



Landslide repairs on US-180 between mileposts 13 and 19, near Luna, Catron County, New Mexico

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LANDSLIDE REPAIRS ON US-180 BETWEEN MILEPOSTS 13 AND 19, NEAR LUNA, CATRON COUNTY, NEW MEXICO

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Abstract—Three landslides within the Tertiary Pueblo Creek Formation were repaired on US-180 near Luna during 1993 in two separate projects. Data had been initially collected on one of the landslides as far back as 1979. All three had been continuing maintenance problems and regularly received maintenance asphalt patches before being repaired. One of the slide repairs involved excavating material above the slip surface and replacing it with select fill, which was keyed into bedrock for stability. The other two slides were repaired by excavating material above the slip surface and replacing it with local soils and reinforcing geogrid. Both repair methods had sufficiently high safety factors (1.25) when modeled on slope stability computer programs; each method of repair should perform adequately.

INTRODUCTION

In 1993 three landslide areas were repaired on US-180 near Luna, New Mexico at mileposts (MP) 13.5, 18.54 and 18.66 (Fig. 1). These repairs were made as part of two projects undertaken for major road improvements that were let to contract by the New Mexico State Highway and Transportation Department (NMSHTD). This portion of US-180 was originally constructed in the 1920s and 1930s by the Bureau of Public Roads and lies within the Apache and Gila National Forests. The highway alignment traverses the San Francisco Mountains and lesser volcanic hills of the Mogollon Slope.

The highway cut slopes are primarily in Tertiary volcanic and sedimentary rocks of the Pueblo Creek Formation (Ratté, 1989). These rocks are covered by Quaternary deposits. The volcanic rocks consist of hard andesites and rhyolites and less competent andesites and cobble-boulder tuff breccias laced with quartz stringers and some dikes. The sedimentary rocks consist of breccias, conglomerates, volcanic ashes and mud flows. The Quaternary material includes colluvium, rockslide debris and landslide debris.

The primary goal of the highway improvement projects was to create a wider roadway template to bring the roadway up to current safety standards. The roadway was increased from two 11-ft lanes with no shoulders to two 12-ft lanes with 6-ft shoulders. This required extensive presplitting and blasting of the rock sidewalls. Due to the weathered nature of the rock, an overrun of 10,000 yd³ (20%) of blasted material was generated in the vicinity of milepost 17. The rock was more extensively fractured than expected and much of it fell onto the

roadway. Traffic was halted and rerouted on a winding and bumpy dirt Forest Service road for 3 weeks.

EARLY OBSERVATIONS

Roadway settlement along US-180 at MP 13.5 had been an ongoing maintenance problem, and was suspected to be the manifestation of a landslide. The settlement was investigated in 1979 using NMHSTD drill crews. Two exploratory holes were drilled into the slide mass and standard penetration tests (SPT) were performed at 5-ft intervals. Undisturbed soil samples were obtained for soil strength determination, and two slope inclinometers were installed in the exploratory holes. Number 1 was 8.3 ft right of centerline, and Number 2 was farther down the slide mass and 43.2 ft right of centerline.

The investigation indicated that the original ground surface had not been cleared and grubbed of its original vegetation and organic debris prior to placement of fill for the highway. The vegetation at the interface of the natural ground and overlying fill eventually decomposed to form a zone of weakness, which formed a shear surface when the overlying fill became saturated by infiltration of snowmelt and rain. The slip surface was located by the inclinometer readings, which showed movement at a 25-ft depth in inclinometer Number 1 and at a 20-ft depth in inclinometer Number 2. The investigation also revealed that the original natural ground was part of a dormant prehistoric landslide mass underlain by a fine- to medium-grained sandstone bedrock.

Slide repair recommendations were made to the NMSHTD by the Geotechnical Section after analyzing data from the site investigation. The recommendations were given in October of 1979, together with recommendations for controlling rock fall from cut slopes adjacent to the highway from the Arizona state line east for 15 mi.

RECENT OBSERVATIONS AND REPAIRS

Because of lack of funding and higher priorities, slope stabilization and highway widening projects for this stretch of roadway were not let to contract until 1991. Highway maintenance crews periodically patched the roadway through the landslide area during the 12 yr period since 1979 and regularly cleared fallen rock from the highway. After project construction began it was discovered that the slide correction had been left out of the plans.

During construction the slide mass began to move again. In early February 1992, the head of the slide dropped 10 in. in a 4-hr period. The ground was wet from recent rain and snow. A series of arcuate cracks and distresses had developed in the roadway over approximately a 200-ft length. The cracks extended from the shoulder of the east bound lane, across the centerline, and 8 ft into the west bound lane. A sag of up to 0.625 ft was measured along the centerline profile for a distance of 150 ft. The contractor cut a shoe fly detour into the adjacent hillside to accommodate traffic. By May 1992, the head of the slide had dropped a total of 4 ft. A typical landslide hummock had also

