DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

FOLIO OF THE
GOLDEN QUADRANGLE, COLORADO
MAP I-761-D

Base from U.S. Geological Survey, 1965
Photorevision as of 1971
10,000-foot grid based on Connecticut coordinate system central zone
1000-meter Universal Transverse Mercator grid ticks, zone 13

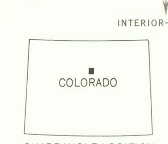
APPROXIMATE MEAN DECLINATION, 1973

SCALE 1:24 000

1 ½ 0 1 MILE

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL



QUADRANGLE LOCATION

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1973—G73017

MAP SHOWING EARTH MATERIALS THAT MAY COMPACT AND CAUSE SETTLEMENT IN THE GOLDEN QUADRANGLE, JEFFERSON COUNTY, COLORADO

By
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1973

EXPLANATION

Areas underlain by earth materials that may compact and thus cause settlement of structures; classification based mainly on origin and composition

WINDBLOWN SILT – Pale-brown (buff) pebbly fine earth with scattered white particles. Deposits vary in thickness, locally patchy; each deposit mapped is in part 3 feet or more thick, maximum thickness less than 10 feet

ORGANIC SILT – Dark-gray to brown pebbly fine earth with organic material more than 10 percent by volume. As much as 5 feet thick. May be absent beneath reservoirs, ponds, and embankments. Probably present beneath mine-tailing piles; extension of contacts shown by dots

INTRODUCTION

Settlement of some manmade structures may occur in various parts of the Golden quadrangle because of certain kinds of earth materials on which they are built. The particles of these earth materials in their original positions are so arranged that they may become compacted to a more dense arrangement. Compaction causes the ground surface to subside, which in turn causes settlement of structures on it. The presence of compactible earth material does not necessarily mean that settlement will occur, or that it will be excessive. Among the principal causes of compaction are the weight of the structure upon the earth material and saturation of the material. Because settlement is generally uneven, it may cause damage to the structure; such damage commonly can be prevented.

This map shows those areas in the quadrangle where geologic investigations have shown that the ground surface is underlain by one or the other of two kinds of natural earth materials that may compact and cause settlement. These compactible materials are classified mainly on the bases of their origin and composition because these reflect the physical characteristics of the materials and, thus, their expectable engineering behavior. The explanation briefly describes the two kinds of materials. The following discussion defines terms where appropriate and explains compaction and its significance to land-use planners, landowners, students, and others who may be interested.

The map and explanation are a practical presentation of the distribution and character of the chosen map units at the scale of the base map. Use of the map does not necessarily eliminate the need for detailed geologic and engineering studies of a proposed site prior to acquisition, design, and construction.

SUBSIDENCE AND COMPACTION

Subsidence is sinking of the ground surface, and it is characterized by essentially vertical, rather than horizontal, movement. As the ground surface sinks it causes settlement of buildings or other construction situated on it. There are several causes of subsidence; one of them is compaction of the earth material that underlies the ground surface.

Compaction is the rearrangement of earth particles from a less dense to a more dense fitting, or packing, so that they occupy less space; this is illustrated in figures 1 and 2. An earth material that is closely packed

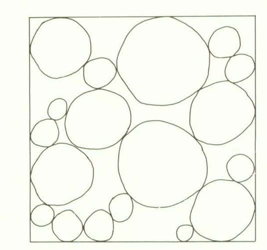


Figure 1. – Diagram of several earth particles of different sizes, magnified many times, as they might occur in their original arrangement as a deposit of low density; the upper line represents the ground surface.

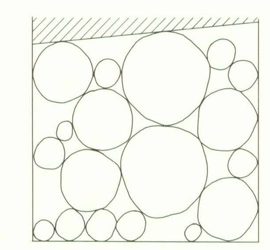


Figure 2. – Diagram of the same earth particles, magnified as in figure 1, as they might occur in a more dense arrangement following compaction to a higher degree of density; note the tilted, lowered ground surface.

is said to be dense, or to have a high degree of density; a material that is loosely packed is said to be less dense, or to have a low degree of density. During the rearrangement the total volume of the material decreases, causing the ground surface to subside.

There are two kinds of earth materials in this quadrangle that may cause a significant amount of settlement. One is windblown silt; it is characteristically firm in spite of its low density, but when wet it looses its firmness and may compact if it bears a load. The other material is organic silt, a characteristic deposit of streams in this area. If it bears a load it may compact, whether wet or dry, in part because of more dense packing, but in part because of compression of the organic matter among the earth particles.

Windblown silt

A deposit of windblown silt has relatively low density when compared to a deposit of sand and gravel or to most other geologic materials. Thus windblown silt in the Golden quadrangle is more likely to undergo compaction, and thus cause settlement, than are most of the other kinds of materials present. The less dense the original material, the more compaction that may take place. Moreover, because of natural variation within each material, it is possible, even under the same load, to get more compaction at one point than at another, even though the two points may be close together. Thus settlement may be uneven, and it is the uneveness of settlement that is particularly damaging to overlying structures.

The windblown silt consists mainly of silt-size particles with some clay- and sand-size material, a few scattered rounded pebbles, and some small white bits of calcium carbonate (lime), all intermixed and weakly cemented together by calcium carbonate. It commonly is broken by cracks into small, slim vertical columns several inches long. Layering is indistinct but most apparent in the lowermost part. Deposits are easily eroded, and so are patchy, especially near the margins. Windblown silt is widespread, but generally it is less than 3 feet thick and is unmapped; a thickness of 5 feet was observed, and the maximum thickness undoubtedly is less than 10 feet. It is most commonly found on the upper, flatter parts of hills and ridges.

