UTAH GEOLOGICAL SURVEY
a division of
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PLATE 6

EXPANSIVE-SOIL- AND ROCK-SUSCEPTIBILITY MAP FOR THE ST. GEORGE–HURRICANE METROPOLITAN AREA

by

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14°
TRUE NORTH
MAGNETIC NORTH
Approximate mean declination, 2007

UTAH
Map Location

Basemap consists of National Agricultural Imagery Program natural color aerial photography.

Universal Transverse Mercator Projection, zone 12.
North American Datum 1983.

SYMBOLS

- Municipality boundary
- Interstate Highway
- State Highway
- Major local surface street
- Other road

Scale 1:24,000

1 0.5 0 1 2 Miles

1 0.5 0 1 2 Kilometers

EXPLANATION

SOIL

ESH Soils with high susceptibility for volumetric change are typically clay rich and have a liquid limit (LL) $\geq$45, a plasticity index (PI) $\geq$20, and/or a swell/collapse test (SCT) value of $\geq$3 percent swell. Soils with these characteristics are of limited aerial extent at the surface in the study area, but are frequently found at depth as shown by the geotechnical database (see GEOTECHNICAL DATA EVALUATION section in accompanying text). This phenomenon reflects the fact that most of the geotechnical data available for the study area come from the municipalities of St. George, Santa Clara, Ivins, and Washington, portions of which are underlain at shallow depth (typically <20 feet) by bedrock with high or moderate susceptibility for volumetric change. The influence of this shallow, often clay-rich source rock on overlying soils is apparent in the geotechnical data collected from below a depth of 60 inches.

ESM Soils classified by the Natural Resources Conservation Service (NRCS) as having moderate susceptibility for volumetric change (LL from 20 to 50, and PI from nonplastic [NP] to 30). These values overlap at their upper ends with soils in the high susceptibility category. Chen (1988) recognized that while PI is an indicator of expansive potential, other factors also exert an influence, and therefore reported a range of PI values when categorizing soil's capacity to shrink or swell.

ESL Soils classified by the NRCS as having low susceptibility for volumetric change (LL from 0-30, and PI from NP-15). These values overlap at their upper ends with soils in the moderate susceptibility category. However, the low category includes soils with highly variable potential for volumetric change that do not fit easily into the moderate or high categories.

ROCK

ERH Bedrock units with high shrink/swell susceptibility include claystone horizons in the Virgin Limestone Member of the Moenkopi Formation; the Petrified Forest Member of the Chinle Formation, known locally as the "Blue Clay;" the lower red beds of the Dinosaur Canyon Member and the Whitmore Point Member of the Moenave Formation; the Iron Springs Formation, which contains abundant clay-rich strata in its lower part; and a thin interval (maximum thickness 90 feet) of montmorillonitic clay that lies between the Carmel Formation and the overlying Iron Springs Formation. Landslides mapped within these rock units were also included in the high-susceptibility category. These bedrock units contain an abundance of expansive clay minerals and are commonly associated with expansive rock problems in the study area.

ERM Bedrock units with moderate shrink/swell susceptibility include the Shnabkaib and lower, middle, and upper red members of the Moenkopi Formation; the Co-op Creek and Crystal Creek Members of the Carmel Formation; and the Temple Cap Formation. These rock units are chiefly fine grained and contain alternating strata of shale, claystone, mudstone, siltstone, sandstone, and limestone. Not all or necessarily the majority of these strata contain expansive clay minerals, but past experience in the study area has shown that a sufficiently high percentage of strata do contain expansive clays that foundation problems are often associated with these rock units. Where mapped as undivided, we assigned a moderate susceptibility to the Moenkopi Formation, Carmel Formation, and grouped Triassic, Triassic/Jurassic, and Jurassic/Cretaceous rocks. Landslides mapped within moderate-susceptibility units are also included in this category.

ERL Bedrock units with low shrink/swell susceptibility include the Timpoweap Member of the Moenkopi Formation and the the Kayenta Formation. Although we consider these units to have a low susceptibility relative to the bedrock units identified above, they contain some fine-grained, clay-rich strata that may cause shrink/swell problems locally.

