



- **Evaluating Structural Policy Coverage in Home Insurance**  
**Evaluating Structural Policy Coverage in Home Insurance Understanding the Scope of Foundation Repair Guarantees Reviewing Contractor Backed Warranty Provisions Examining Conditions That Void Certain Warranties Checking if Homeowner Policies Cover Soil Movement Considering Add On Insurance for Extended Protection Determining Coverage Limitations for Pier Systems Clarifying Fine Print in Repair Service Agreements Seeking Assurance Through Third Party Backed Guarantees Exploring Extended Coverage for Unexpected Repair Costs Exploring Available Options for Warranty Transfers**
- **Visual Inspection Methods for Early Problem Detection**  
**Visual Inspection Methods for Early Problem Detection Using Laser Level Surveys to Track Floor Movement Applying Ground Penetrating Radar for Subsurface Clarity Establishing Baselines with Digital Crack Gauges Harnessing Infrared Thermography for Hidden Moisture Installing Wireless Tilt Meters for Continuous Monitoring Scheduling Routine Evaluations of Structural Support Identifying Early Shifts with Smart Sensor Technology Analyzing Data from Remote Monitoring Systems Assessing Elevation Changes with Precision Tools Reviewing Signs of Deterioration in Hard to Reach Areas Interpreting Detailed Reports from Third Party Engineers**
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## Understanding the key components of a comprehensive warranty for foundation repair, including coverage duration and scope.

When it comes to foundation repair, understanding the key components of a comprehensive warranty is crucial for any homeowner. Soil stabilization techniques improve the longevity of foundation repair service **foundation wall repair service** interior design. A well-crafted warranty can provide peace of mind and protect your investment long after the repair work is completed. Here's a breakdown of what to look for when reviewing contractor-backed warranty provisions.

Firstly, consider the coverage duration. This is the period during which the warranty is valid. For foundation repairs, longer is usually better. Aim for warranties that cover at least 10 to 25 years, as this shows the contractor's confidence in their work. Some even offer lifetime warranties, which can be a significant selling point. However, always ensure you understand what 'lifetime' means - is it the lifetime of the product, the home, or your ownership?

Next, examine the scope of the warranty. This defines what is covered and under what conditions. A comprehensive warranty should cover all aspects of the repair work, including materials and labor. It should also outline how issues will be addressed if they arise, such as whether the contractor will perform follow-up inspections or if you'll need to monitor and report any problems.

Look for warranties that cover both workmanship and manufacturer defects. Workmanship coverage protects you from faulty installation or repair errors, while manufacturer defects coverage safeguards against issues with the products used, like steel piers or polyurethane foam.

Another key component is transferability. If you sell your home, can the new owner benefit from the remaining warranty coverage? A transferable warranty can add value to your property and provide reassurance to potential buyers.

Lastly, review the claim process and exclusions. Understand how to make a claim if needed - is there a specific procedure or contact person? Also, know what's not covered. No warranty will protect against every possible issue, so it's important to be aware of exclusions like acts of God (natural disasters), poor home maintenance, or unrelated structural issues.

In conclusion, reviewing contractor-backed warranty provisions thoroughly is a vital step in ensuring your foundation repair investment is protected long-term. Don't hesitate to ask questions if any part of the warranty is unclear; a reputable contractor should be more than willing to explain their warranty provisions comprehensively. After all, a robust warranty is a sign of quality work and customer commitment.

## **Evaluating the transferability of warranties in the event of property sale or change of ownership.**

When purchasing or selling property such properties often include warranties backed by contractors which covers specific defective conditions within certain periods such warranties often subject owners sellers buyers brokers contractors to confusion regarding transferability. Evaluating this transferability therefore becomes paramount during transactions involving property sales or changes in ownership. It's essential that all parties involved understand how these warranties function under new ownership to avoid misunderstandings down the line.

Contractor-backed warranties typically cover specific aspects of a property such as roofing, plumbing or electrical systems that were either installed or repaired by a contractor during renovations or improvements made on said property. When reviewing such warranties it's crucial firstly to determine if they can be transferred at all since not all warranties offer this provision; understanding whether transferability applies explicitly within warranty terms ensures clarity among transacting parties from outset thus avoiding future disputes arising post-transaction completion dates once defects potentially surface during warranty coverage periods without recourse available due non-transferability clause being overlooked earlier stages negotiations process transaction completion itself etcetera .

Secondly understanding duration remaining under warranty becomes critical especially considering asset depreciation factors involved alongside timeline expectations regarding defect manifestations etcetera; This awareness allows new owners gauge adequately whether continuing existing warranty remains beneficial depending upon remaining coverage duration vis à vis expected lifespan utilities covered warranties ensuring beneficial outcome investments made particularly concerning resale value perspectives long term holding periods etcetera assessments need carefully conducted ensuring potential risks mitigated adequately preventing financial losses arising unexpectedly despite initial impressions warranties providing adequate safety nets covering defects issues .Thirdly verifying transferability logistics procedures involved ensures smooth transition facilitating necessary documentation requirements met promptly avoiding delays hiccup transfers instances including contractor verification processes often requiring proof ownership transfer documents confirming new owner legitimately taking possession property alongside adherence warranty terms conditions ensuring claims processed seamlessly avoiding prolonged disputes arising due procedural lapses overlooked during transitions etcetera .Moreover evaluating contractors reliability track record handling warranty claims becomes imperative especially considering practical implications involved particularly concerning response times claim processing efficiency enabling swift resolutions defect issues identified thereby minimizing inconveniences disruptions daily living routines occupants property affected adversely due protracted claim resolution processes etcetera .

Lastly engaging legal expertise reviewing contractor backed warranty provisions ensures thorough scrutiny language used within documents identifying loopholes vagueness ambiguities potentially leading misinterpretations disputes future stages transactions;

Professional legal guidance ensures robustness contractual agreements reached providing comprehensive coverage addressing potential scenarios arising facilitating clear communication expectations among transacting parties involved thereby fostering trust confidence ensuring seamless transitions ownership without unnecessary complications arising post transaction completion .In conclusion evaluating transferability contractor backed warranties event property sale change ownership necessitates meticulous attention detail encompassing verification transferability provisions remaining warranty durations logistical procedures contractors reliability alongside engaging legal expertise ensuring robustness agreements reached ultimately safeguarding interests parties involved fostering smooth transaction processes ensuring peace mind long term investment security etcetera .

Overall careful consideration given evaluating transferability contractor backed warranties ensures properties bought sold retain intended value propositions offering necessary protections defect issues arising thereby

### **Assessing the contractor's financial stability and reputation to ensure long-term warranty fulfillment.**

When it comes to reviewing contractor-backed warranty provisions, one of the most critical aspects to consider is the contractor's financial stability and reputation. This isn't just about checking boxes on a list; it's about ensuring peace of mind and long-term protection for your investment.

Imagine you've just had a brand-new roof installed, and the contractor offers a robust 20-year warranty. That's great, but what happens if the contractor goes out of business in five years? Their promise to cover repairs or replacements suddenly evaporates, leaving you high and dry. This is why assessing the contractor's financial health is paramount. You want to make sure that the company has the longevity and financial backing to stand behind their warranty for its entire duration.

Start by looking at the contractor's track record. How long have they been in business? A well-established company with a proven history is a good sign. Then, delve into their financial statements. Are they profitable? Do they have a steady cash flow? These indicators can provide insight into whether the contractor will still be around to honor their warranty commitments in the future.

Reputation is another key factor. What do past clients say about the contractor? Positive reviews and testimonials can indicate that the contractor takes their warranties seriously and follows through on their promises. Conversely, a trail of unhappy customers or unresolved complaints should raise red flags.

Don't hesitate to ask the contractor for references or examples of past warranty work they've honored. A reputable contractor should be able to provide these without hesitation. Additionally, check with industry associations and local licensing boards to ensure the

contractor is in good standing and has the necessary certifications.

In essence, reviewing a contractor-backed warranty isn't just about understanding the terms and conditions; it's about evaluating the contractor's ability and willingness to fulfill those promises. By assessing their financial stability and reputation, you're taking proactive steps to safeguard your investment and ensure that the warranty is more than just words on paper. It's about having confidence that your contractor will be there for you, today and tomorrow.

### **Analyzing the warranty's service and response time guarantees for addressing future foundation issues.**

When reviewing contractor-backed warranty provisions, one of the most critical aspects to analyze is how future foundation issues are addressed, particularly the service and response time guarantees. Foundation problems can be some of the most costly and structurally significant issues a homeowner might face, so ensuring that these are adequately covered is paramount.

Firstly, it's essential to understand the scope of the warranty's coverage regarding foundation issues. Some warranties might only cover specific types of problems, such as settlement or cracking, while others may have a more comprehensive approach. Be sure to check if the warranty covers both minor repairs and major structural issues.

Next, evaluate the service guarantees. This includes understanding what kind of service the contractor promises. Look for warranties that offer transferability, as this can be a significant selling point if you decide to sell your home. Additionally, check if the warranty provides for regular inspections or maintenance services, as these can help catch potential issues early before they become major problems.

