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Field Notes

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FOREST SERVICE • U.S. DEPARTMENT OF AGRICULTURE

ENGINEERING FIELD NOTES

This publication is a monthly newsletter published to exchange Engineering information and ideas among Forest Service personnel.

The publication is not intended to be exclusive for engineers. However, because of the type of material in the publication, all engineers and engineering technicians should read each monthly issue.

The publication is distributed from the Washington Office directly to all Forest, Regional, Center, Station, Area, Laboratory, and Research Offices. Adequate copies are printed to provide all who wish a personal copy. If you are not now receiving a personal copy and would like one, ask your Office Manager or the Regional Information Coordinator to increase the number of copies sent to your office. Use form 7100-60 for this purpose. Copies of back issues are also available from the Washington Office and can be ordered on form 7100-60.

It is intended that the material in the Field Notes be primarily written and used by Forest Service Field Engineers; however, material from other publications may be used.

Field Note material should always be informative and cannot contain mandatory instructions or policy. The length of an article may vary from several sentences to several typewritten pages. Material need not be typed (neatly written or printed is acceptable), or edited before being submitted to the Washington Office. The Washington Office will edit and prepare the camera copy to accommodate our format and allowable space.

Each Region has an Information Coordinator to whom field personnel should submit both questions and material for publication. The Coordinators are:

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R–2	Alfred Buerger	R–8	Ernest Quinn
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F I E L D   N O T E S

ENGINEERING GEOLOGY IN A MASSIVELY UNSTABLE REGION[1]/ (EARLY DETECTION OF SLIP-SURFACE GEOMETRY)

By: Thomas K. Collins and Billie G. Hicks
Klamath National Forest, Region 5--California

The Klamath National Forest in northern California contains one of the most landslide-prone regions of the world. High rainfall, steep slopes, and weak foundation materials have combined to produce hundreds of landslides. The greatest instability is found in the western part of the Forest in a zone 20 miles wide centered along the Klamath River. Graphitic slates and serpentinized-ultrabasic rocks are especially unstable in this zone.

Every year on the Klamath Forest about 70 miles of new roads are built for timber harvesting and recreational access. One of the jobs of the engineering geologists is to make foundation studies for road route planning, location, and design. The foundation studies provide data for building roads which will have the least impact in terms of triggering new landslides or reactivating dormant landslides. The following deals with one aspect of these foundation studies: Making a preliminary estimate of slip-surface geometry based on the field expression of head scarps and lateral scarps.

ROADS AND INCIPIENT LANDSLIDES

In the massively unstable zone on the Klamath National Forest, one of the common situations encountered during reconnaissance engineering geology is the discovery of a ground crack across a proposed road route. The ground crack may be very subtle, but it can usually be traced up the slope, then across the slope, and finally down the slope to where it crosses the proposed road route again. A landslide is developing, and the ground crack marks the trace of the head scarp and lateral scarps. If the landslide is more developed, the scarps will be visible and their angles can be measured.

Based on this field data, the effect of the landslide on road construction must be determined. How large and how deep is the landslide? What is the shape of the slip surface, and will the road cut slope undermine it? Along with other foundation conditions, some estimates of the landslide geometry must be made to determine:

1. Whether this section of road can be built without causing unacceptable resource damage,

1/Presented at the 1971 Annual Meeting of the Association of Engineering Geologists held in Portland, Ore.

2. What alteration of design standards may be required to cross the landslide with least disturbance, and

3. Whether potential maintenance costs or resource damage justifies expenditures for landslide stabilization.

On the Klamath Forest, evaluation of incipient landslides must usually be made without benefit of drilling and seismic exploration. The landslides are usually inaccessible, except by hiking, and there are so many landslides that the cost of a detailed exploration program for each one is prohibitive. Therefore, field evidence was examined to see what clues there might be to the size and shape of the slip surface. Scores of landslides in various stages of development were examined. We found that the topographic expression of ground cracks, head scarps, and lateral scarps on some incipient landslides could be used to make rough estimates of slip-surface geometry. These projections were found most applicable to slumps and to bedrock failures; e.g., wedge failures.

In addition to reconnaissance road location, this geometric analysis was helpful in drawing up a drilling and seismic exploration program for landslides on existing roads. The preliminary estimate of slip-surface geometry guided the placement of drill holes and seismic spreads to obtain maximum foundation data with least cost, and provided a better estimate of the proposed exploration costs.

LANDSLIDE WIDTH

Slope stability analysis usually pictures a landslide in longitudinal cross section from the crown to the foot. Based on the known slope distance and the elevation difference of the crown and the foot, various hypothetical slip surfaces are fitted to the longitudinal cross section. When the only limiting conditions are the slope distance and the elevation difference between crown and foot, then many slip surfaces must be considered in safety factor analysis; and many geometric variations from the actual slip surface must be considered.

To determine the slip-surface geometry, especially depth, more accurately, the width of a landslide can be very useful. Landslide width can lead to more realistic boundary limits than landslide length (slope distance). Three problems are found in using length alone:

1. As time passes, the head scarp often continues to fail, and the crown migrates upslope. The potentiality of many variations in landslide length introduces many variations in estimating slip-surface geometry (especially depth). On most landslides, width is a more stable boundary measurement. In general, length will change more than width.

2. On many landslides, length is a greater distance than width. For example, the length may be 800 feet and the width 200 feet. If only the length and width are known, there is more room for errors in determining the depth of the slide surface by using length rather than width.

