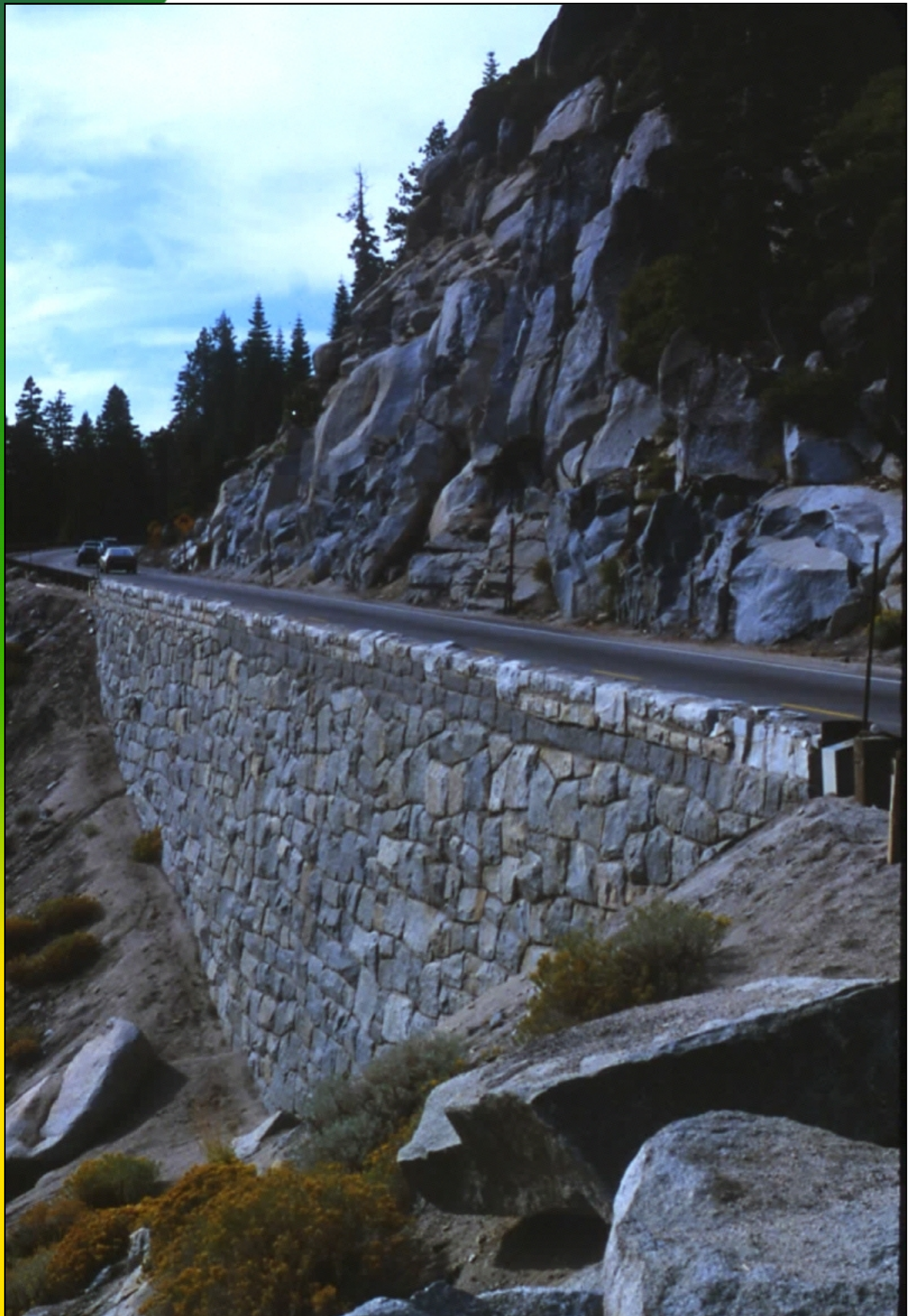
# Lecture 6

# GEOTECHNICAL INPUT FOR THE DESIGN OF RETENTION STRUCTURES

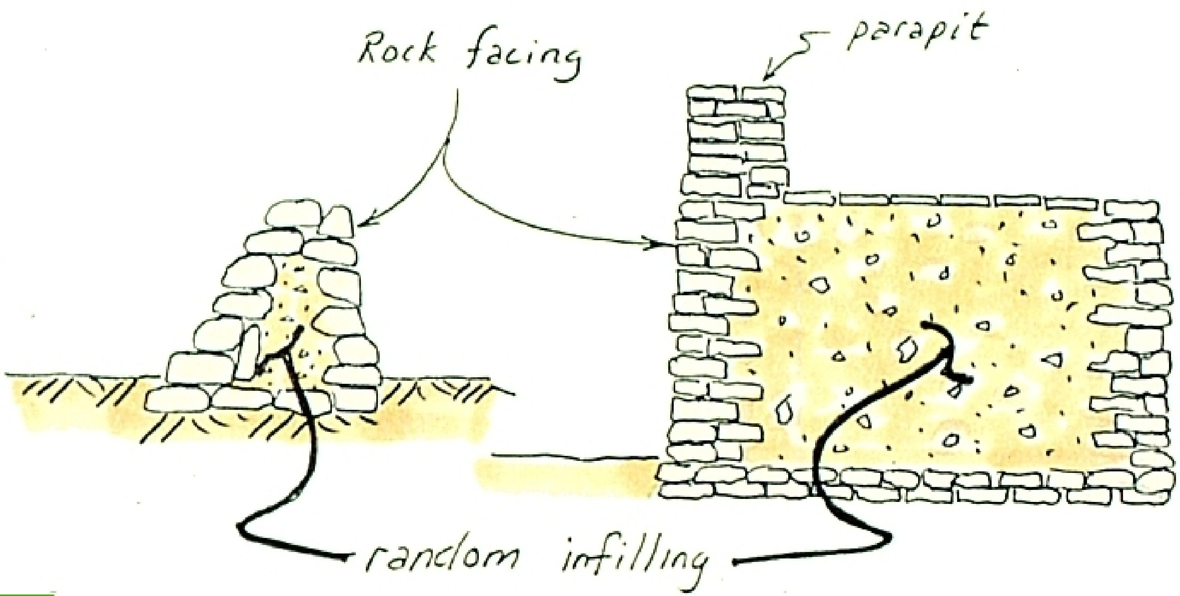
**J. David Rogers, Ph.D., P.E., P.G.**
Karl F. Hasselmann Chair in Geological Engineering
Missouri University of Science & Technology
for the course

## GE 441 Geotechnical Construction Practice



- Stacked **cyclopean masonry walls** have provided excellent service for many centuries
- This is a cyclopean wall using native rock and cement mortar, on Tioga Pass highway, just outside Yosemite National Park, which was completed in 1964

# Masonry walls can be very resilient




- **Masonry gravity retaining wall** systems have been constructed since 6600 BC in Jericho. We can learn much from observing what has survived and what has not. The basic objective of early walls was to provide military bastions and protection from attack. Most of these structures were built using rock facing with random fill, as sketched above.

