# Lecture 4

# SLOPE FACE TREATMENT

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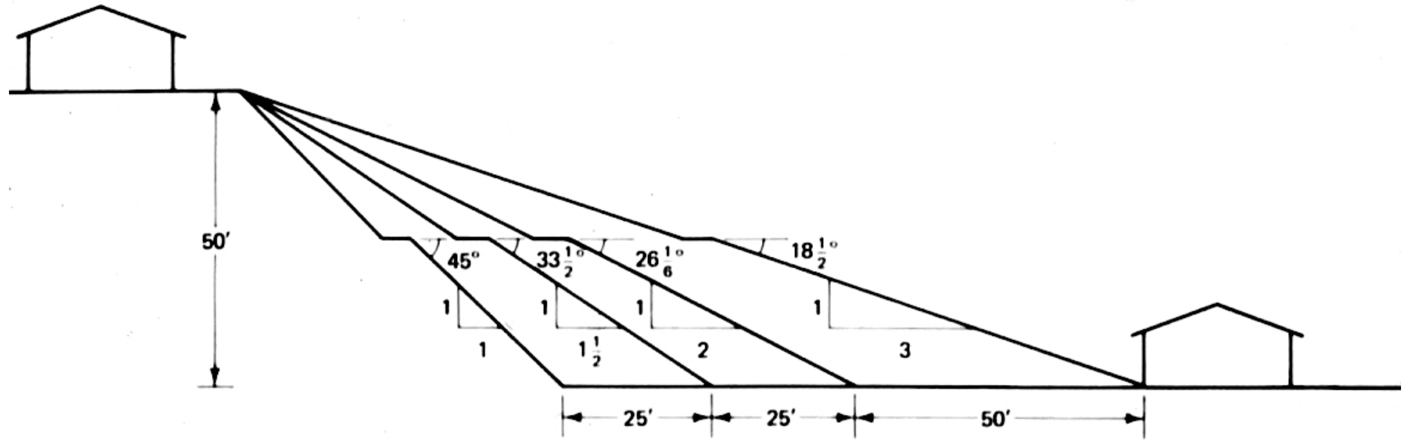
## GE 441 Geotechnical Construction Practice

# Part 1

# CUT SLOPES IN ROCK




| *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.**

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# Cut slope erosion not a big issue in dry areas

- 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. US Hwy 93 southeast of Hoover Dam.

