

# COEXISTING WITH EXPANSIVE SOIL

*An Informational Guide for Homeowners*



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## OVERVIEW

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Homes in California are built on a variety of soil types with differing characteristics that can affect homes and surrounding improvements in different ways. So called expansive soils are particularly noteworthy because they can cause significant property damage, if not properly addressed. Clayey soils can swell and exert thousands of pounds of force as they absorb water from irrigation, rain or other sources---enough to lift buildings and crack concrete. Other potential effects around homes may include lifting and cracking of patio slabs, tilting and cracking of walls, and lateral displacement of improvements towards slopes. You can determine if your property has expansive soils from your home buyer's disclosures, the local building department, or geotechnical professionals (soil engineers and geologists). If your property has expansive soil, there are important things you should know in order to properly maintain your home and associated improvements – and to properly construct any additional improvements you may want. To begin, you should:

- Become familiar with how expansive soils behave;
- Maintain good drainage on your property;
- Practice consistent and measured landscape irrigation;
- Inspect your yard and improvements frequently for maintenance items;
- Repair broken irrigation and plumbing leaks promptly;
- Keep concrete cracks and joints sealed to reduce water infiltration;
- Consult with qualified geotechnical professionals when making changes or improvements to your home;
- For new construction, incorporate design and construction measures that will mitigate potential expansive soil effects to a degree that is acceptable to you;
- Hire licensed contractors that have experience with expansive soils;
- Note that additional construction costs associated with addressing expansive soil may be small relative to the costs required to repair damaged improvements at a future date.

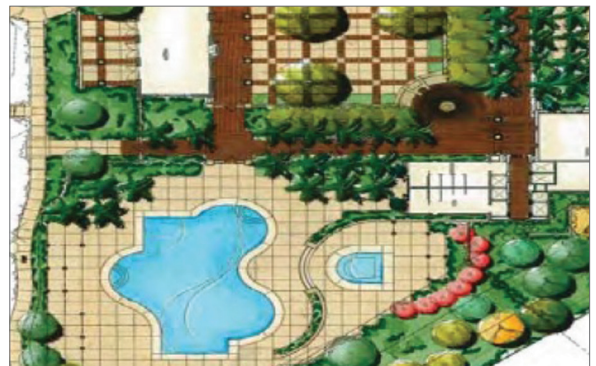


If you are reading this booklet, your home may be constructed on expansive soil (sometimes referred to as swelling or heaving soil). Your home buyer's disclosure document will typically address this issue. You can also check with the local building department and a qualified geotechnical professional. They will usually know if expansive soil is found in your area. Because it is common, building codes have specific requirements for new homes and other improvements constructed on expansive soil.

You should read your home buyer's disclosure documents and this booklet to make sure you know the important considerations regarding the design, installation and maintenance of improvements on your property. This information can help you avoid costly and frustrating experiences with expansive soil. This is a publication prepared by some members of the California Geotechnical Engineering Association, so the information about expansive soil and the measures taken to reduce its impacts may be particular to California but in many cases the general principles will apply regardless of geographic region. This guide will help you understand some of the basics about expansive soil. However, it is not intended to be a substitute for consultation with a qualified geotechnical professional to evaluate your specific property. The basic expansive soil issues you should be familiar with include:

- Its nature and behavior
- How it can affect your home and other improvements on your property
- Principles for designing and constructing landscaping, patios, pools, etc.
- Proper maintenance practices, and
- Reasonable performance expectations for home improvements.

If you are embarking on a home improvement project, make sure your project team (architects, engineers, and contractors) is aware of issues associated with expansive soil.



## WHAT IS EXPANSIVE SOIL?

An expansive soil is a clay-rich soil that swells or shrinks when its moisture content increases and decreases. Certain clay minerals in soil have an affinity for water and can absorb large amounts of water. When they do, they can increase in volume (swell). The opposite is also true - as they dry and lose water, they decrease in volume (shrink). Clayey soil can crack as it dries. Vertical and/or horizontal ground movement can occur when significant changes in moisture levels occur in expansive soils. Soils have varying amounts of expansion potential depending on the type and amount of clay that they contain. Geotechnical professionals usually classify soils as having very low, low, medium, high or very high expansion or swell potential according to guidelines in building codes. There are specific laboratory tests to evaluate a soil's expansion potential.

