Lecture 4

SLOPE FACE TREATMENT

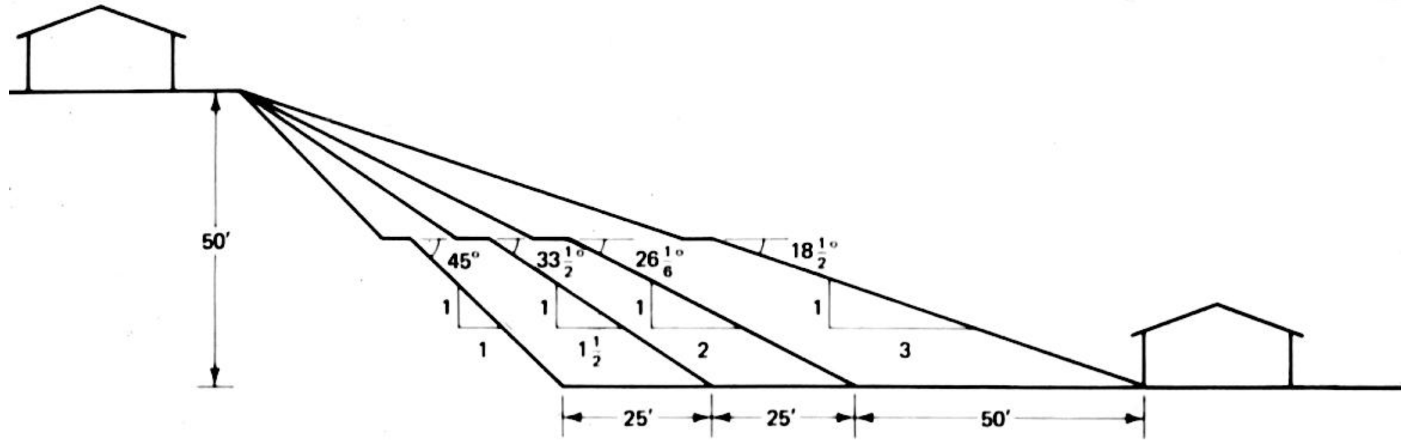
J. David Rogers, Ph.D., P.E., P.G.
Karl F. Hasselmann Chair in Geological Engineering
Missouri University of Science & Technology
for the course

GE 441 Geotechnical Construction Practice

Part 1

CUT SLOPES IN ROCK

UMR



Slope	*Angle from horizontal (°)*	*Grade (%)*
1 : 1	45	100
1 1/4 : 1	39	80
1 1/2 : 1	33 1/2	67
1 3/4 : 1	30	57
2 : 1	26 1/2	50
2 1/4 : 1	24	44
2 1/2 : 1	22	40
2 3/4 : 1	20	37
3 : 1	18 1/2	34
5 : 1	11 1/2	20

