## Section 12: Expansive Soils

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why are Expansive Soils a Threat to Polk County?</td>
<td>2</td>
</tr>
<tr>
<td>Expansive Soil Hazard Assessment</td>
<td>3</td>
</tr>
<tr>
<td>Hazard Identification</td>
<td>3</td>
</tr>
<tr>
<td>Vulnerability and Risk</td>
<td>3</td>
</tr>
<tr>
<td>Community Expansive soils Issues</td>
<td>4</td>
</tr>
<tr>
<td>Mitigation Plan Goals and Public Priorities</td>
<td>6</td>
</tr>
<tr>
<td>Expansive soils Mitigation Action Items</td>
<td>6</td>
</tr>
<tr>
<td>Expansive soils Resource Directory</td>
<td>11</td>
</tr>
<tr>
<td>Federal Resources</td>
<td>11</td>
</tr>
<tr>
<td>Additional Resources</td>
<td>11</td>
</tr>
</tbody>
</table>
Why are Expansive Soils a Threat to Polk County?

Soil is an essential component in the construction and stability of houses, commercial buildings, and other structures. Since structures are built on soil, structural damage to a structure can occur if the soil expands, contracts or slides. There are three basic types of naturally occurring soil: sand, silt and clay. Clay soils are generally classified “expansive.” Expansive soil is a soil that under some condition is capable of increasing its volume when wetted; normally, a soil containing expansive clay minerals.

Expansive soils and bedrock underlie more than one-third of Earth’s land surface. In the United States, these materials are prevalent in the Southern, Western and Rocky Mountain States. Expansive soils expand to a significant degree upon wetting and shrinks upon drying. Types of structures most often damaged from swelling soil include building foundations and walls of residential and light (one-or two-story) buildings, highways, canal and reservoir linings, and retaining walls. Lightly loaded one- or two-story buildings, warehouses, residences, and pavements are especially vulnerable to damage because these structures are less able to suppress the differential heave of the swelling foundation soil than heavy, multistory structures.

Predictions of heave with time are rarely reliable because the location and time when water is available to the soil cannot be easily foreseen. Most heave and the associated structural distress occurs within five to eight years following construction, but the effects of heave may also not be observed for many years until some change occurs in the foundation conditions to disrupt the moisture regime. It is important in the engineering context to determine the magnitude of heave and the procedures of ways to minimize distress of structures.

The effects of expansive soils can be dramatic if the soils’ supporting structures are allowed to become too wet or too dry. In 1982, a FEMA report found that expansive soils are the most costly natural hazard in the US, causing more damage than all other natural hazards combined, including earthquakes, floods, tornadoes and hurricanes.

Expansive soils are one of the nation’s most prevalent causes of damage to buildings and construction. Annual loses are estimated between $2 billion and $9 billion. Losses include severe structural damage, cracked driveways, sidewalks and basement floors, heaving of roads and highway structures, condemnation of buildings, and disruption of pipelines and sewer lines.

In Polk County, more than 162,000 acres contain soils with moderate to severe shrink-swell potential. Soils identified as
possessing moderate to severe shrink-swell potential are shown in Map 10.

Expansive Soil Hazard Assessment

Hazard Identification

All soils will change in volume with a change in moisture content. This is soils’ shrink-swell characteristic. Shrinking and swelling soils can lead to damaging foundations and structures. The change in volume is influenced by the kind and amount of clay in the soil. Expansive soils contain a high percentage of certain kinds of clay particles that are capable of absorbing large quantities of water. Soil volume may expand ten percent or more as the clay becomes wet. The powerful force of expansion is capable of exerting pressures of 20,000 pounds per square foot or greater on foundations, slabs or other confining structures.8

The items in Table 12.1 are signs to look for to determine possible expansive soil-related movement. The probability that a foundation has experienced some movement increases with the number of indicators observed, their frequency, and location in the structure.

Table 12.1. Indicators of Expansive Soil Movements.