- **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).**

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

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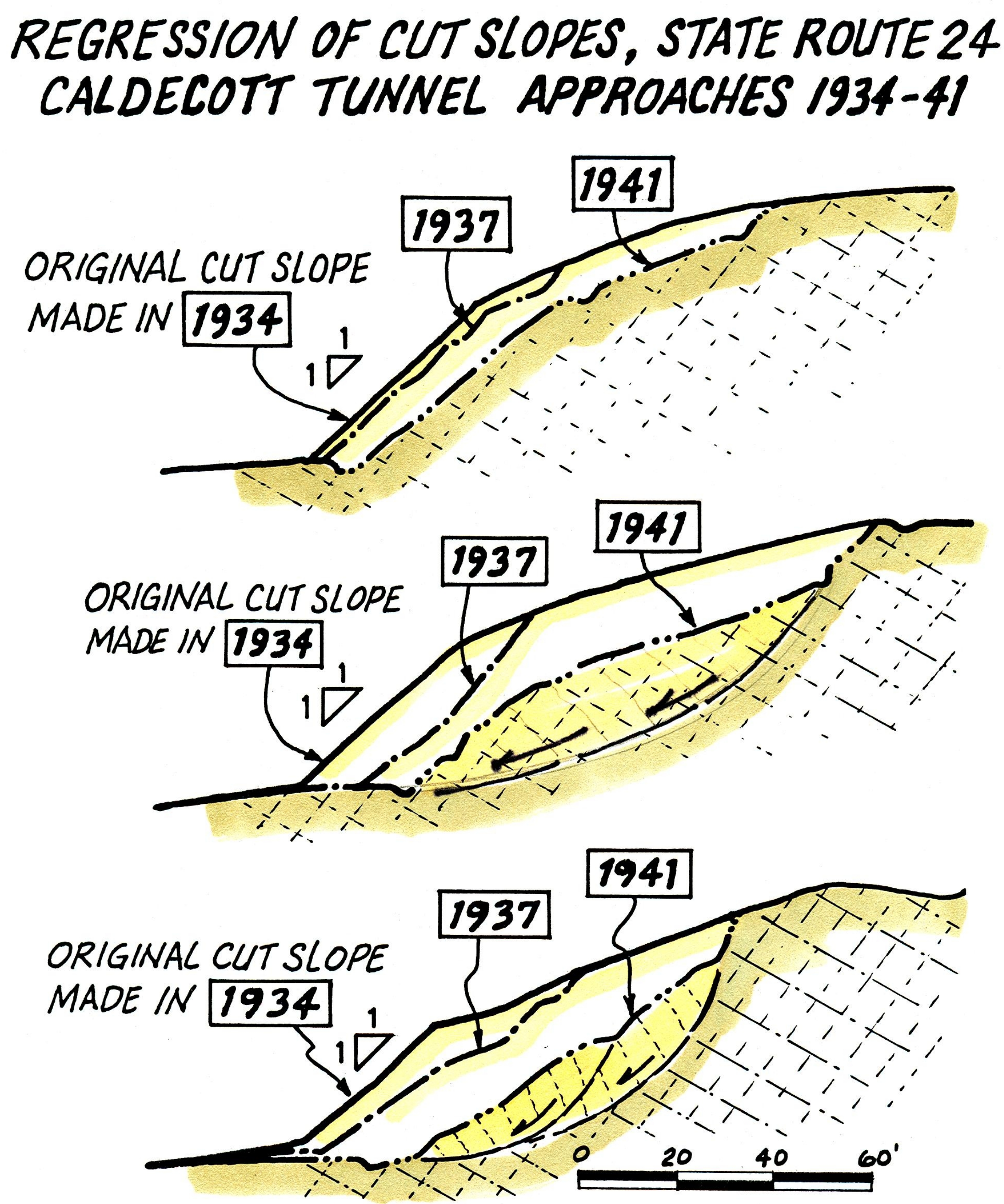
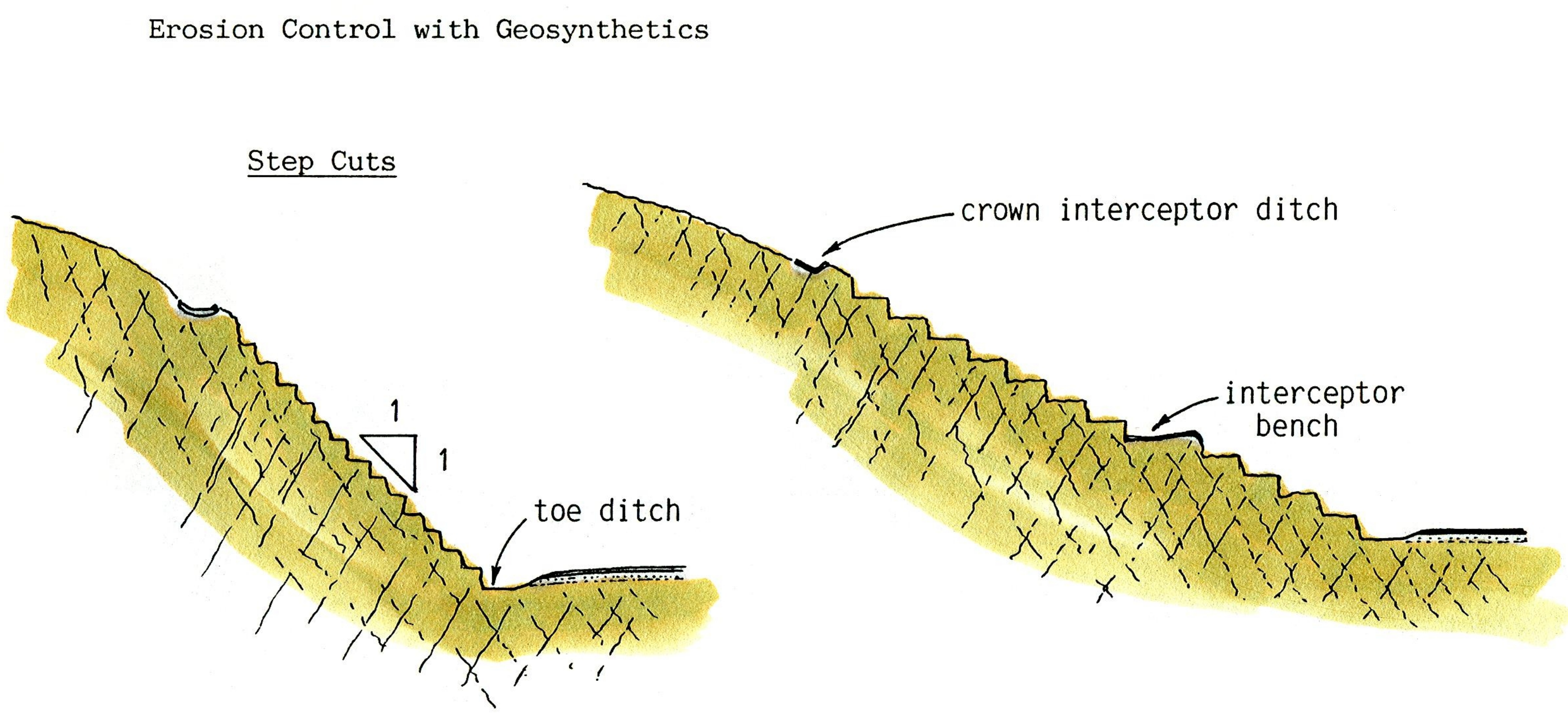