Response time guarantees are equally crucial. When dealing with foundation issues, time is often of the essence. A small crack can quickly grow and cause substantial structural damage if left unaddressed. Therefore, look for warranties that specify a response time. Ideally, the contractor should guarantee a response within a few days to a week at most. Also, consider if the warranty outlines a timeframe for completing the repairs once the issue has been diagnosed.

Another aspect to consider is the dispute resolution process. Even with the best intentions, disagreements can arise. Warranties should have clear guidelines on handling disputes efficiently and fairly. This could involve mediation or arbitration clauses designed to resolve issues promptly.

Lastly, consider who backs the warranty. Is it the contractor alone, or is it backed by a third-party insurer or a manufacturer? Third-party backing can add an extra layer of security, as it means there's another party holding the contractor accountable.

In conclusion, analyzing the service and response time guarantees for addressing future foundation issues is a vital part of reviewing contractor-backed warranty provisions. By ensuring comprehensive coverage, prompt response times, and fair dispute resolution processes, you can safeguard your investment and gain peace of mind knowing that your home's foundation is protected long term. Always remember to read the fine print carefully and ask the contractor any questions you might have before signing any agreement. After all, it's part of your investment in the home's future, and you deserve to feel confident and satisfied with the protection you're purchasing. For any concerns don't hesitate to talk it over with professionals and experts in this field. Informed decisions are smart decisions when it comes to your home, for most people it's your biggest investment, so treat it like one. And act accordingly keeping your best interest at heart. For any concerns don't hesitate to talk it over with professionals. For most people it's your biggest investment, so treat it like one. And act accordingly keeping your best interest at heart." As homes are often vulnerable

### **Reviewing exclusions and limitations within the warranty provisions to understand what is not covered.**

When reviewing contractor-backed warranty provisions, one of the most crucial aspects to examine is the section on exclusions and limitations. These parts of the warranty outline what is not covered, which is equally as important as knowing what is covered. Understanding these clauses can help manage expectations and prevent unpleasant surprises should something go wrong with the work or materials provided.

Exclusions typically refer to specific items or situations that are not protected under the warranty. For instance, a contractor might exclude damage caused by natural disasters, such as floods or earthquakes, or issues arising from misuse or lack of maintenance by the property owner. These exclusions are often detailed explicitly to avoid any ambiguity. It's essential to read through these carefully; if something seems unclear, don't hesitate to ask the contractor for clarification.

Limitations, on the other hand, set boundaries on the extent of coverage provided by the warranty. This could include time limits, such as a one-year or five-year warranty period, after which any repairs or replacements would not be covered. There might also be financial limits, where the contractor agrees to cover costs up to a certain amount but anything beyond that would be the responsibility of the property owner. Additionally, some warranties may limit coverage to certain types of damages or defects but not others.

One common limitation is that warranties often do not cover consequential damages-indirect losses that occur as a result of the main problem. For example, if a roof leak causes water damage to your furniture, even if the roof repair is covered under warranty, replacing damaged furniture might not be.

Reviewing these exclusions and limitations thoroughly ensures you have a comprehensive

understanding of your rights and responsibilities under the warranty agreement. It allows you to make informed decisions about additional insurance coverage you might need and helps maintain a good working relationship with your contractor by avoiding misunderstandings about what is covered and what isn't. Moreover, knowing these details can aid in planning for potential future expenses that might fall outside the scope of the warranty.

In conclusion, examining exclusions and limitations within contractor-backed warranty provisions is a vital step in understanding your coverage fully. It empowers you with knowledge about potential scenarios where you might need additional protection and helps set realistic expectations for what your contractor will handle post-project completion. Therefore, take your time reading through these sections; it's an investment in peace of mind and financial security down the road

### **Exploring additional benefits such as routine inspections or maintenance services included in the warranty.**

When reviewing contractor-backed warranty provisions, it's crucial to explore additional benefits such as routine inspections or maintenance services that might be included. These extras can significantly enhance the value of the warranty and ensure the longevity and optimal performance of your investment, whether it's a new roof, HVAC system, or other significant installation.

Routine inspections are often overlooked but are incredibly beneficial. They allow professionals to identify and address minor issues before they escalate into major problems. For instance, a routine inspection of a newly installed roof can detect small leaks or damaged shingles early on, preventing extensive water damage down the line. Similarly, regular checks on an HVAC system can ensure it runs efficiently, saving you from costly repairs or replacements.

Maintenance services included in the warranty can also provide substantial long-term savings. Regular maintenance keeps your systems running smoothly and extends their lifespan. For example, a contractor might offer periodic cleaning and tuning of your HVAC system as part of the warranty, which can improve energy efficiency and reduce utility bills over time.. Moreover periodical maintenance also ensures safety standard compliance which might otherwise be neglected without such provisions; especially crucial when dealing gas appliances or electrical systems . Therefore having such clauses included ensures your peace-of-mind alongwith cost savings . Such provisions can also enhance property value; particularly relevant when considering future resale prospects . Understanding these additional benefits can help you make informed decisions when selecting contractors or negotiating warranty terms . By prioritizing these aspects ,you can maximise returns from your investment thus making reviews pertaining warranty provisions an indispensable exercise .

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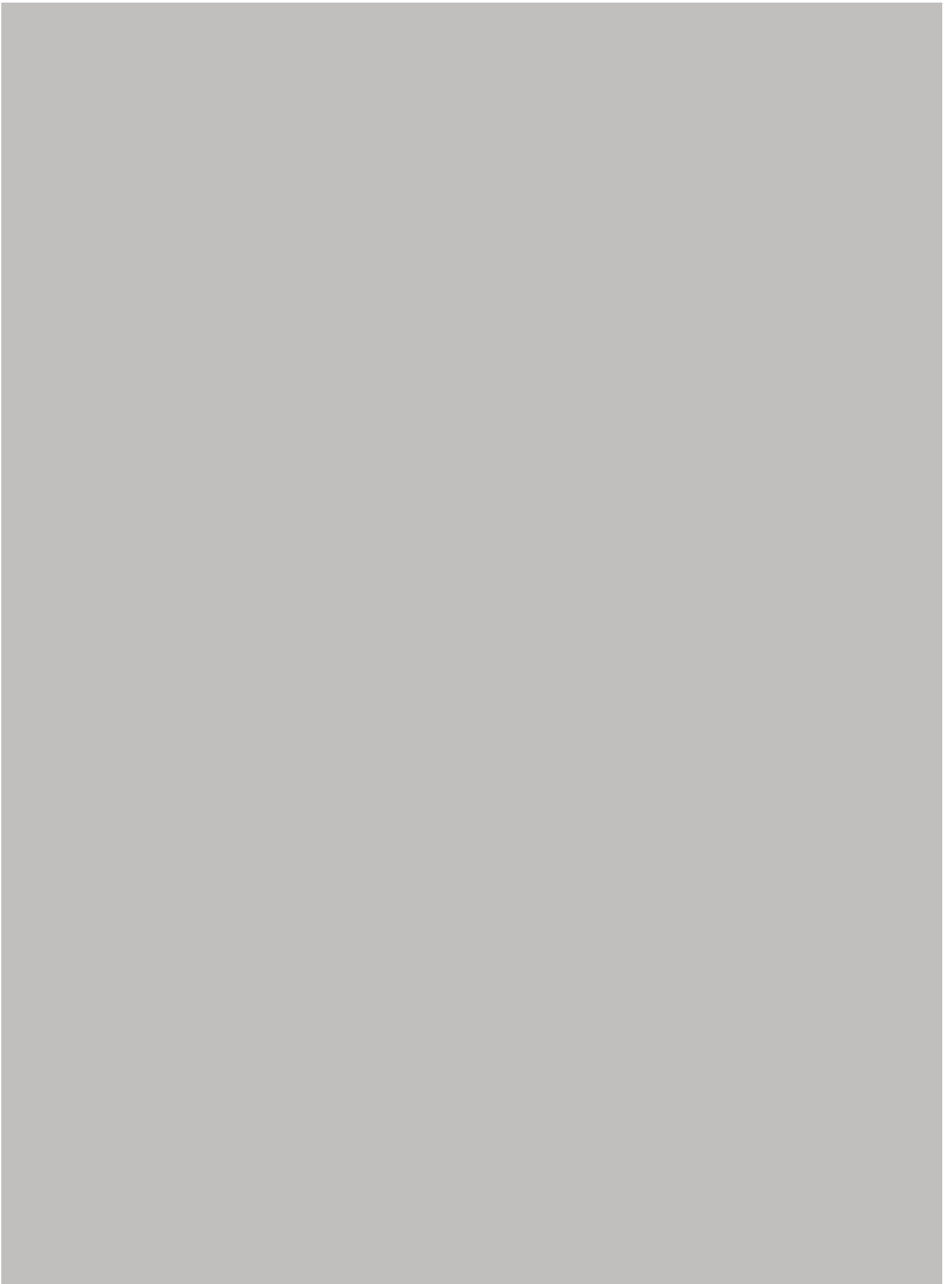