- Stacked masonry wall at Macchu Pichu, the lost Inca city sitting at an altitude of 7400 feet in the Peruvian Andes
- Without mortar or reinforcement, these walls have withstood centuries of earthquakes, precipitation and neglect

- Above left:  Stacked cyclopean masonry wall in Guatemala
- Above right: Undulating masonry rock retaining wall about 100 years old in Glenwood Springs, CO.
- Gravity walls can withstand minor foundation movements and differential settlement

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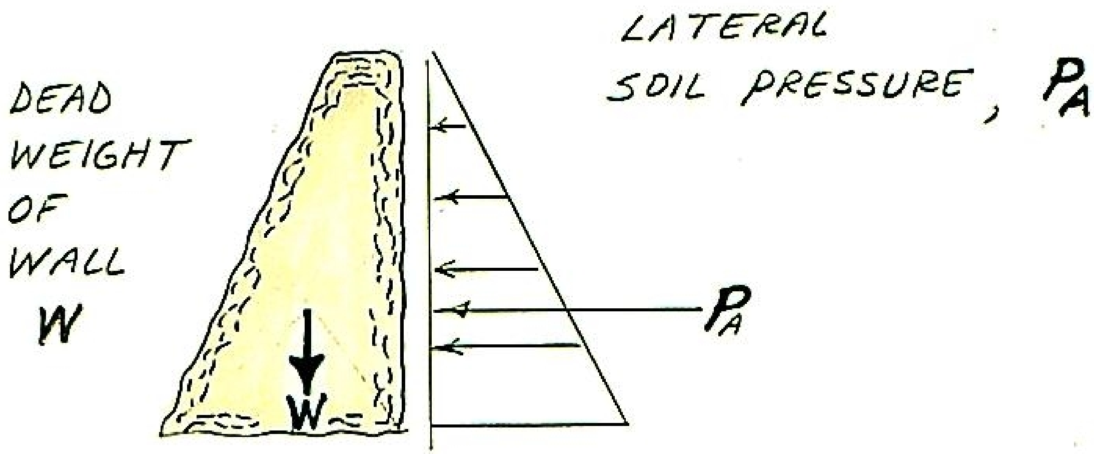
- **Masonry retaining wall in Cincinnati accommodates the grade by employing vertical offsets, or "steps."**
- **Steps are usually employed because there is some sacrifice in load capacity if the wall is built on-grade.**
- **The difference in cost can be substantial, while the increased active pressure is usually between 1 and 11 %, for 2% to 20% grades.**

