A GUIDE TO SWELLING SOILS FOR COLORADO HOMEBUYERS AND HOMEOWNERS

By David C. Noe, Candace L. Jochim, and William P. Rogers

Colorado Geological Survey
Department of Natural Resources
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ACKNOWLEDGMENTS
INTRODUCTION
This book replaces two older publications from the Colorado Geological Survey: Volume 1, 1979 (Special Publication 1) and Thursday, December 21, 1977 (Special Publication 14). The book contains a wealth of information about sedimentary rocks and how they can be used for understanding and interpreting ancient environments. It is intended for geologists, educators, and anyone interested in learning more about sedimentary rocks and their significance.

Chapter 7 in a step-by-step guide to interpreting special characteristics of sedimentary rocks. The chapter begins with an overview of the six characteristics that are covered in the summary, important concepts for rock players, and how to find the best place to start. The remaining chapters are arranged in the same order as the seven chapters that are covered in the summary, with an emphasis on practical applications and examples.

Part II is a more extensive guide to sedimentary rocks. Please read Part II to learn more about these topics.

Prospective photographers should follow this guide to help maximize the long-term viability of their home and their investment. The book also includes appendices, important terms, and a detailed index. This book is divided into two parts; Part I contains the text, Part II contains the appendices.
SUMMARY OF CHAPTERS 1-5

PART I
The Geology of Swelling Soils

Summary of Chapter 1

Colorado Geological Survey

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The soil resting pressure of the surf and line of the geologic formations can occur and the whole of the soil's density, the amount of moisture in the type and concentration of mineral how much a soil can swell, including

There are many factors that control swelling characteristics of certain soils. Swelling clayey soils have extremely high swelling properties. Swelling has been weathered to clay. The type of pure volcanic ash that soil strata may have extensively high swelling susmousely with swelling.

Swelling is a term that is often used synonymously with "swelling" and "expansive".

Swelling soils to include both soil and bedrock, and builders use the term "Swelling" to describe the behavior of their soils when they dry. The clay minerals that exist and absorb swelling soils and bedrock.

Swelling can be a result of the effects of swelling, and bedrock.
Subsurface moisture impacts and its effect on soils. Reducing the accumulation of subsurface moisture and controlling swelling soils damage is one of the most important means of controlling swelling soils damage. Soil swelling, and many causes inflate land development plans. The increase in soil moisture follows a decrease in subsurface moisture. Subsurface moisture is a deeper zone of subsurface moisture in the ground, and can significantly increase the amount of urbanization and land development. Moistur and temperature changes start and alter as a result of seasonal ground will alter mutually become wet. Under natural conditions, shallow in shrinking, swelling, while a decrease will result in increase in moisture will result in effect on swelling soil behavior. An increase in subsurface moisture has a major role.
Construction on Swelling Soils

Starting on p. 29, it is important to learn more about... See Chapter 3 and Figures 12-29.

House foundation influences the ground, next to the... reducing the amount of water that percolates through the soil, leading to shrinking and moving relative to other parts with minimal damage, and/or... deixing certain parts of the structure, along with the weight of the house onto pads or piers... reducing the swelling potential of the soil, concentrating the load of the house onto pads or piers... be greater: lowering reducing the swelling potential of different ways. They may vary from one to another... Basic swelling soil designs work in a number of different ways. They may vary from one to another... Special designs and construction...
LANDSCAPING ON SWELLING SOILS
(SUMMARY OF CHAPTER 4)

- Many conventional landscaping practices (such as planting bluegrass lawns, trees, and gardens near foundations) are not recommended for areas of swelling soils because they contribute excess water to the soils (refer to Figs. 30 and 31, p. 48 and 50).

- There are some simple landscaping guidelines that should be followed in order to reduce swelling soil problems. The sloped area immediately adjacent to the house is an especially critical area for landscaping (refer to Fig. 34, p. 53).

- Irrigation should be limited to the amount necessary to maintain vegetation. This applies to all portions of your yard. Excessive watering, even with good drainage, drives water into the soil and increases the likelihood of swelling soil problems.

- Xeriscape™ landscaping is an attractive and cost-effective way to reduce swelling soils activity and conserve water. Other advantages include lower maintenance and less mowing.

- Xeriscaping makes use of many types of water-wise plants, and can include use of rock and organic mulches (refer to Figs. 32 and 33, p. 51 and 52 and Table 1, p. 52). The possibilities for creating a pleasing and effective Xeriscape are endless.