# **Residential Foundation Repair Services**

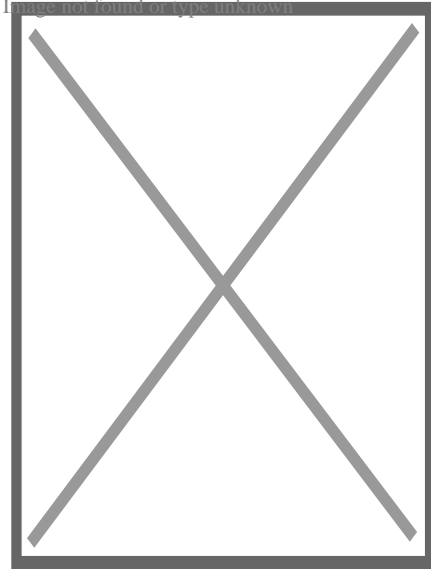


# **Strong Foundations, Strong Homes**

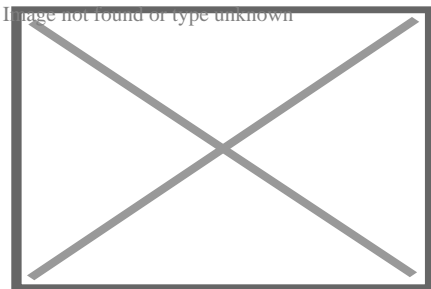


## About Water damage

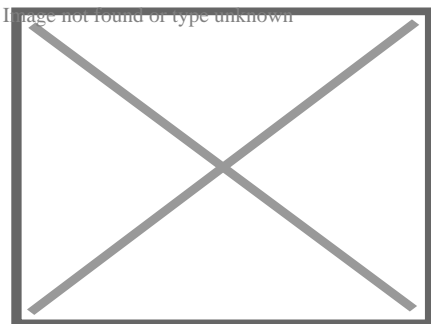
The examples and perspective in this article **may not represent a worldwide view of the subject**. You may improve this article, discuss the issue on the talk page, or create a new article, as appropriate. *(March 2011)* *(Learn how and when to remove this message)*



Interior of part of a damaged home in New Orleans after Hurricane Katrina



Family photographs damaged by flooding



A smaller and more minor water spot caused by rainwater leaking through a roof

**Water damage** describes various possible losses caused by water intruding where it will enable attack of a material or system by destructive processes such as rotting of wood, mold growth, bacteria growth, rusting of steel, swelling of composite woods, de-laminating of materials such as plywood, short-circuiting of electrical devices, etc.

The damage may be imperceptibly slow and minor such as water spots that could eventually mar a surface, or it may be instantaneous and catastrophic such as burst pipes and flooding. However fast it occurs, water damage is a major contributor to loss of property.

An insurance policy may or may not cover the costs associated with water damage and the process of water damage restoration. While a common cause of residential water damage is often the failure of a sump pump, many homeowner's insurance policies do not cover the associated costs without an addendum which adds to the monthly premium of the policy. Often the verbiage of this addendum is similar to "Sewer and Drain Coverage".

In the United States, those individuals who are affected by wide-scale flooding may have the ability to apply for government and FEMA grants through the Individual Assistance program.<sup>[1]</sup> On a larger level, businesses, cities, and communities can apply to the FEMA Public Assistance program for funds to assist after a large flood. For example, the city of Fond du Lac Wisconsin received \$1.2 million FEMA grant after flooding in June 2008. The program allows the city to purchase the water damaged properties, demolish the structures, and turn the former land into public green space.<sup>[citation needed]</sup>

## Causes

[edit]

Water damage can originate by different sources such as a broken dishwasher hose, a washing machine overflow, a dishwasher leakage, broken/leaking pipes, flood waters, groundwater seepage, building envelope failures (leaking roof, windows, doors, siding, etc.) and clogged toilets. According to the Environmental Protection Agency, 13.7% of all water used in the home today can be attributed to plumbing leaks.<sup>[2]</sup> On average that is approximately 10,000 gallons of water per year wasted by leaks for each US home. A tiny, 1/8-inch crack in a pipe can release up to 250 gallons of water a day.<sup>[3]</sup> According to *Claims Magazine* in August 2000, broken water pipes ranked second to hurricanes in terms of both the number of homes damaged and the amount of claims (on average \$50,000 per insurance claim<sup>[citation needed]</sup>) costs in the US.<sup>[4]</sup> Experts suggest that homeowners inspect and replace worn pipe fittings and hose connections to all household appliances that use water at least once a year. This includes washing machines, dishwashers, kitchen sinks, and bathroom lavatories, refrigerator icemakers, water softeners, and humidifiers. A few US companies offer whole-house leak protection systems utilizing flow-based technologies. A number of insurance companies offer policyholders reduced rates for installing a whole-house leak protection system.

As far as insurance coverage is concerned, damage caused by surface water intrusion to the dwelling is considered flood damage and is normally excluded from coverage under traditional homeowners' insurance. Surface water is water that enters the dwelling from the surface of the ground because of inundation or insufficient drainage and causes loss to the dwelling. Coverage for surface water intrusion<sup>[5]</sup> to the dwelling would usually require a separate flood insurance policy.

## Categories

[edit]

There are three basic categories of water damage, based on the level of contamination.

**Category 1 Water** - Refers to a source of water that does not pose substantial threat to humans and classified as "**clean water**". Examples are broken water supply lines, tub or sink overflows or appliance malfunctions that involves water supply lines.

**Category 2 Water** - Refers to a source of water that contains a significant degree of chemical, biological or physical contaminants and causes discomfort or sickness when consumed or even exposed to. Known as "**grey water**". This type carries microorganisms and nutrients of microorganisms. Examples are toilet bowls with urine (no feces), sump pump failures, seepage due to hydrostatic failure and water discharge from dishwashers or washing machines.

**Category 3 Water** - Known as "**black water**" and is grossly unsanitary. This water contains unsanitary agents, harmful bacteria and fungi, causing severe discomfort or sickness. Type 3 category are contaminated water sources that affect the indoor environment. This category includes water sources from sewage, seawater, rising water from rivers or streams, storm surge, ground surface water or standing water. Category 2 Water or Grey Water that is not promptly removed from the structure and or have remained stagnant may be re classified as Category 3 Water. Toilet back flows that originates from beyond the toilet trap is considered black water contamination regardless of visible content or color.[<sup>6</sup>]

## Classes

[edit]

Class of water damage is determined by the probable rate of evaporation based on the type of materials affected, or wet, in the room or space that was flooded. Determining the class of water damage is an important first step, and will determine the amount and type of equipment utilized to dry-down the structure.[<sup>7</sup>]

**Class 1** - Slow Rate of Evaporation. Affects only a portion of a room. Materials have a low permeance/porosity. Minimum moisture is absorbed by the materials. \*\*IICRC s500 2016 update adds that class 1 be indicated when <5% of the total square footage of a room (ceiling+walls+floor) are affected \*\*

**Class 2** - Fast Rate of Evaporation. Water affects the entire room of carpet and cushion. May have wicked up the walls, but not more than 24 inches. \*\*IICRC s500 2016 update adds that class 2 be indicated when 5% to 40% of the total square footage of a room (ceiling+walls+floor) are affected \*\*

**Class 3** - Fastest Rate of Evaporation. Water generally comes from overhead, affecting the entire area; walls, ceilings, insulation, carpet, cushion, etc. \*\*IICRC s500 2016 update adds that class 3 be indicated when >40% of the total square footage of a room (ceiling+walls+floor) are affected \*\*



**Class 4 - Specialty Drying Situations.** Involves materials with a very low permeance/porosity, such as hardwood floors, concrete, crawlspaces, gypcrete, plaster, etc. Drying generally requires very low specific humidity to accomplish drying.

## Restoration

[edit]

See also: Convectant drying

Water damage restoration can be performed by property management teams, building maintenance personnel, or by the homeowners themselves; however, contacting a certified professional water damage restoration specialist is often regarded as the safest way to restore water damaged property. Certified professional water damage restoration specialists utilize psychrometrics to monitor the drying process.<sup>[8]</sup>

## Standards and regulation

[edit]

While there are currently no government regulations in the United States dictating procedures, two certifying bodies, the Institute of Inspection Cleaning and Restoration Certification (IICRC) and the RIA, do recommend standards of care. The current IICRC standard is ANSI/IICRC S500-2021.<sup>[9]</sup> It is the collaborative work of the IICRC, SCRT, IEI, IAQA, and NADCA.

Fire and Water Restoration companies are regulated by the appropriate state's Department of Consumer Affairs - usually the state contractors license board. In California, all Fire and Water Restoration companies must register with the California Contractors State License Board.<sup>[10]</sup> Presently, the California Contractors State License Board has no specific classification for "water and fire damage restoration."

## Procedures

[edit]

Water damage restoration is often prefaced by a loss assessment and evaluation of affected materials. The damaged area is inspected with water sensing equipment such as probes and other infrared tools in order to determine the source of the damage and possible extent of areas affected. Emergency mitigation services are the first order of business. Controlling the source of water, removal of non-salvageable materials, water extraction and pre-cleaning of impacted materials are all part of the mitigation process. Restoration services would then be rendered to the property in order to dry the structure, stabilize building materials, sanitize any affected or

cross-contaminated areas, and deodorize all affected areas and materials. After the labor is completed, water damage equipment including air movers, air scrubbers, dehumidifiers, wood floor drying systems, and sub-floor drying equipment is left in the residence. The goal of the drying process is to stabilize the moisture content of impacted materials below 15%, the generally accepted threshold for microbial amplification. Industry standards state that drying vendors should return at regular time intervals, preferably every twenty-four hours, to monitor the equipment, temperature, humidity, and moisture content of the affected walls and contents.[6] In conclusion, key aspects of water damage restoration include fast action, adequate equipment, moisture measurements, and structural drying. Dehumidification is especially crucial for structural components affected by water damage, such as wooden beams, flooring, and drywall.