3. Length alone will not indicate the correct orientation of the longitudinal profile of a slip surface. Some landslides (e.g., wedge failures), do not move directly down the dip of the slope; they move at some angle to the dip of the slope. By considering the symmetry or asymmetry of the width boundaries (lateral scarps), the orientation of the slip surface can be better located.

TRANSVERSE PROFILES

A landslide can be viewed along its width by a transverse cross section just as its length can be viewed by a longitudinal cross section. Some typical transverse profiles of slip surfaces can be examined on existing slope failures. After the landslide debris has moved downslope out of the source area, the slip surface is exposed. Field examination of numerous exposed slip surfaces reveals transverse profiles of slip surfaces similar to the profiles in figure 1. The V-shaped profile is characteristic of bedrock failures controlled by major geological structures, such as faults and bedding planes. The U-shaped profile is characteristic of failures in unconsolidated or weakly consolidated materials, such as soil and marine terrace deposits.

Using this schematic geometry, it is possible to obtain a rough approximation of slip surface depth on many landslides. For example, a hillside has started to fail. A fresh head scarp and lateral scarps are visible. In plan view (fig. 4) the lateral scarps are roughly parallel; therefore, the width of the landslide is fairly constant. The width, measured from the left to right lateral scarp, is 100 feet. In transverse profile (fig. 2), the left and right lateral scarp each dip 45^{o} and measure 5 feet in slope distance.

First, the maximum depth that the slip surface is likely to reach will be considered. The 45^{o} lateral scarps are projected to maximum depth, in this case, 50 feet (See transverse profile of slip surface A in fig. 2). A wedge failure along the intersection of two faults could produce such a V-shaped profile. However, unless there is evidence to suggest a wedge failure, the slip surface will probably not have such a steep V-shpaed profile. Instead, the slip surface will be more U-shaped. Based on this assumption, the lateral scarps can be projected to more probable transverse profiles. Transverse profiles B, C, and D in figure 2 are projections of some typical U-shapes. The general shape and maximum depth of profiles B, C, and