<table>
<thead>
<tr>
<th>Exterior Indicators</th>
<th>Interior Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Diagonal (stair-stepping) cracks in brick walls.</td>
<td>• Cracks in sheetrock walls or ceilings.</td>
</tr>
<tr>
<td>Cracks may go through brick or mortar and vary in width</td>
<td>• Bowed or non-vertical walls.</td>
</tr>
<tr>
<td>• Sagging brick lines when sighting along a wall.</td>
<td>• Bottom of wall separating from floor.</td>
</tr>
<tr>
<td>• Bowed or non-vertical walls.</td>
<td>• Cracks at wall corners.</td>
</tr>
<tr>
<td>• Separation of wood trim joints at corners.</td>
<td>• Cracks above doors.</td>
</tr>
<tr>
<td>• Separation of concrete driveway, patio, or sidewalk from foundation.</td>
<td>• Sticking doors (warped door frames).</td>
</tr>
<tr>
<td>• Titling of landscaping/retaining walls.</td>
<td>• Sticking windows.</td>
</tr>
<tr>
<td></td>
<td>• Sloping floor surface.</td>
</tr>
<tr>
<td></td>
<td>• Cracks in ceramic or vinyl tile.</td>
</tr>
<tr>
<td></td>
<td>• Cracks in concrete floor $\frac{1}{16}$th inch across or wider</td>
</tr>
</tbody>
</table>


Vulnerability and Risk

Although the Soil Survey of Polk County identifies areas of Polk County that have moderate to severe shrink-swell potential, a vulnerability assessment that describes the value of property improvements exposed to expansive soils has not yet been conducted for Polk County. Depending on the severity of the expansive soils, it poses a risk for property damage and damage to infrastructure including roads, sidewalks, and pipelines.
When sufficient data is collected for hazard identification and vulnerability assessment, a risk analysis can be completed. Insufficient data currently exists to complete a risk analysis.

Community Expansive Soils Issues

Public Roads

Characteristic expansive or swelling materials are highly plastic clays and clay shales that often contain colloidal i.e., expanding lattice clay minerals such as the montmorillonites. One cause of soil expansion is intake of water into the montmorillonite. In order for potentially expansive soils to actually swell in an engineered structure, they must initially be in a water deficient condition as a result of stress or climate or both, and then water must become available as a result of a change in the soil's environment. In semiarid climates with deep water tables, decreased evapotranspiration produces increases in water content of soils beneath covered areas. Pavement heaving resulting from either of the water sources mentioned may take several years to become noticeable.

In Polk County, there are several roads that show signs of pavement heaving due to underlying expansive soils: James Howe Road, Crowley Road, Perrydale Road and Grand Ronde Road seem to be underlain with expansive soils. At the north end of Perrydale road, there are obvious horizontal cracks indicative of pavement heaving.

Standard stabilization methods include chemical treatments to reduce the expanding lattice materials’ affinity for water and the construction of physical barriers to prevent ingress of water. Hydraulic barriers in the form of horizontal and vertical membranes coupled with shoulder and ditch paving are recommended for both new construction and existing pavements in areas currently exhibiting distress. While such measures cannot prevent all future swelling of the potentially expansive pavement subgrades, they will reduce the amount of swelling and delay its occurrence.

Property

Shrinking and swelling i.e., damaging movements of soils can damage a number of property improvements. The differential movement caused by swell or shrinkage of expansive soils can increase the probability of damage to a structure’s foundation. Differential rather than total movements of the foundation soils are generally responsible for the major structural damage. These movements originate from changes in soil moisture.

Damages sustained by structures include: distortion and cracking of pavements and on-grade floor slabs; cracks in grade beams, walls, and drilled shafts; jammed or misaligned doors and windows; and failure of steel or concrete blocks supporting grade beams. Lateral forces may lead to buckling of basement and retaining walls. The magnitude of damages to structures can be extensive,
impair the usefulness of the structure, and detract aesthetically from the environment. Maintenance and repair requirements can be extensive, and the expenses can grossly exceed the original cost of the foundation.  

Design and construction of structures, when unaware of the existence and behavior of swelling soils, can worsen a readily manageable situation. Where swelling soils are not recognized, improper building or structure design, faulty construction, inappropriate landscaping and long-term maintenance practices unsuited to the specific soil conditions can become a continuing, costly problem.

Footings in expansive soils react differently than patios, driveways and roads i.e., concrete and asphalt where the cracking and heaving appear temporary as the soils dry and shrink back to their original position. The concentrated weight of a structure will inhibit the soil’s upward expansion. Outward expansion, on the other hand, may continue. The footings will not be returned to their original position as the soils dry and shrink. Instead, they can “ooze” down to a slightly lower level. This process can accumulate if the wetting and drying is allowed to continue season after season, year after year.