## See also

[edit]

- Indoor mold

## References

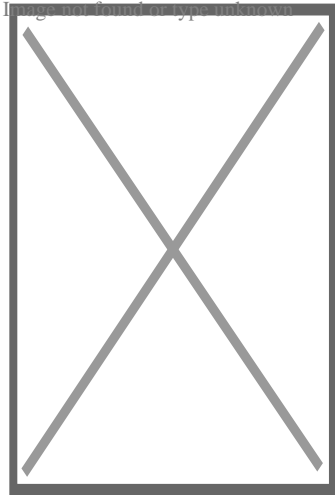
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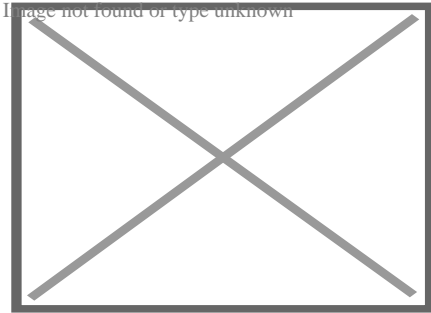
## About soil mechanics



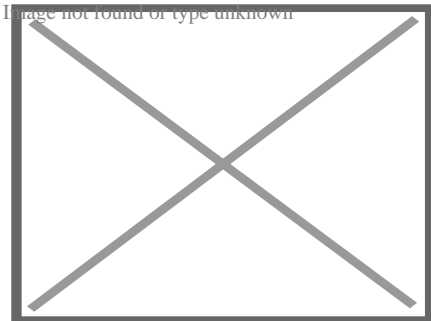
This article may be too long to read and navigate comfortably. Consider splitting content into sub-articles, condensing it, or adding subheadings. Please discuss this issue on the article's talk page. *(February 2025)*



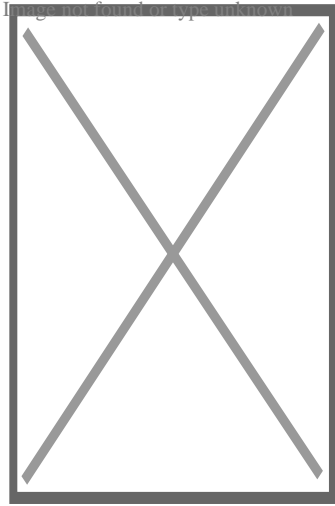
The Leaning Tower of Pisa – an example of a problem due to deformation of soil



Slope instability issues for a temporary flood control levee in North Dakota, 2009



Earthwork in Germany



Fox Glacier, New Zealand: Soil produced and transported by intense weathering and erosion

**Soil mechanics** is a branch of soil physics and applied mechanics that describes the behavior of soils. It differs from fluid mechanics and solid mechanics in the sense that soils consist of a heterogeneous mixture of fluids (usually air and water) and particles (usually clay, silt, sand, and gravel) but soil may also contain organic solids and other matter.<sup>[1][2][3][4]</sup> Along with rock mechanics, soil mechanics provides the theoretical basis for analysis in geotechnical engineering,<sup>[5]</sup> a subdiscipline of civil engineering, and engineering geology, a subdiscipline of geology. Soil mechanics is used to analyze the deformations of and flow of fluids within natural and man-made structures that are supported on or made of soil, or structures that are buried in soils.<sup>[6]</sup> Example applications are building and bridge foundations, retaining walls, dams, and buried pipeline systems. Principles of soil mechanics are also used in related disciplines such as geophysical engineering, coastal engineering, agricultural engineering, and hydrology.

This article describes the genesis and composition of soil, the distinction between *pore water pressure* and inter-granular *effective stress*, capillary action of fluids in the soil pore spaces, *soil classification*, *seepage* and *permeability*, time dependent change of volume due to squeezing water out of tiny pore spaces, also known as *consolidation*, *shear strength* and stiffness of soils. The shear strength of soils is primarily derived from friction between the particles and interlocking, which are very sensitive to the effective stress.<sup>[7][6]</sup> The article concludes with some examples of applications of the principles of soil mechanics such as slope stability, lateral earth pressure on retaining walls, and bearing capacity of foundations.

## Genesis and composition of soils

[edit]

# Genesis

[edit]

The primary mechanism of soil creation is the weathering of rock. All rock types (igneous rock, metamorphic rock and sedimentary rock) may be broken down into small particles to create soil. Weathering mechanisms are physical weathering, chemical weathering, and biological weathering [1][2][3] Human activities such as excavation, blasting, and waste disposal, may also create soil. Over geologic time, deeply buried soils may be altered by pressure and temperature to become metamorphic or sedimentary rock, and if melted and solidified again, they would complete the geologic cycle by becoming igneous rock.[3]

Physical weathering includes temperature effects, freeze and thaw of water in cracks, rain, wind, impact and other mechanisms. Chemical weathering includes dissolution of matter composing a rock and precipitation in the form of another mineral. Clay minerals, for example can be formed by weathering of feldspar, which is the most common mineral present in igneous rock.

The most common mineral constituent of silt and sand is quartz, also called silica, which has the chemical name silicon dioxide. The reason that feldspar is most common in rocks but silica is more prevalent in soils is that feldspar is much more soluble than silica.

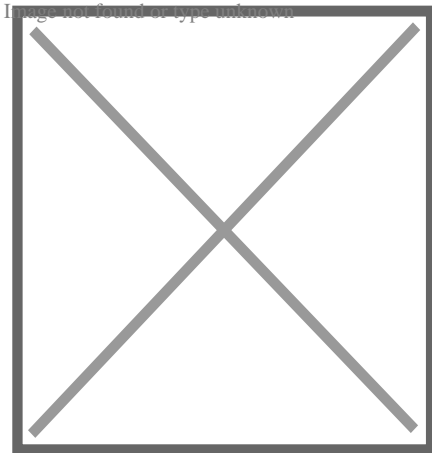
Silt, Sand, and Gravel are basically little pieces of broken rocks.

According to the Unified Soil Classification System, silt particle sizes are in the range of 0.002 mm to 0.075 mm and sand particles have sizes in the range of 0.075 mm to 4.75 mm.

Gravel particles are broken pieces of rock in the size range 4.75 mm to 100 mm. Particles larger than gravel are called cobbles and boulders.[1][2]

## Transport

[edit]



Example soil horizons. a) top soil and colluvium b) mature residual soil c) young residual soil d) weathered rock

Soil deposits are affected by the mechanism of transport and deposition to their location. Soils that are not transported are called residual soils—they exist at the same location as the rock from which they were generated. Decomposed granite is a common example of a residual soil. The common mechanisms of transport are the actions of gravity, ice, water, and wind. Wind blown soils include dune sands and loess. Water carries particles of different size depending on the speed of the water, thus soils transported by water are graded according to their size. Silt and clay may settle out in a lake, and gravel and sand collect at the bottom of a river bed. Wind blown soil deposits (aeolian soils) also tend to be sorted according to their grain size. Erosion at the base of glaciers is powerful enough to pick up large rocks and boulders as well as soil; soils dropped by melting ice can be a well graded mixture of widely varying particle sizes. Gravity on its own may also carry particles down from the top of a mountain to make a pile of soil and boulders at the base; soil deposits transported by gravity are called colluvium.[<sup>1</sup>][<sup>2</sup>]

The mechanism of transport also has a major effect on the particle shape. For example, low velocity grinding in a river bed will produce rounded particles. Freshly fractured colluvium particles often have a very angular shape.

## Soil composition

[edit]

### Soil mineralogy

[edit]

Silts, sands and gravels are classified by their size, and hence they may consist of a variety of minerals. Owing to the stability of quartz compared to other rock minerals, quartz is the most common constituent of sand and silt. Mica, and feldspar are other common minerals present in sands and silts.[<sup>1</sup>] The mineral constituents of gravel may be more similar to that of the parent rock.