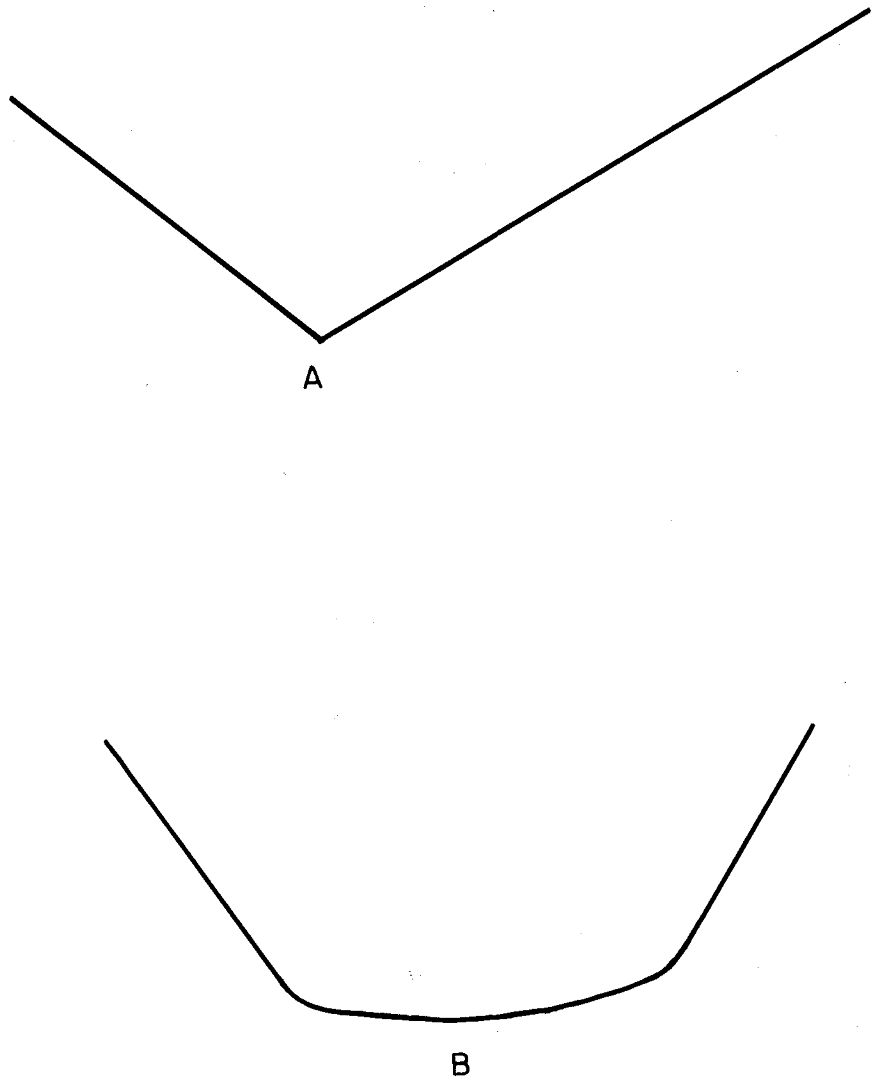

Figure 1. --Transverse Profiles of Landslide Slip Surfaces

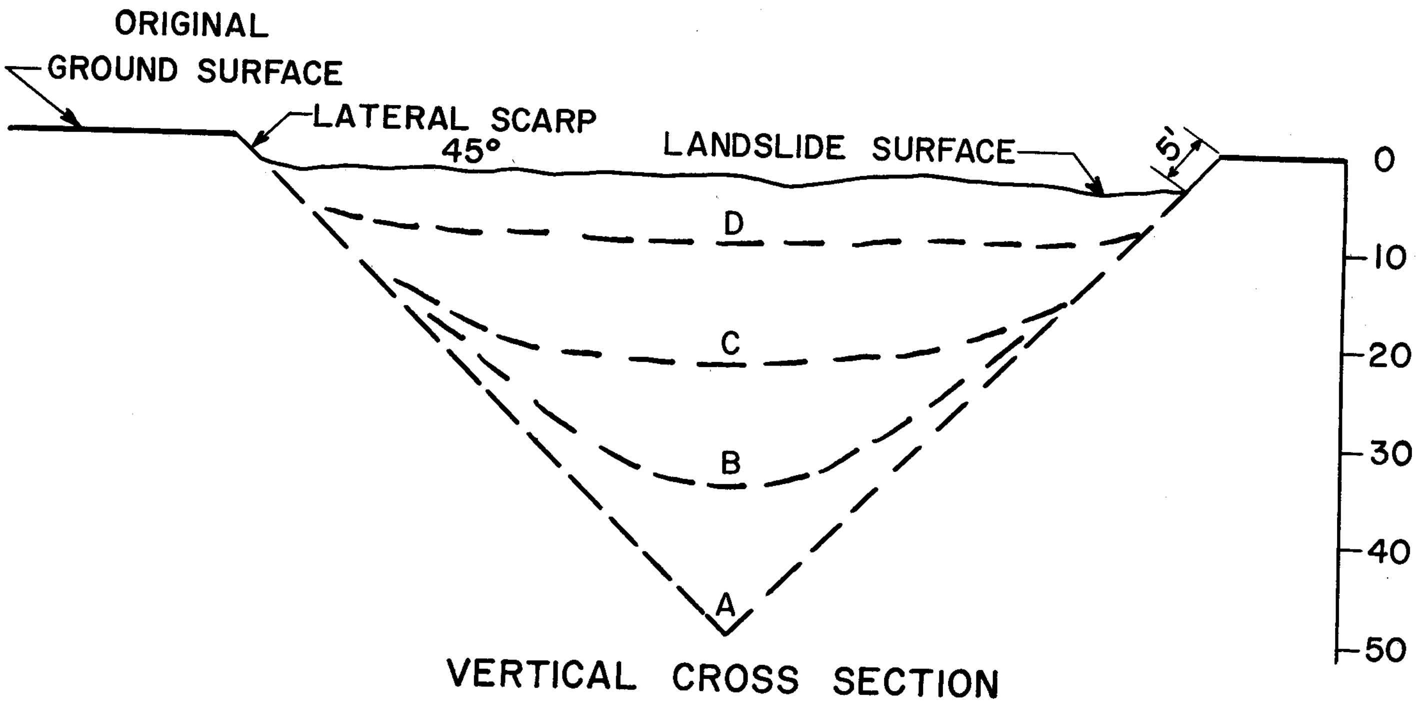

Figure 2.--Transverse Profiles of Landslide Slip Surfaces

D are based on field measurements of exposed slip surfaces found on other landslides. On landslides having a U-shaped slip surface, such as slumps in weakly consolidated materials, the maximum depth from the initial ground surface to the slip surface often ranges from 10 to 35 percent of the landslide width.

Depending on how much of the lateral scarp is exposed and on the shape of the ground surface, the estimated range for maximum depth can be narrowed down even further. Also, the topographic expression of other landslides in the area may provide some clues to the shape and maximum depth of the transverse profile to be projected. For example colluvium in a certain area might usually fail on a bedding plane which parallels the slope; therefore, the slip surface will have a longer, flatter central profile than a deep slump would have. Another aid is the head scarp. The angle of the head scarp can be measured and a probable slip surface can be projected from it onto a longitudinal cross section. Then the slip surface on the longitudinal cross section can be correlated with the slip surface on the transverse cross section. The geometry of the slip surface can be further delimited by interpretation of the boundary scarp of the landslide.

PLAN VIEW

The boundary scarp of a landslide includes both the head scarp and the left and right lateral scarps. The plan view of the boundary scarp can sometimes indicate the general shape of the slip surface. Two plan views are illustrated in figure 3 as representative of two shapes of slip surfaces.

In plan view A the boundary scarp has an inverted V-shape. The distinctive feature is the asymmetry and linearity of the lateral scarps. The trace of one or both lateral scarps on the ground surface does not run directly down the dip of the slope. A linear lateral scarp which trends downslope at a large angle to the dip of the slope is characteristic of many landslides controlled by a major geological structure; e.g., a fault, a bedding plane, or a prominent joint. When major geological structures are planar, their trace on a uniform slope is linear. When randomly orientated planar structures are involved in landslides, they often produce linear asymmetrical lateral scarps. For a given slope, the trend of the lateral scarp will depend on the strike and dip of the planar structure. On landslides controlled by the intersection of two planar surfaces, the transverse profile of the slip surface from lateral scarp to lateral scarp will usually have an asymmetrical V-shape (fig. 1, item A).

