ASSOCIATION OF ENGINEERING GEOLOGISTS

"Serving Professionals in Engineering, Environmental, and Ground-Water Geology"

THE ROCKY MOUNTAIN SECTION NEWSLETTER

MEETING DATE

THURSDAY
NOVEMBER 8, 2001

TIME
5:45 p.m. Social Hour
6:30 p.m. Dinner
7:30 p.m. Presentation

LOCATION
GEOLOGY MUSEUM
Colorado School of Mines
Golden, CO

COST
$20 Members
$22 Non-members
Free for Students

RESERVATIONS
c/o AEG Reservation Line
(303) 790-2161 x 243
BY NOON, FRIDAY
NOVEMBER 2nd

Collapsible Soils in Western Colorado

Jonathan L. White Colorado Geological Survey

Collapsible soils are unusual in that they have the property to compact, settle, or disperse naturally when moisture is added, generally under very light loads, or just the overburden weight alone. In many circumstances, the settlement can be relatively rapid. The collapse of soil can be the result of differing soil processes in differing depositional systems. Collapsible soils are also referred as hydrocompactive soils, hydrocompressible soils, low-density soils, shrinking soils, and dispersive soils. In western Colorado it is a significant soil problem with engineered works, and a soil property that first impacted the area's early settlers.

Soil-collapse mechanisms can include the mechanical volume-reduction of soil structure from the introduction of water, soil-mass loss from dispersion in fresh water (dispersive and/or piping soils), and soil-mass loss from dissolution of gypsiferous soils and residual soils from evaporitic bedrock. Collapsible soils can be found in recent deposits in alluvial, eolian, colluvial, and alluvial-fan geomorphic systems, generally in clay to silt-rich or evaporite bedrock, where the climate is arid to semi-arid. They can be quite destructive in foundations, roadways, septic systems, and water diversion and retention structures (canals, irrigation ditches, and dams).

At the end of the 19th and beginning of the 20th Century, some of the first settlers of the plateau region of Western Colorado looked to fruit crops for their livelihood. The semi-arid but moderate climate was well suited for fruit orchards once irrigation canal systems could be constructed. But serious problems occurred when certain lands were first used for agriculture and wetted by irrigation.

They sank, so much (up to 4 feet in places!) that irrigation-canal flow directions were reversed, ponding occurred, and whole orchards, newly planted with fruit trees imported by rail and wagon at considerable expense, were lost.

While not understood, fruit growers and agriculturists began to recognize the hazards of "sinking ground." Early horticulturists made one of the first references to collapsible soil in a 1910 publication, "Fruit-growing in Arid Regions; an account of approved fruit-growing practices in the inter-mountain country of western United States." They warned about sinking ground and in their chapter, "Preparation of Land for Planting," made one of the first recommendations for mitigation of the hazard. They stated that, when breaking out new land for fruit orchards, the fields should be flood irrigated for a suitable time to induce soil collapse, <u>before</u> final grading of the orchard field, irrigation channels excavation, and planting the fruit tree seedlings.

The reference cited above briefly stated that, "The tendency to settle appears to be due to the porous conditions of the subsoil." Such soil properties are diametrically opposite from the swelling problems that are found in "fat," plastic-clay soils. Collapsible soils are generally dry, low density, silty soils with high void-space or air gaps between the soil grains, where the soil particle binding agents are highly sensitive to water. These micro-pores can sometimes be seen by the naked eye. The binding agents of the collapsible soil structure can be very strong while the soil is in a dry state, and may possess high bearing capacities able to support heavy structures. When water is introduced, the binding agents break, soften, or dissolve such that the soil fabric's skeletal structure quickly weakens and fails. The soil grains shear against each other and re-orient in tighter, denser, configurations. This re-configuration causes a net volume decrease in the soil mass that, in turn, results in settlement of the ground surface. This condition can occur just by the weight of the soil itself, called the overburden, or the weight of a structure, such as a home foundation, concrete or pavement slab, or dam abutment.

While there are various types of soil-binding agents, collapse rate is dependent on saturation rate of the soil. Because the introduction of water causes this collapse, the terms hydrocompactive and hydrocompressible are also used to describe these soils.

There are other types of soil collapse. One involves piping and formation of soil fissures and caverns in dispersive and erodable soils, caused by active suspension and removal of soil particles by flowing water. Another involves soil with a high evaporite-mineral or gypsum content, where actual dissolving of mineral grains and the cementation matrix (soil-mass loss) can result in volume loss and settlement at the surface.

Collapsible soils are derived from a number of different types of sediment deposition, but the key is really geology, climate, and resultant geomorphology. Many regions of Colorado, outside of the very hard rocks that form the major mountains, are underlain by poorly indurated (soft), clay- and silt-rich, sedimentary bedrock. The bedrock weathers easily and forms residual soils, susceptible to rapid erosion. It has been shown that semi-arid areas are more prone to high sediment yields (expressed as tons of soil per acre lost by erosion, per year), which is to say that the deposition of new sediments eroded from poorly vegetated hillsides is quick. Semi-arid regions have less vegetation and sufficient runoff of intense thunderstorms to transport large amounts of sediment. Sediment yields reach their peak within the range of 12-20 inches in annual precipitation that is typical for most of western Colorado, the intermontane valleys, and the high prairies next to the Front Range.

Various studies of case histories have shown that certain types of recent sediment deposits and soils can be susceptible to collapse. Those soils include (1) windblown deposits of dust, silt, and fine sand, called loess; (2) hillside gravity deposits called colluvium; (3) unsorted, water-borne material (mud and debris) in alluvial/debris-flow fans or as hillside slope wash; and (4) overbank deposits called alluvium (recent silt and clay laid along tributary streams and gently sloped mud flats).