- Regression of 1:1 rock cuts along CA State Route 24 over a 7 year period, between 1934 and 1941.
- These slopes rapidly retreated to a more stable inclination, close to 2:1
- Slope face treatment cannot prevent landslide failures, such as the two lower examples

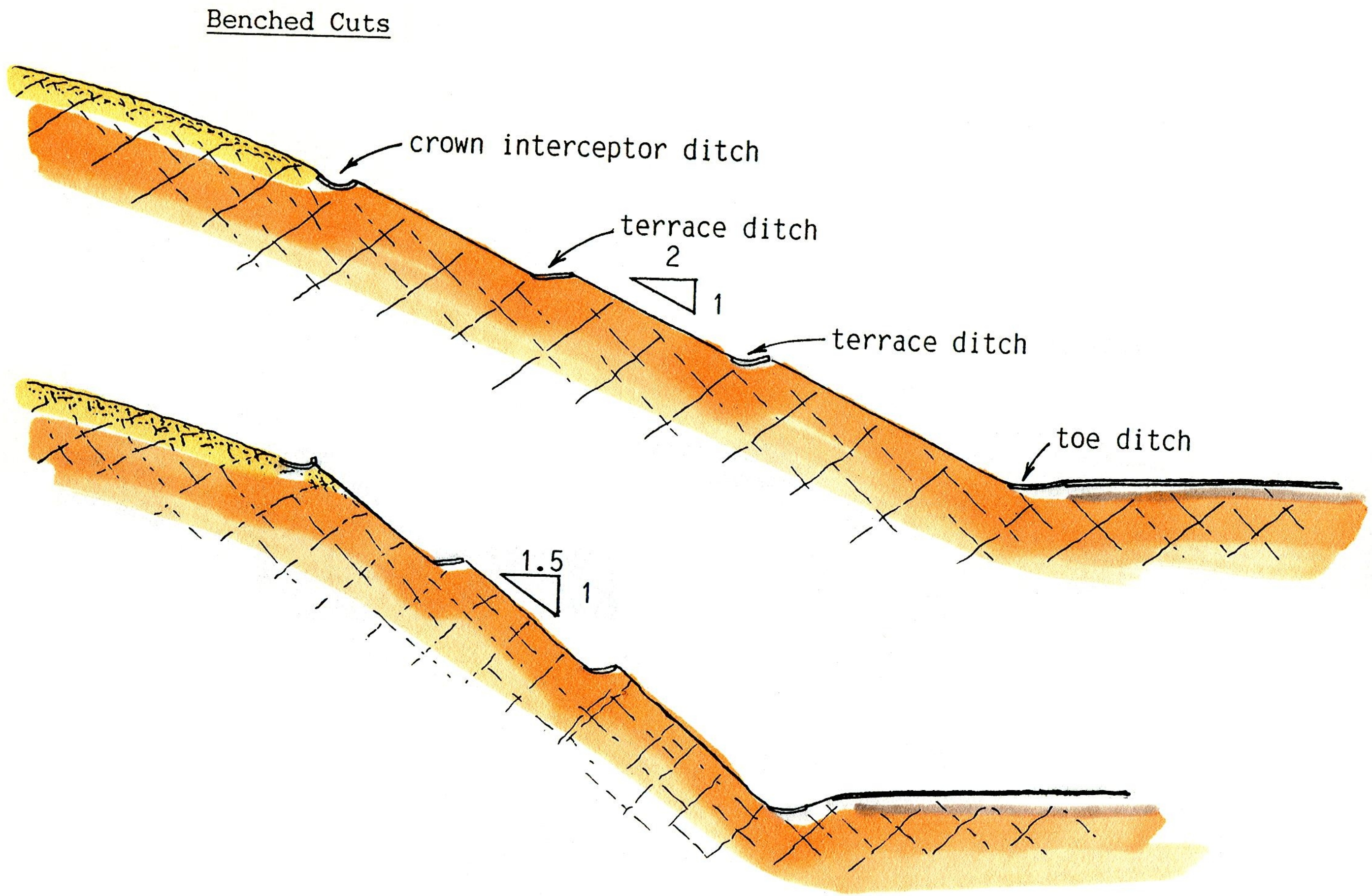
- "Serrated cuts", or "step cut" slopes are intended to retard rill erosion in semi-homogeneous materials.  They are used chiefly in semi-arid climates.




- **In the late 1920s the U.S. Bureau of Public Roads introduced 1:1 step cuts in Arizona. 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**

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

- **Detail of disintegrating steps in highly fractured metamorphic rock after 15 years (1990). 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**




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

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# Rockfall Debris

- A characteristic problem of steep roadcuts in glacial tills is their tendency to shed blocky debris during storms or rapid thaw cycles, as shown here
- Tills contain blocks of varying size, which are angular.  This make them difficult for drilling rock anchors, requiring an overburden drilling system
- This slope would need to be faced with gabion mesh attached to rockbolt anchors, with diagonal cable ties; or construct a roadside ditch with a debris fence

