide moving in an east-southeasterly direction, and smaller auxiliary slides on the flanks of the larger block. All of the slides have one common fault at their crown but movement in the smaller slides is oblique to the main mass. Other

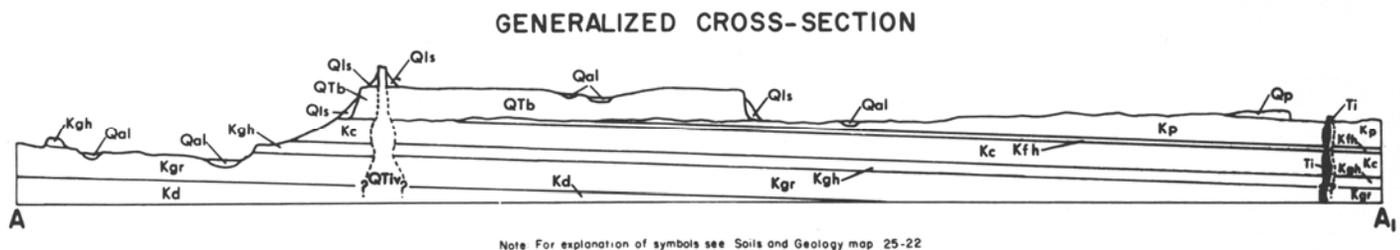


Figure 3. Generalized cross-section of Wagon Mound area.

## STABILIZATION OF A LANDSLIDE



*Figure 4. Aerial view looking west of additional distress January 16, 1973. Note auxiliary slides near the north and south end of cut slope.*

slides of the same complexity about the main fault of this system on the north and south flanks of the basalt mesa.

Excavation during construction completely removed the montmorillonite bed (zone of failure) from the lower bench in the middle cut slope. The shear zones of the smaller slides have relatively high secondary carbonate contents; however, slickensides along the shear zones have montmorillonite skins that vary from a feather edge to 1 in. in thickness. No secondary carbonate deposits were found in the upper portion of the main slip surface. This indicates that the primary slip surface is youngest and slope failure is of a retrogressive type.

The present condition of the slides corroborates the original analysis based primarily on exposed site conditions. Additional movement has obviously been caused by poor drainage on the 1.85:1 slope as well as the upper 45 ft bench. The top of the bench could have provided better drainage if it had been properly shaped and the soils compacted.

## FURTHER RECOMMENDATIONS

Three methods to further stabilize this slope were considered, two for further rebalancing the mechanical forces and the other for chemical treatment. Of the two mechanical methods, one involving further decapitation of the slide and buttressing of the middle slope, was abandoned because it was too expensive, might overload the incompetent shales below the lower bench and would reduce the width of the upper bench excessively. The other mechanical method lowers the upper bench without reducing its width and requires removal and partial replacement of the auxiliary slide. Chemical treatment is probably the most practical but is not the simplest method. It is a relatively new process, which requires the injection of selected chemicals into cracks, fissures and drill holes in the slide to change the type of clays along slip surfaces to more cohesive soils.

It was suggested that several thousand gallons of a thin lime slurry be pumped into the large cracks in the upper bench for experimental purposes. Bench treatment to seal out the water was also recommended. No significant corrective measures have been taken to date. The slide mass does not present an immediate hazard to the traveling public. No catastrophic movement is expected, but the slope is an aesthetic eyesore and may, if further lateral spreading of the failed area occurs, eventually entail a considerable maintenance expense.