CONCEALED

CHESR Area of highly expansive soil or rock ($\geq$5 percent swell) in the shallow subsurface ($\leq$20 feet), but with little or no evidence of such material at the ground surface. Based on past engineering experience, such highly expansive soil or rock can cause differential displacements at the ground surface even when overlain by as much as 20 feet of nonexpansive material, and these areas are considered to have a high potential for expansive soil and rock problems.

DISCUSSION

Expansive soil and rock contain a significant percentage of clay minerals that can absorb water directly into their crystal structure when wetted, and therefore increase in volume as they get wet and shrink as they dry out. Some clay minerals can swell as much as 2000 percent upon wetting. The resulting expansion forces can be greater than 20,000 pounds per square foot, and can easily exceed the loads imposed by small structures, resulting in cracked foundations and other structural damage. Many bedrock formations in the St. George – Hurricane metropolitan area consist in whole or part of shale, claystone, or mudstone strata, which contain expansive clay minerals. These rock units and the expansive soils derived from them are capable of significant expansion and contraction when wetted and dried, causing structural damage to buildings; cracked driveways; damage to curbs, gutters, and sidewalks; and heaving of roads and canals. Because expansive soil and rock rarely if ever cause rapid, catastrophic property damage or are a threat to life safety, for purposes of this study, expansive soil and rock are considered adverse construction conditions and not geologic hazards.

For additional information about expansive soil and rock in the St. George – Hurricane metropolitan area, refer to the Problem-Soil-and-Rock text document in this report.

USING THIS MAP

The Expansive-Soil-and-Rock-Susceptibility Map shows the location of known or suspected expansive soil and rock in the St. George – Hurricane metropolitan area. The map is intended for general planning purposes to indicate where expansive soil and rock conditions may exist and special studies may be required. The UGS recommends performing a site-specific geotechnical foundation/geologic-hazards study for all development at all locations in the study area. Site-specific studies can resolve uncertainties inherent in generalized mapping and help ensure safety by identifying the need for special foundation designs or mitigation techniques. The presence and severity of expansive soil and rock along with other adverse construction conditions and geologic hazards should be addressed in these investigations. If expansive soil or rock is present at a site, appropriate design recommendations should be provided.

MAP LIMITATIONS

The Expansive-Soil-and-Rock-Susceptibility Map is based on limited geologic and geotechnical data; site-specific studies are required to produce more detailed geotechnical information. The map also depends on the quality of those data, which varies throughout the study area. The mapped boundaries between susceptibility categories are approximate and subject to change with additional information. The hazard from expansive soil and rock may be different than shown at any particular site because of geological variations within a map unit, gradational and approximate map-unit boundaries, and the small map scale. This map is not intended for use at scales other than the published scale, and is designed for use in general planning to indicate the need for site-specific studies.

MITIGATION

Although potentially costly when not recognized and properly accommodated in project design and construction, problems associated with expansive soil and rock rarely are life threatening. As with most adverse construction conditions, early recognition and avoidance is the most effective way to mitigate potential problems. However, expansive soil and rock are widespread in the St. George – Hurricane metropolitan area and avoidance is generally not a viable or cost-effective mitigation option.

In Utah, soil test requirements are specified in the soil and foundations provisions of International Building Code (IBC) (International Code Council, 2006a) Chapter 18 (p. 343) and the foundations provisions of the International Residential Code (IRC) (International Code Council, 2006b) Chapter 4 (p. 42), which are adopted statewide. IBC Section 1802.2.2 (p. 343) and IRC Section R401.4 (p. 67) contain requirements for soil investigations in areas where expansive soil may be present. Where the presence of expansive soil or rock is confirmed, possible mitigation techniques include soil or rock removal and replacement with noncohesive, compacted backfill; use of special foundation designs such as drilled pier and beam foundations or stiffened slab-on-grade construction; moisture barriers; foundation soil prewetting; chemical stabilization of expansive clays (Nelson and Miller, 1992); and careful site landscape and drainage design to keep moisture away from buildings and expansive soils (Keller and Blodgett, 2006).