Soil Risks and Hazards Understanding

Acid Sulfate Soils

Acid sulfate soils, formed from iron sulfides in tidal margins, can cause sulfuric acid oxidation when exposed to air, releasing iron and other metals into the environment. This process negatively impacts plant growth and animal life, as well as engineering structures, as sulfuric acid and associated salts can rapidly corrode metals and concrete in buildings, channels, pipelines, and roads, reducing their expected lifespan and weakening structures.

Soil Taxonomy refers to unoxidized soil materials that can become highly acidic, such as those found in tidal marshes. Oxidation of sulfidic materials forms a sulfuric horizon with a pH of 3.5 or less, making soil active acid sulfate and relatively benign when saturated with water.However, when exposed to aerobic conditions like drainage, mining, excavation, or dredging, they create environmental challenges.

Occurrence and Identification

Acid sulfate materials are more commonly exposed in modern land reshaping due to excavation to greater depths. These dark soil materials can be mistaken for topsoil and can be corrosive to concrete in direct contact. Runoff from these materials is also harmful to plants and soil organisms.

Engineers face challenges when dealing with sulfide-bearing soil materials in tidal environments, dredged materials, and mine spoil. These materials can cause low soil bearing strength, uneven subsidence, and blockage of tile drains. Destructive vegetation along outflow channels accelerates streambank erosion. Mono-sulfides form on the bottom of streams draining acid sulfate soils, which oxidize and deplete dissolved oxygen during flooding, killing fish and aquatic life. High levels of aluminum and iron in acidic waters can also cause fishkills and lesions.

Sulfidic materials are found in the unoxidized zone of soil-geologic columns in upland areas, often hidden below the soil surface. Soil surveys may not always identify these elements. Identifying these materials, regardless of depth, can prevent mining or construction activities.If the area is disturbed, it is imperative to implement suitable reclamation measures.

Sulfidic materials are dark gray to black before oxidation, and can be identified by incubation under moist aerobic conditions. The material becomes sulfidic if its pH drops to 3.5 within 8 weeks, and when exposed to hydrogen peroxide, it undergoes a violent oxidation reaction with heat release.

Soil oxidation in field conditions transforms sulfidic materials into active acid sulfate soils with a pH of 3.5 or less. New colors emerge from the formation of mineral jarosite and iron oxides in soil cracks and crevices. These soils, called Kette Klei in the Netherlands, are identified by a pale yellow sulfate mineral, jarosite.

Earth Collapse in Soil Pits:

Earth collapse causes numerous deaths annually, including construction workers, agricultural workers, homeowners, inspectors, and children.The US reports an annual death toll of 100 construction workers and 1,000 work-related injuries due to excavation cave-ins, while at least 12 children are killed annually.Most fatalities occur in unstable earth conditions and difficult escape. Causes include suffocation, internal injuries, and spinal fractures. Trench depths range from 4 to 25 feet, with one fatality occurring in a 4-foot trench.

What Causes Earth Collapse?

Soil, weighing around 3,000 pounds per cubic yard, significantly impacts trench walls due to its weight. The stability of trench walls is influenced by factors such as soil type, natural faults, water content, weather conditions, excavation depth, previous soil disturbance, surcharge loads, and equipment vibrations.

Soil stability assessment at a project site requires accurate soil characterization, groundwater, and site conditions. Soils have irregular properties due to layering and moisture content. Soil survey reports and soil scientists can identify local conditions, but they don't provide a definitive basis for decisions. Properly trained contractors can use soil information for protective measures.

Warning Signs of Trench Instability

- Tension cracks near excavation edges.
- Soil subsidence at top edge.
- Surface soil falling or soil particles dislodged.
- Saturated soils, water seeping, or ground water rising.
- Extended period of surface water in pit or trench.
- Expansion of excavation sides or bottom.
- Undercutting by equipment or falling soils.
- Lateral movement of protective shoring.
- Instability in areas where pit or trench is excavated in previously excavated ground.

Erosion by Water and Wind

Soil erosion is the removal of nutrients and organic matter from the surface soil, which is crucial for plant growth. Common forces include water and wind, which can be slow or rapid. Without protection, surface soil is exposed to the full force of wind and water, causing erosion quickly.

Processes:

Erosion processes involve the detachment and short transport of soil particles from the soil surface. Deposition occurs when soil particles are detached by water, either by raindrops or by adhesive friction in a rill. Deposition occurs on the footslope or toeslope of a hillslope, where the velocity of flow lessens. Sheet and rill erosion can be invisible to up to 10 tons per acre, while accelerated erosion results in the loss of the most productive layer of the soil at a faster rate than soil development. This destabilizes crop growth and contributes excess sediment to streams, lakes, and estuaries.

Erode and deposition represent the dynamic processes of cutting and filling, and soil parent materials evolve from erosional deposition. Accelerated erosion and slow accumulation of organic matter have a destabilizing effect on food production and sustainability. Balancing crop production with natural forces requires conservation measures, which require a good knowledge of the soil and how human actions affect its ability to stay in place.

Water Erosion

Water erosion prediction equations rely on rainfall, soil holding capacity, surface cover, slope length, and slope gradient. Management solutions address these factors. Soil survey reports provide information on erosivity, soil loss tolerance, and slope gradient. A general recommendation is to build organic matter in surface soil to improve soil aggregation and water infiltration. Water movement into the soil reduces water flow across the surface. Cover from crops, grass, residue, or straw protects the surface from raindrops and slows water movement. Minimum tillage or no-till systems maintain surface cover and increase organic matter. Contour tillage, terraces, and check dams reduce erosive distance and slope gradient.

Wind Erosion

Wind erosion occurs when bare soil surfaces are subjected to saltation, a process where detachable particles hit other particles on the surface. Soil survey reports assign soils to wind erodibility groups based on factors such as soil texture, organic matter content, carbonate effervescence, rock fragment content, mineralogy, soil moisture, surface cover, roughness, wind velocity, direction, and unsheltered distance. Conservation practices aim to maintain surface cover and reduce unsheltered distances with windbreaks or wind-resistant planting strips.

Hydro-Compactible Soils

Collapsible soil, also known as hydro-compactible or low-density soils, loses volume upon wetting or load application, reaching nearly 20% of its original volume. Settlement of these soils can be rapid and damaging to structures and facilities. They remain stable until runoff is concentrated in areas with land use changes. European settlements in the Southwest have expanded from stream valleys to alluvial fans, posing a risk. Avoiding collapsible soils is easier and cheaper than remediating them.

Collapsible Soil Characteristics

- High void ratio: A loose honeycomb of silt and sand particles coated with clay or cementing agents.
- Low bulk density: 1.1 to 1.4 grams per cubic centimeter.
- Geologically young age: Less than 30% clay content.
- Less than 10% moisture content: Far less than saturation.
- Large percentage of pore space: 40 to 60%.
- Most commonly, arid or semiarid climate.
- Developed areas: Ponding, poor surface drainage, concentrated or curving cracks, tilted structures, misaligned joints, and evidence of crack repair.
- Undeveloped areas: Small depressions, "sinks" created by human activities, and "sinks" where runoff is concentrated or impounded.

Building Guidelines for Collapsible Soils

- Reduce load per unit area.
- Build large structures on floating foundations or piles below collapsing soil depth.
- Convey surface waters to offsite or noncollapsible areas.
- Restrict septic systems use or locate them away from homes.
- Waterproof sewer and street drains.
- Seal surface soil layers with liners or cement.
- Avoid building on collapsible soils.