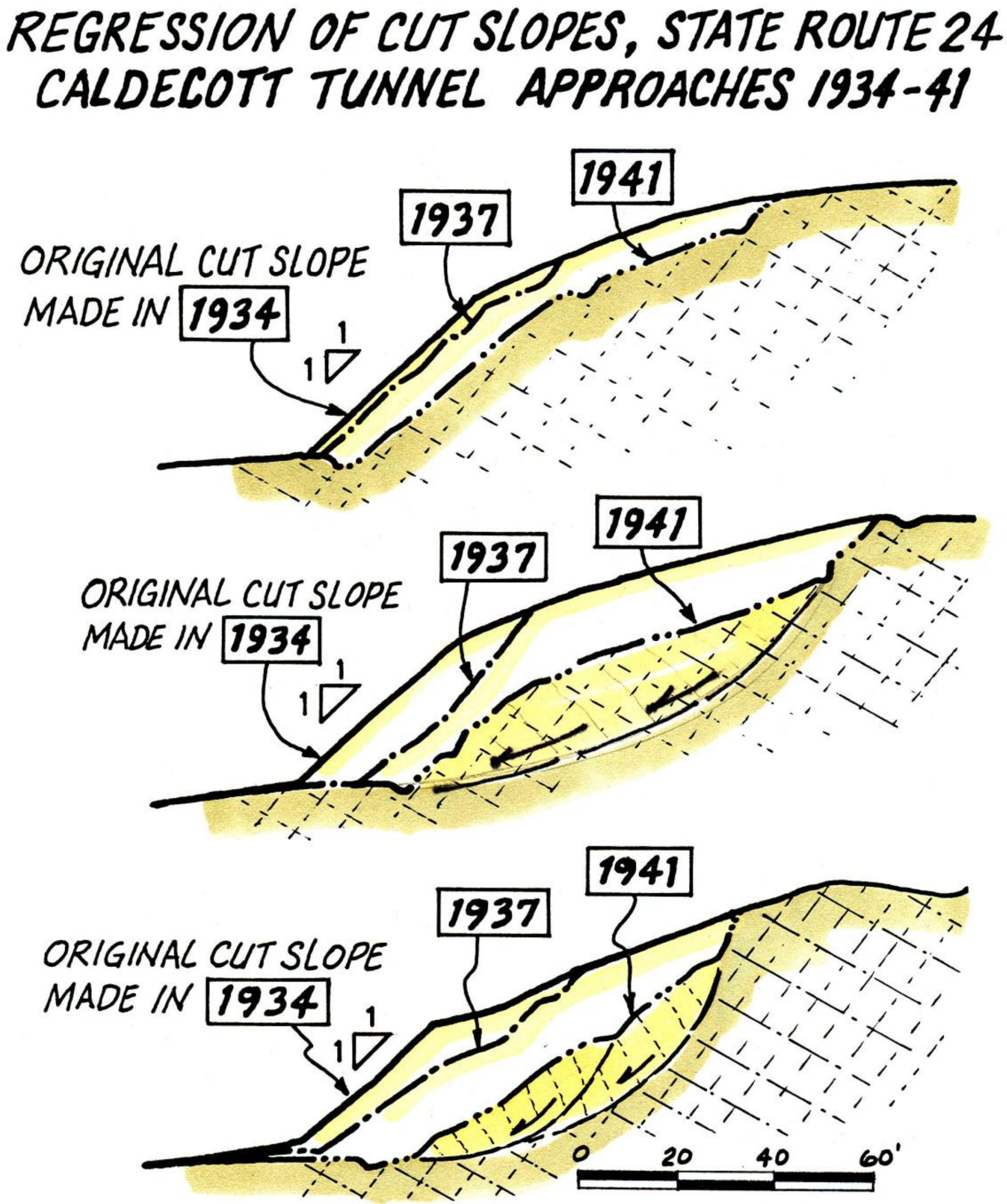
- **Slope inclination is usually described as the run divided by the rise, such as "3:1", meaning three parts horizontal to one part vertical, or about 18-1/2 degrees from horizontal.**

- Steep cuts in competent rock may remain stable for long periods of time. Even so, a wide debris trough should be excavated at the foot of such cuts to catch falling rock and dissipate its energy.

- **Steep cuts in weathered rock, shale or soil may degrade rapidly, especially during periods of sustained precipitation and runoff, as shown here (note tilted fence posts).**