In the second plan view (fig. 3, item B) the trace of the head scarp on the ground surface is a curve, and the traces of the lateral scarps are rough symmetrical lines which trend directly down the dip of the slope. Sometimes the boundary scarp will include only

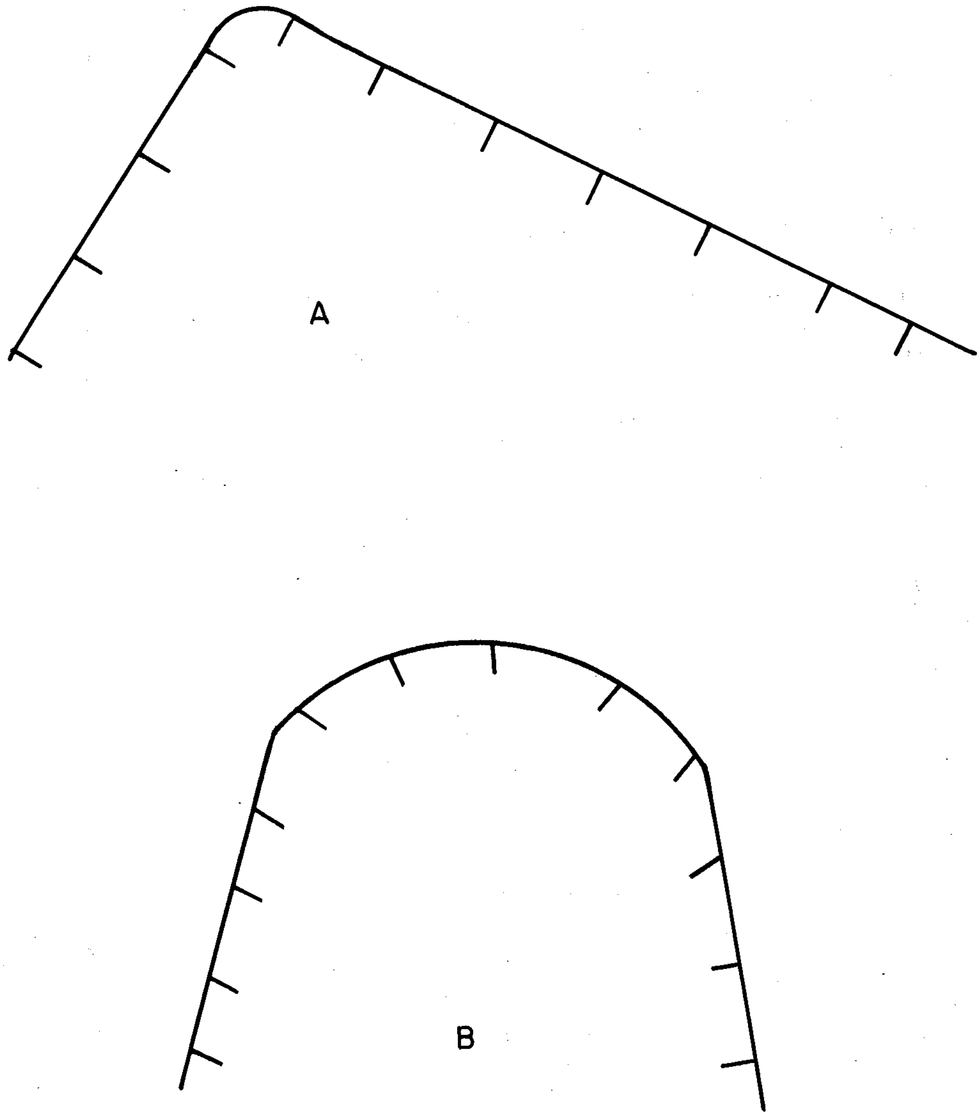

Figure 3. --Landslide Boundary Scarps
Plan View

the curved section. The significance of the change from the curved head scarp to the rough symmetrical lateral scarps is the change from a steep to a more gentle dip along the slip surface. On this type of landslide the transverse profile of the slip surface taken from the left to the right lateral scarp is U-shaped.

COMPARISON OF THE TWO PLAN VIEWS

In the first plan view the asymmetry and linearity of the boundary scarp are characteristic of landslides controlled by major geological structures; i.e., faults, bedding plans, and joints. The landslide can be viewed as failure in an anisotropic medium. In the second plan view, the curve and the rough symmetry of the boundary scarp are characteristic of landslides in weakly consolidated and unconsolidated materials; e.g., colluvium and marine terrace deposits. In some respects, the landslide can be viewed as failure in an isotropic medium.

THE CHORD

A landslide whose boundary scarp has a plan view similar to figure 4 often has a slip surface which drops off steeply from the crown and then flattens out between the lateral scarps to an angle approximately equal to or less than the original ground slope. The longitudinal profile of the slip surface in figure 5 is a schematic representation of this relationship. This profile is diagrammatic; the actual slip surface may be more curved. On the plan view in figure 4 a chord line is drawn which connects the extremities of the curve of the crown and which lies within the plane of the original ground surface. From the top of the crown a perpendicular line to the chord can be constructed which lies within the plane of the original ground surface. The slope distance along this perpendicular line is labeled "S". In longitudinal cross section (fig. 5), a perpendicular line (labeled "D") to the original ground surface is constructed from the chord to the slip surface. This perpendicular line will intersect the slip surface near the area along which the slip surface abruptly changes from a steep to a more gentle dip. Perpendicular line "D" is a rough approximation of the maximum depth to the slip surface. If the angle of the head scarp and the original ground slope are known, the depth line, "D", can be solved trigonometrically. For example:

