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LANDSLIDES ON SHALE IN SOUTHERN ILLINOIS

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ABSTRACT

This paper presents the case histories of two landslides in southern Illinois. The first landslide presented occurred along a highway cut at Ford's Hill on Illinois Route 3 near Chester, Illinois. The second landslide occurred in the embankment of a large retention pond in southern Illinois. Both failure planes were along the surface of the weathered shale bedrock in response to excess pore pressures. Backfigured strength at the time of failure was low and at the residual strength of the weathered shale.

KEYWORDS

Case Histories of Slopes, Dams and Embankments
Natural Slopes
Embankments
Dams and Tailings

INTRODUCTION

Slides along Ford's Hill on Route 3 south of Chester have occurred since the highway was constructed in the 1930's. Major slides occurred in 1935, 1952, 1970, and 1988, generally during the springtime after periods of heavy rain or snowfall when the ground was saturated.

The second slide to be discussed occurred in the dike of a large retention pond in February, 1995. The scarp length was about 500 lineal feet and was located where the dike was the tallest (55 ft) and crossed a former creek. Figure 1 contains a vicinity map which shows the approximate location of the slides.

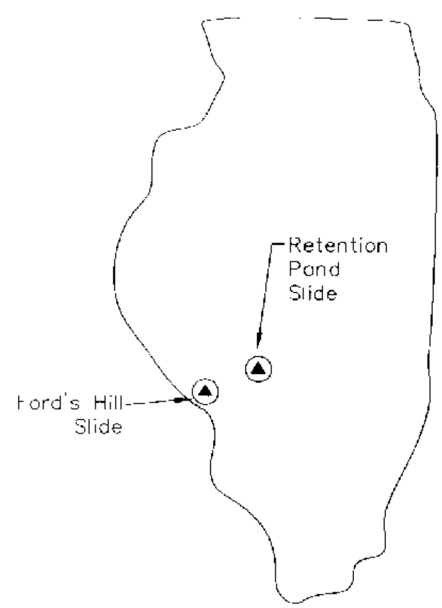

Fig. 1. Vicinity Map

FORD'S HILL SLIDE

This project involved the stabilization of a series of active landslides along a highway cut of Illinois Route 3 south of Chester, Illinois. The study involved the review of air photos, geologic mapping, and a total of 15 test borings, ranging in depth from 5 to 60 feet. In the summer of 1994, shallow standpipe piezometers were installed in four borings and inclinometers in five. Inclinometer casings were perforated to measure groundwater levels in bedrock. Laboratory tests included conventional index tests, consolidated-drained triaxial tests, and ring shear tests to evaluate the residual friction angle. Also, five test borings and 14 test pits were competed by IDOT in early 1995 to evaluate the feasibility of constructing a French drain along the east edge of the pavement.

The slide planes occurred at the soil/rock contact based on inclinometer measurements. The bedrock at the slide locations was a Mississippian-Aged Shale. The test borings indicated that the slide material was a mixture of residual/talus soils consisting of a matrix of stiff, medium to high plastic clay with about 10 to 20 percent gravel and cobbles. Bedrock below the slide was generally limestone with occasional shale partings or beds. Based on inclinometer data and site observation, the slide plane was judged to be 20± feet below the pavement at the contact between the soil and bedrock. The drained friction angle at the slide plane was estimated to be 17° based on back-calculations and laboratory test data. Figure 2 shows a cross-section through the most active slide area, Station 946+00. Data from the borings, inclinometer, and piezometers are included on the cross-section.

Three stabilization alternatives were considered in detail: drilled piers, Insert walls and drainage. Drainage was much less expensive (about 20%) of the other options, but involved greater risk of not stopping the slide. Therefore, it was used following the observational method. That is, drainage was installed and then the slide performance monitored. If drainage was not successful, the other more expensive measures would have been used. The drainage option which consisted of a French drain with a series of laterals was installed during the winter of 1995/96. Installation of the French drain was hampered due to the existence of boulders. Drainage proved successful in arresting the slides based on at least two wet seasons of instrumentation readings.

RETENTION POND SLIDE

The dike forming the pond was constructed in two episodes; a 35 foot high compacted clay dike built in 1969, and a 20 foot high "raise" constructed in 1989 on the upstream slope of the older dike. The 1989 raise consisted of two materials: 1) bottom ash placed underwater and extending to the crest of the older dike, and 2) compacted clay above the bottom ash extending to the crest. Both clay dikes were well compacted, but the bottom ash was very loose due to underwater placement. The dike rests on a foundation of stiff clayey soils about 20 to 30 feet thick overlying weathered shale and limestone bedrock. Over time the surface of the Pennsylvanian-Aged Shale has weathered to high plastic clay containing fissures and zones of weakness (slickensides) along which movement has occurred in the past (perhaps ancient landslides). A thin stratum of locally water-washed decomposed limestone and/or glacial till overlies this high plastic clay.