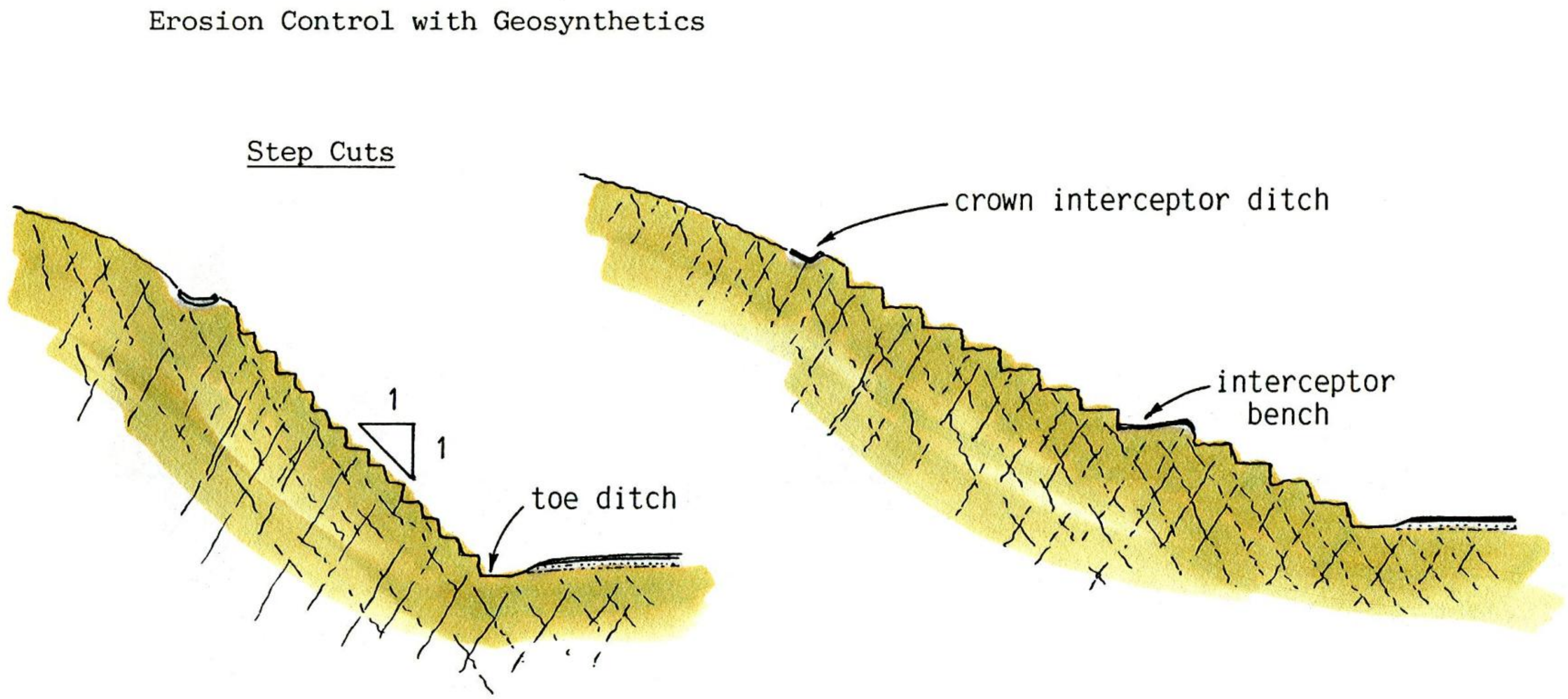
UMR

- Selective raveling of steep cuts in competent rock are a recurring problem. Joint patterns and intensity generally control long-term behavior. Note the sawtooth shape of the raveling cut shown above, caused by the intersection of steeply-inclined bedding and one set of joints.



- Regression of 1:1 rock cuts along CA State Route 24 over a 7 year period, between 1934 and 1941.
- These slopes rapidly retreated to a more stable inclination, close to 2:1
- Slope face treatment cannot prevent landslide failures, such as the two lower examples

- **“Serrated cuts”, or “step cut” slopes are intended to retard rill erosion in semi-homogeneous materials. They are used chiefly in semi-arid climates.**



- **The Bureau of Public Roads introduced 1:1 step cuts in Arizona in the late 1920s. They have since been applied to slopes as flat as 2:1, as shown at right. A drainage interceptor bench must be inclined to provide gravity flow for drainage**