The common clay minerals are montmorillonite or smectite, illite, and kaolinite or kaolin. These minerals tend to form in sheet or plate like structures, with length typically ranging between  $10^{?7}$  m and  $4 \times 10^{?6}$  m and thickness typically ranging between  $10^{?9}$  m and  $2 \times 10^{?6}$  m, and they have a relatively large specific surface area. The specific surface area (SSA) is defined as the ratio of the surface area of particles to the mass of the particles. Clay minerals typically have specific surface areas in the range of 10 to 1,000 square meters per gram of solid.[<sup>3</sup>] Due to the large surface area available for chemical, electrostatic, and van der Waals interaction, the mechanical behavior of clay minerals is very sensitive to the amount of pore fluid available and the type and amount of dissolved ions in the pore fluid.[<sup>1</sup>]

The minerals of soils are predominantly formed by atoms of oxygen, silicon, hydrogen, and aluminum, organized in various crystalline forms. These elements along with calcium, sodium,

potassium, magnesium, and carbon constitute over 99 per cent of the solid mass of soils.<sup>[1]</sup>

## Grain size distribution

[edit]

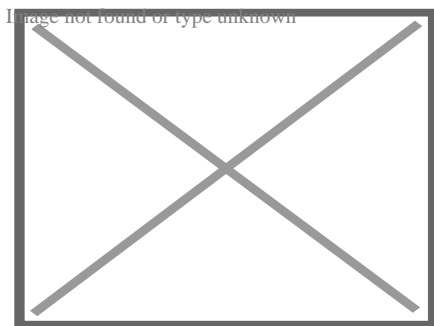
Main article: Soil gradation

Soils consist of a mixture of particles of different size, shape and mineralogy. Because the size of the particles obviously has a significant effect on the soil behavior, the grain size and grain size distribution are used to classify soils. The grain size distribution describes the relative proportions of particles of various sizes. The grain size is often visualized in a cumulative distribution graph which, for example, plots the percentage of particles finer than a given size as a function of size. The median grain size,  $d_{50}$ , which 50% of the particle mass consists of finer particles. Soil behavior, especially the hydraulic conductivity, tends to be dominated by the smaller particles, hence, the term "effective size", denoted by  $d_{10}$  the size for which 10% of the particle mass consists of finer particles.

Sands and gravels that possess a wide range of particle sizes with a smooth distribution of particle sizes are called *well graded* soils. If the soil particles in a sample are predominantly in a relatively narrow range of sizes, the sample is *uniformly graded*. If a soil sample has distinct gaps in the gradation curve, e.g., a mixture of gravel and fine sand, with no coarse sand, the sample may be *gap graded*. *Uniformly graded* and *gap graded* soils are both considered to be *poorly graded*. There are many methods for measuring particle-size distribution. The two traditional methods are sieve analysis and hydrometer analysis.

## Sieve analysis

[edit]



Sieve

The size distribution of gravel and sand particles are typically measured using sieve analysis. The formal procedure is described in ASTM D6913-04(2009).<sup>[8]</sup> A stack of sieves with accurately dimensioned holes between a mesh of wires is used to separate the particles into size bins. A known volume of dried soil, with clods broken down to individual particles, is put into the top of a

stack of sieves arranged from coarse to fine. The stack of sieves is shaken for a standard period of time so that the particles are sorted into size bins. This method works reasonably well for particles in the sand and gravel size range. Fine particles tend to stick to each other, and hence the sieving process is not an effective method. If there are a lot of fines (silt and clay) present in the soil it may be necessary to run water through the sieves to wash the coarse particles and clods through.

A variety of sieve sizes are available. The boundary between sand and silt is arbitrary. According to the Unified Soil Classification System, a #4 sieve (4 openings per inch) having 4.75 mm opening size separates sand from gravel and a #200 sieve with an 0.075 mm opening separates sand from silt and clay. According to the British standard, 0.063 mm is the boundary between sand and silt, and 2 mm is the boundary between sand and gravel.<sup>[3]</sup>

## Hydrometer analysis

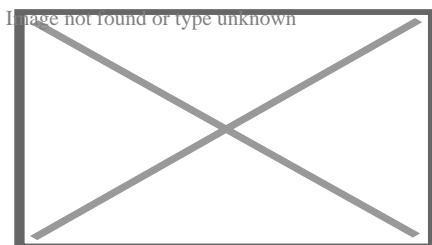
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The classification of fine-grained soils, i.e., soils that are finer than sand, is determined primarily by their Atterberg limits, not by their grain size. If it is important to determine the grain size distribution of fine-grained soils, the hydrometer test may be performed. In the hydrometer tests, the soil particles are mixed with water and shaken to produce a dilute suspension in a glass cylinder, and then the cylinder is left to sit. A hydrometer is used to measure the density of the suspension as a function of time. Clay particles may take several hours to settle past the depth of measurement of the hydrometer. Sand particles may take less than a second. Stokes' law provides the theoretical basis to calculate the relationship between sedimentation velocity and particle size. ASTM provides the detailed procedures for performing the Hydrometer test.

Clay particles can be sufficiently small that they never settle because they are kept in suspension by Brownian motion, in which case they may be classified as colloids.

## Mass-volume relations

[edit]



A phase diagram of soil indicating the masses and volumes of air, solid, water, and voids



There are a variety of parameters used to describe the relative proportions of air, water and solid in a soil. This section defines these parameters and some of their interrelationships.<sup>[2][6]</sup> The basic notation is as follows:

$V_a$ ,  $V_w$  and  $V_s$  represent the volumes of air, water and solids in a soil mixture;

$W_a$ ,  $W_w$  and  $W_s$  represent the weights of air, water and solids in a soil mixture;

$M_a$ ,  $M_w$  and  $M_s$  represent the masses of air, water and solids in a soil mixture;

$\rho_a$ ,  $\rho_w$  and  $\rho_s$  represent the densities of the constituents (air, water and solids) in a soil mixture;

Note that the weights,  $W$ , can be obtained by multiplying the mass,  $M$ , by the acceleration due to gravity,  $g$ ; e.g.,  $W_s = M_s g$

Specific Gravity is the ratio of the density of one material compared to the density of pure water ( $\rho_w = 1 \text{ g/cm}^3$ )

$$G_s = \frac{\rho_s}{\rho_w}$$

*Specific gravity of solids*,  $G_s$

Note that specific weight, conventionally denoted by the symbol  $\gamma$ , may be obtained by multiplying the density ( $\rho$ ) of a material by the acceleration due to gravity,  $g$

*Density*, *bulk density*, or *wet density*,  $\rho$ , are different names for the density of the mixture, i.e., the total mass of air, water, solids divided by the total volume of air water and solids (the mass of air is assumed to be zero for practical purposes):

$$\rho = \frac{M_s + M_w}{V_s + V_w + V_a} = \frac{M_t}{V_t}$$

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*Dry density*,  $\rho_d$ , is the mass of solids divided by the total volume of air water and solids:

$$\rho_d = \frac{M_s}{V_s + V_w + V_a} = \frac{M_s}{V_t}$$

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*Buoyant density*,  $\rho'$ , defined as the density of the mixture minus the density of water is useful if the soil is submerged under water:

$$\rho' = \rho - \rho_w$$

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where  $\rho_w$  is the density of water

*Water content*,  $w$ , is the ratio of mass of water to mass of solid. It is easily measured by weighing a sample of the soil, drying it out in an oven and re-weighing. Standard procedures are described

by ASTM.

$$w = \frac{M_w}{M_s} = \frac{W_w}{W_s}$$

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*Void ratio*,  $e$ , is the ratio of the volume of voids to the volume of solids:

$$e = \frac{V_v}{V_s} = \frac{V_t - V_s}{V_s}$$

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*Porosity*,  $n$ , is the ratio of volume of voids to the total volume, and is related to the void ratio:

$$n = \frac{V_v}{V_t} = \frac{V_v}{V_s + V_v} = \frac{e}{1+e}$$

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*Degree of saturation*,  $S$ , is the ratio of the volume of water to the volume of voids:

$$S = \frac{V_w}{V_v}$$

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From the above definitions, some useful relationships can be derived by use of basic algebra.

$$\rho = \frac{(G_s + Se)\rho_w}{1+e}$$

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$$\rho = \frac{(1+w)G_s\rho_w}{1+e}$$

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$$w = \frac{Se}{G_s}$$

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## Soil classification

[edit]

Geotechnical engineers classify the soil particle types by performing tests on disturbed (dried, passed through sieves, and remolded) samples of the soil. This provides information about the characteristics of the soil grains themselves. Classification of the types of grains present in a soil does not *clarification needed* account for important effects of the *structure* or *fabric* of the soil, terms that describe compactness of the particles and patterns in the arrangement of particles in a load carrying framework as well as the pore size and pore fluid distributions. Engineering geologists also classify soils based on their genesis and depositional history.

# Classification of soil grains

[edit]

In the US and other countries, the Unified Soil Classification System (USCS) is often used for soil classification. Other classification systems include the British Standard BS 5930 and the AASHTO soil classification system.<sup>[3]</sup>

## Classification of sands and gravels

[edit]

In the USCS, gravels (given the symbol *G*) and sands (given the symbol *S*) are classified according to their grain size distribution. For the USCS, gravels may be given the classification symbol *GW* (well-graded gravel), *GP* (poorly graded gravel), *GM* (gravel with a large amount of silt), or *GC* (gravel with a large amount of clay). Likewise sands may be classified as being *SW*, *SP*, *SM* or *SC*. Sands and gravels with a small but non-negligible amount of fines (5–12%) may be given a dual classification such as *SW-SC*.

## Atterberg limits

[edit]

Clays and Silts, often called 'fine-grained soils', are classified according to their Atterberg limits; the most commonly used Atterberg limits are the *liquid limit* (denoted by *LL* or 



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{\displaystyle L\_{liquid\ limit}}

) and *plastic limit* (denoted by *PL* or 



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{\displaystyle P\_{plastic\ limit}}

) and *shrinkage limit* (denoted by *SL*).

The liquid limit is the water content at which the soil behavior transitions from a plastic solid to a liquid. The plastic limit is the water content at which the soil behavior transitions from that of a plastic solid to a brittle solid. The Shrinkage Limit corresponds to a water content below which the soil will not shrink as it dries. The consistency of fine grained soil varies in proportional to the water content in a soil.