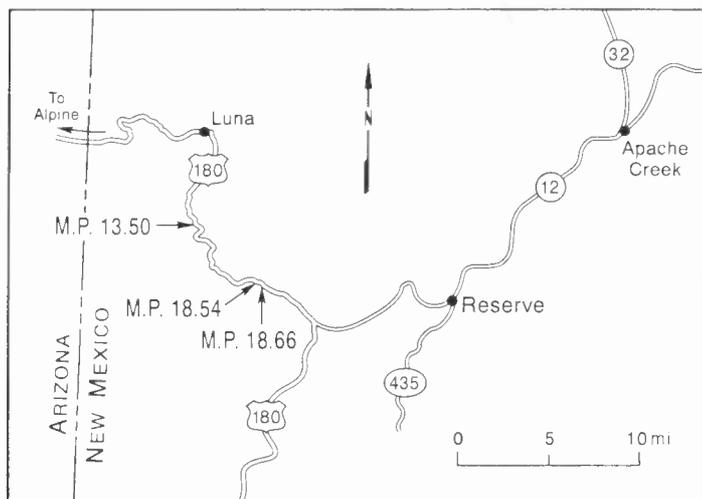


FIGURE 1. Index map of the Luna, New Mexico region, showing locations of landslides on US-180 repaired during 1993.

developed on the side slope between the head of the slide and a creek located 50 ft vertically below the top of the moving mass. Based on the 1992 movement and information obtained in the 1979 investigation a corrective design was once again developed.

Remediation consisted of removing the mobile slide mass and organic shear plane and keying the new embankment material into bedrock. Approximately 12,000 yd³ were excavated. A french drain, consisting of gravel wrapped in filter fabric, was placed along the backslope of the excavation in order to divert water away from the new embankment (Fig. 2). A perforated lateral drain collector pipe was placed at the bottom of the french drain and connected to a nonperforated pipe that discharged above the stream at the lowest elevation of excavation. Select fill was placed in 12 in. lifts and compacted to 95% of maximum obtainable density as determined by AASHTO T-99 (Proctor test). Select fill consisted of sandy, well-draining material with a high angle of internal friction (35°) and little or no cohesion. This material was obtained from cut slopes adjacent to the new Luna bridge 6 mi from the excavation. The replacement material was keyed into bedrock for a 20 ft width (see cross-section and profile, Figs. 3, 4). Construction took approximately 7 weeks to complete.



FIGURE 2. Landslide repair at MP 13.5, showing french drain being constructed on back slope of excavation, autumn 1993.

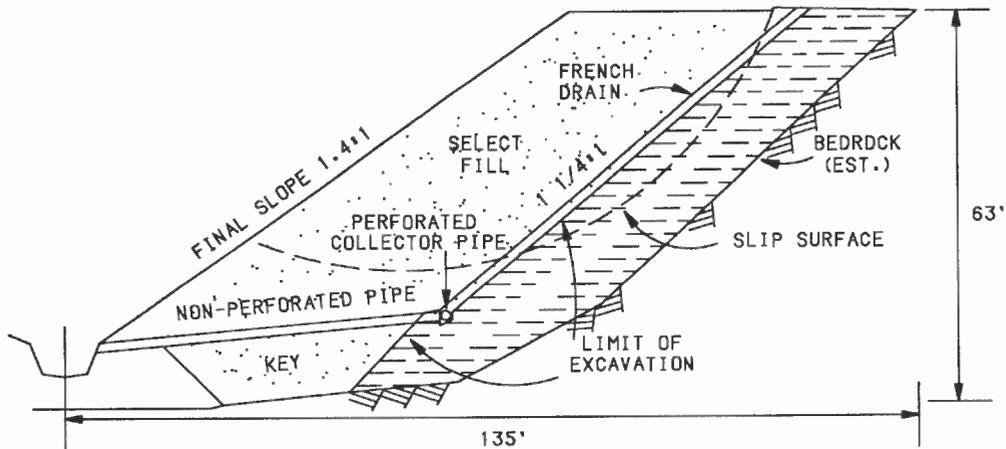


FIGURE 3. Cross-section at MP 13.5, detailing slide repair.

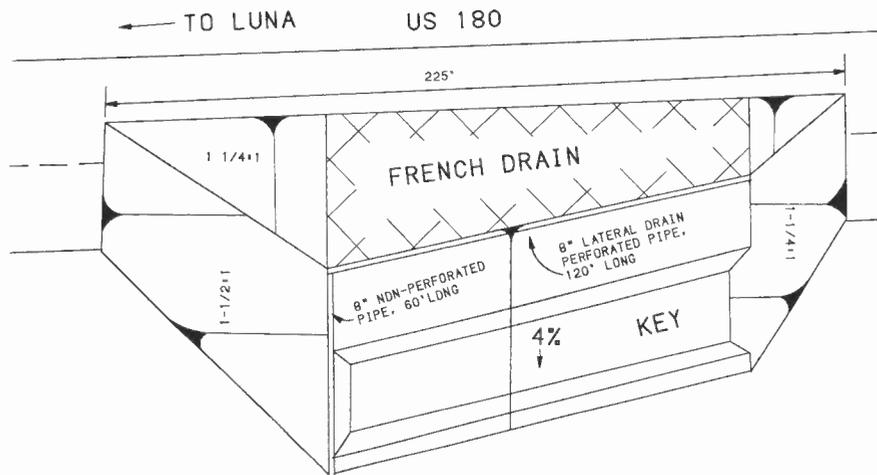


FIGURE 4. Plan view of excavated area at MP 13.5.