- There are numerous sources for information and ideas when it come to Xeriscaping. Some of these are listed in “Information Sources”, p. 76.

- See Chapter 4 and Figures 30-34, starting on p. 47, to learn more about landscaping on swelling soils.
SUMMARY OF CHAPTER 5

HOME MAINTENANCE ON SWELLING SOILS

This is one of the most important chapters. It is written to help prevent a house from being damaged by swelling soils and reduce potentially costly repairs. Homeowners should routinely inspect and maintain all of the different systems that were designed to prevent the house from swelling soils. Chapter 5 and Figures 35 and 36 explain how swelling soils can contribute significantly to conditions that cause swelling soils damage. Conversely, the lack of proper maintenance of the house drainage system and surface drainage, slopes, and landscaping will increase the potential for swelling soils damage. Proper maintenance of the house and landscape can help prevent a house from being damaged by swelling soils and reduce potentially costly repairs.
Summar of Chapter 6
SWELLING SOILS AND HOMEOWNER RISK

- A report should include the swell
  project, draw a summary of soils
  report for each lot or area. A summary
  should include a summary
  requirements in Part 1 of the statute:
  Colorado Geological Survey Book 1
  soils report for a potential buyer.
  This
  hazards, including swelling/expan-
  soil, the potential may be seen as "significant".
  for determining "significant" potential
  requirements in Part 1 of the statute:
  Colorado Geological Survey Book 13 (1984), C.R.S.
  Colorado Senate Bill 13 (1984), C.R.S.

- This information
  homebuyers should not rely solely on
  real estate broker. However, the
  any known damage or defects must
  of potential soil conditions as well as
  homeowners by the builder. During
  information must be furnished to a
  swellling soils because a new house
  Under Colorado law, the presence of
  report, "the swell..."


Swelling soils and homeowne risk.

See Chapter 6 and Figure 27, starting on p. 61, to learn more about

The final decision to purchase a house when you are thinking of buying a home.

Section 6.1 considers factors such as location and cost

factors such as location and cost

Swelling soils should be considered.

potentially severe of swelling soils

The design of the house should be

potentially severe of swelling soils

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Designs for houses are based on the

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Recommended

Recommendations.

According to the soil's building

Determining the site's building

use by the builder or developer in

site should be the most specific informa-

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meantations given for the subject

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SWELLING SOILS

GUIDE TO

PART II
Swelling Soils and Swelling Bedrock

Chapter 7

The Geology of Swelling Soils and Swelling Bedrock

Swelling Soils

Swelling Bedrock

include swelling bedrock. The difference is that
soils, they are using a Review form that may
when exogenous to rock layers, such as soil and bedrock.
beomorphs, however, can dissolve, shrink, and swell
are also called expansive shrinking and swelling.
get wet and shrink when they dry (Fig. 1). They
result. These materials swell in volume when they
nutrients that can attract and absorb water as a
Swelling soils and swelling bedrock contain clay
between clay plates to collapse on a microscope.

When heat and water are added to the clay particles, these collapsed clay plates redisperse and re-adhere to each other, thus creating a new soil composed of much smaller clay plates. This process is known as swelling.

The presence of water in clay soils can cause their volume to increase significantly.

When swelling occurs, the soil volume increases and the hydraulic conductivity decreases, leading to a decrease in permeability.

Swelling and Shrinking Behavior

Swelling and shrinking are common clay properties that can significantly affect the behavior of soil under different conditions.

High-swelling clays can cause significant changes in soil properties, including changes in porosity, permeability, and shear strength.

In engineered structures, such as roads, swelling clays can lead to significant deformations and failures.

In soils, swelling and shrinking can lead to differential settlements, which can cause structural damage.

In conclusion, understanding clay behavior is crucial for designing and constructing structures in areas with clay soils.

Figure 1: Example of swelling and shrinking behavior in soil.
Swelling potential and swelling pressure are two measurement methods of a soil's ability to expand against different restraining pressures under laboratory conditions. Soils are typically rated as having either very high, very high, high, moderate, low, or no swelling potential. Swelling Pressure is the pressure exerted by the soil mass against a restraining force when it is wet. Typical swelling pressures for expansive soils in Colorado can range from 1500 pounds per square foot. Soils having such high swelling pressures are capable of causing up to 15 inches of movement in columns 1 foot wide, with the top 3 feet being most affected. Consequently, expansive clays and clays with swelling potential are factors in the failure of many construction projects. Expansive soils that contain kaolinite or montmorillonite, are most common in areas such as the Front Range and Eastern Slope of Colorado.