As the transitions from one state to another are gradual, the tests have adopted arbitrary definitions to determine the boundaries of the states. The liquid limit is determined by measuring the water content for which a groove closes after 25 blows in a standard test.<sup>[9]</sup><sup>[clarification needed]</sup> Alternatively, a fall cone test apparatus may be used to measure the liquid limit. The undrained shear strength of remolded soil at the liquid limit is approximately 2 kPa.<sup>[4]</sup><sup>[10]</sup> The plastic limit is the water content below which it is not possible to roll by hand the soil into 3 mm diameter cylinders. The soil cracks or breaks up as it is rolled down to this diameter. Remolded soil at the plastic limit is quite stiff, having an undrained shear strength of the order of about 200 kPa.<sup>[4]</sup><sup>[10]</sup>

The *plasticity index* of a particular soil specimen is defined as the difference between the liquid limit and the plastic limit of the specimen; it is an indicator of how much water the soil particles in the specimen can absorb, and correlates with many engineering properties like permeability, compressibility, shear strength and others. Generally, the clay having high plasticity have lower permeability and also they are also difficult to be compacted.

## Classification of silts and clays

[edit]

According to the Unified Soil Classification System (USCS), silts and clays are classified by plotting the values of their plasticity index and liquid limit on a plasticity chart. The A-Line on the chart separates clays (given the USCS symbol *C*) from silts (given the symbol *M*).  $LL=50\%$  separates high plasticity soils (given the modifier symbol *H*) from low plasticity soils (given the modifier symbol *L*). A soil that plots above the A-line and has  $LL>50\%$  would, for example, be classified as *CH*. Other possible classifications of silts and clays are *ML*, *CL* and *MH*. If the Atterberg limits plot in the "hatched" region on the graph near the origin, the soils are given the dual classification 'CL-ML'.

## Indices related to soil strength

[edit]

### Liquidity index

[edit]

The effects of the water content on the strength of saturated remolded soils can be quantified by the use of the *liquidity index*, *LI*:

$$\displaystyle LI = \frac{w - P_L}{P_L - P_U}$$

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When the *LI* is 1, remolded soil is at the liquid limit and it has an undrained shear strength of about 2 kPa. When the soil is at the plastic limit, the *LI* is 0 and the undrained shear strength is about 200 kPa.<sup>[4][11]</sup>

### Relative density

[edit]

The density of sands (cohesionless soils) is often characterized by the relative density,  $D_r$

$$D_r = \frac{e_{max} - e_{min}}{e_{max} - e_{min}} 100\%$$

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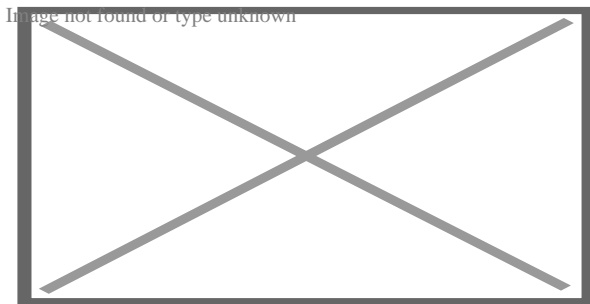
where:  $e_{max}$  is the "maximum void ratio" corresponding to a very loose state,  $e_{min}$  is the "minimum void ratio" corresponding to a very dense state and  $e$  is the in situ void ratio. Methods used to calculate relative density are defined in ASTM D4254-00(2006).<sup>[12]</sup>

Thus if  $D_r = 100\%$  the sand or gravel is very dense, and if  $D_r = 0\%$  the soil is extremely loose and unstable.

### Seepage: steady state flow of water

[edit]

This section is an excerpt from Seepage.[edit]

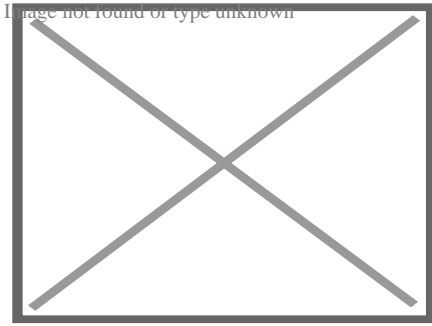


A cross section showing the water table varying with surface topography as well as a perched water table

In soil mechanics, seepage is the movement of water through soil. If fluid pressures in a soil deposit are uniformly increasing with depth according to  $\sigma_v = \gamma_w z$ , where  $z$  is the depth below the water table, then hydrostatic conditions will prevail and the fluids will *not* be flowing through the soil. However, if the water table is sloping or there is a perched water table as indicated in the accompanying sketch, then seepage will occur. For steady state seepage, the seepage velocities are not varying with time. If the water tables are changing levels with time, or if the soil is in the process of consolidation, then steady state conditions do not apply.

### Effective stress and capillarity: hydrostatic conditions

[edit]



Spheres immersed in water, reducing effective stress

Main article: Effective stress

To understand the mechanics of soils it is necessary to understand how normal stresses and shear stresses are shared by the different phases. Neither gas nor liquid provide significant resistance to shear stress. The shear resistance of soil is provided by friction and interlocking of the particles. The friction depends on the intergranular contact stresses between solid particles. The normal stresses, on the other hand, are shared by the fluid and the particles.<sup>[7]</sup> Although the pore air is relatively compressible, and hence takes little normal stress in most geotechnical problems, liquid water is relatively incompressible and if the voids are saturated with water, the pore water must be squeezed out in order to pack the particles closer together.

The principle of effective stress, introduced by Karl Terzaghi, states that the effective stress  $\sigma'$  (i.e., the average intergranular stress between solid particles) may be calculated by a simple subtraction of the pore pressure from the total stress:

$$\sigma' = \sigma - u,$$

where  $\sigma$  is the total stress and  $u$  is the pore pressure. It is not practical to measure  $\sigma'$  directly, so in practice the vertical effective stress is calculated from the pore pressure and vertical total stress. The distinction between the terms pressure and stress is also important. By definition, pressure at a point is equal in all directions but stresses at a point can be different in different directions. In soil mechanics, compressive stresses and pressures are considered to be positive and tensile stresses are considered to be negative, which is different from the solid mechanics sign convention for stress.

## Total stress

[edit]

For level ground conditions, the total vertical stress at a point,  $\sigma_v$ , is on average the weight of everything above that point per unit area. The vertical stress beneath a uniform surface layer with density  $\gamma$  and thickness  $z$  is given by the equation:

$$\sigma_v = \rho g H = \gamma H$$

where  $\gamma$  is the acceleration due to gravity, and  $\gamma$  is the unit weight of the overlying layer. If there are multiple layers of soil or water above the point of interest, the vertical stress may be calculated by summing the product of the unit weight and thickness of all of the overlying layers. Total stress increases with increasing depth in proportion to the density of the overlying soil.

It is not possible to calculate the horizontal total stress in this way. Lateral earth pressures are addressed elsewhere.

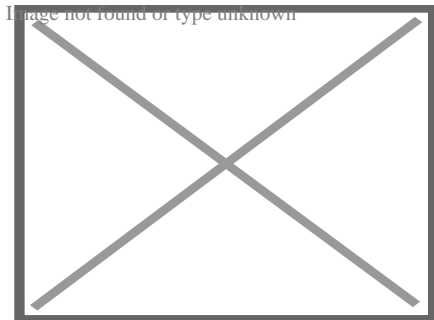
## Pore water pressure

[edit]

Main article: Pore water pressure

### Hydrostatic conditions

[edit]



Water is drawn into a small tube by surface tension. Water pressure,  $u$ , is negative above and positive below the free water surface.

If the soil pores are filled with water that is not flowing but is static, the pore water pressures will be hydrostatic. The water table is located at the depth where the water pressure is equal to the atmospheric pressure. For hydrostatic conditions, the water pressure increases linearly with depth below the water table:

$$u = \rho_w g z_w$$

where  $\rho_w$  is the density of water, and  $z_w$  is the depth below the water table.

### Capillary action

[edit]

Due to surface tension, water will rise up in a small capillary tube above a free surface of water. Likewise, water will rise up above the water table into the small pore spaces around the soil particles. In fact the soil may be completely saturated for some distance above the water table. Above the height of capillary saturation, the soil may be wet but the water content will decrease with elevation. If the water in the capillary zone is not moving, the water pressure obeys the equation of hydrostatic equilibrium,  $\frac{dw}{dz} = -\rho_w g$ , but note that  $w$  is negative above the water table. Hence, hydrostatic water pressures are negative above the water table. The thickness of the zone of capillary saturation depends on the pore size, but typically, the heights vary between a centimeter or so for coarse sand to tens of meters for a silt or clay.<sup>[3]</sup> In fact the pore space of soil is a uniform fractal e.g. a set of uniformly distributed D-dimensional fractals of average linear size L. For the clay soil it has been found that  $L=0.15$  mm and  $D=2.7$ .<sup>[13]</sup>

The surface tension of water explains why the water does not drain out of a wet sand castle or a moist ball of clay. Negative water pressures make the water stick to the particles and pull the particles to each other, friction at the particle contacts make a sand castle stable. But as soon as a wet sand castle is submerged below a free water surface, the negative pressures are lost and the castle collapses. Considering the effective stress equation,  $\sigma' = \sigma - u$ , the water pressure is negative, the effective stress may be positive, even on a free surface (a surface where the total normal stress is zero). The negative pore pressure pulls the particles together and causes compressive particle to particle contact forces. Negative pore pressures in clayey soil can be much more powerful than those in sand. Negative pore pressures explain why clay soils shrink when they dry and swell as they are wetted. The swelling and shrinkage can cause major distress, especially to light structures and roads.<sup>[14]</sup>

Later sections of this article address the pore water pressures for seepage and consolidation problems.