Two other potential slides were corrected in these projects at mileposts 18.54 and 18.66. Both were identified by the arcuate cracks in the road before any major mass movement occurred. Subsurface investigations were performed in January of 1990 and corrections were designed and included in the project plans. Organic material was found below the surface of these two areas, indicating the same type of failure mode as described earlier. These areas were also underlain by the same type of old landslide debris found in the slide at MP 13.5. Inclinometer readings at these two locations failed to identify a slip plane due to the less active state of these slide masses.

The problem of the slide movement at MP 18.66 was being compounded by a stream undercutting and removing material toward the base of the slide mass. During initial construction of this road, the stream was rechannelled away from the bank. After many years of eroding its way back to its natural channel, it began to cut away at the embankment built to support the road above. As erosion continued, the outlet section of a 48-in. culvert, 30 ft above the stream, lost support. This 8-ft section eventually fell off. The slope was gradually steepened to nearly vertical. MP 18.54 showed the same type of settlement of the pavement and shoulder as MP 18.66, but without loss of the side slope. Both areas had received as many as 14 in. of asphalt patches over the years.

These two areas were repaired using a soil reinforcing geogrid fabric. The first area (MP 18.54) was 250 ft in length and required an excavation of 2400 yd³. It was reconstructed beginning at a depth of 12 ft with 10 layers of geogrid spaced 1 ft apart using backfill obtained from the opposite cut slope, after discarding large boulders and clumps of clay. The backfill was again obtained from the opposite cut slope. This area also contained a zone of unreinforced backfill on the outside of the reinforced area (Figs. 5, 6). Once begun, these two repairs took about 10 weeks to complete.

Two completely different approaches were taken in the repair of these slides, although their situations were similar. The two slides at MP 18.54 and 18.66 were drilled and analyzed with corrections

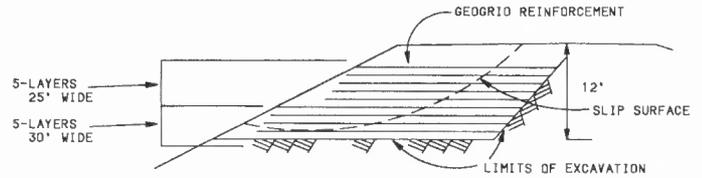


FIGURE 5. Cross-section at MP 18.54, showing geogrid placement in top 12 ft of roadway.

designed using soil reinforcing geogrid and local soils with deleterious materials removed. The slide correction at MP 13.5 was also analyzed but an entirely different correction method was used. This involved replacing the slide mass with select borrow having the desired strength parameters and keying of the select borrow into the bedrock and providing for drainage.

SAFETY FACTORS

For modeling purposes a safety factor of 1.0 is considered to represent failure while a 1.25 represents stability. Both repair methods described above were modeled with a safety factor of 1.25 based on slope stability computer programs, and each type of repair should perform adequately.

ACKNOWLEDGMENTS

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REFERENCES

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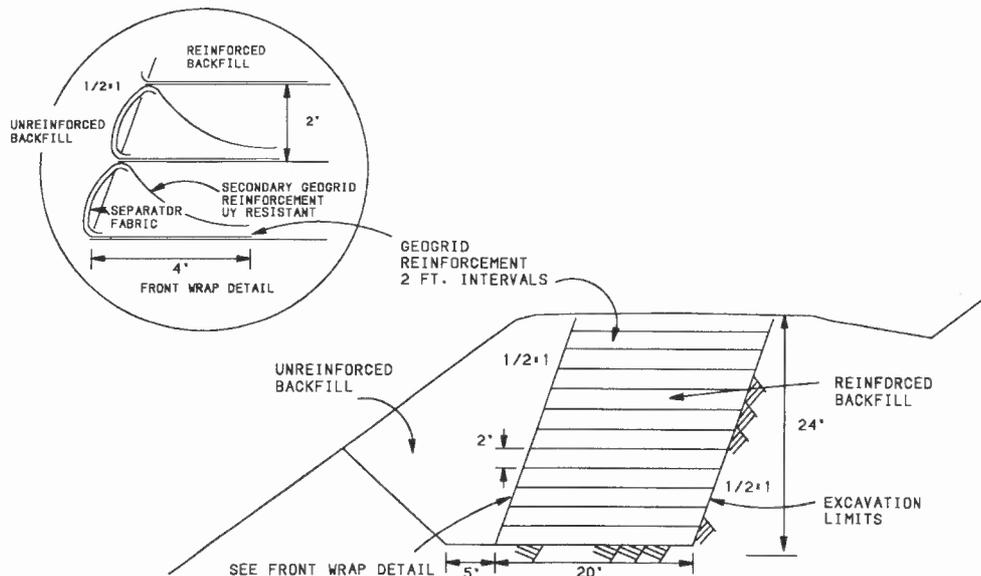


FIGURE 6. Cross-section at MP 18.66, showing geogrid reinforcement in top 24 ft of roadway.