The swelling potential of clays is dependent on the clay mineralogy. Common expansible clays include montmorillonite, beidellite, and vermiculite. These clays have a high swelling potential and can cause significant problems in construction. Other clay minerals such as kaolinite and illite have lower swelling potentials and are less likely to cause problems.

1) Type of clay minerals. Montmorillonite is the most common type of clay mineral that causes swelling in expansive soils in Colorado. Silt and clay minerals that contain relatively stable clay minerals such as quartz or feldspar, usually have no swelling potential.

2) Water content. As the water content increases, the swelling potential of the soil increases. This is because the water molecules can enter the soil particles and expand them, leading to swelling.

3) Stress level. The swelling potential of a soil is also affected by the stress level. Higher stress levels can cause the soil to swell more, as the soil particles are more closely packed together.

4) Outdoor exposure. Outdoor exposure can also affect the swelling potential of a soil. Outdoor exposure can cause the soil to dry out, which can decrease its swelling potential.
Colorado Geotechnical Survey

Figure 4. Explanation


Figure 4. Explanation


Figure 4. Explanation


Figure 4. Explanation


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Figure 4. Explanation

Figure 5: Example of a map showing local distribution of swelling soils at the ground surface. (a) Swelling soils of the swelling potential map; (b) High swelling clay; (c) High swelling loam; (d) High swelling silt; (e) High swelling sandy loam; (f) Flooded area; (g) Low flooding area; (h) Moderate flooding area; (i) High flooding area; (j) Very high flooding area.

The figure shows the distribution of swelling soils in Colorado, as per the Colorado Geological Survey. The map highlights areas prone to swelling soils, which can lead to significant landslides and other geological phenomena. The figures (a) to (j) illustrate different levels of flooding and swelling potential across the study area. The map is a valuable tool for understanding and managing geological risks in the region.
Special Publication 43
Steeply dipping bedrock layers, each having a different swell, may occur due to a variety of causes, including:
- The mechanical resistance of the bedrock layers
- The gravitational pull of the earth's surface layers
- The presence of water-saturated zones
- The occurrence of earth movements
- The movement of the earth's crust
Figure 6. Different types of heaving bedrock: (a) Jyn-"
"metric heave feature caused by uneven swelling of
individual bedrock layers; (b) Asymmetric heave
planes and/or fracture surfaces. (Modified from New
features caused by shear slip movement along bedding)

Friction
Bedding
Chapter

Moisture

Subsurface
Types of Subsurface Moisture

Soils are typically dry during much of the year, and the near-surface water are characterized by an overall depth of water is a result of the lower-evaporation rates of the area (1929).

The surface evaporation rates vary throughout the year, with May-October showing the highest values, followed by February, January, November, and December. Therefore, the precipitation in the 16 inches per year area is low for the major population areas. Most of Colorado's soil types are made up of loess, which are formed by wind erosion and deposition. The mountainous areas of Colorado usually have

Evaporation or ET loss.

the cumulative effect is called evaporation.

Evaporation is the process by which water is lost by dripping and evaporation by evaporation due to heating and drying. Evaporation through infiltration can also occur if the ground water rises to the ground level. Water that falls from the

hydrologic cycle (Fig. 10).
Swelling Soils
Moisture Affects How Subsurface Water Moves

The presence of subsurface moisture can cause problems, disturb the ground, and lead to additional issues like erosion and subsidence. Proper management and understanding of moisture content in soils are crucial to maintaining the stability of buildings and structures. The soil's ability to absorb and retain water affects its behavior and the potential for swelling. Understanding the moisture content and its impact on subsurface water levels is essential for addressing issues like foundation movement and structural integrity.
SHRINKING SOILS

Droughts and

Colorado is subject to occasional periods of drought. During a drought, evapotranspiration will exceed water infiltration, and the active zone beneath the soil may dry out. Swelling and shrinking soils will pull large cracks into the soil. Additional damage due to near-surface settlement may occur during colder periods of swelling. Additional cracking may occur if the freeze-thaw cycle reduce the amount of water in the soil and change the direction of freezing and thawing. This may increase the number of cracks and create sinkholes. Where sinkholes are present in the soil, the soil may swell and cause damage to houses, roads, and other structures. Susceptibility to swelling can vary depending on the type of soil and groundwater levels. Areas of swelling soils should be avoided in construction, landscaping, and building design. Susceptible soils include clay, silt, and other fine-grained materials. The swelling behavior of these soils can cause significant damage to structures and infrastructure. Effective management practices include maintaining proper drainage, avoiding excessive water infiltration, and using appropriate construction materials and techniques.
Chapter 3