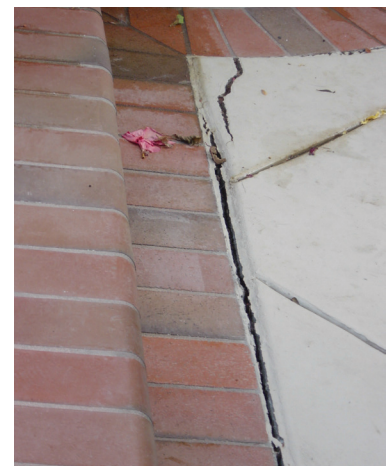


### EXPANSIVE SOIL BASICS:

- Some amount of ground movement is unavoidable when expansive soils are present.
- Most movement typically occurs within the first few years of any changes in construction or improvements to the site (such as changes in landscaping) until soil moisture nears or approaches equilibrium.
- Some longer term cyclical soil movement may continue to occur in response to seasonal changes in soil moisture.

There are several general types of ground movement associated with expansive soils that can affect a property. These include heave, settlement, and lateral movements near top of slope areas. It is often difficult to differentiate between ground movement caused by expansive soil and other soil phenomena.

**Heave.** The forces exerted by swelling expansive soil can be large. Builders attempt to design and construct house foundations such that they are strong enough to accommodate expansive soil movement with little adverse effects. Minor cracking and cosmetic distress can still occur with properly designed structures. Swelling soil can also cause other improvements around a home - such as driveways, patio slabs, walls, and pools to lift, tilt, or move laterally. If excessive, these types of movements can be aesthetically objectionable. If pools and spas are not designed to accommodate expansive soil, they may crack or plumbing may be damaged and leak. This can cause additional soil wetting and possibly even more heaving.





**Settlement.** As expansive soil dries out, it will shrink. If it shrinks enough, the ground surface may drop perceptibly. Supported improvements may also drop or tilt and develop cracks or separations. This type of ground movement may also displace improvements laterally, resulting in cracks or gaps at joints.

**Top of Slope Movements.** Properties located at the tops of slopes that have expansive soil will undergo lateral and vertical soil movements when the soil swells or shrinks. One type of movement is referred to as Lateral Fill Extension (LFE). LFE will occur when soil moisture levels increase following the grading of a slope. As the soil absorbs moisture, it expands. This expansion is accommodated by ground movement in the direction of least resistance. Away from slopes, the primary direction of ground movement will be upwards (heave). However, closer to the slope, the direction of movement will largely be outwards towards the face of the slope. The lower amount of heave along the top of the slope is often mistaken as settlement.



The lateral movement near the tops of slopes will often displace improvements in that area; patio slabs may develop gaps where they meet the house; columns for patio structures may develop a “lean” if the tops are attached to the home; gaps may develop around the perimeter of pools; and the construction joints in side yard walls may get wider in response to this type of ground movement.

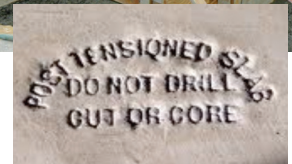
Another type of movement associated with expansive soils and slopes is called slope creep. Slope creep can occur along the face of a slope and within a short distance back from the top of the slope. With slope creep, seasonal or other cyclic wetting and drying of the near surface soils causes those soils to creep slowly down slope under their own weight. Distinguishing between the effects of slope creep and LFE is sometimes difficult. Slope creep can be reduced by maintaining uniform soil moisture levels.

As noted previously, there are many mechanisms unrelated to expansive soils that can cause ground movement and related distress. A site specific assessment by a geotechnical professional, structural engineer, or other construction professional may be necessary to identify the cause(s) of any observed distress.

## WHAT IS DONE TO REDUCE EXPANSIVE SOIL PROBLEMS DURING CONSTRUCTION?

Land developers and home builders take a number of measures during site grading and home construction to reduce the impacts of expansive soil. Some of these measures are required by local and national building codes while others are based on local experience and the recommendations of the design team. Here are a few examples of such measures:

- During grading and construction, water may be added to soil to reduce its potential for absorbing large amounts of water after a home is completed. This reduces its swelling potential.
- Residential lots are typically designed and graded to direct surface runoff water away from the perimeter of the home, away from slope areas, and toward suitable drains or gutters.
- Foundation and floor slab systems are designed and constructed to be rigid enough to accommodate expansive soil movements without significant damage.
- Homes are set back from the tops of slopes in accordance with building code requirements to reduce the effects of LFE and slope creep on those structures.
- Walls and other improvements at the tops of slopes may have deepened foundations, heavier reinforcement, and/or joints and connections to accommodate movement.