50 feet = S = Slope distance from top of crown to chord

50° = Angle of head scarp

25° = Angle of original ground slope

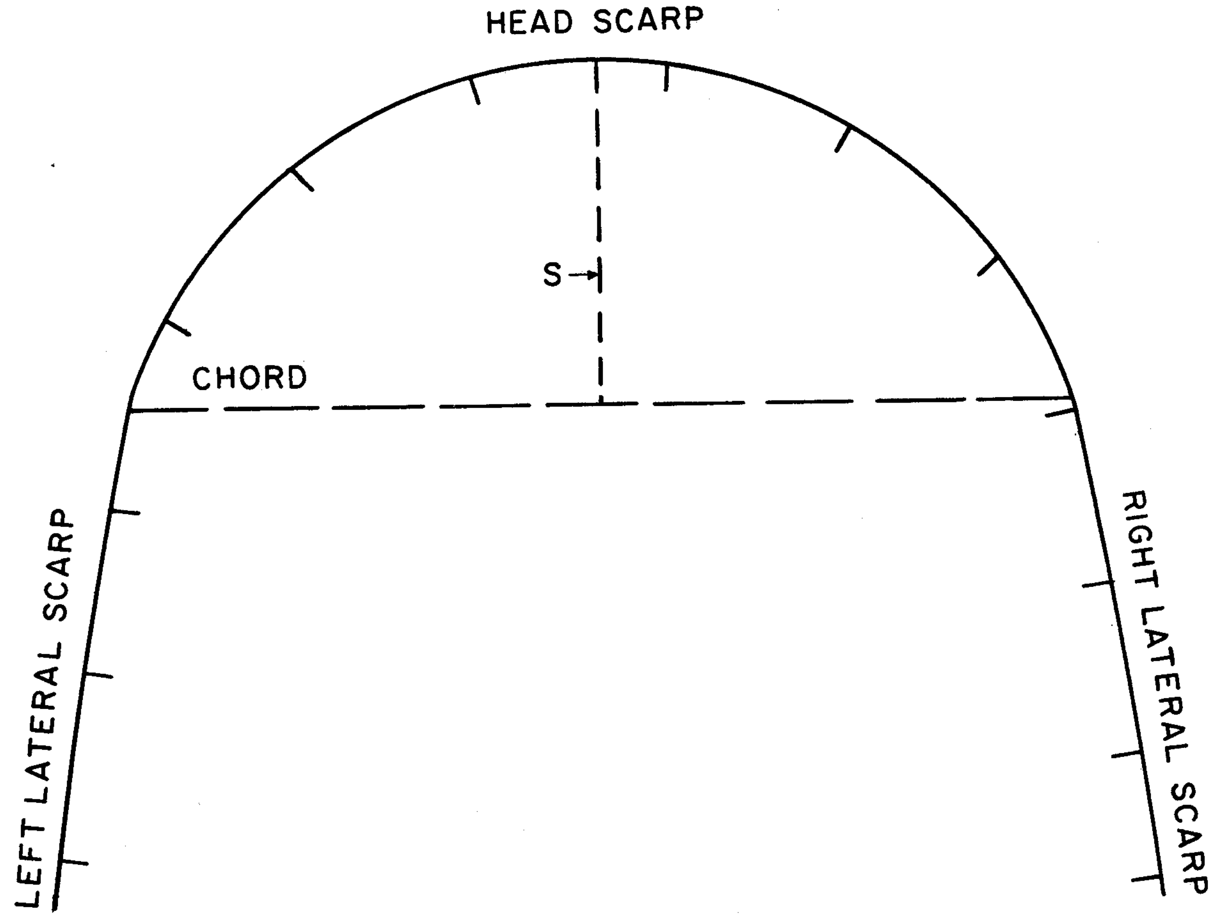

Figure 4. --Plan View of Landslide

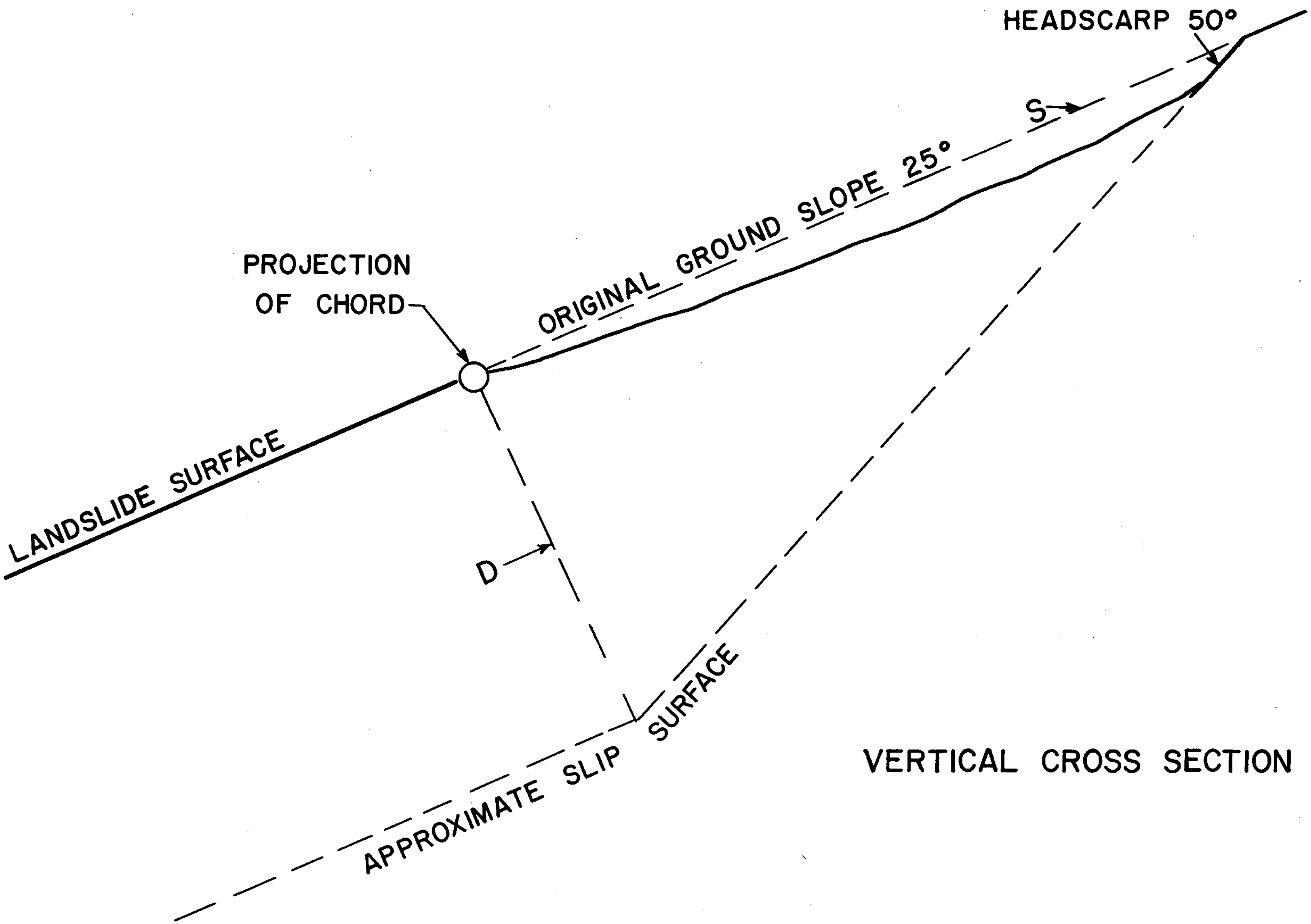

Figure 5. --Longitudinal Profile of
Landslide Slip Surface

$$D = S \tan(\text{angle of head scarp} - \text{angle of original ground slope})$$

$$D = 50 \tan(50^\circ - 25^\circ)$$

$$D = 23 \text{ feet}$$

Since the portion of the slip surface from the crown to the abrupt change in dip may be curved and not as continuously steep as the head scarp, it is usually best to decrease the angle of the head scarp used in the formula by several degrees; depth "D" will correspondingly be reduced.

SUMMARY

By gathering all field measurements which limit the topographic expression of the slip surface, and then correlating these measurements in longitudinal and transverse cross section, the geometry of a slip surface can be estimated within certain ranges. This geometric analysis has been found helpful on numerous landslides, but it is not meant to apply to all landslides. The general cases presented are meant as guides. The complex causes of unstable slopes will often produce many variations from this schematic geometry. For example, the plan view of a boundary scarp in an isotropic medium may be asymmetrical, rather than symmetrical, because of the non-uniform distribution of ground water.

Field work is continuing on these and other aspects of slip-surface geometry. More data may modify some of these initial geometric projections. The goal is to put together the best 3-dimensional picture of the slip surface that limited data permits.

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CLASSIFICATION OF CRANKCASE OILS