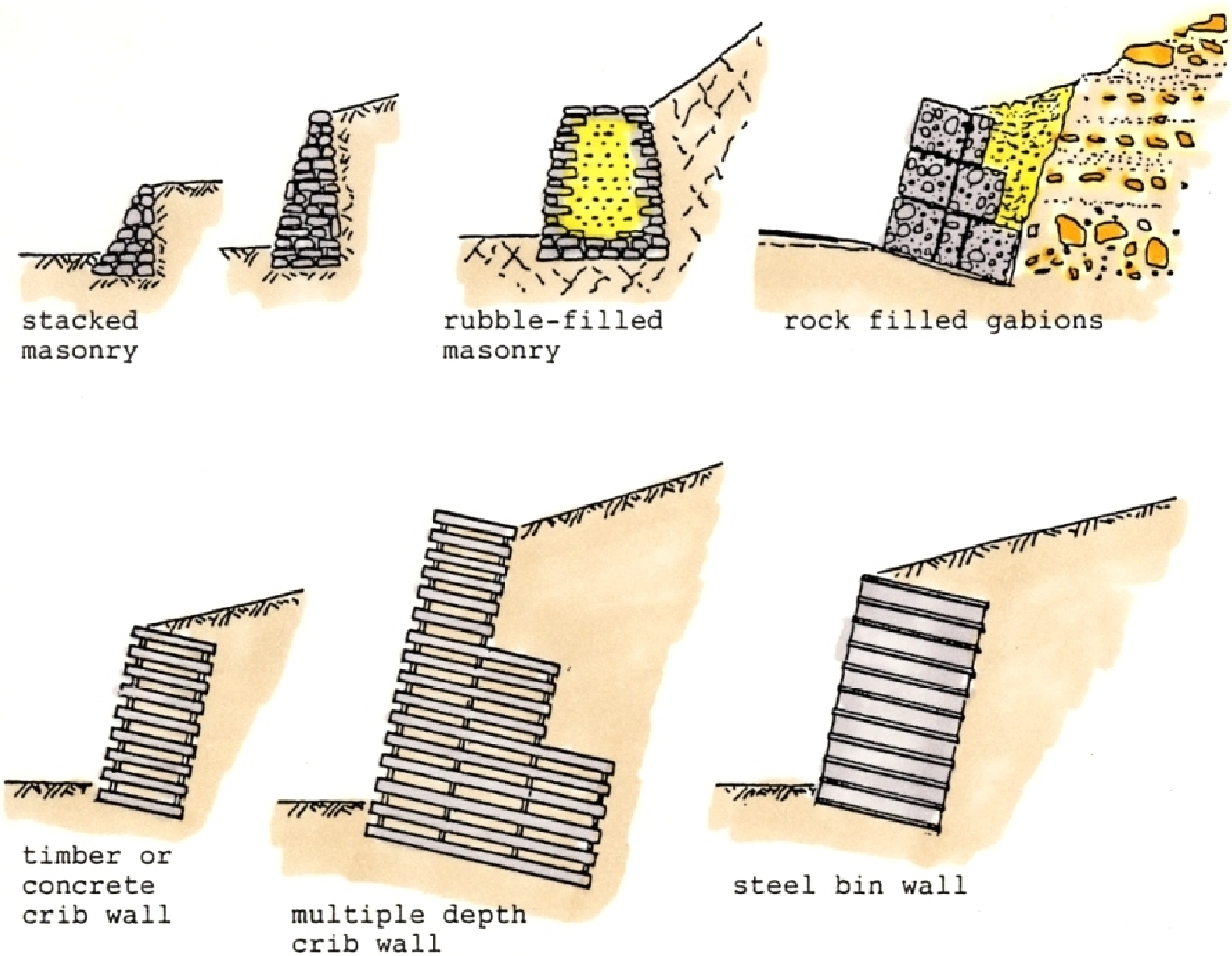
# Part 1

# GRAVITY WALLS

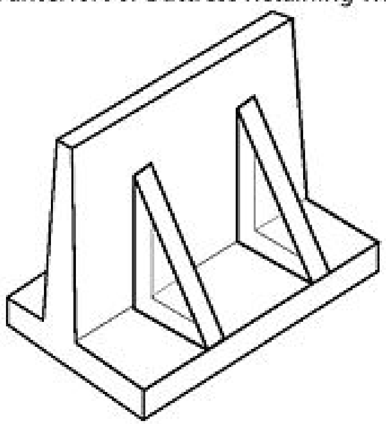
# Gravity Walls: Oldest and Most Common Wall System