## WHAT CAN HOMEOWNERS DO TO REDUCE PROBLEMS FROM EXPANSIVE SOIL?

### **Maintenance**

Proper maintenance of both developer-installed and homeowner-installed improvements is a key to reducing expansive soil related problems. Homes and improvements on expansive soil must be maintained regularly. Some improvements will require periodic repairs to keep up their appearances and performance.

### IMPORTANT MAINTENANCE PRINCIPLES RELATED TO EXPANSIVE SOIL:



- A. Water your yard in moderation but also consistently. To avoid significant changes in soil moisture, you will likely need to water more in dry times and less in wetter seasons. Don't turn off your irrigation, if you are going to be away from home for an extended time, especially during dry weather.
- B. Repair water leaks and breaks in irrigation systems, plumbing, pools and spas promptly.





- c. Verify that properties adjacent to your lot, especially slopes that are owned by others (e.g., city, association, or neighbor) are properly maintained and irrigated. Notify the owners of those properties if you identify issues that may adversely affect your property.
- d. Keep water away from places it normally does not belong. For example, if gaps or cracks in patio slabs or pool decks develop, repair or seal them promptly to reduce the potential for water infiltration.

e. Maintain proper drainage on your property. Don't let water flow to, or collect in places where it can cause soils to become overly wet. Don't modify the ground level or surface drainage pattern at your property without consulting a knowledgeable construction or design professional. Make sure drain inlets are at, or just below, the ground surface level so water can flow into them.

f. Inspect your property and improvements for the effects of expansive soil frequently and perform maintenance as needed. Pay particular attention to areas near slopes, perimeter walls (including walls shared with others) and connections where wall types change. For instance, gates, and connections between wrought iron fence and masonry wall will periodically need adjustments. If you are unsure of what to look for or if you notice something particularly concerning, consult a qualified professional for advice.



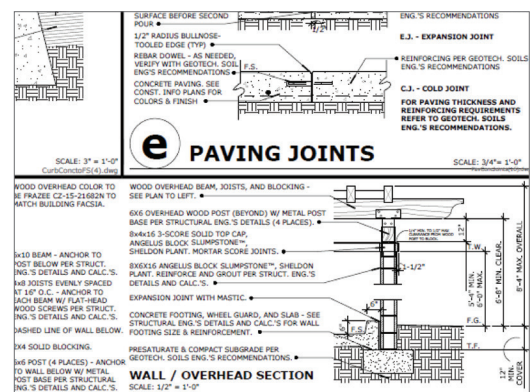
NOTE: Even with proper maintenance, the effects of expansive soil cannot be totally eliminated. You should expect some amount of periodic (and seasonal) adjustment, repair and/or replacement of the affected features.

## NEW CONSTRUCTION

If you hire people to assist you with an improvement project, we recommend that you verify they are properly licensed (also bonded if contractors). In California, pool and landscaping contractors are required to be licensed. Professional and contracting licenses can be checked via the internet in California and other states. When installing exterior improvements at a property with expansive soils, precautionary measures should be taken during both the design and construction phases of the project.

### 1. Design Measures:

Depending on the complexity of your project, you may need to consult with a professional who is familiar with expansive soil and methods to reduce the potential problems associated with it. The designers and contractors you enlist should be qualified and experienced with building on expansive soils. Many building departments require a licensed geotechnical engineer to be involved in the design and construction of such things as pools, retaining walls, and house additions. Addressing some of the principles may determine how well your improvements perform.