By: Thomas W. Stockdale, Region 3--Albuquerque

The conditions under which internal combustion engines have been operating have gradually become more severe. These conditions combined with anti-pollution devices and higher operating temperature have made it necessary to develop higher grade crankcase lubricating oils.

For many years there was no one industry-wide rating system for oils. The user of a MIL specification found it very difficult to correlate the MIL specification with an SAE specification, for example.

Recently the Society of Automative Engineers (SAE), American Petroleum Institute (API), American Society of Testing Material (ASTM), many of the vehicle manufacturers, and the military combined forces to develop one set of specifications and one classification system. The following two charts show the latest oil classes, the previous designations, and descriptions of each in the normal gasoline and commercial categories:

New API Crankcase Oil Classification - Gasoline Engine Type

Old Class	New Class	Description of Oil
ML	SA	Mild conditions, oil w/o additive except possibly a foam depressant, antioxidant, and antiscuff.
MM	SB	Minimum protection afforded by compounding some antioxidant and antiscuff capabilities. In use since 1930's.
MS(1964)	SC	Covers 1964-1967 manufacturer's warranty, low temperature antisludge and antirust performance.
MS(1968)	SD	Covers 1968-1971 manufacturer's warranty, more protection against low temperature antisludge and antirust performance. May be used in place of SC.
None	SE	Covers highest requirements of 1972 model vehicles, high temperature antioxidation plus low temperature antisludge and antirust.

Note: Oils designated in the "S" series refer to service station type crankcase lubricants for gasoline engines.