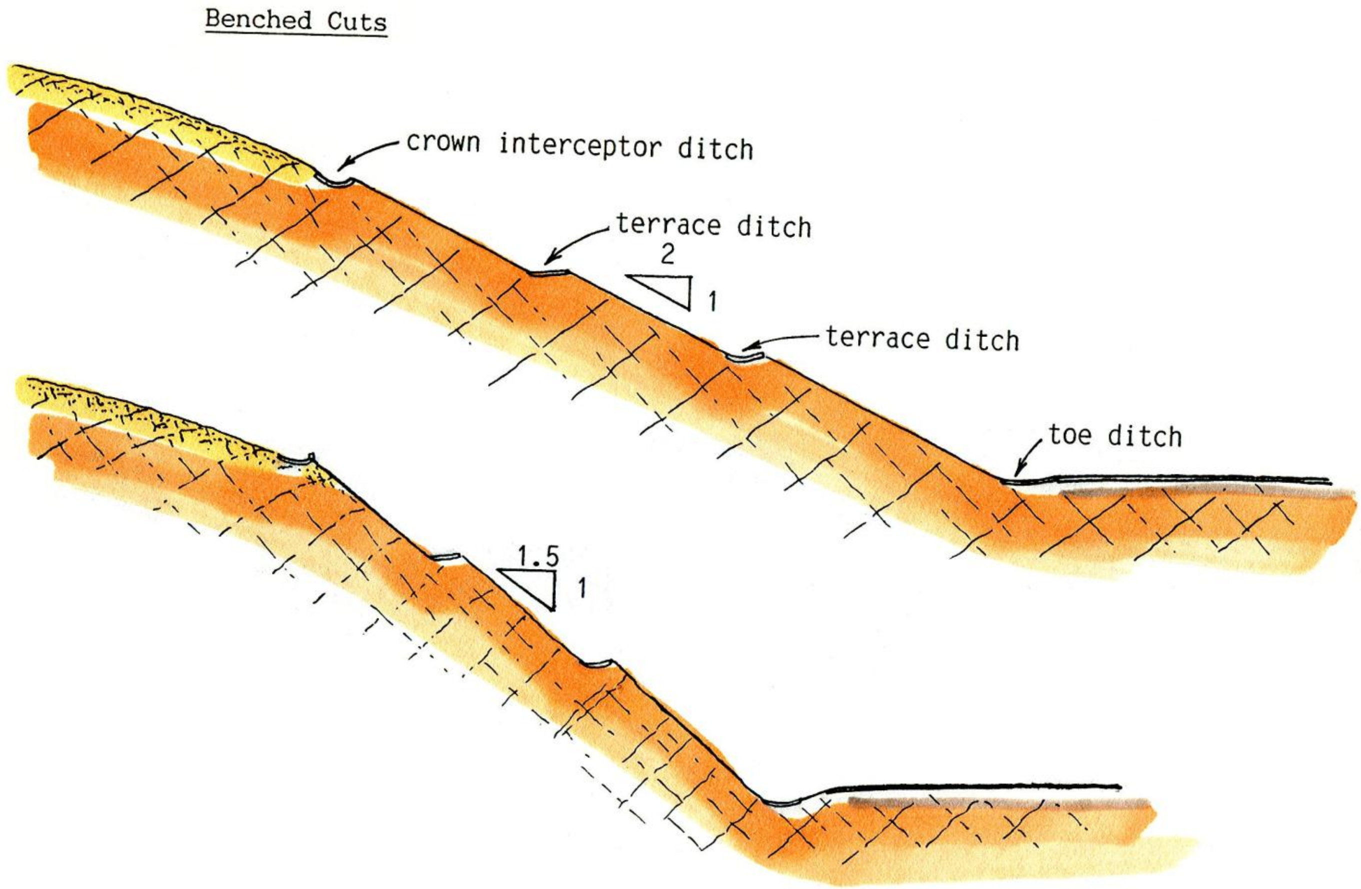
UMR

- Stepped cut along Interstate 210 near Sunland, CA cut in preCambrian metamorphic gneiss complex in the mid-1970s. This cut is just over 150 feet high

UMR

- **Detail of disintegrating steps in highly fractured metamorphic rock after 15 years (1990), along Interstate 210. The steps are 3 feet high and 4.5 feet wide. The vegetation is natural (volunteers), mostly creosote. The area receives about 20 inches of annual rainfall**