The overall slide consisted of two portions; shallow and deep. The deep slide occurred first 70 feet below the crest at about the top of the high plastic clay noted above. A generalized section through the center of the failure is shown in Figure 3. It was hypothesized that movement of the dike on the deep failure plane then formed a crack that extended through the clay dikes and bottom ash. As the crack widened, it created a void that was filled by soil and bottom ash migrating into it. This resulted in the upper dike settling. Concurrently the bottom ash and granular haul road at the top of the original dike permitted hydrostatic pressure equal to the pond head to develop beneath the toe of the upper clay dike. This water pressure lifted the toe allowing the upper clay dike to move laterally. Finally rainwater in the tension cracks of the failed upper dike aggravated further movement. Lowering of the pond by 6 feet reduced the rate of movement significantly.

The deep slide was not visually apparent at first, but was detected by deep instrumentation (inclinometers). The pond level was raised approximately 6 feet four months prior to the visual existence of the slide. When the pond level was raised, the deep failure was believed initiated by water pressure in the pervious water-washed zone directly above the high plastic clay.

The backfigured friction angle along the failure plane assuming no cohesion was 14.5°. This low friction angle was consistent with laboratory measurements of residual (large displacement) friction angles measured in fissured or slickensided high plastic clays and shale found in this area. An interim repair which was performed in the summer of 1995 has arrested movement of the slide. The interim repair consisted of removal of about 20 feet of soil at the crest of the dike for about 600 lineal feet to reduce the driving forces of the slide. A cutoff wall and a drainage wall has been designed as a permanent repair if the dike is to be reconstructed.