### Water at particle contacts

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**Water at  
particle  
contacts**

- Intergranular contact force due to surface tension

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**Intergranular  
contact force due  
to surface tension**



## Shrinkage caused by drying

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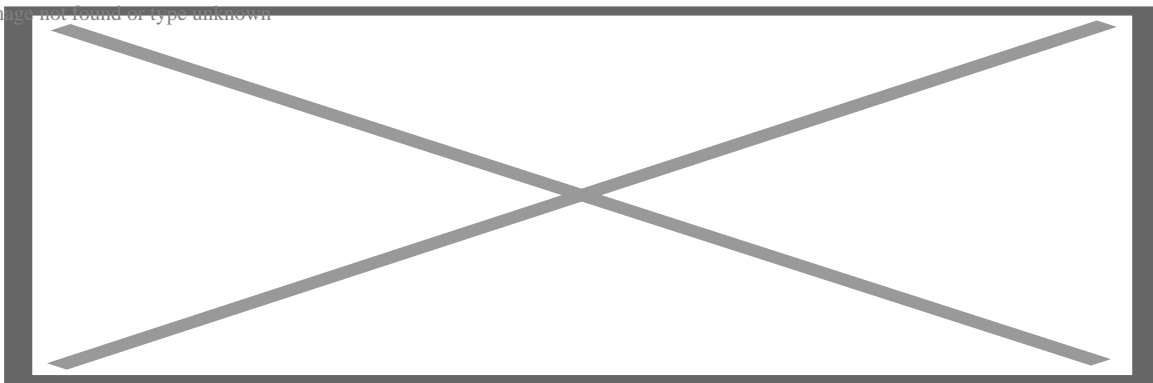
Shrinkage caused by  
drying

## Consolidation: transient flow of water

[edit]

Main article: Consolidation (soil)

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Consolidation analogy. The piston is supported by water underneath and a spring. When a load is applied to the piston, water pressure increases to support the load. As the water slowly leaks through the small hole, the load is transferred from the water pressure to the spring force.

Consolidation is a process by which soils decrease in volume. It occurs when stress is applied to a soil that causes the soil particles to pack together more tightly, therefore reducing volume. When this occurs in a soil that is saturated with water, water will be squeezed out of the soil. The time required to squeeze the water out of a thick deposit of clayey soil layer might be years. For a layer of sand, the water may be squeezed out in a matter of seconds. A building foundation or construction of a new embankment will cause the soil below to consolidate and this will cause settlement which in turn may cause distress to the building or embankment. Karl Terzaghi developed the theory of one-dimensional consolidation which enables prediction of the amount of settlement and the time required for the settlement to occur.<sup>[15]</sup> Afterwards, Maurice Biot fully developed the three-dimensional soil consolidation theory, extending the one-dimensional model previously developed by Terzaghi to more general hypotheses and introducing the set of basic equations of Poroelasticity.<sup>[7]</sup> Soils are tested with an oedometer test to determine their compression index and coefficient of consolidation.

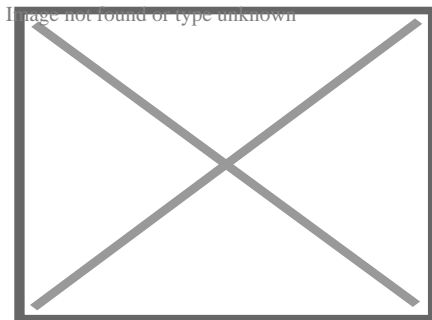
When stress is removed from a consolidated soil, the soil will rebound, drawing water back into the pores and regaining some of the volume it had lost in the consolidation process. If the stress is reapplied, the soil will re-consolidate again along a recompression curve, defined by the

recompression index. Soil that has been consolidated to a large pressure and has been subsequently unloaded is considered to be *overconsolidated*. The maximum past vertical effective stress is termed the *preconsolidation stress*. A soil which is currently experiencing the maximum past vertical effective stress is said to be *normally consolidated*. The *overconsolidation ratio*, (OCR) is the ratio of the maximum past vertical effective stress to the current vertical effective stress. The OCR is significant for two reasons: firstly, because the compressibility of normally consolidated soil is significantly larger than that for overconsolidated soil, and secondly, the shear behavior and dilatancy of clayey soil are related to the OCR through critical state soil mechanics; highly overconsolidated clayey soils are dilatant, while normally consolidated soils tend to be contractive.<sup>[2][3][4]</sup>

## Shear behavior: stiffness and strength

[edit]

Main article: shear strength (soil)



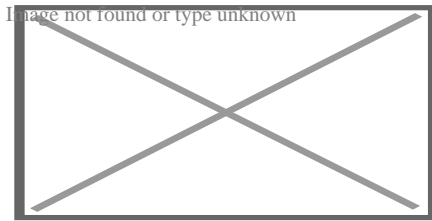
Typical stress strain curve for a drained dilatant soil

The shear strength and stiffness of soil determines whether or not soil will be stable or how much it will deform. Knowledge of the strength is necessary to determine if a slope will be stable, if a building or bridge might settle too far into the ground, and the limiting pressures on a retaining wall. It is important to distinguish between failure of a soil element and the failure of a geotechnical structure (e.g., a building foundation, slope or retaining wall); some soil elements may reach their peak strength prior to failure of the structure. Different criteria can be used to define the "shear strength" and the "yield point" for a soil element from a stress–strain curve. One may define the peak shear strength as the peak of a stress–strain curve, or the shear strength at critical state as the value after large strains when the shear resistance levels off. If the stress–strain curve does not stabilize before the end of shear strength test, the "strength" is sometimes considered to be the shear resistance at 15–20% strain.<sup>[14]</sup> The shear strength of soil depends on many factors including the effective stress and the void ratio.

The shear stiffness is important, for example, for evaluation of the magnitude of deformations of foundations and slopes prior to failure and because it is related to the shear wave velocity. The slope of the initial, nearly linear, portion of a plot of shear stress as a function of shear strain is called the shear modulus

# Friction, interlocking and dilation

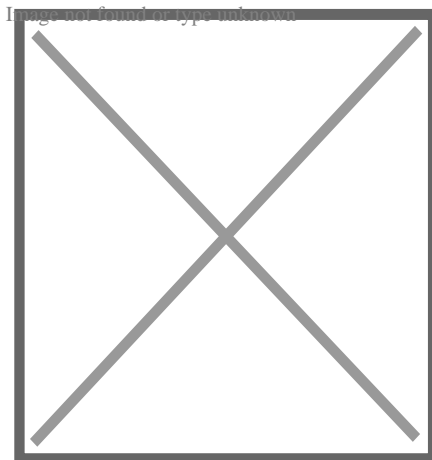
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Angle of repose

Soil is an assemblage of particles that have little to no cementation while rock (such as sandstone) may consist of an assembly of particles that are strongly cemented together by chemical bonds. The shear strength of soil is primarily due to interparticle friction and therefore, the shear resistance on a plane is approximately proportional to the effective normal stress on that plane.<sup>[3]</sup> The angle of internal friction is thus closely related to the maximum stable slope angle, often called the angle of repose.

But in addition to friction, soil derives significant shear resistance from interlocking of grains. If the grains are densely packed, the grains tend to spread apart from each other as they are subject to shear strain. The expansion of the particle matrix due to shearing was called dilatancy by Osborne Reynolds.<sup>[11]</sup> If one considers the energy required to shear an assembly of particles there is energy input by the shear force,  $T$ , moving a distance,  $x$  and there is also energy input by the normal force,  $N$ , as the sample expands a distance,  $y$ .<sup>[11]</sup> Due to the extra energy required for the particles to dilate against the confining pressures, dilatant soils have a greater peak strength than contractive soils. Furthermore, as dilative soil grains dilate, they become looser (their void ratio increases), and their rate of dilation decreases until they reach a critical void ratio. Contractive soils become denser as they shear, and their rate of contraction decreases until they reach a critical void ratio.



A critical state line separates the dilatant and contractive states for soil.

The tendency for a soil to dilate or contract depends primarily on the confining pressure and the void ratio of the soil. The rate of dilation is high if the confining pressure is small and the void ratio is small. The rate of contraction is high if the confining pressure is large and the void ratio is large. As a first approximation, the regions of contraction and dilation are separated by the critical state line.