UMR

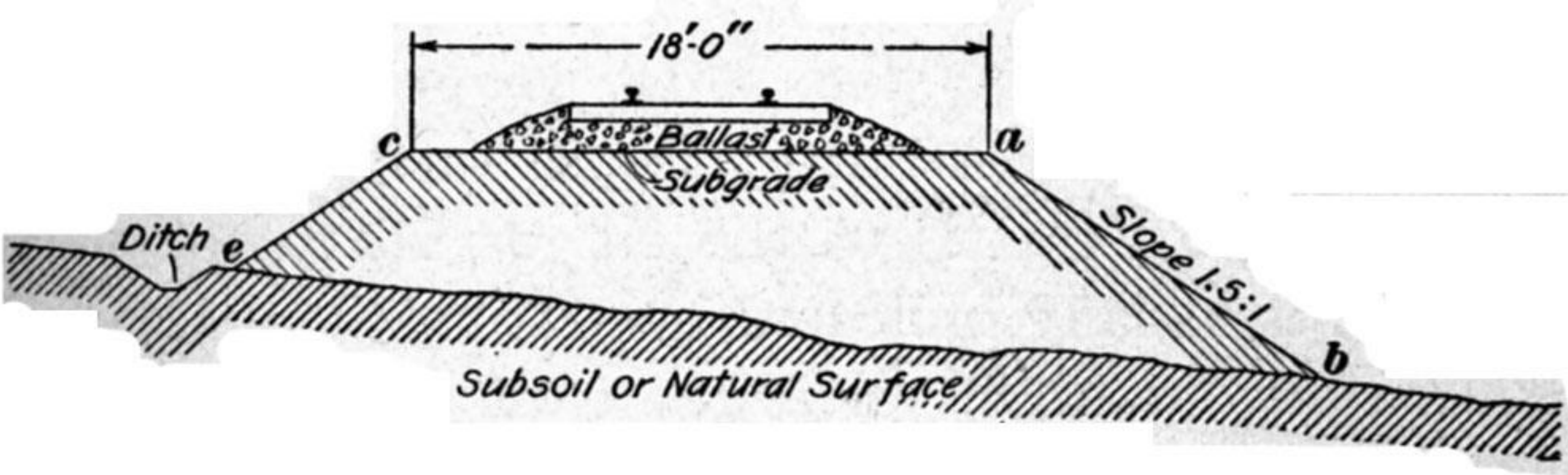


- **Benched cuts with drainage interceptor terraces became commonplace with the Interstate Highway program in the mid-1950s**

UMR

Part 2

FILL SLOPES



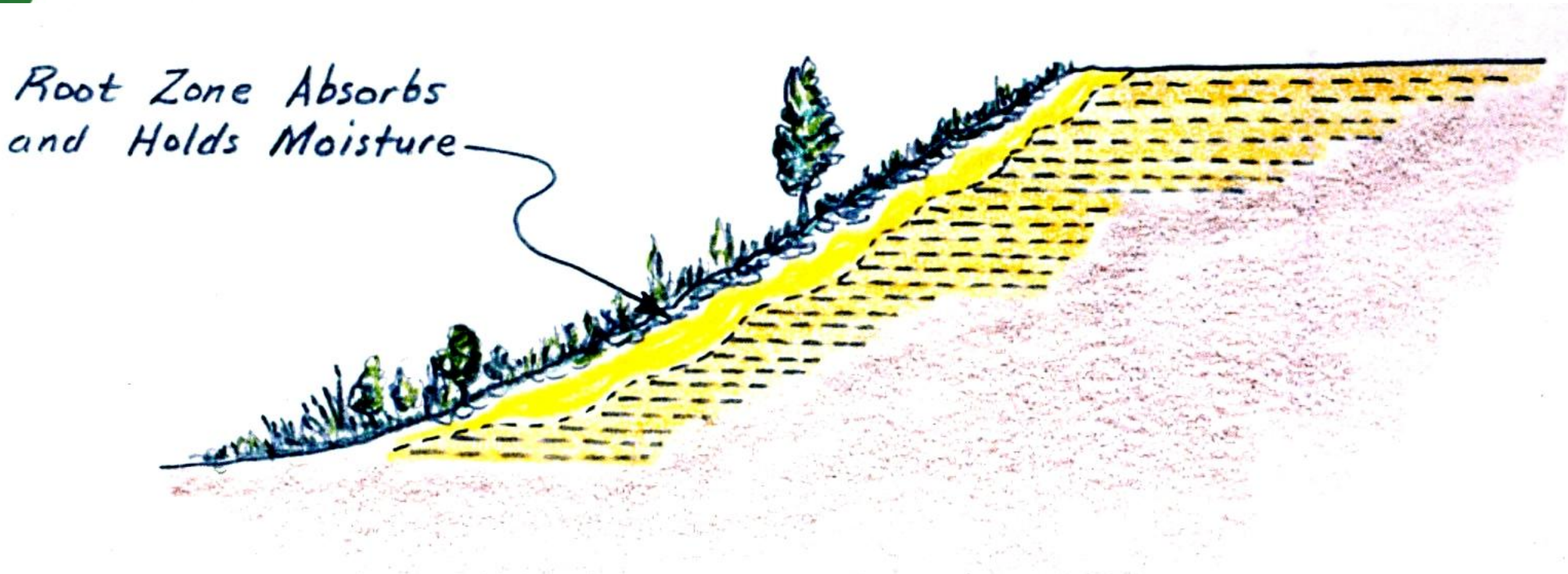
- **Early fill slopes were typically inclined at about 1.5:1 (33.6 degrees).**
- **This inclination approximated the natural angle of repose of excavated granular mixtures, cast over the slope.**