New API Crankcase Oil Classification -
Commercial Engine Type

Old Class	New Class	Description of Oil
MIL-A (old) MIL-B (old) Sup. 1 (old) DG	CA	Light duty diesel with quality fuel and mild gasoline engine service. Used in late 1940's and 1950's. Normal aspiration, protection from corrosion and deposits.
MIL-A MIL-B (old) Sup. 1 DM (old)	CB CB	Moderate duty diesel with low quality fuel and mild gasoline engine service. Introduction in 1949. Normal aspiration, protection from corrosion and deposits.
MIL-B 101-B S-3 (old) DM	CC	Moderate duty diesel and gasoline lightly supercharged. Introduced in 1961. Protection from high temperature deposits (diesel engines only), rust, corrosion, and low temperature deposits.
S-3 DS MIL-L-45199B	CD	Severe duty diesel with supercharger and in high speed, high output, protection from corrosion, high temperature deposits, with any fuel range.

Note: Oils designated in the "C" series refer to commercial type crankcase lubricants for gasoline and diesel engines.

SA and SB oils are for older engines only or general lubrication for pumps, furnace blowers, and electric motors. SD type oils are much better than SC, especially in rusting and deposit resistance. Doubling the zinc dithosphate from 0.09 to 0.18 percent has helped make the SE type oil. Other additives include sulfurized phenates and calcium alkyl phenyl sulfides. The SE type oil may be used in place of SD or SC oils. The new classification for both normal gasoline engine oils and commercial engine oils is open ended; new categories may be added without changing the old designation. Manufacturers may indicate lubrication needs and petroleum companies may indicate suitability by the new classification.

The overall testing of SE oils is handled by the ASTM. However, many auto manufacturers also assist in the testing. General Motors, for example, tests for low temperature rust and high temperature lubricating qualities. Ford tests for oil insolubles, sludge formation and varnishing. Other manufacturers also help in the testing. The U.S. Department of Defense tests for bearing corrosion in the SE type oils. The cost to be qualified is approximately $8,000.

SE type oils should always be used when the manufacturer recommends it in his owners' guides and manuals. Most all 1972 sedans and station wagons require SE oil. Chevrolet recommends SE oil for their 1972 1/2, 3/4, and 1-ton trucks. Dodge and Ford recommend SD quality oils. However, a driver may want to use SE oil after summarizing his specific driving habits, loads, trailer pulling, accessories, and speeds. If a driver notices a solidified grease-like oil on the dip stick, slow draining oil, low oil pressure, a switch to SE type oil might solve the problem.

A number of oils are now available that may be used as a single lubricant source for all types of equipment--from the sedan, station wagon, light truck variety to large turbocharged crawler-type diesel tractors. These so-called "goofproof-type" oils enable a diversified fleet to use only one oil which saves on time, inventory, and confusion. It is important to note however that many of these oils may be rated SE or CD, but not both. Depending upon the type of equipment, a fleet manager may not want to consider oils that do not meet the highest quality levels in both the normal gasoline and commercial categories.

In the past, some difficulty has arisen in providing a crankcase oil that would meet both the Series 3 requirements of Caterpillar and the low ash content requirements of Detroit Diesel. To meet the warranty requirements for Detroit Diesel the total ash content must be less than 1 percent. Most of the diversified type fleet oils rated CD will meet Caterpillar and Detroit Diesel specifications. These oils may be used without restriction in all Forest Service diesel equipment.

In summary, with most controls and regulations becoming more strict and difficult for the fleet manager, the classification of crankcase oils has definitely taken a step for the better. The API, SAE, ASTM, Department of Defense, and many automotive companies have combined in providing a most useful and practical classification of crankcase oils. In most cases the quality of oil required by the manufacturers owners' guides and manuals is satisfactory.

It may be beneficial to use higher quality lubricants than those recommended by the manufacturer, especially if it is possible to use one class of oil in all vehicles in a fleet. By using one class it is possible to save on storage space, take advantage of bulk prices, and eliminate the possibility of a lower grade oil being used in an engine requiring the highest quality lubricant.

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PRESERVATION OF TREE LAND CORNERS

By: George F. Butts, Registered Land Surveyor
Green Mountain National Forest

"How should we remonument a living tree corner?" This question was asked in the Restoration and Monumentation Committee, LSD, ACSM in March of 1971. Our discussion of a method developed and used on the Green Mountain National Forest seemed to answer the question. A written procedure of this method may assist other surveyors in answering the same question.

This method uses a 5/8-inch diameter by 36-inch long copperweld survey marker with a brass head, as a reference marker. Normally, two markers per corner tree are used; however, three or four are used when conditions dictate. The markers are driven flush with the ground, very close to the tree, but not so close that the growing tree will displace the marker. The flush markers are not easily seen and possibly misinterperted by lay users of the property bounds. The flush markers resist being displaced by falling timber, logging vehicles or other traffic. When setting the markers, good reference marking must be practiced. A dimple is cut in the brass head to mark the exact point of reference and an identifying character is stamped on the marker. On our Forest we generally stamp BO-1 (Bearing Object No. 1), BO-2, etc.