Damage is most noticeable if the footings “ooze” at varying rates under different areas of the structure. Cracks may appear, windows and doors may stick and floors may slope as the footings become progressively more out of level. Improper drainage, plumbing leaks, and even thirsty trees can cause this differential.

Damage occurs within a few months following construction, may develop slowly over a period of about five years, or may not appear for many years until some activity occurs to disturb the soil moisture.

Some possible actions to mitigate the potential damage to structures caused by expansive soils are set forth in Table 10.2. Some of these actions may require the assistance of an expert.
<table>
<thead>
<tr>
<th><strong>TYPICAL SOURCES</strong></th>
<th><strong>POSSIBLE PROBLEMS</strong></th>
<th><strong>POSSIBLE ACTIONS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Rainfall</td>
<td>Non-uniform runoff from roof may result in localized heave.</td>
<td>Maintain soil sloping away from all sides of the foundation for a distance of at least 5 feet, use gutters with downspouts that discharge at least 3 feet from the foundation. Extend discharge a minimum of 3 feet from the foundation and use splash blocks to avoid erosion or use flexible discharge tubes. Slope ground away from all sides of foundation, keep dirt line several inches below the brick line, use clay soil fill to create positive slope away from the foundation. Do not use sandy soils for fill next to foundation - use clays. Compact fill to shed water, not absorb it. Do not flood or pond irrigation water, slope ground surface away from foundation with edging, use mulch to slow evaporation. Check for and correct any leaks at joints and valves.</td>
</tr>
<tr>
<td>• Gutter Downspout / Roof Gutters</td>
<td>Concentrated sources of water may lead to non-uniform foundation movements.</td>
<td></td>
</tr>
<tr>
<td>• Poor Drainage</td>
<td>Localized source of water from rainwater flowing or ponding next to the foundation may lead to localized heave of the foundation.</td>
<td>Slope ground away from all sides of foundation. Do not flood or pond irrigation water, slope ground surface away from foundation with edging, use mulch to slow evaporation. Check for and correct any leaks at joints and valves.</td>
</tr>
<tr>
<td>• Flower Beds</td>
<td>Localized source of water may result in non-uniform foundation movements.</td>
<td></td>
</tr>
<tr>
<td>• Sprinkler</td>
<td>Valves and joints may leak with time, resulting in localized water sources that may cause non-uniform foundation movements.</td>
<td>Plant trees a distance greater than their mature height from the foundation. If existing trees are closer, install an approximately 4-foot deep tree root/vertical moisture barrier system near the foundation and possibly prune trees if barrier system is under the drip line of the tree. Install interceptor trench drain up slope to collect and divert seepage water around foundation soils and discharge down slope or to a sump. Monitor water bills, get leak detection plumber to isolate and repair leaks, verify repairs with pressure tests.</td>
</tr>
<tr>
<td>• Trees</td>
<td>Tree roots grow under foundation and dry out soils causing non-uniform foundation settlements.</td>
<td></td>
</tr>
<tr>
<td>• Shallow Subsurface Seepage / Moving Down Slope</td>
<td>Concentrated source of water to foundation soils may result in non-uniform heave of the foundation.</td>
<td></td>
</tr>
<tr>
<td>• Plumbing Line Leaks</td>
<td>Leaks in sewer or water lines provide localized source of water than may lead to localized foundation movements.</td>
<td></td>
</tr>
<tr>
<td>Moisture Vapor Rising from Wetter Soil Beneath Foundation</td>
<td>Gradual and uniform rise in soil moisture under foundation may lead to gradual heave of structure.</td>
<td>Normal occurrence, foundation stiffness should be designed and constructed for this long-term condition.</td>
</tr>
</tbody>
</table>


**Mitigation Plan Goals**

Plan goals are broad statements of direction and help focus future efforts. Goals are important because they are a bridge between the far-reaching, overall mission and the individual action items identified to reduce Polk County’s risk from flood, landslide, wildfire, severe winter storm and windstorm, drought, expansive soils and seismic and volcanic events.
Goal #1: PUBLIC EDUCATION AND AWARENESS

Provide public information and education/awareness to all residents of the county concerning natural hazard areas and mitigation efforts.