UMR

- This shows a sidehill fill slope supporting a newly constructed road along the crest of the Berkeley-Oakland Hills, CA above Claremont Canyon in late 1934.

- Rill erosion is common in low cohesion fill materials, like sands and silts. This photo shows the impact of a single series of storms on an unprotected fill slope

- In the 1988 the old UBC an allowance was made waiving terrace drains for fill slopes inclined at 3:1 or flatter. This view shows rill erosion developed on such a slope, despite a healthy grass cover

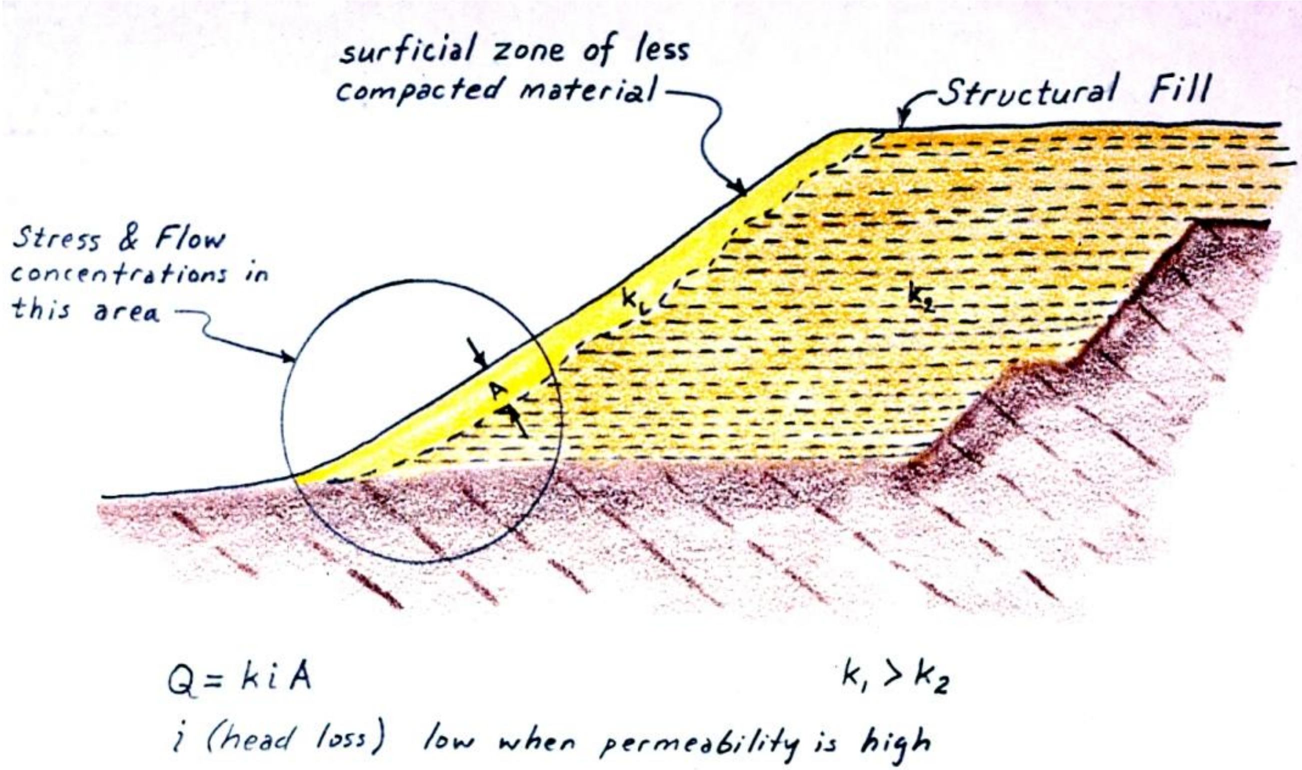


- The face of an inclined embankment cannot be compacted as densely as the interior fill because the slope deforms more elastically under load. This low density zone tends to foster growth
- Unfortunately, a heavy mat of vegetation is often formed, with greater permeability than the underlying fill