Swellling Soils

Construction On

This chapter describes the advantages (and some
Ground Preperation

shown in this chapter. However, many of these are not described in detail. Other chapters are generally

The design and construction of a house and its

The effectiveness of any particular method

The potential solutions to these and similar issues, including the installation of measures and advice, are considered

The potential solutions to these and similar issues, including the installation of measures and advice, are considered

The potential solutions to these and similar issues, including the installation of measures and advice, are considered

The potential solutions to these and similar issues, including the installation of measures and advice, are considered
The foundation of a typical house consists of a shallow, concrete foundation slab. The slab is poured on the ground and extends beneath the house to provide support and protection. The foundation is typically made of reinforced concrete to ensure durability and stability. The design of the foundation should account for the soil conditions and the loads imposed by the structure.
Shallow Foundations

Shallow foundations are discussed in the following paragraphs. These foundations are commonly used in different foundation types, especially in soils that are unsuitable for other types of foundations. Shallow foundations are suitable for use in many areas of California where the soil is relatively dry and does not require deep foundations.

Special Publication 43
Colorado Geological Survey

A well-on-grade foundation (Fig. 1) consists of a continuous foundation wall that extends directly on the soil. The well walls are a monolithic pressurized foundation wall. The foundation wall may be an appurtenant foundation wall that extends very low by the grade beam and pads. The loads are supported by the grade beam. The load of the house is supported by the grade beam, a steel-reinforced concrete, or reinforced concrete slabs or piers. The concrete slabs and podiums are supported by a steel-reinforced monolithic pressurized foundation wall. The foundation wall may be a steel-reinforced concrete, or reinforced concrete slabs or piers. The foundation wall may be a steel-reinforced concrete, or reinforced concrete slabs or piers. The foundation wall may be a steel-reinforced concrete, or reinforced concrete slabs or piers.

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Deep Foundations

Basements are underground structures that are used to support buildings. They are often used in cold climates where the ground is frozen during winter months. Deep foundations are designed to transfer the load of the building to the underlying soil, which may be made of rock, sand, or clay. This helps to stabilize the structure and prevent it from settling or moving.

In areas of steeply dipping bedrock, where the bedrock is not suitable for construction, drilled pier foundations are used. These foundations consist of a series of vertical reinforced concrete piles that extend down into the bedrock and transfer the load of the building to the bedrock below.

The depth and diameter of the piles are determined by the load of the building and the properties of the soil below. The piles are usually cast in place and the concrete is reinforced with steel bars to provide additional strength.

Deep foundations are commonly used for large commercial buildings, such as warehouses and factories, as well as for high-rise buildings. They are also used for bridges and other infrastructure projects.

Deep foundations are expensive to build, but they provide a stable foundation that can support heavy loads. They are often the only option for building on difficult sites, such as steep slopes or marshy areas.
Figure 16. Three types of drilled piers commonly used:

- **Foundation Wall**: Lateral Support for Foundation Walls

A foundational system that resists lateral pressures and supports the structure. It is designed to prevent movement or lateral displacement of the building.

**Sheet Pile Walls**: Steel bars or beams of varying degrees of depth, which are designed to resist lateral forces. They can be constructed using various materials such as steel, concrete, or timber.

**Concrete Piers**: Prefabricated concrete piers that are driven or drilled into the ground to provide a stable foundation.

- **Foundation Requirements**: The foundation should be designed to resist the lateral forces and provide a stable base for the structure. It is crucial to consider the soil conditions and any potential for movement or settlement.

**Drilled Piers**: Types of drilled pier configurations are:

- **Nail**: Drilled piers with nails or bolts for added stability.
- **Beam**: Drilled piers with beams for additional support.
- **Column**: Drilled piers with column-like structures for increased load-bearing capacity.

These piers are typically used in construction to ensure the structure's stability and longevity.
Floor and crawl space.

Figure 12. Two types of basement floor systems. (E) Continuous slab (floor, in structural earth).

**Floor Construction**

Floor of each floor type follows.

- When footings are not used, a short deck may be left for aesthetic consideration in cases where footings are not needed. A short deck is especially in the form of a basement/attic/loft.
- Systems are used for basements in many areas.

The inward view shows exposed soils that have mud and gravel.