SUBSIDENCE IN ALLUVIAL SOILS CAUSED BY INTENSIVE WATER WITHDRAWAL

Seminar in Geomorphology
GG.0438

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OUTLINE OF DISCUSSION

1. INTRODUCTION
2. CAUSES OF LAND SUBSIDENCE IN ALLUVIAL SEDIMENTS
3. MONITORING LAND SUBSIDENCE
4. MINIMISING OF FUTURE SUBSIDENCE
5. SUMMARY

1. INTRODUCTION

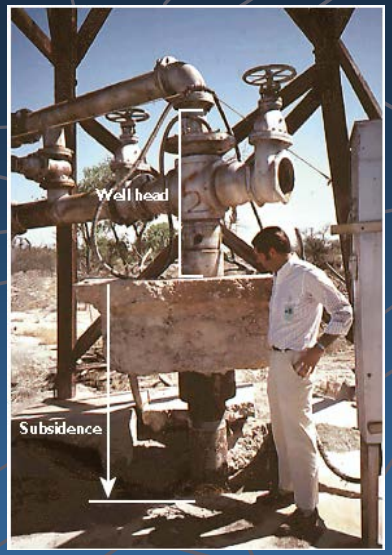
- Land subsidence is either a gradual settling or sudden sinking of earth's surface due to subsurface movement of earth materials,
- Damages resulted from subsidence and fissures are often costly and disruptive,
- Subsidence in alluvial soil is mostly caused by continuous overdraft of water,
  - Indicators of subsidence :
    - Earth fissures,
      - Differential settlement as a result of distinct geological formations of subsurface earth material , or
      - Distinct rate of ground water withdrawal in adjacent areas.
    - Change in flood-inundation frequency and distribution,
    - Structural failures such as sewer lines, levees and road ways, and
    - Collapsing cavity formation
      - Commonly triggered by ground-water-level declines, and
      - Enhanced percolation of water through rocks such as salt, gypsum, anhydride and carbonate minerals.

Pictorial perspectives

Fissure

Damage due to thermal permafrost equilibrium disruption

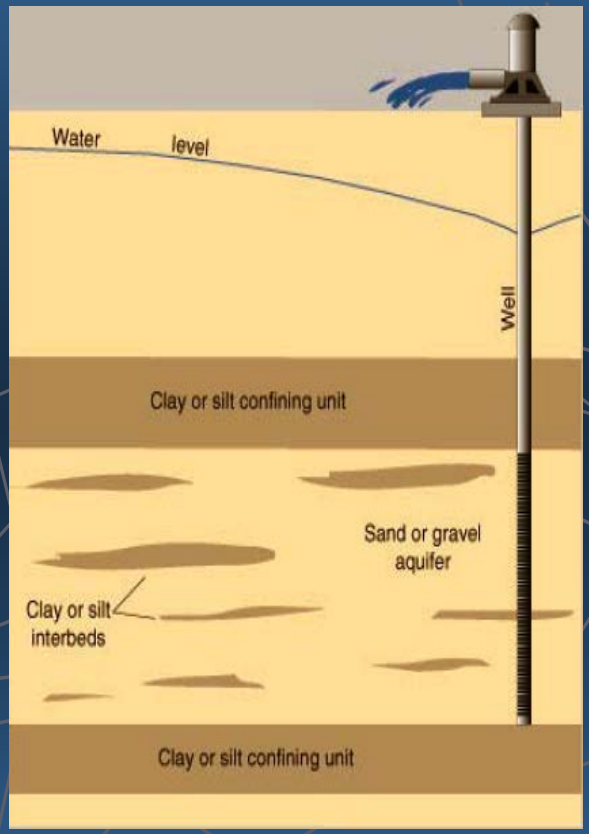
Sinkhole subsidence



Well case protrudes above ground as a result of subsidence

2. CAUSES OF LAND SUBSIDENCE IN ALLUVIAL SOILS

- When the pores become empty due to water withdrawal, the solid particles tightened and packed together. This causes subsidence,
- In case, clay and silt confining unit are found in the subsurface aquifer, the clay or silt bed compressed as a result of loss of support due to continuous water withdrawal,
- Hydro-compaction occurs when dry, low-density sediments collapse because of an increase in moisture content. These usually happen to collapsible soils such as mudflow deposits in alluvial fans and wind deposited silts (loess), and
- Drainage of organic soils, particularly peat and muck (spread manure) induces biological oxidation, compaction and desiccation. This reduces the volume of soil, as a result subsidence happens.