UMR

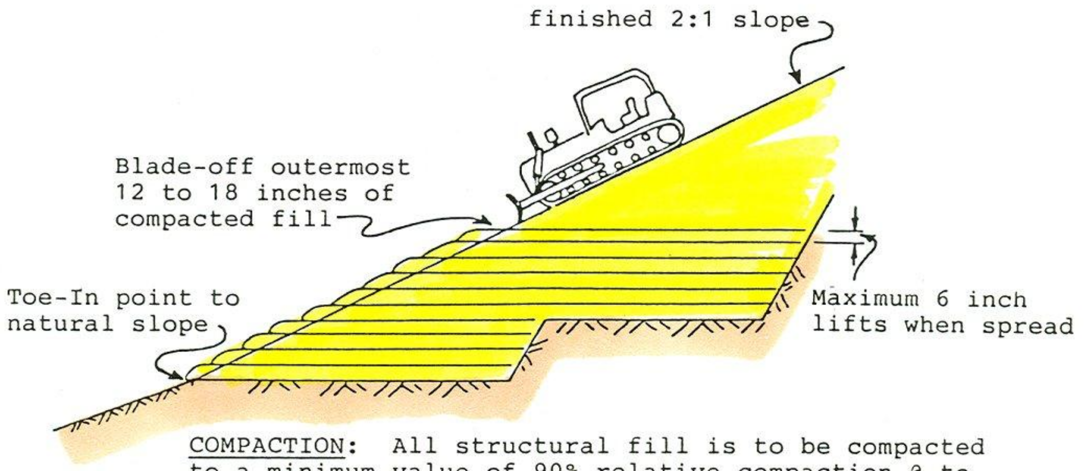
- When this mat of vegetation is subjected to sustained intense precipitation, it tends to separate like a rug falling off a polished floor, as shown above.

- **Cut slopes failures are usually shallow, involving a wet mat of organic material, which often detaches at the root line, within 1 to 3 feet of the ground surface**



- **The low density zone along the face of a fill slope can be mitigated by: 1) trimming; 2) embedment of geotextiles, or 3) by emplacement of deep-rooting woody vegetation**

UMR



COMPACTION: All structural fill is to be compacted to a minimum value of 90% relative compaction @ to ASTM D1557-79.

NOTES:

1. Grub & scarify slope prior to earthwork activities. Minimum organic content 2% (by weight) in structural fill.
2. Benches/Excavation to extend a minimum of 0.50 feet beneath soil or regolith horizon at all locations. Bench widths are at the discretion of the contractor. The required depth of excavation is to be confirmed in the field during construction by either the soils engineer or the engineering geologist.
3. The maximum finish slope is to be 2:1 (horizontal to vertical).

- **Trimming involves drifting of the upper 1.5 feet by a tracked dozer, removing loose material. Unfortunately, it is much more difficult to plant a trimmed slope, and "tree pits" may be required to plant bushes or trees so that their roots can tap successfully.**

- **Dressing a fill slope is the process by which the slope is trimmed to its final inclination, as shown here. Note construction staking.**

- A “dressed slope” is usually walked by a tracked dozer, leaving the track marks. This serrated surface provides superior catchment for hyrdroseeding of most grasses

- **Track walking a fill slope will not compact it appreciably because the track contact pressures (between 5 and 10 psi) are well below those imparted by a mechanical compactor (>135 psi for a pad roller)**

UMR

- **Rolling a fill slope with a pad roller imparts between 135 and 175 psi contact pressure beneath the roller teeth**

- The contact pressure is the roller weight on the teeth multiplied by the cosine of the slope inclination (about 11% reduction on a 2:1 slope).