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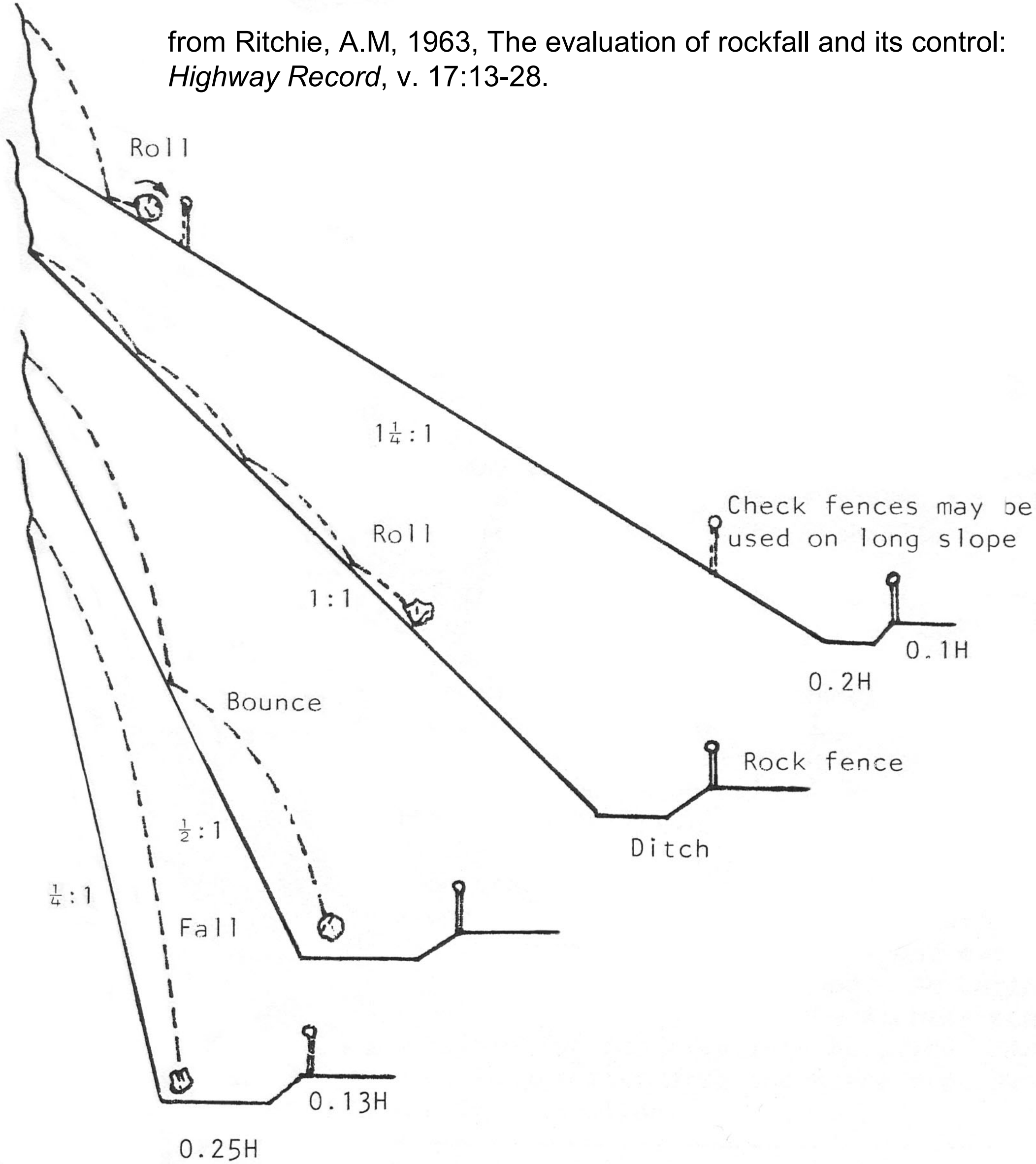
# Chain Link Debris Fences

- In the 1960s chain link fences were often placed to catch raveling rocky debris, to prevent its landing on the highway
- It was surprising how much debris could accumulate behind such lightweight fences, as seen at upper left
- In the case at lower left, larger diameter ductile iron pipes were employed, to provide increased support
- The problem with these is periodic mucking

from Ritchie, A.M, 1963, The evaluation of rockfall and its control: *Highway Record*, v. 17:13-28.

# Rockfall Mitigation




- One of the vexing problems of rock cut slopes is the tendency for discrete blocks to detach themselves and roll downslope, gaining momentum as they bounce and roll
- The chart at left was developed by Ritchie in1963, which was reproduced in Hoek & Bray's *Rock Slope Engineering* in 1977.
- The ditch at the base of the cut is intended to absorb a good portion of the falling rock's kinetic energy. In many case the floor of this ditch is covered with 18 inches of loose gravel, to aid in energy absorption.