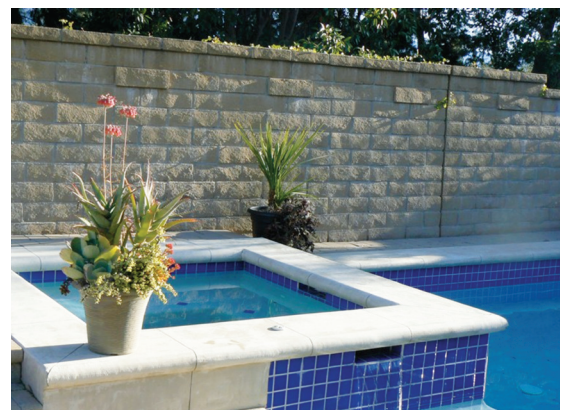
**Keep in mind that:**

- A. Some amount of ground movement should be anticipated when designing improvements on expansive soil. You should consult with a geotechnical engineer – and other design professionals, as necessary – to determine the pattern and amount of ground movement that is expected, in order to ensure that the improvements will perform in an acceptable manner under those conditions.
- B. Ground movements associated with LFE and slope creep will be greater near the top (edge) of the slope. Keep sensitive and costly structures like pools, spas, home additions, and barbecues islands as far away from the top of the slope as possible. As they get closer to the slope, more rigorous measures against expansive soil movement will be required in their design and construction. Most building codes provide minimum set-back guidelines for structure foundations and pools constructed adjacent to slopes. Additional precautions are typically necessary for any improvements that are to be constructed within slope set-back zones.



- C. Expansive soil forces on improvements like patio slabs, pools, and decks can be very large. Reinforcing, strengthening, and connecting (or purposely disconnecting) such improvements must be carefully considered.
- D. Some tilting of pools located in slope areas is likely to occur over extended periods of time. Pool shells should be designed to accommodate this movement. The trim and other detailing around the perimeter of the pool should be designed to accommodate the expected movement.

- E. Trees and similar vegetation with large root systems will draw moisture out of the soil, resulting in soil shrinkage and ground settlement. Foundations and other improvements next to such landscaping can be affected. Consult a landscape architect familiar with expansive soil issues before installing exterior landscaping.
- F. Large sections of continuous flatwork extending back from top of slope areas should be avoided. Sections of properly reinforced flatwork should be separated by landscaping zones, joints, or other architectural features to accommodate movement in an aesthetically acceptable manner.
- G. Existing walls and fences may not be designed as retaining walls. Placing additional soil behind retaining walls, or against non-retaining walls, may cause them to move or even fail. Ensure that excess soil generated from your project will be placed in appropriate area or disposed of offsite.





## 2. Construction Measures:

A proper design is of little value if it is poorly executed. The following guidelines apply to the construction phase of home improvement projects:

- A. Be sure to hire contractors that are licensed, qualified, conscientious, and understand expansive soil issues. Make sure you have a written contract which clearly defines the contractor's scope of work, costs, and other terms of your agreement. Verify that specific and appropriate measures have been taken to mitigate the effects of expansive soils.
- B. Don't let expansive soils dry out before or during construction. The soils can be covered with plastic or wetted prior to construction, as necessary, to ensure proper moisture. In some cases, pre-wetting for extended periods of time (days or even weeks) may be necessary. Generally, however, pre-wetting should only be done in consultation with a geotechnical professional. Fill placed during construction should have proper moisture content and compaction. Pre-wetting of soils is particularly important where patio decks abut swimming pools. Without proper ground preparation, a patio deck supported on the ground surface is likely to heave more relative to a pool shell supported at a greater depth.
- C. Trust but verify. Don't assume that the local building inspector (if involved) will look at everything. For many projects, you should consider hiring a professional to provide independent verification that the mitigation measures related to expansive soil are being properly carried out by your contractor.



Examples of other design measures and practices that address expansive soil are provided in the appendix at the end of this booklet. Unfortunately, building on expansive soil may increase construction costs. However, these costs are normally much less than the maintenance and repair costs for projects that are inadequately designed or constructed. How far you go and what measures you decide to take depend not only on your budget, but also on your architectural choices, your tolerance for the effects of expansive soil such as tilting, gaps and cracking, and your expectations for future maintenance and routine repairs.

### LIVING WITH EXPANSIVE SOIL

Too many homeowners are unaware of the nature of expansive soil and potential issues resulting from this phenomenon. Since the effects of expansive soil cannot be totally eliminated, homeowners should set realistic expectations regarding the performance of improvements constructed on this type of ground. This, along with good maintenance, can alleviate many issues. With the assistance of knowledgeable, competent design professionals and contractors, new improvements can be constructed to reduce the problems that will inevitably arise if expansive soil issues are not considered. You should consult such a professional, including a qualified geotechnical professional, in order to analyze the issues and properly design your improvements.