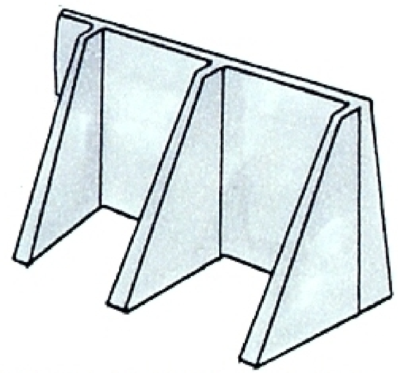


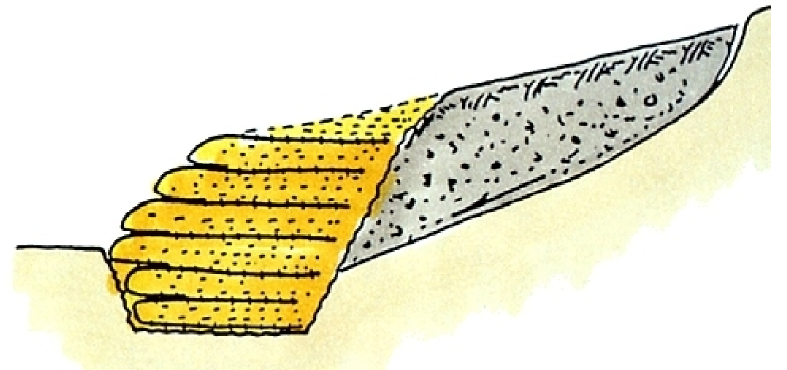

- **Gravity walls** are designed to use their effective weight to resist the lateral pressures engendered by soil backfill, considering seepage, surcharge, and earthquake loads



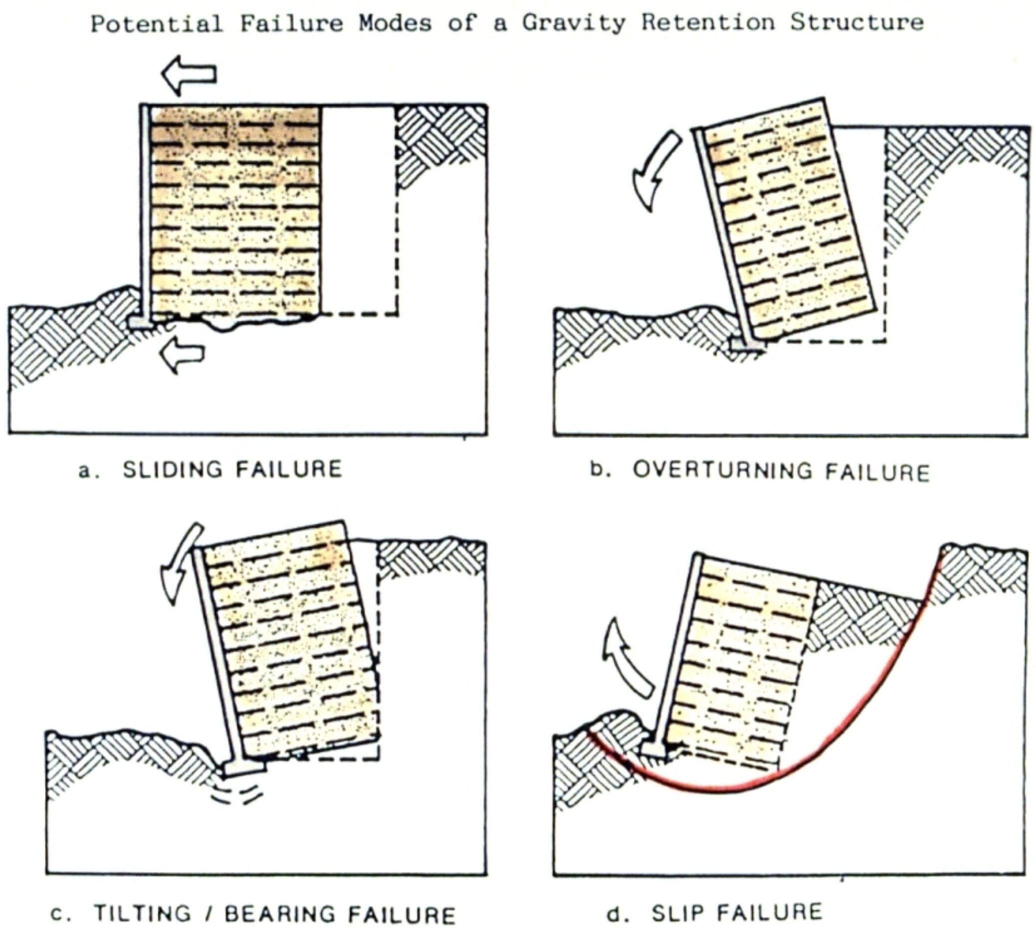

- **Common forms of gravity retaining wall systems in the modern era**




- **Conventional gravity walls like those shown at left are gradually being replaced by combination systems, such as the Mechanically Stabilized Embankment structure, shown at right**




- **Four basic failure modes are considered in the design of gravity retaining systems: basal sliding; overturning, tilting/bearing failure and global slope stability. You'd be surprised how often #4 is forgotten or ignored**