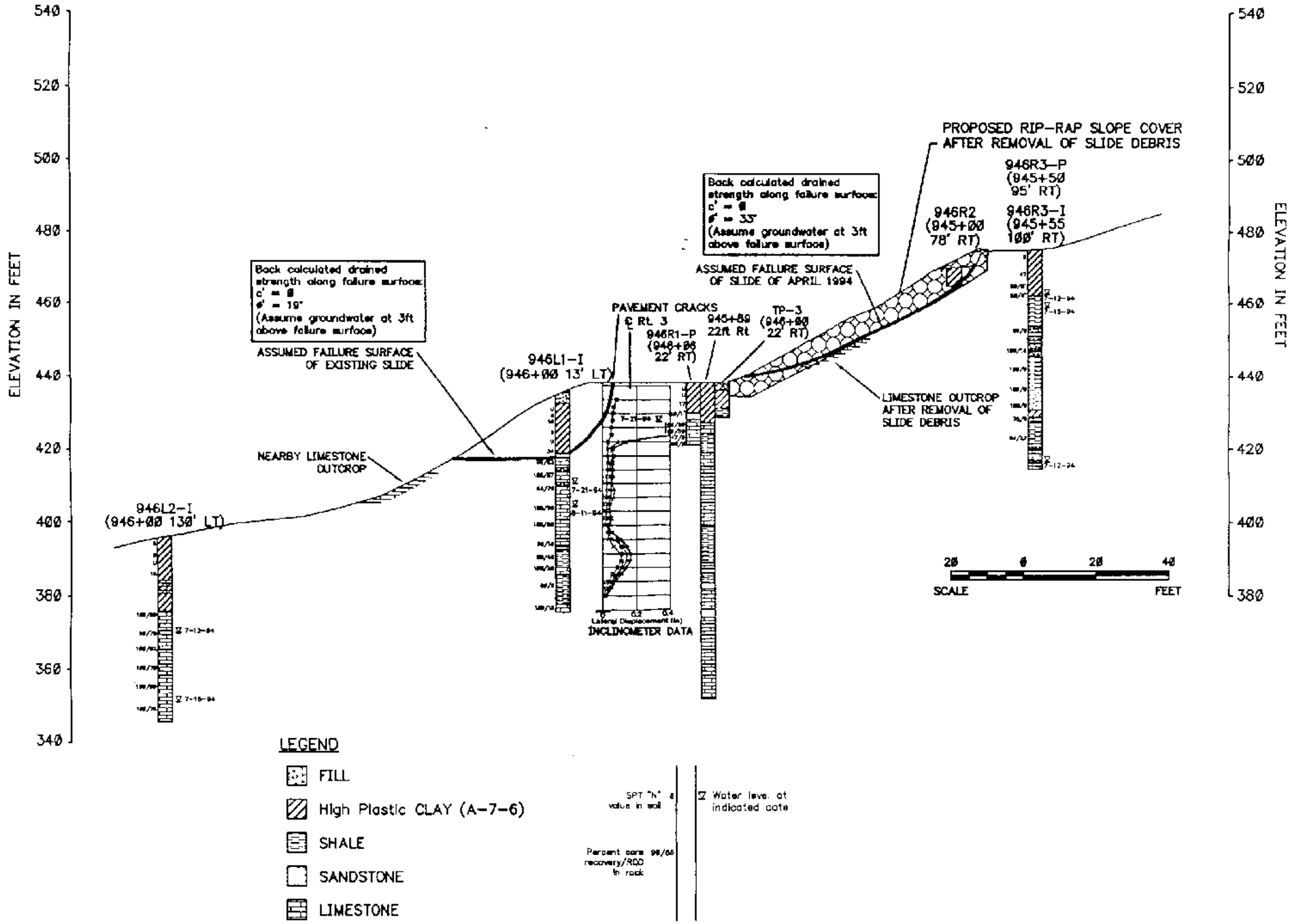

Fig. 2. Ford's Hill Slide Sta. 946+00 Cross Section

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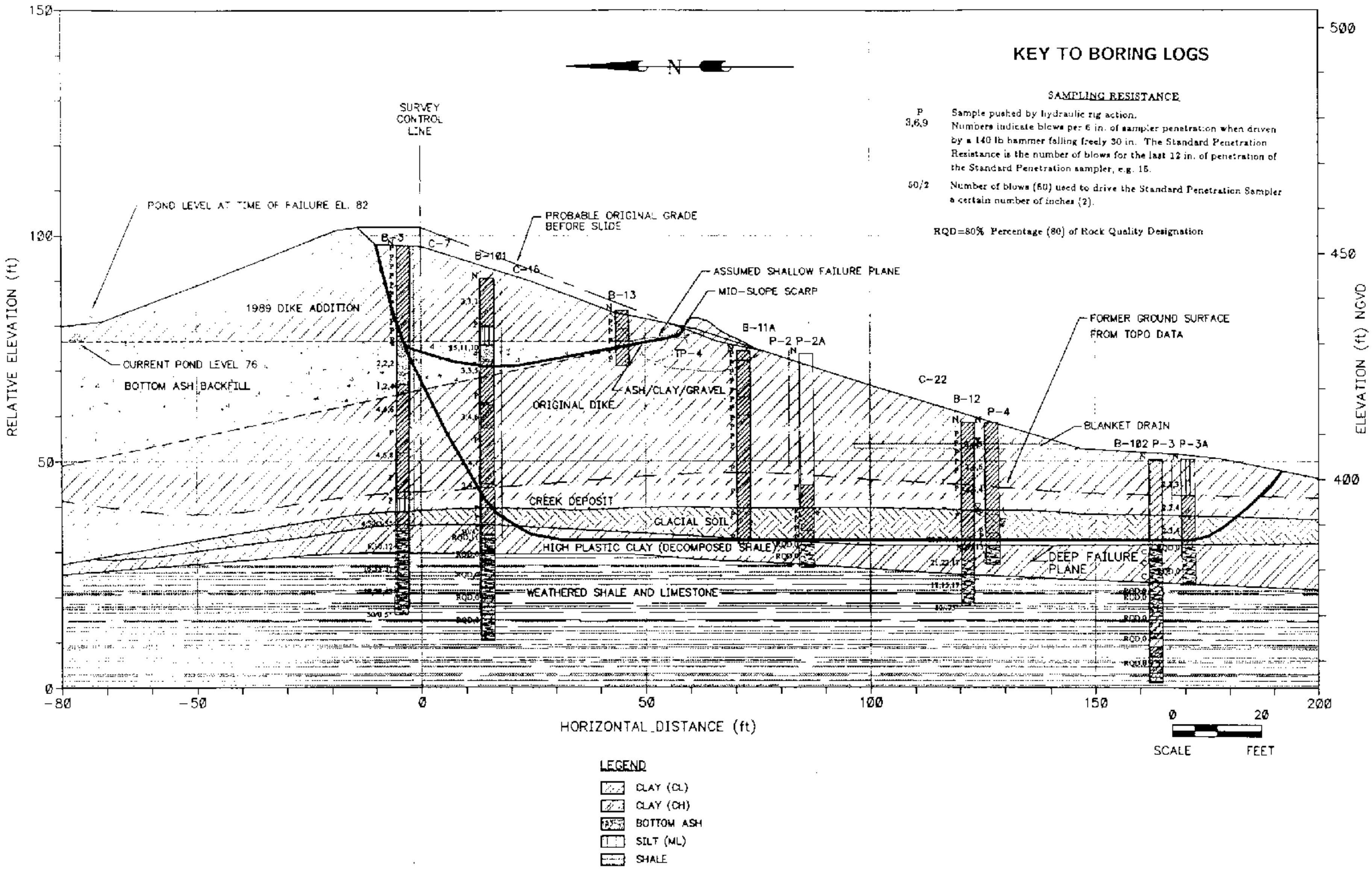

Fig. 3. Retention Pond Slide Generalized Cross Section

CONCLUSIONS

Both slides occurred in slickensided clay shales of southern Illinois in response to excess pore pressure. Backfigured strengths for the slides indicate a residual friction angle in the range of about 15 to 17 degrees. Future designs of cut slopes or embankments founded on similar shales should consider this relatively low strength. Laboratory ring shear tests and direct shear stress with reversals confirmed similar residual strengths as the backfigured strengths. In both cases failure occurred along a nearly horizontal slide plane parallel to bedding.

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