Water readily moves downward through this material. If the water enters the deposit faster than it can drain out, the water accumulates, thereby raising the level of the ground-water table and filling the spaces among the particles. The water in the deposit weakens the cement and tends to push the particles apart; both effects make the particles more susceptible to compaction. Normally, saturation of windblown silt causes no significant problem, but if the deposit supports a load, perhaps a house or other manmade construction, the normal strength of the material may be overcome and compaction occurs. The increase in ground-water content may come about from natural events such as heavy or extended rain or snowmelt, or from human causes such as lawn or crop irrigation, broken water or sewer pipes, septic-tank systems, leaking irrigation canals, or cracked swimming pools.

Organic silt

Organic silt, as the term is used here, is stream-deposited silt that contains more than 10 percent organic material by volume. The silt consists mainly of silt-size particles intermixed with some clay- and sand-size particles and scattered rounded pebbles. Layering is generally indistinct. Deposits are situated in the bottom of drainage courses and locally on low adjacent terraces. Organic silt is believed to have been removed for the construction of the larger stock-pond and reservoir dams, and irrigation canals; it may or may not have been removed from the ground surface beneath the smaller ponds and reservoirs, but it is shown as absent.

Stream-deposited silt that contains a considerable amount of organic material may become more dense by compression as well as by compaction. The particles of carbonaceous matter, which cause the dark color of the sediment, are generally derived from the partial decomposition of vegetation. The particles have an open structure and can be compressed, or squeezed, to a smaller volume by the addition of weight; this compression of the organic matter permits the adjacent earth particles to rearrange into a more compact structure. The more organic material contained, the more compaction and settlement that may take place, and because of natural variation in the original material, settlement is uneven.

FACTORS OF COMPACTION

The presence of windblown or organic silt does not necessarily mean that the ground surface will subside by compaction. Several factors such as the present compactness of the silt, the moisture content, the thickness of the layer, the amount of organic material contained, and the weight of the load per unit area on the material mainly determine whether compaction, and thus subsidence, will occur.

TIME OF COMPACTION

It is not generally possible to predict exactly when compaction may occur. Depending on the factors mentioned above, compaction may occur soon after construction, or several to many years later. However, it is most expectable in house construction within the first few years after construction, and most likely during spring or summer within a few years after lawns are planted. A seeming delay in compaction may be an expression of the time required for enough lawns to be started in the area so that saturation takes place beneath foundations. Once compaction has begun, it may soon be completed, or it may be only partly completed and additional compaction may occur at a future time.

AMOUNT OF COMPACTION

The amount of compaction possible at a site cannot be predicted accurately, but its approximate amount may be inferred from tests on samples from the locality. Because the total amount of compaction that can occur is related to the thickness of the deposit at the site, and because these deposits are thin in the Golden quadrangle, the expectable compaction ranges from a fraction of an inch to a very few inches.

DAMAGE FROM COMPACTION

Subsidence, when it does occur, is generally uneven and so differential settlement may occur over an area as small as a house. The uneven settling can cause twisting or wrenching, which is commonly expressed in a building by sticking windows, jammed doors, and cracked walls, ceilings, floors, and foundations. If subsidence is severe, one part of a building may be displaced several inches in relation to an adjacent part. A building designed to withstand such disturbance may be virtually unaffected if the settlement is minor; built-in means of adjustment are not uncommon, although correction may be somewhat expensive. Structural difficulties in buildings similar to the difficulties caused by compaction may also be caused by landsliding, expansive clays, and subsidence caused by underground mining excavations.

RELATION TO PLANNING

Because windblown and organic silt may compact or compress, the potential hazard of these materials should be considered in land-use planning and in the design of construction to be placed on or immediately adjacent to deposits of them. If either material is present at a site, foundations can be designed to transmit the load to more competent material below the compactible deposits, or the deposit may be removed, or it may be replaced with a satisfactory fill.

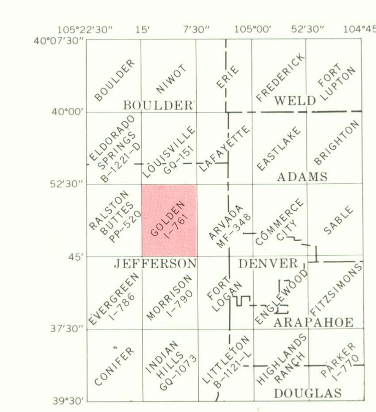
If a fill is carefully engineered, it may be possible to produce a satisfactory result using potentially compactible earth materials. Engineering a fill generally can prevent compaction and can promptly provide near-maximum stability for foundations. The advice of a soils engineer is recommended before acquisition of land and design of construction; he may approve use of a loose earth material in an engineered fill, perhaps mixing it well with other, more stable, materials. Note that although surface depressions are commonly filled in order to obtain a better landform for development, such filling is not necessarily engineered. As both windblown silt and organic silt are useful for landscaping, they may be used elsewhere on the construction site, or they may be sold.

BACKGROUND INFORMATION

Areas of windblown silt and organic silt shown on this map are compiled mainly from a geologic map prepared by Van Horn (1968) and an engineering geologic map by Gardner, Simpson, and Hart (1971), with minor modifications and additions, text, and explanation by Howard E. Simpson, in February 1972. The publications are listed below.

Gardner, M. E., Simpson, H. E., and Hart, S. S., 1971, Preliminary engineering geologic map of the Golden quadrangle, Jefferson County, Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-308 [1972].

Van Horn, Richard, 1968, Preliminary surficial geologic map and materials test data of the Golden quadrangle, Jefferson County, Colorado: U.S. Geol. Survey open-file map.



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OF GOLDEN QUADRANGLE