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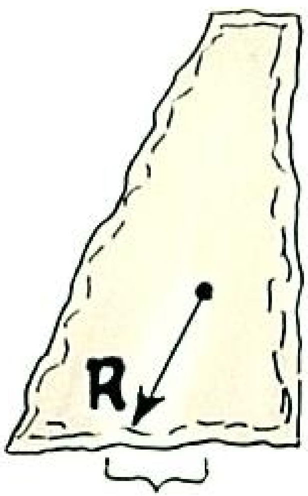
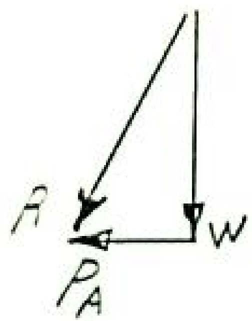



The Resultant Thrust, R, must fall within middle third of the base



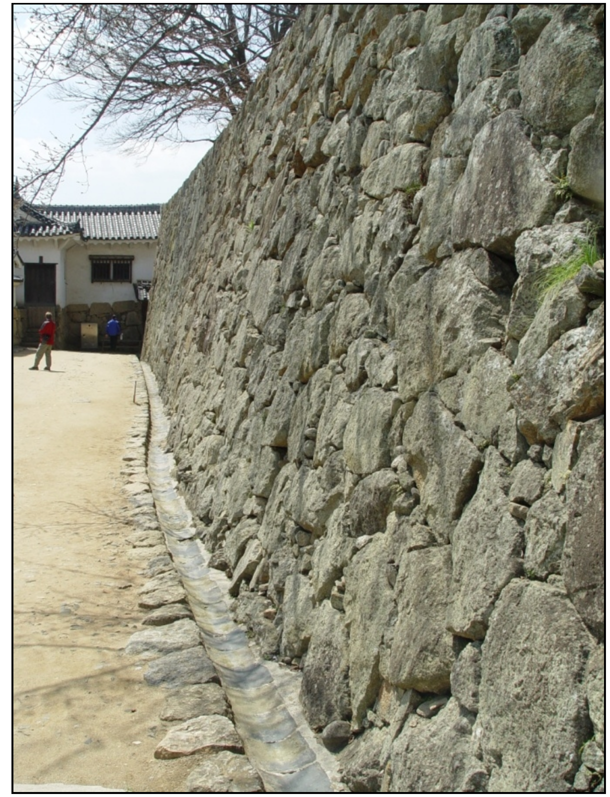

$P_A$ = active load against wall

W = dead weight of the wall

R = resultant vector thrust

- **The most basic requirement of a gravity wall is that the resultant thrust, R, must project within the middle third of the footing**

# Battered Masonry Walls

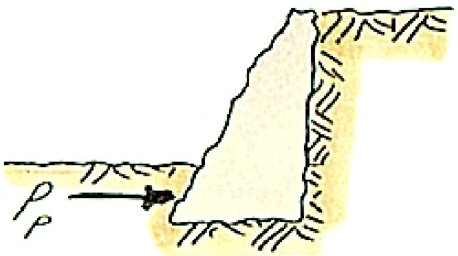


Above left & right: Ancient masonry walls  were usually constructed with a healthy batter, and drained through natural gaps.

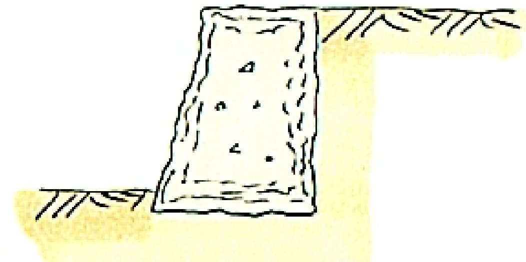
Lower left: modern equivalents are employ weepholes and/or geomembrane drains

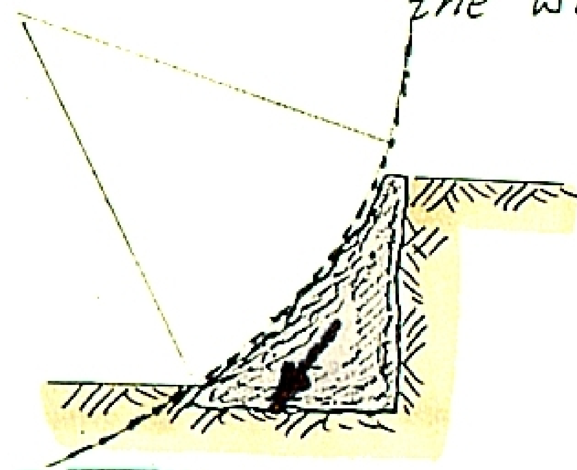
If this fundamental cannot be achieved, can do 3 things:

- Gain passive soil resistance to react against lateral soil pressure by simple embedment




- Increase weight of the wall





- increase footing width to broaden middle third

**Roosevelt Dam on the Salt River in Arizona was constructed as a cyclopean masonry gravity dam by the US Reclamation Service in 1903-11**

# Tapered or flared toe



**Ancient fortifications, like Hemeji Castle in Japan, which dates to 1346, employed flared walls designed to spread load over a broad area, while discouraging ascent of the increasingly steep face**