**The rock fence between the highway and ditch is intended to catch bouncing rocks. The fence may require repair after each incident, and the ditch should be mucked out as it becomes filled with rockfall debris.**

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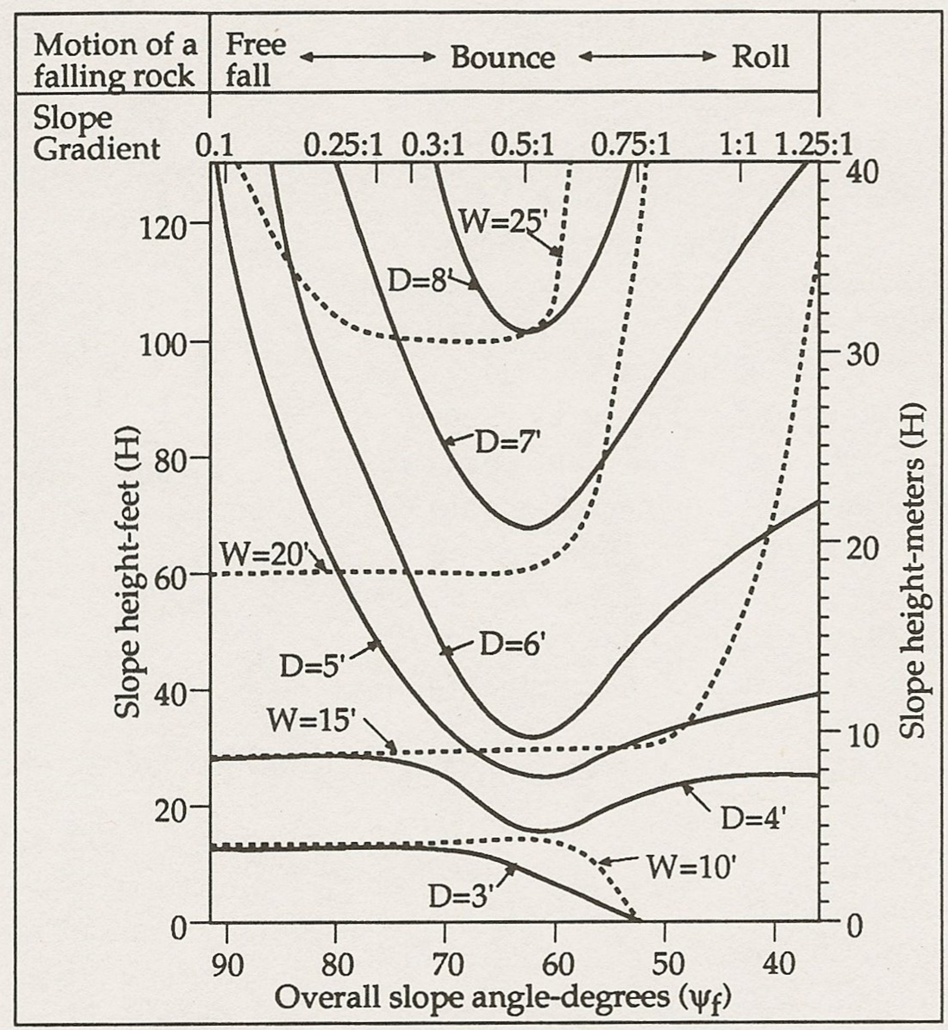
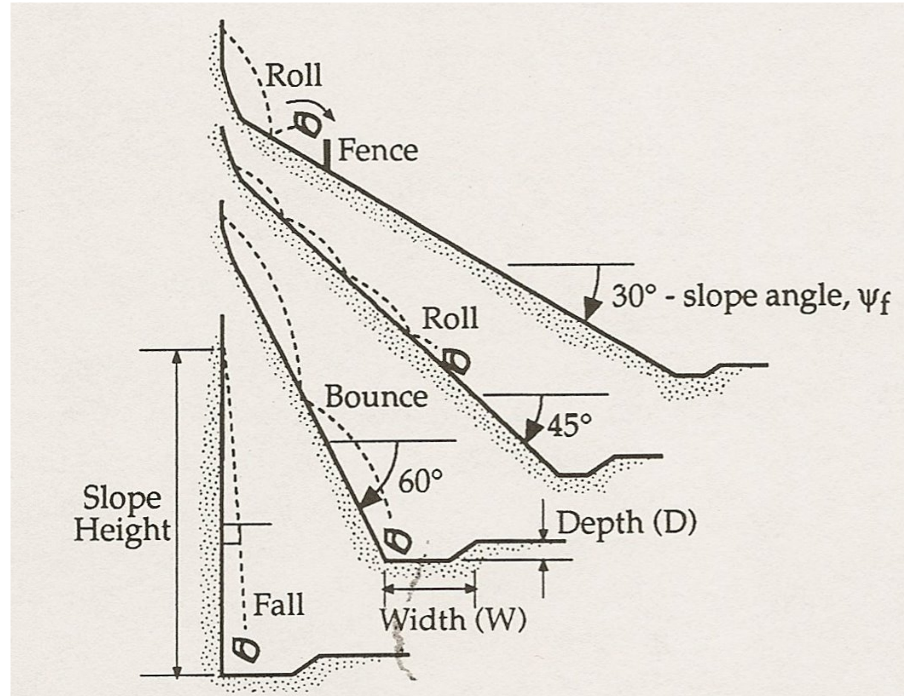
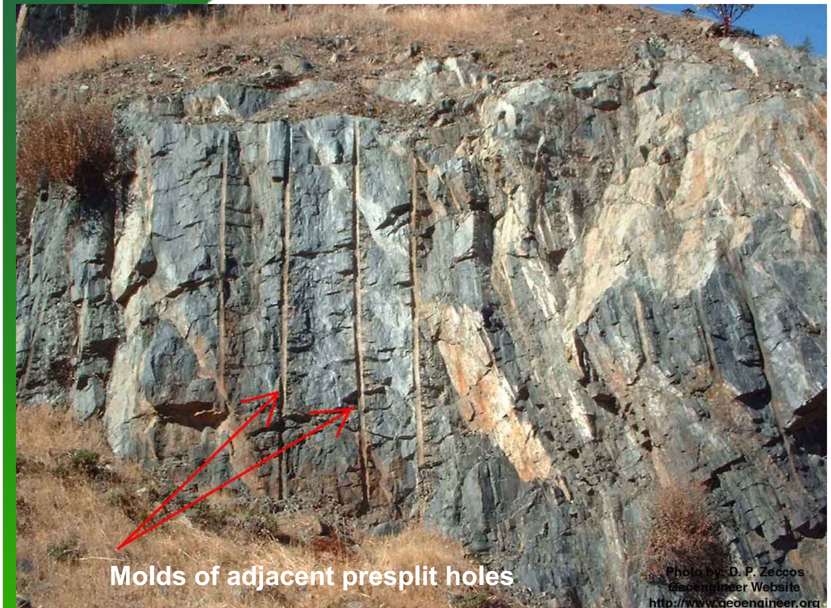
# Sizing the rockfall ditch