Goal #2: PREVENTIVE AND IMPLEMENTATION

Develop and implement activities to protect human life, commerce, property and natural systems.

Goal #3: COLLABORATION AND COORDINATION

Strengthen hazard mitigation by increasing collaboration and coordination among citizens, public agencies, non-profit organizations, businesses, and industry.

Goal #4: FUNDING AND PARTNERSHIPS

Seek partnerships in funding and resources for future mitigation efforts.

Goal #5: EMERGENCY OPERATIONS

Coordinate and integrate natural hazard mitigation activities, where appropriate, with emergency operations plans and procedures.

Goal #6: NATURAL RESOURCES UTILIZATION

Link land use planning, development criteria, codes, and natural resources and watershed planning with natural hazard mitigation.

Expansive Soils Mitigation Action Items

The following mitigation action items were formulated through researching regional and national mitigation plans and natural hazards planning literature, and interviews with local stakeholders. Plan action items were refined through discussions with the mitigation plan steering committee and through an open house at which the county received comments from the public.

The expansive soils action items provide direction on specific activities that organizations and residents in Polk County can undertake to reduce risk and prevent loss as a result of development on or near expansive soils. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

This section lists action items identified to reduce the risk from expansive soils’ impacts in Polk County. The expansive soils action
items apply to structures and to pavement subgrade soils. Under short-term and long-term actions items, there is further separation between action items for structures and action items for pavement subgrades. These action items are designed to meet the mitigation plan goals.

Expansive Soils Action Items

*Expansive soils action items* include general mitigation activities capable of implementation, given existing resources and authorities.

**STRUCTURES**

**ES #1: Educate the public about expansive soils.**

*Ideas for Implementation*

- Ensure proper drainage away from the structure;
- Plant trees at least fifteen (15) feet away from foundations on expansive soils;
- **Preconstruction**: Prior to building the structure, perform a soils test of the site to ensure the soils are stable or to determine the approximate effect the soils will have on the structure;
- **Post-construction**: Maintain a uniform and constant moisture level in the soil and provide additional strength and support to the foundation;
- Replace existing soil with an impermeable soil or compact the soil (i.e., engineered fill) for a building location;
- Grade sites for landscaping away from the structure, and maintain the grade established by the builder of the structure;
- Repair plumbing leaks;
- Discourage the removal of downspout extensions and splash blocks to harvest water that runs off of roofs. Release downspout water at least five (5) feet away from foundation walls via non-erosive surfaces;
- Maintain sprinkler heads and lines to avoid breaks that could allow water to pool next to the foundation, and
- Regarding subsurface drainage, encourage the installation of drains if necessary to eliminate ponding; and
- Apply chemical soil treatments to stabilize the soil.

**Coordination Organization:** Community Development  
**Internal Partners:** Building, GIS  
**External Partners:** Building contractors, property owners with expansive soils, soils and geotechnical engineers, engineering geologists, realtors, arborists, landscapers, NRCS, OSU Extension, Polk SWCD  
**Timeline:** On-going  
**Plan Goals Addressed:** Preventive & Implementation; Natural Resources Utilization

---

**PAVEMENT SUBGRADE**

**ES #2: Develop revisions for and revise the Polk County Road Standards for areas of the county with expansive soils.**

*Ideas for Implementation*

- Revise the Polk County Road Standards, particularly for county roads in areas with expansive soils.

**Coordination Organization:** Public Works Roadmaster  
**Internal Partner:** Community Development  
**External Partners:** ODOT, cities  
**Timeline:** On-going  
**Plan Goals Addressed:** Preventive & Implementation

---

**ES #3: Determine the feasibility of installing hydraulic barriers or physical restraints to prevent the entry of water into expansive soils.**

*Ideas for Implementation*

- Determine the feasibility of encapsulating the expansive soil for complete isolation from all water sources (only for new pavement construction); or

- Determine the feasibility of utilizing mechanical methods that provide physical restraint for the soil to keep it from swelling.

**Coordination Organization:** Public Works  
**Internal Partner:** Community Development  
**External Partners:** ODOT, cities  
**Timeline:** On-going
Plan Goals Addressed: Preventive & Implementation; Natural Resources Utilization.