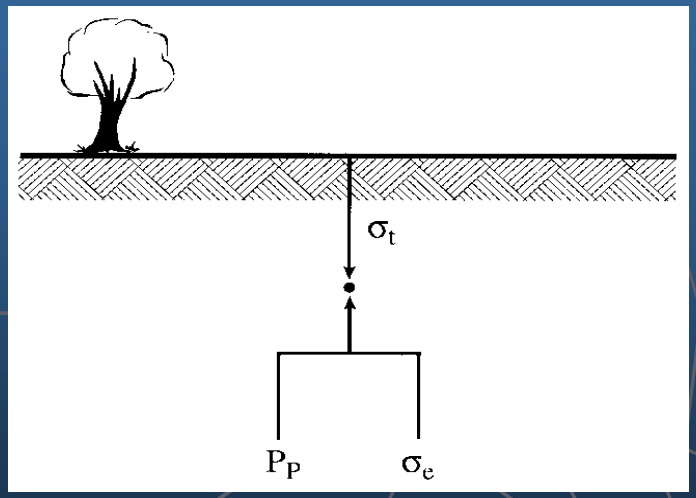


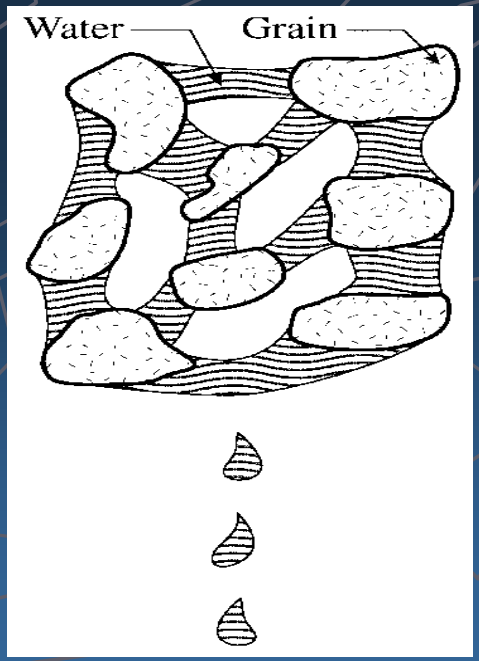
Clay and silt confining unit and interbeds

Mathematical expressions:

$\sigma_t = \sigma_e + P_P$

σ_t	=	total stress,
σ_e	=	effective stress, and
P_p	=	hydraulic head.





3. MONITORING LAND SUBSIDENCE

- A recurrent measurements of land-surface elevation are needed to monitor subsidence.

  Monitoring can be done by:

  - Benchmark placement reviews,
  - GPS and extensometer measurements, and
  - Aerial photography and Interferometric Synthetic Aperture Radar (InSAR).
- Extensometer is the most effective means of determining precise and continuous point deformation in areas where there is an undergoing aquifer-system compaction, extensometers provide excellent subsidence data, but costly to use in sufficient number to provide adequate information for the entire area,
- Aerial photography is reliable method to identify new fissures and monitor existing ones but it is usually difficult to use it as previous photographs are mostly unavailable for comparison,
- InSAR is a powerful new tool to measure deformation of the earth's crust at an unprecedented level of spatial detail and high degree of measurement resolution. Under best conditions, land-surface elevation changes can be measured on the order of 2.5 cm or less with InSAR.

4.MINIMIZING FUTURE SUBSIDENCE

- Switching from ground water to surface-water supplies,
- Reducing water use and determining locations for pumping and artificial recharge that would minimize subsidence,
- Optimization models coupled with ground-water flow models can be used to develop better strategies, and
- Monitoring land subsidence in suspected cities is required for groundwater extraction regulation, construction of infrastructure and spatial development planning is required.

5. SUMMARY

- Subsidence is a slow geological calamity whose emergency and development are not detected easily,
- Damages that can be resulted from subsidence and fissures often are costly and disruptive as it is a gradual phenomenon; its effects are cumulative and may lead to a sudden damage, and
- Therefore, optimization of ground water utilization and regulation should be introduced in areas where subsidence is likely to occur and damage infrastructures such as road ways, bridges and pipe lines.

Thanks for listening