DENVER
THE MILE HIGH CITY

Subsidence/Expansive Soils

Description:

Land subsidence is the sinking of the land over manmade or natural underground voids. Subsidence occurs naturally and also through man-driven or technologically exacerbated circumstances. Natural causes of subsidence include the development of sinkholes, rock sliding downward along faults, natural sediment compaction, and melting of permafrost. Man-driven or technology exacerbated subsidence conditions are associated with the lowering of water tables, extraction of natural gas, or subsurface mining activities. As the underground voids caused by these activities settle or collapse, subsidence occurs on the surface. In Colorado, the types of subsidence of greatest concern are settlement related to collapsing soils, sinkholes, and ground subsidence over abandoned mine workings.

Subsidence may result in serious structural damage to buildings, roads, irrigation ditches, underground utilities, and pipelines. It can disrupt and alter the flow of surface or underground water. Weight, including surface developments such as roads, reservoirs, and buildings and manmade vibrations, from such activities as blasting or heavy truck or train traffic, can accelerate natural processes of subsidence, or incur subsidence over manmade voids. Fluctuations in the level of underground water caused by pumping or by injecting fluids into the earth can initiate sinking to fill the empty space previously occupied by water or soluble minerals. The consequences of improper use of land subject to ground subsidence can be excessive economic losses, including the high costs of repair and maintenance for buildings, irrigation works, highways, utilities, and other structures. This results in direct economic losses to citizens as well as indirect economic losses through increased taxes and decreased property values.

Expansive, or swelling soils or rock, are defined as soils or soft bedrock that increase in volume as they get wet and shrink as they dry out. They are also commonly known as bentonite, expansive, or montmorillinitic soils.

Damage from swelling clays can affect most types of structure in Colorado. Some structures, such as downtown Denver's skyscrapers, generally have well engineered foundations that are too heavily loaded for swelling damage to occur. At the opposite extreme are public schools and single family homes, which are generally constructed on a minimal budget and which may have under-designed lightly loaded foundations that are particularly subject to damage from soil movements. Homeowners and public agencies that assume they cannot afford more costly foundations and floor systems often incur the largest percentage of damage and costly repairs from swelling soil.

Where swelling soils are not recognized, improper building or structure design, faulty construction, inappropriate landscaping and long term maintenance practices unsuited to the specific soil conditions can become a continuing, costly problem. Design problems might include improper foundation loading, improper depth or diameter of drilled pier, insufficient reinforcing steel, and insufficient attention to surface and underground water. Miscalculating the severity of the problem for a particular clay soil can result in damage although some mitigating measures were taken.

Construction problems related to swelling soils include lack of reinforcing steel, insufficient or improperly placed reinforcing steel, mushroom-topped drilled piers, and inadequate void space between soils and grade beams. Allowing clays to dry excessively before pouring concrete and permitting the ponding of water near a foundation during and after construction also are contributing factors in swelling-soil related construction problems. Building without allowance for basement or ground floor movement in known swelling soils areas is a very common source of property damage. Improper landscaping problems include inadequate management of surface drainage and planting vegetation next to the foundation so irrigation water enters the soil.

History:

One evening in 1974 a Lafayette, CO, trailer park resident noticed a two-foot hole in his front yard. By morning the hole was 10 feet deep and 10 feet across. The trailer was moved as the hole continued to grow until it was about 25 feet deep and 25 feet in diameter. The sidewalk, a telephone pole, a concrete pad and a fence had to be replaced after the hole was filled. Fortunately a gas line exposed by subsidence did not rupture. The property owner backfilled the hole, acknowledging the site had previously subsided and had been filled. An inclined shaft to an old coal mine underlies the site. The workings were abandoned more than 50 years ago.

A Carbondale, CO, rancher's stock watering pond excavated in a pasture collapsed because of hydrocompaction. A bowl-shaped depression 60 feet across and 8 feet deep resulted when he attempted to pond water in his field. The soils were so permeable that the pond would not hold water, and the wetted soils under the pond collapsed. Many roads and other improvements in that area of Colorado have been destroyed or damaged by soaking of collapsible, low density soils.

The Colorado Highway Department, recognizing that severe hydrocompaction along a highway alignment could totally destroy a road, investigated the potential for hydrocompaction along the alignment of I-70 from Rifle to Debeque. Water was impounded in a small pond and a road fill was placed beside the pond as a model of probable future conditions. The result of the test was that the ground surface sank three feet in one month. The test provided design information to prevent the possible future total failure of a portion of the highway. The engineering geologic investigation saved taxpayers millions of dollars.

About 50 percent of Colorado's soil has a high or very high potential for shrinking and swelling and is a perpetual natural phenomenon. Arid or semi-arid areas with seasonal changes of soil moisture, such as Colorado, experience a much higher frequency of swelling problems than areas that have more constant soil moisture.

Several structures on the Southern Colorado State University Campus northeast of Pueblo have been damaged because swelling soils were not recognized or compensated for adequately in design,

construction and maintenance of buildings, sidewalks, driveways, and water lines. Water percolating into dry soils exposed by construction excavation caused the clays to expand, exerting tremendous upward pressures. Floors, walls, ceilings, sidewalks, water lines, driveways, and other improvements have sustained an estimated $1.5 million in damages.

In 1976 at the site of the new maximum security facility for the Colorado State Prison in Fremont County, swelling soils and bedrock were shown on geologic maps. Field investigations and soils tests resulted in a remedial plan by the geologic and soils engineers, architect, builder and others on foundation design, drainage and landscaping. Millions of dollars in potential damages were avoided.

Preparedness:

Colorado Geological Survey – A Guide to Swelling Soil for Colorado Homebuyers and Homeowners

Learn more:

Colorado Geological Survey Swelling Soils, Sinkholes, Subsidence

Sources:

Colorado Natural Hazards Mitigation Plan

Colorado Geological Society