The exact point of a corner tree is generally accepted as the center of the tree at the 1-foot stump height. Because an instrument cannot by set up over this point, a procedure must be used that enables the surveyor to obtain the required measurements. The procedure we developed follows:

1. The copperweld bearing rods are set as described above.

2. With the instrument occupying BO-1 (see fig. 1), angle C-12 to corner tree and angle C-12 to BO-2 are measured, and distances C-12 to BO-1 to corner tree, and BO-1 to BO-2 are taken. To preserve the actual side shot on the tree, a survey tack is placed for sight and a nail placed on the side of the tree for distance, so that observations from BO-1 will define the exact corner point as near as may be determined without cutting the tree. Figure 2 shows a typical view of a corner tree as seen from the instrument.

3. The instrument is moved to BO-2, and angles C-12 to D-1, C-12 to BO-1 and C-12 to corner tree are turned and distances BO-2 to D-1, BO-2 to corner tree are measured.

4. The determination of the tree's center from BO-2 need not be exact, only accurate enough to detect major blunders. If a closed traverse is run, sufficient observations have been made to detect large blunders in the remaining lines. The error generated by a short backsight is eliminated by sighting on C-12 from BO-2.

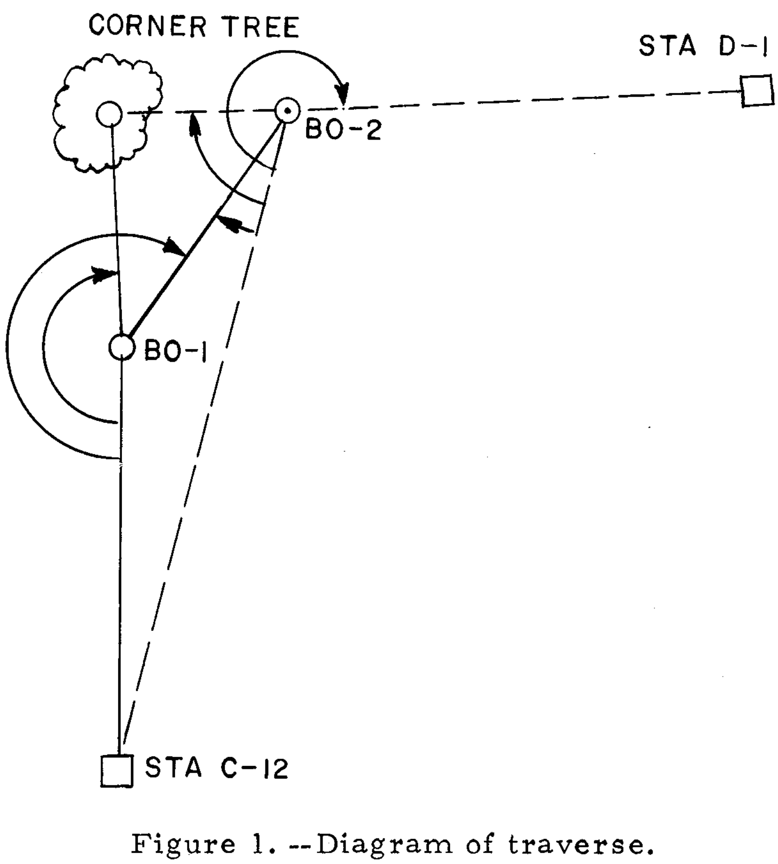

Figure 1. --Diagram of traverse.

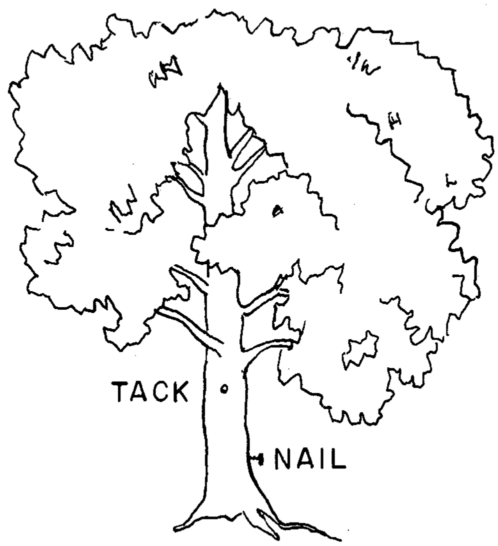

Figure 2.--Corner tree showing tack and nail.

In addition to being recognized by laymen, living trees have an advantage no other land corner monument possesses--they are nearly impossible to move. The trees are, however, subject to rapid disappearance by fire, hurricane, bulldozers or other hazards. If the corner tree is destroyed, the exact corner can be precisely relocated with little effort from the copperweld markers. If only one marker remains, the exact corner can be relocated by running the proper bearing; thus the original corner point is preserved.

EDITOR'S NOTE: Note that the copperweld monument is used for a reference mark. Actual legal land corner monuments installed under the Forest Service Cadastral Engineering Program must meet or exceed standards in FSM 7150.

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CORRECTIONS for Field Notes, Volume 4, Numbers 7 and 8, July-August 1972--"Who's Who in the Washington Office Division of Engineering."

On page 1: Richard G. Deleissegues' name was inadvertently misspelled and placed in the wrong position. Please line out Dick's name and leave that position (Technical Data System) vacant. Place Mr. Deleissegues' name in the position marked vacant at the top of page 2 (Technical Recruitment, Development and Training).

On page 4: The Photographic Laboratory has moved to Rosslyn, Va. Ralph Fortune's phone number has changed to area code 703 557-3150.

On page 5, third paragraph: Change William R. Kinworthy's phone extension to: 70491.