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## APPENDIX

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### DESIGN AND CONSTRUCTION IDEAS FOR EXTERIOR IMPROVEMENTS

The following are some selected examples of measures that may help reduce the effects of expansive soil. Whether a particular idea or concept is right for your case will depend on many factors such as how expansive your soil is, who is doing the construction, your budget, aesthetics, and your expectations and tolerances related to the effects of expansive soil. Consult with a professional engineer, architect, and/or licensed contractor as well as your local building department when considering improvements on expansive soil.

#### ***Patio and Pool Decks:***

Reinforcing steel bars within concrete slabs are generally recommended to strengthen the slabs against cracking if heave or settlement occurs. Such reinforcing as well as steel dowels (bars inserted across a joint where two distinct hard improvements join) can help to prevent both horizontal and vertical separations at joints and slab cracks.

Control joints should also be used to allow separations along the joints rather than cracking within less desirable areas of slabs (less visual impact). Large continuous sections of flatwork should be avoided near top of slope areas. Planters, open areas, or other features should be provided between flatwork sections to accommodate lateral ground movement without significant visual impact.

Steps may be constructed by overlapping slabs with a slip sheet between them rather than building all the steps as one interconnected feature. This can help to accommodate potential lateral movements and allow individual steps to move independently of other steps, thereby reducing the potential for unsightly cracks and separations.

Consider using interlocking concrete paving stones (no grout) rather than concrete slabs for patio flatwork - or incorporate bands of these pavers between areas of concrete or other continuous decking. The pavers may shift when expansive soils move but can be reset and adjusted relatively easily if movements are more significant.

#### ***Walls and Fences:***

Fencing such as wood or wrought iron which are more tolerant of movements may be considered. Connections to other hard surfaces such as other walls or structures (including the house) should be carefully thought out. Often, these connection points will be stress points as the walls moved by expansive soil forces. Purposely allowing for movements at these points can limit unsightly cracking or breakage. Special connections can be incorporated that allow for movements yet mask the visual effects of such movements (like slip joints). As mentioned in this guide, deeper foundations for walls (sometimes piles) may reduce the potential for leaning and tilting, especially near tops of slopes. However, some aesthetic impacts such as leaning and tilting should be anticipated.



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### ***Pools and Spas:***

Pools and spas near tops of slopes will tend to tilt and move laterally. The shells should be heavily reinforced and designed with expansive soil in mind. Consider using materials or tile patterns at the waterline that will mask the visual impact if the pool or spa shell tilts. As with other exterior structures, be careful when tying pools and spas into other hardscape. Design to accommodate movements and stressed at these points. Plumbing connections should be able to tolerate several inches of movement of the spa or pool.

### ***Shade Structures, Patio Covers and Elevated Decks/ Balconies:***

If such structures are attached to the house but also supported on the ground, the attached points should be designed to tolerate some movement of the structure if it is lifted or pulled by expansive soil forces. Alternatively, detaching the structure entirely from the house may avoid cracking of the area where the structure would have been attached. Consider tying column foundations together and also to the house foundation with buried concrete beams (grade beams) to resist the lateral movements. Alternatively, design columns and posts so they may be brought back to vertical if the foundations (bottoms) move laterally but the tops remained fixed.

### ***Outdoor Counters, BBQ Islands, Fireplaces, etc:***

These structures usually should have relatively stiff, isolated foundations. Since they will tend to move under the influence of soil, tile and stone work may crack or pop off if the structures are too flexible. Hard connections to other structures or hand improvements, such as the house or patio deck, pool coping, etc. should be avoided.

### ***Landscaping:***

Vegetation requiring less watering should be considered. Where more water loving varieties are planted, install liners and/or below ground collector drains in the planters to keep excess water from getting into deeper and/or surrounding expansive soil. Avoid constructing planters immediately adjacent to house foundations. Keep sprinklers away from foundations. Consider drip irrigation. Use automated irrigation system with timers that can be seasonally adjusted. Get professional advice tailored to your climate for recommended irrigation practices. Consider rain gauge monitored irrigation systems to prevent overwatering during the winter (home use products more recently have become available). Consider artificial grass. (New products are much more available than in years past).



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