The common characteristic of these soils is recent and rapid deposition; these depositional dynamics result in an inherently unstable internal structure. The generally dry environmental conditions of the area cause these deposits to quickly desiccate (dry out) in their original condition, without the benefit of further re-working or packing of the sediment grains by water. Local ground-water levels generally never rise into these mantles of soil, so they never become saturated. Only through human development and land use do local ground-water levels rise. Thus, the soils become introduced to moisture through combinations of field irrigation, lawn and landscaping irrigation, capillary action beneath impervious slabs, leaking or broken water and sewer utilities, and altered surface and subsurface drainage.

Structures and underground utilities founded on these types of soils suffer from distress because of differential settlement. The shifting and settling of the structure can be seen in a number of ways, such as cracking, shearing, bending, or separation. There are available engineering techniques to mitigate collapsible soils. They are grouped broadly into (1) ground modifications that mitigate the collapse potential of the soil, (2) structural-reinforcement techniques, and (3) deeper foundations that transfer building loads through the collapsible soil horizon to a competent soil or rock layer below.

In regions susceptible to collapsible soil occurrences, it is important that site-specific geotechnical investigations are completed and any structures founded in these soils are appropriately designed. Mitigation of the potential hazard at the time of construction is always cheaper than future remedial repair work. The most important thing to remember is that collapsible soils are dry in their natural state, and it is important that they remain so where structures have been constructed. Water and drainage management is always important for new-site development, but is even more important for maintenance of existing structures.

The CGS has been studying collapsible soils in Colorado for a number of years, and will be publishing both a regional-susceptibility map and statewide report on susceptibility of collapsible soils in Colorado in 2002. The regional study focuses on the Roaring Fork River Corridor in Garfield, Eagle, and Pitkin Counties, and will be available as a map series late this winter. The more-comprehensive, statewide report is planned to be available in the summer of 2002.

Fall 2001/Spring 2002 Speakers and Locations

December 13th – Family Night at CSM Museum – Jonathan Caine (USGS) – Pole to Pole - A Geologic Journey of Antarctica and Greenland

January 10th – Golden Community Center – Bob Schuster (retired USGS) - Dams Built on Pre-Existing Landslides

February 14th – CSM Student Center – Student Career Night

March 14th – Golden Community Center – Myles Carter, AEG President

April 11th – Golden Community Center – Dr. Perry Rahn, South Dakota School of Mines, AEG Jahns Distinguished Lecturer

May 9th – Golden Community Center – Open

Please let Peggy Ganse or Tim Petz know if you or someone you know would be interested in giving a talk at an upcoming RMS meeting.

GITA Rocky Mountain Chapter November Meeting

The November luncheon meeting of the Rocky Mountain Chapter of the Geospatial Information & Technology Association (GITA) will be held on Friday November 9, 2001 at the USGS Cartographic Center (Bldg. 810, Entrance W-5), Denver Federal Center in Lakewood, Colorado.

Time: 11:30 am - 1:30 pm
Speaker: Joseph J. Kerski
Title: "Finding Your Way Through USGS Data"

The event includes a tour of the USGS National Map Center, a 17-acre facility, including production areas for hydrography and digital elevation models and discussions of research projects on abandoned mine lands and urban growth. Door prizes, including a personal GPS unit, will be given out at the luncheon.

Rocky Mountain GSA Symposium

The 2002 Rocky Mountain Section Geological Society of America meeting will be held May 7 and 8 (Tuesday and Wednesday) on the campus of Southern Utah University in Cedar City, Utah. Of particular interest to engineering geologists will be a symposium entitled, "Hillside and Mountain Slope Hazards in the Rocky Mountains." In addition to invited speakers, we are also accepting a limited number of volunteered abstracts. If you have a topic that may be appropriate, please contact one of the symposium coordinators, Paul Santi at psanti@mines.edu or 303-273-3108 or Frank Ashland at fashland.nrugs@state.ut.us.

CGS Durango GeoConfernce

The 2001 GeoConfernce occurred October 15-17 in Durango, Colorado. The conference was a huge success with students and professionals attending from all across the state and mountain west. Over thirty speakers presented on land use issues, geologic hazards and mitigation, the San Juan Basin and the San Juan Mountians.

Section News

1. Alyssa Kohlman is actively seeking speakers for the CSM Student Section. Please contact her at alyssakohlman@hotmail.com if you are interested in sharing your knowledge and experience.

2. Please forward any newsworthy items to Kristi McQuiddy newsletter@aegrms.org.

Memories from the AEG National Convention

Jerry Higgins, Peggy Ganse, and Tim Petz at the Gateway Arch

Representatives from the CSM student section also attended the meeting and made good contacts with the student chapter from UW Madison and are planning to initiate some sort of student activity at future annual meetings, with the help of Chris Mathewson.

Section Website

The new RMS website location is up and running at http://www.aegrms.org. Updates and changes are occurring on a regular basis during this initial startup time. Any webworthy items can be set to Ed Friend at webmaster@aegrms.org.

RMS Officer Contact List

Chairperson	Tim Petz, Church & Associates, Inc., 303.463.9317, chair@aegrms.org
Chair-elect	Jim Wright, GEI Consultants, Inc., 303.662.0100, chair-elect@aegrms.org
Secretary	Scott Walker, GEI Consultants, Inc., 303.662.0100, secretary@aegrms.org
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Membership	Scott Walker, GEI Consultants, Inc., 303.662.0100, membership@aegrms.org
Newsletter	Kristi McQuiddy, GEI Consultants, Inc., 303.662.0100, newsletter@aegrms.org
Website	Ed Friend, GEI Consultants, Inc., 303.662.0100, webmaster@aegrms.org
Past Chair	Peggy Ganse, Haley & Aldrich, 303.534.5789, ext. 3210, pastchair@aegrms.org