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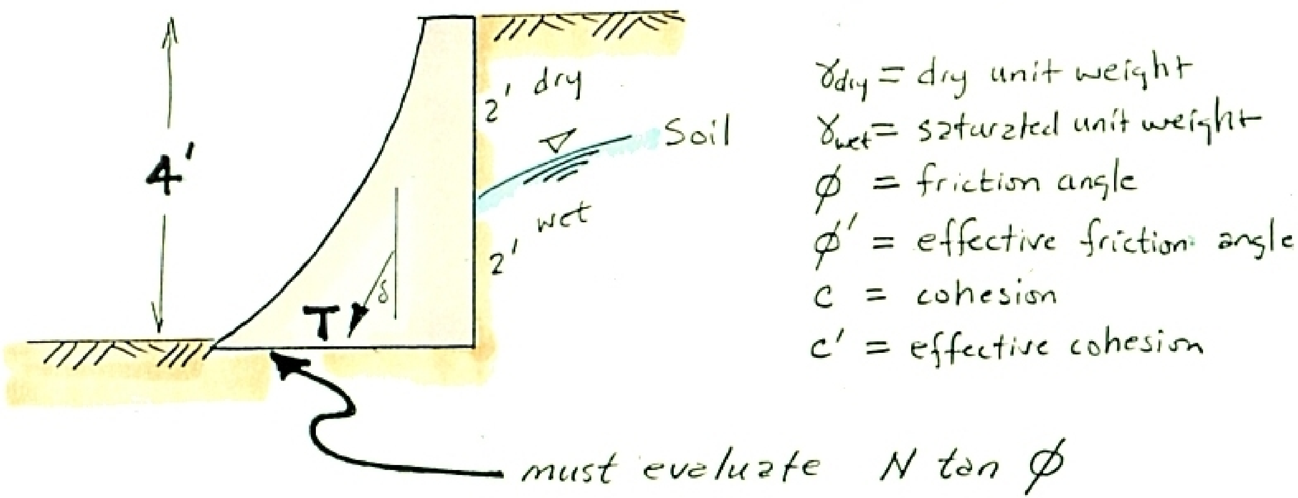
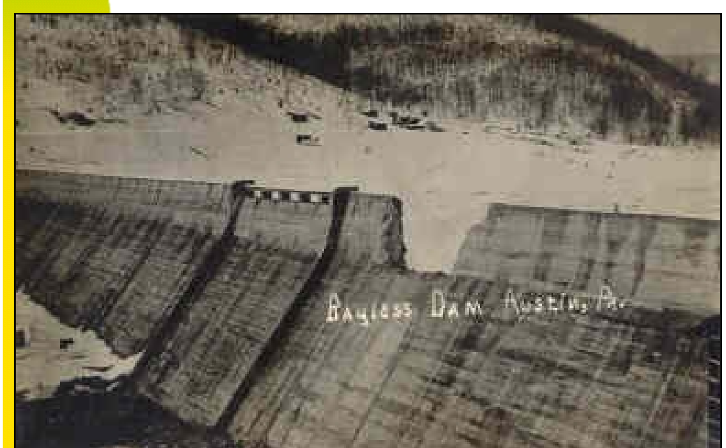
# Gravity Retaining Wall Stability Criteria – Continued

## 2. Resistance to Sliding



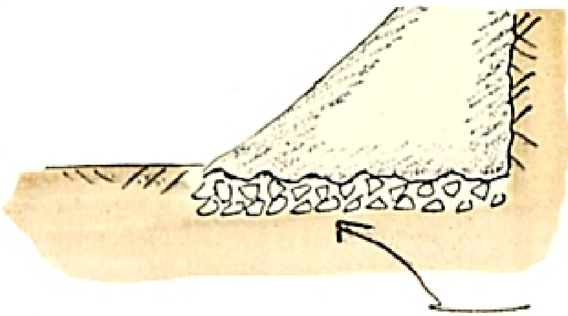

**T** = effective thrust of wall, after subtracting the pore pressure



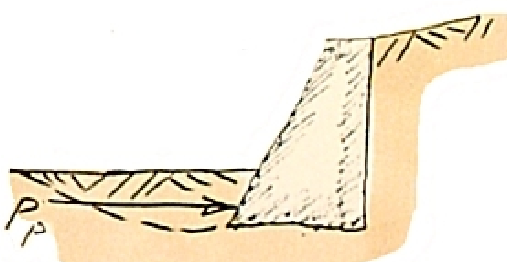

**The Bayless Dam near Austin, Pennsylvania failed by basal sliding along a shale foundation in 1911, despite the reservoir being lowered by notching the dam (left).**

