Expansive Soils in and Around Boulder County, Colorado

General information on expansive soils

- Pure montmorillonite can swell to 15x its dry volume.
- Typical swelling soils expand 25%-50%.
- An increase in volume of 3% is considered a potential hazard for engineering projects.
- The greatest amount of damage is done to lightweight structures: road, small buildings.

The Pierre Shale: The source of most swelling in Boulder County

- Underlies much of the central U.S. west to the Rocky Mountains
- The average thickness is 8,000 ft.
- It is made up of 50%-75% clay, but not all of this is expansive.
- Swelling is mainly in bentonite beds 10-30 cm thick containing nearly 100% smectites.
- Swelling potential is not uniform but is concentrated in specific areas.

Three factors making expansive soils particularly problematic near Boulder

1. **The proximity of the Pierre Shale to the surface**
   -Along much of the Front Range the Pierre Shale is at or near the surface.
   -Expansive soils 10 ft. or more below structural foundations do not tend to cause damage
   -Excavation can remove overburden that was constraining potentially expansive soils.
2. **Climate**
   -Boulder is dry- only 19.4 inches of precipitation per year.
   -Precipitation is concentrated in April, May and June
   -This leads to high variations in soil moisture content.
   -New landscape irrigation can compound the problem.
3. **Orientation of the Pierre Shale along the Front Range**
   -Beds have a nearly vertical alignment where uplifted along the Front Range.
   -This creates a 1.5-3.2 km wide band along the Front Range.
   -A dip angle of 30° or greater leads to the particular case of *heaving bedrock*
   Many beds intersect the ground surface each with different swell potentials.
   Bentonite layers with high concentrations of smectites can have extreme swelling
   These form longitudinal bands that can be hundreds of meters long

Why *heaving bedrock* is so problematic

- Detection is more difficult.
  -Boreholes are insufficient. They can miss the narrow bentonite beds.
  -Trenching is the only reliable detection method.
- Conventional mitigation techniques do not tend to work.
  -The only reliable mitigation techniques is overexcavation and backfill.

Five Reasons for overexcavation as a mitigation technique for *heaving bedrock*

1. It removes discontinuities in the bedrock and leaves an essentially homogeneous subsoil.
2. Heaving effects are dissipated through the backfill soil. It provides sufficient overburden.
3. Backfill material can be controlled to desired and relatively predictable properties.
4. It gives a more precise picture of the underlying bedrock.
5. Specially engineered layers can be included to regulate seepage.