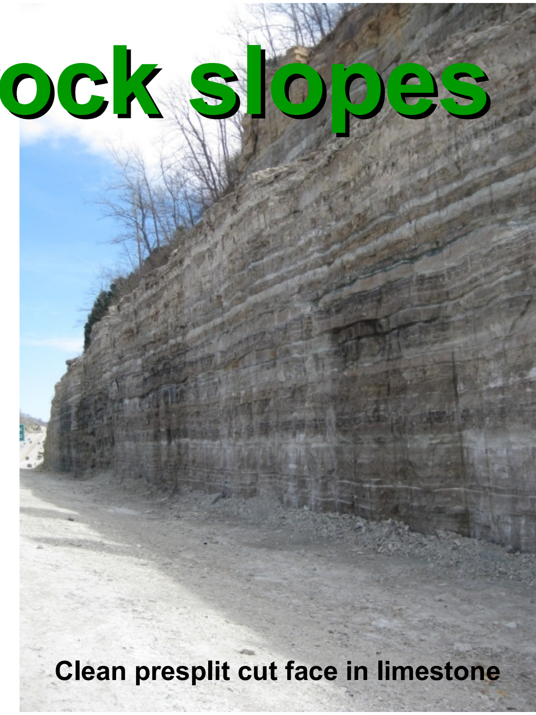

- Ritchie (1963) developed these charts to estimate the required width and depth of the roadside ditch. Note three motions: free fall, bounce, and roll. Rocks that are equidimensional tend to be more round, and bounce farther than elongate shapes. The advantages of a near-vertical slope on preventing bounce can be appreciated.

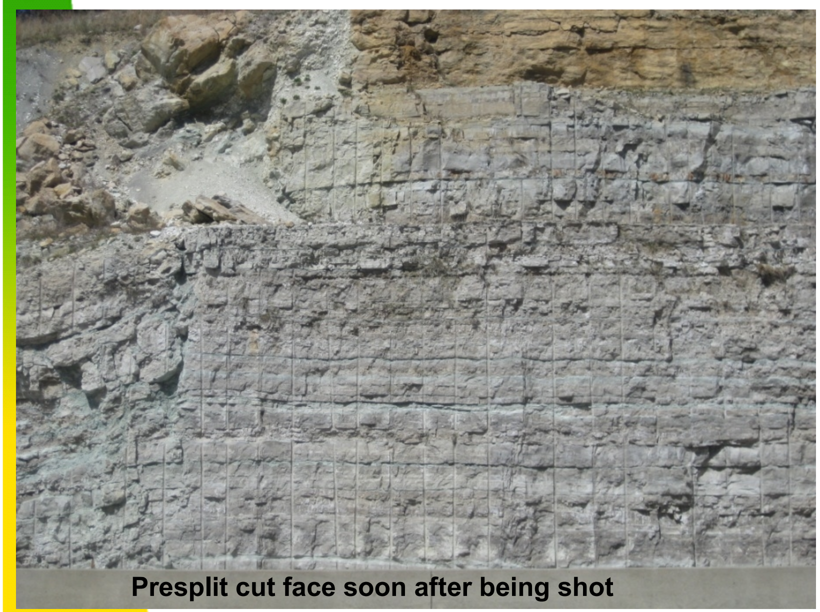
# Presplit rock slopes



Molds of adjacent presplit holes


Drilling presplit holes


Clean presplit cut face in limestone


Presplit cut face soon after being shot

- **Most rock cuts in competent rock are excavated using a blasting process known as presplitting**
- **A line a parallel holes are drilled on spacings between 10 and 14 times the drill hole diameter (shown above), sometimes adjacent to buffer or cushion holes set at slightly wider spacings**
- **Presplitting produces a continuous crack at the back of the cut before the remainder of the burden rock is detonated, lessening the blast energy against the finished cut face**

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# Problems with Presplit Cuts

- **Presplit cuts only work well if the underlying rock is relatively uniform and homogeneous, and bereft of differential weathering.**
- **Upper left shows result or presplitting across an old filled sink, which has a broken and chaotic structure, which has promoted raveling (Interstate 44 near Pacific, MO)**
- **Lower left shows a setback bench, intended to prevent raveling debris from free-falling to the base of the cut. The debris is piling up on the bench. A tapered cut, laying the slope back at 50 or 60 degrees, would have worked better here (5th St. and State Route 109 in Eureka, MO).**

# Setbacks are crucial



**Above Right: Typical presplit cut slope in limestone and dolomite sequence in Fenton, MO. Note grass-covered bench between the face and the roadway.**

- **Above Left: Close-up view of fresh talus being deposited on the grass-covered beltway along the base of the presplit cliff. Note the volume of material. This slope was cut in 2003, about 7 years before the picture was taken.**

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