

Foundations on Problematic or Difficult Soils

- EXPANSIVE OR SWELLING SOILS
- COLLAPSIBLE SOILS
- SOFT OR COMPRESSIBLE GROUND

EXPANSIVE SOILS

- ▶ Such soil undergoes large volume changes when their environment is changed; swell when moisture increases and shrinks when moisture is decreased
- ▶ Such soil are characterized by presence of clay mineral like Illite & Montmorillonite.
- ▶ Generally classified as CH, MH, or OH by Unified Classification System.
- ▶ Expansive Soils are known to cause severe damage to civil engineering structures resting on it.

Criteria for Classification of Expansive Soils

Expansion Potential	Very Low	Low	Medium or Moderate	High	Very High or Critical
Liquid Limit (LL)	0-20	20-35	35-50	50-70	70-90
Plasticity Index (PI)	0 – 10	10 – 15	15 – 25	25 – 35	>35
Expansion Index (EI)	0 - 20	21 - 50	51 - 90	91 - 130	>130
% Swell at $\sigma_v = 6.9$ kPa	-	0 - 2	2 - 6	6 - 10	>10

•PI = Plasticity Index = LL-PL

•EI= $1000(h_p-h_o)/h_o = 10$ (% primary swell)

• σ_v = Surcharge Pressure

DAMAGE CAUSED BY SWELLING OF SOIL



Cracks (repaired) in residential buildings

(Shah Abdul Latif University, Khairpur)

DAMAGE CAUSED BY SWELLING OF SOIL



Failure of Walls

(Shah Abdul Latif University, Khairpur)

DAMAGE CAUSED BY SWELLING OF SOIL



Lifting of floor slab due to Swelling of underneath soil

DAMAGE CAUSED BY SWELLING OF SOIL



Crack in Wall



Cracks in Exterior Wall

DAMAGE CAUSED BY SWELLING OF SOIL



Cracks in Pavement



Uneven Roads

Field Identification of Expansive Soils



Shrinkage cracks at DG Khan Site



Shrinkage cracks at DG Khan Site



Gomal University, Dera Ismail Khan



Gujranwala (Nandipur) Site

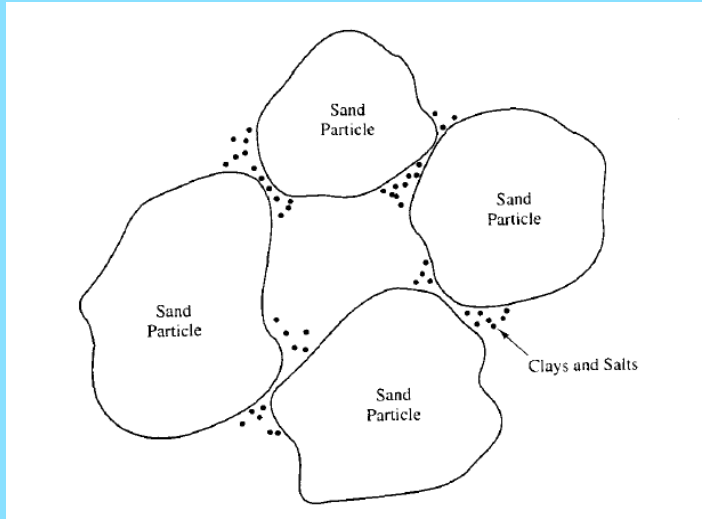
Treatment methods

- **Chemical Stabilization**
- **Moisture control**
- **Through control of placement condition**
- **Pre-wetting**
- **Soil Replacement**
- **Blending with non swelling soils**
- ✓ **Surcharge Loading**
- ✓ **Constructing on slab-on-grade beam which may be supported by piles**

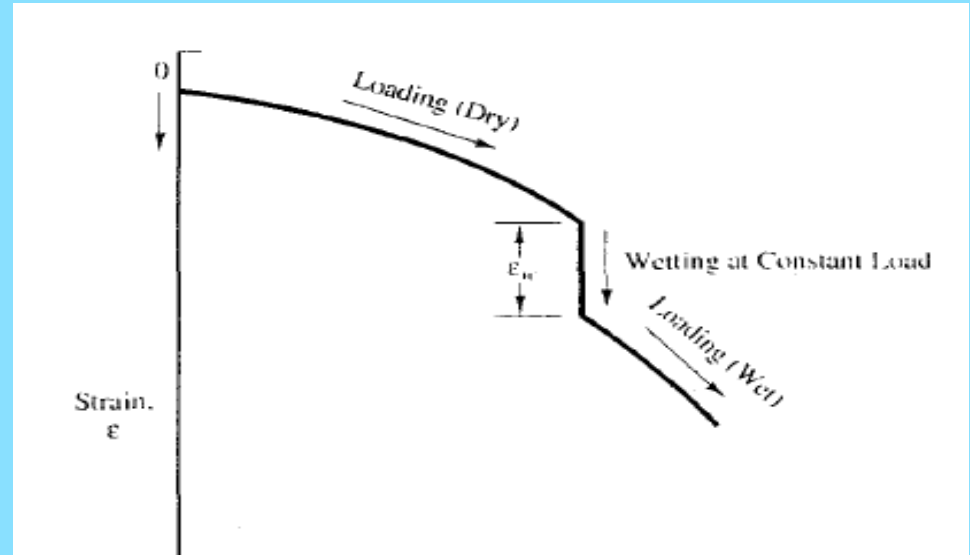
Measures to control swelling

- ▶ Improve drainage around building
- ▶ Avoid watering (irrigation) around building
- ▶ Avoid constructing slab-on-grade floors
- ▶ Prewetting before construction
- ▶ Make foundations rigid
- ▶ Bypass such soil through Piles

Foundation on Collapsible Soils



Structure of Collapsible Soil



Stress ~ Strain Behavior

Failure Mechanism: When such soils are relatively dry, pose high strength but upon wetting/saturation, their structure is collapsed and the results is large settlement of the foundation

Preventive Measure: Pre-wetting, Deep foundation, Water control etc.

Preventive Measures

- ▶ Pre collapse before the construction by in-situ compaction, i.e., Dynamic compaction
- ▶ Prewetting
- ▶ Excavate and re-compact to break the structure
- ▶ Grouting
- ▶ Improve drainage to avoid wetting

SOFT/COMPRESSIBLE GROUND

- ▶ Include soft clays, highly organic soils, etc
- ▶ Prone to large settlement
- ▶ Try to avoid placing foundations and bypass by deep foundation
- ▶ Soil replacement within influence zone
- ▶ Provide rigid foundation to cater differential settlement
- ▶ Pre-consolidation by fill loading, Sand drains
- ▶ Improvement techniques
- ▶ Delay construction when consolidation is underway