**ES #4: Compact soil in a manner that reduces its suction i.e., affinity for water.**

*Ideas for Implementation*

- Compact subgrade soils to low dry unit weights using kneading methods to reduce swelling for moderately plastic soils.

Coordinating Organization: Public Works  
Internal Partner: Community Development  
External Partners: Property owners, building managers, cities  
Timeline: On-going  
Plan Goals Addressed: Preventive & Implementation; Natural Resources Utilization.

**ES #5: Remove and replace expansive subgrade soil with a non-expansive material.**

*Ideas for Implementation*

- Use non-expansive soils or expansive soils treated with lime or other swell-prevention chemicals as the replacement fill.

Coordinating Organization: Public Works  
Internal Partner: Community Development  
External Partners: Soils engineers, ODOT, cities  
Timeline: 3 to 5 years  
Plan Goals Addressed: Preventive & Implementation; Natural Resources Utilization.

**ES #6: Use sub-surface drain tile or perforated pipe wrapped in fabrics or graded granular filters below the edges of pavements.**

*NOTE:* Sub-drains will not have any effect on water moving into expansive soils in the vapor phase or water moving in unsaturated oil in response to gradients in soil suction.

Coordinating Organization: Public Works  
Internal Partner: Community Development  
External Partners: Soils engineers, ODOT, cities  
Timeline: 3 to 5 years  
Plan Goals Addressed: Preventive & Implementation.
Expansive Soils Resource Directory

Federal Resources

National Soil Survey Center (USDA-NRCS)

At the National Soil Survey Center (NSSC), the Director, National Leaders, and Head of the Soil Survey Laboratory are responsible for: policy, technical guidance, procedures, and standards; soil investigation assistance; soil survey laboratory functions; developing handbooks and manuals to guide soil survey operations; training on a group and individual basis; developing and maintaining soil survey data and information systems; assistance in planning regional work planning conferences; liaison to NCSS Regional Agriculture Experiment Station Soil Survey Committees; and technical coordination at the national level.

Contact: National Soil Survey Center
Address: 100 Centennial Mall North, Room 152, Lincoln, NE 68508-3866
Phone: 402-437-5499
Fax: 402-437-5336
Website: http://soils.usda.gov/contact/nssc/

Additional Resources

Publications


This 65-page booklet edited by Warren Wray, Ph.D., PE., was prepared by the Shallow Foundation Committee of the Geotechnical Division of the American Society of Civil Engineers. The purpose of this book is to assist homeowners in understanding why expansive soils shrink and heave and how excessive shrinking and heaving can be moderated. It also attempts to define the difference between cosmetic damage and structural damage resulting from expansive soil movement. The information is presented in two parts. Part one discusses the characteristics of expansive soils and how they affect buildings while the second part includes the questions most frequently asked by persons who have, or are building, homes on expansive soils and the answers they seek.

Contact: American Society of Civil Engineers (ASCE)
Phone: 800-548-2723
Website: http://www.pubs.asce.org/cedbsrch.html


Soil survey maps by NRCS provide the most detailed surficial soil maps available. *Soil Survey of Polk County, Oregon* contains engineering test data, estimates of soil engineering properties, and interpretations of properties for each of the major soil series within the county. The maps usually treat only the upper 30 to 60 inches of soil and may not fully define the foundation soil problem.


This book explains when and where geomembranes can be used effectively, and discusses expansive soil conditions and problems as well as control solutions. It includes descriptions of geotechnical membrane placement methods, plus information on costs and durability; and worldwide case studies of buildings, highways, roads, airports, canals, pipelines, railroads, and landfills – all with solutions to expansive soil problems.


Expansive Soils examines factors that influence the design of foundations and pavements built on expansive soils, and explores key design procedures and remedial measures that address these factors effectively. Backed by the authors' extensive research and experience, including interviews with practicing engineers working with expansive soils, this authoritative volume is an important reference text for geotechnical and foundation engineers, geologists, construction professionals, and students.

1 Expansive Soils Research Laboratory. Center for Geotechnical Engineering Science, University of Colorado-Denver.


3 Id.

4 Id.


7 Colorado Geologic Survey.

8 Id.


10 Id.

11 Id.

12 Id.


16 Id.

17 Colorado Geologic Survey.


19 Id.