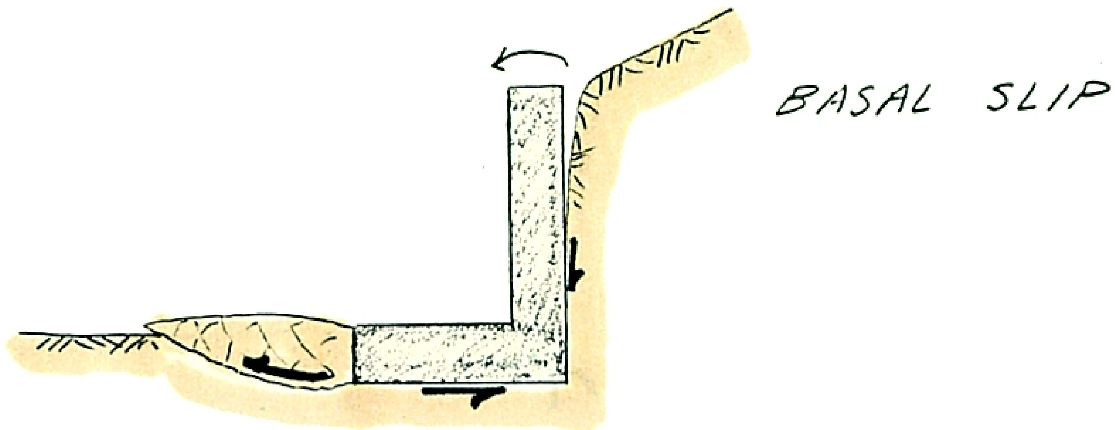
# Methods commonly employed to increase base friction

If the wall cannot sufficiently resist sliding, several methods can be employed:



- Increase $N$ by increasing wall thickness
- Increase $\phi'$ by inserting complete drainage behind wall.
- Increase $\phi'$ by increasing roughness of footing contact; sometimes can do this by placing crushed rock or angular gravel in footing excavation






- **Though not common, basal slip can also occur if the footing embedment is compromised and the base of the footing is lying within *saturated ground***

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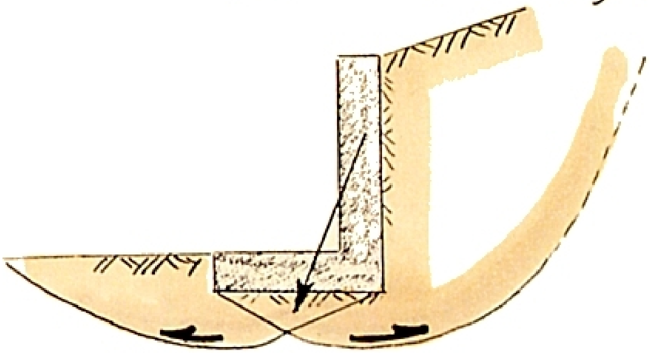
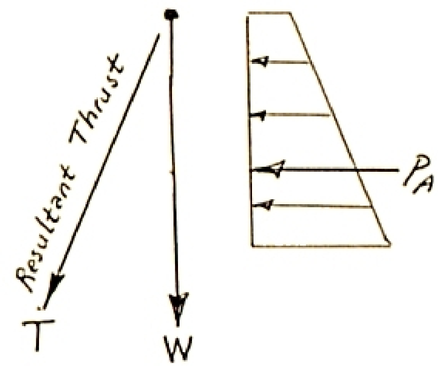
GRAVITY RETAINING WALL STABILITY CRITERION - CONTINUED

3. Soil Bearing Capacity

Wall cannot rotate, or overturn, unless there is localized bearing capacity failure.






- A more complicated check is that against **bearing capacity** and **differential settlement,** which can result because of eccentric forces and inadequate footing design

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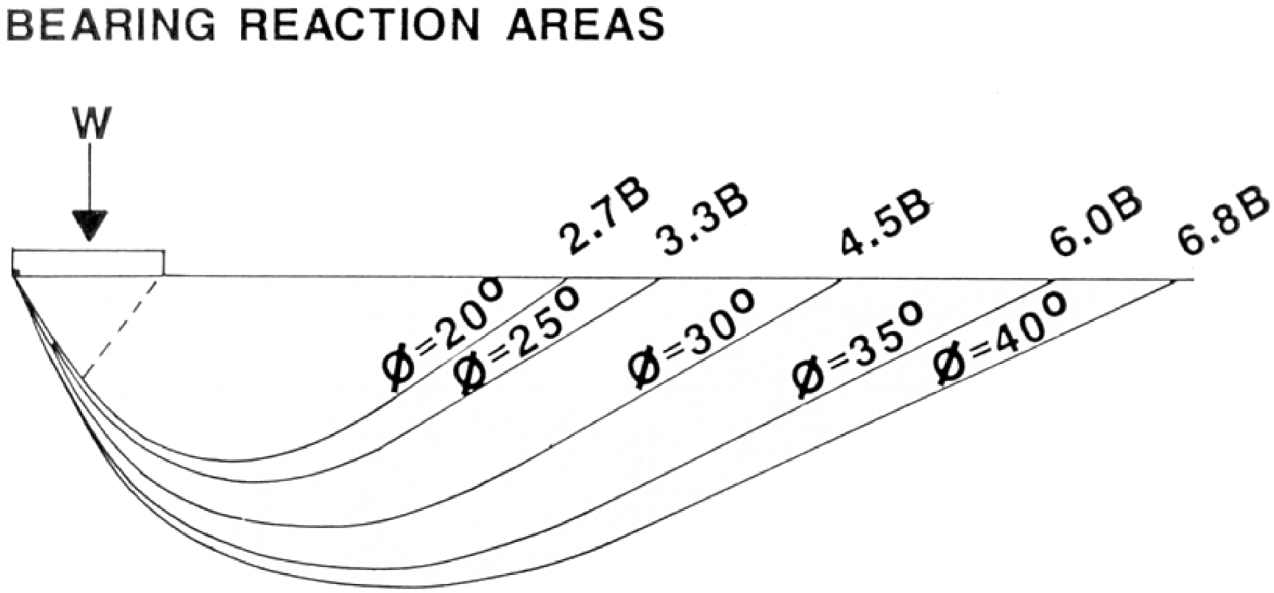


- **Passive reaction wedges** form under differing conditions of soil friction.
- Note that high friction soils influence a ***much greater area*** than lower friction soils

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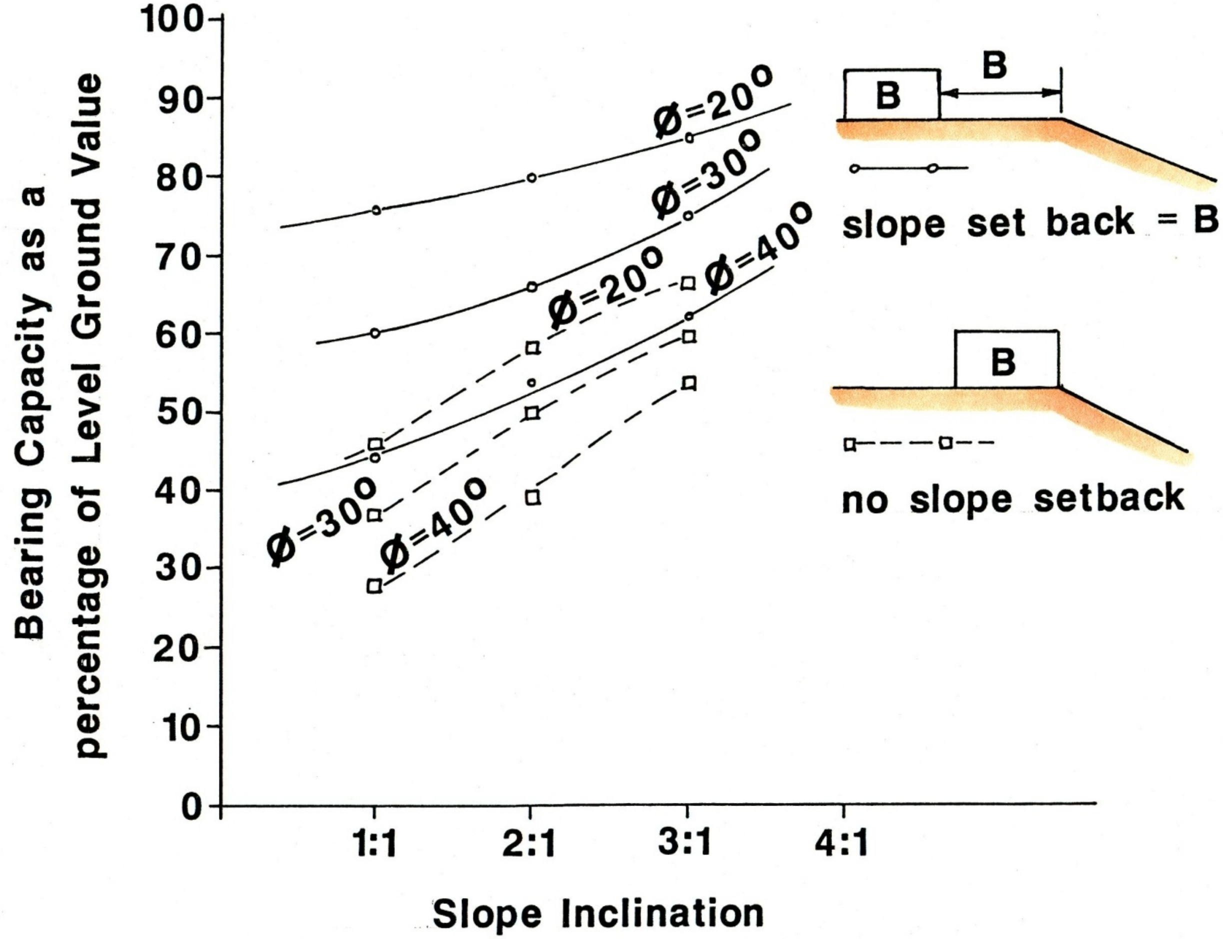


- Chart showing decrease in **design bearing capacity** versus **slope setback** versus **phi angle** of foundation materials

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