## Failure criteria

[edit]

After a soil reaches the critical state, it is no longer contracting or dilating and the shear stress on the failure plane  $\tau_{crit}$  is determined by the effective normal stress on the failure plane  $\sigma'_n$  and the critical state friction angle  $\phi_{crit}$

$$\tau_{crit} = \sigma'_n \tan \phi_{crit}$$

The peak strength of the soil may be greater, however, due to the interlocking (dilatancy) contribution. This may be stated:

$$\tau_{peak} = \sigma'_n \tan \phi_{peak}$$

where  $\phi_{peak} > \phi_{crit}$ . However, use of a friction angle greater than the critical state value for design requires care. The peak strength will not be mobilized everywhere at the same time in a practical problem such as a foundation, slope or retaining wall. The critical state friction angle is not nearly as variable as the peak friction angle and hence it can be relied upon with confidence.<sup>[3][4][11]</sup>

Not recognizing the significance of dilatancy, Coulomb proposed that the shear strength of soil may be expressed as a combination of adhesion and friction components:<sup>[11]</sup>

$$\tau_f = c' + \sigma'_n \tan \phi'$$

It is now known that the parameters  $\phi'$  and  $c'$  in the last equation are not fundamental soil properties.<sup>[3][6][11][16]</sup> In particular,  $\phi'$  and  $c'$  are different depending on the magnitude of effective stress.<sup>[6][16]</sup> According to Schofield (2006),<sup>[11]</sup> the longstanding use of  $c'$  has led many engineers to wrongly believe that  $c'$  is a fundamental parameter. This assumption that  $\phi'$  and  $c'$  are constant can lead to overestimation of peak strengths.<sup>[3][16]</sup>

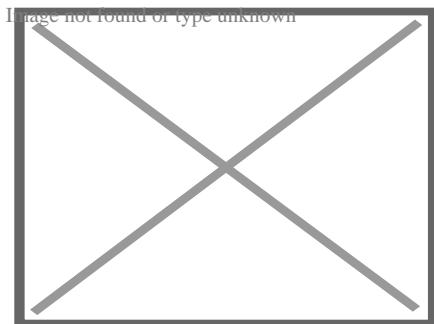
# Structure, fabric, and chemistry

[edit]

In addition to the friction and interlocking (dilatancy) components of strength, the structure and fabric also play a significant role in the soil behavior. The structure and fabric include factors such as the spacing and arrangement of the solid particles or the amount and spatial distribution of pore water; in some cases cementitious material accumulates at particle-particle contacts. Mechanical behavior of soil is affected by the density of the particles and their structure or arrangement of the particles as well as the amount and spatial distribution of fluids present (e.g., water and air voids). Other factors include the electrical charge of the particles, chemistry of pore water, chemical bonds (i.e. cementation -particles connected through a solid substance such as recrystallized calcium carbonate) <sup>[1][16]</sup>

## Drained and undrained shear

[edit]



Moist sand along the shoreline is originally densely packed by the draining water. Foot pressure on the sand causes it to dilate (*see: Reynolds dilatancy*), drawing water from the surface into the pores.

The presence of nearly incompressible fluids such as water in the pore spaces affects the ability for the pores to dilate or contract.

If the pores are saturated with water, water must be sucked into the dilating pore spaces to fill the expanding pores (this phenomenon is visible at the beach when apparently dry spots form around feet that press into the wet sand). <sup>[clarification needed]</sup>

Similarly, for contractive soil, water must be squeezed out of the pore spaces to allow contraction to take place.

Dilation of the voids causes negative water pressures that draw fluid into the pores, and contraction of the voids causes positive pore pressures to push the water out of the pores. If the rate of shearing is very large compared to the rate that water can be sucked into or squeezed out of the dilating or contracting pore spaces, then the shearing is called *undrained shear*, if the shearing is slow enough that the water pressures are negligible, the shearing is called *drained shear*. During undrained shear, the water pressure  $u$  changes depending on volume change tendencies. From the effective stress equation, the change in  $u$  directly effects the effective stress by the equation:

$$\sigma' = \sigma - u,$$

and the strength is very sensitive to the effective stress. It follows then that the undrained shear strength of a soil may be smaller or larger than the drained shear strength depending upon whether the soil is contractive or dilative.

## Shear tests

[edit]

Strength parameters can be measured in the laboratory using direct shear test, triaxial shear test, simple shear test, fall cone test and (hand) shear vane test; there are numerous other devices and variations on these devices used in practice today. Tests conducted to characterize the strength and stiffness of the soils in the ground include the Cone penetration test and the Standard penetration test.

## Other factors

[edit]

The stress–strain relationship of soils, and therefore the shearing strength, is affected by:<sup>[17]</sup>

1. *soil composition* (basic soil material): mineralogy, grain size and grain size distribution, shape of particles, pore fluid type and content, ions on grain and in pore fluid.
2. *state* (initial): Defined by the initial void ratio, effective normal stress and shear stress (stress history). State can be described by terms such as: loose, dense, overconsolidated, normally consolidated, stiff, soft, contractive, dilative, etc.
3. *structure*: Refers to the arrangement of particles within the soil mass; the manner in which the particles are packed or distributed. Features such as layers, joints, fissures, slickensides, voids, pockets, cementation, etc., are part of the structure. Structure of soils is described by terms such as: undisturbed, disturbed, remolded, compacted, cemented; flocculent, honey-combed, single-grained; flocculated, deflocculated; stratified, layered,

laminated; isotropic and anisotropic.

4. *Loading conditions*: Effective stress path - drained, undrained, and type of loading - magnitude, rate (static, dynamic), and time history (monotonic, cyclic).

## Applications

[edit]

# Lateral earth pressure

[edit]

Main article: Lateral earth pressure

Lateral earth stress theory is used to estimate the amount of stress soil can exert perpendicular to gravity. This is the stress exerted on retaining walls. A lateral earth stress coefficient,  $K$ , is defined as the ratio of lateral (horizontal) effective stress to vertical effective stress for cohesionless soils ( $K = \sigma'_h / \sigma'_v$ ). There are three coefficients: at-rest, active, and passive. At-rest stress is the lateral stress in the ground before any disturbance takes place. The active stress state is reached when a wall moves away from the soil under the influence of lateral stress, and results from shear failure due to reduction of lateral stress. The passive stress state is reached when a wall is pushed into the soil far enough to cause shear failure within the mass due to increase of lateral stress. There are many theories for estimating lateral earth stress; some are empirically based, and some are analytically derived.

# Bearing capacity

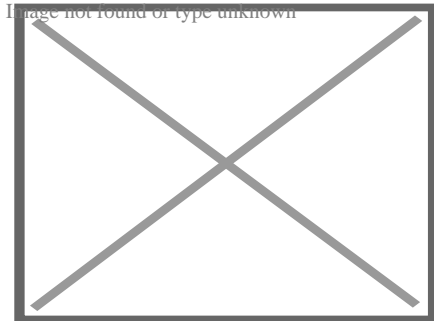
[edit]

Main article: Bearing capacity

The bearing capacity of soil is the average contact stress between a foundation and the soil which will cause shear failure in the soil. Allowable bearing stress is the bearing capacity divided by a factor of safety. Sometimes, on soft soil sites, large settlements may occur under loaded foundations without actual shear failure occurring; in such cases, the allowable bearing stress is determined with regard to the maximum allowable settlement. It is important during construction and design stage of a project to evaluate the subgrade strength. The California Bearing Ratio (CBR) test is commonly used to determine the suitability of a soil as a subgrade for design and construction. The field Plate Load Test is commonly used to predict the deformations and failure characteristics of the soil/subgrade and modulus of subgrade reaction ( $k_s$ ). The Modulus of subgrade reaction ( $k_s$ ) is used in foundation design, soil-structure interaction studies and design of highway pavements.<sup>*[citation needed]*</sup>

# Slope stability

[edit]



Simple slope slip section

Main article: Slope stability

The field of slope stability encompasses the analysis of static and dynamic stability of slopes of earth and rock-fill dams, slopes of other types of embankments, excavated slopes, and natural slopes in soil and soft rock.<sup>[18]</sup>

As seen to the right, earthen slopes can develop a cut-spherical weakness zone. The probability of this happening can be calculated in advance using a simple 2-D circular analysis package.<sup>[19]</sup> A primary difficulty with analysis is locating the most-probable slip plane for any given situation.<sup>[20]</sup> Many landslides have been analyzed only after the fact. Landslides vs. Rock strength are two factors for consideration.

## Recent developments

[edit]

A recent finding in soil mechanics is that soil deformation can be described as the behavior of a dynamical system. This approach to soil mechanics is referred to as Dynamical Systems based Soil Mechanics (DSSM). DSSM holds simply that soil deformation is a Poisson process in which particles move to their final position at random shear strains.

The basis of DSSM is that soils (including sands) can be sheared till they reach a steady-state condition at which, under conditions of constant strain-rate, there is no change in shear stress, effective confining stress, and void ratio. The steady-state was formally defined<sup>[21]</sup> by Steve J. Poulos Archived 2020-10-17 at the Wayback Machine an associate professor at the Soil Mechanics Department of Harvard University, who built off a hypothesis that Arthur Casagrande was formulating towards the end of his career. The steady state condition is not the same as the "critical state" condition. It differs from the critical state in that it specifies a statistically constant structure at the steady state. The steady-state values are also very slightly dependent on the



strain-rate.

Many systems in nature reach steady states, and dynamical systems theory describes such systems. Soil shear can also be described as a dynamical system.<sup>[22][23]</sup> The physical basis of the soil shear dynamical system is a Poisson process in which particles move to the steady-state at random shear strains.<sup>[24]</sup> Joseph<sup>[25]</sup> generalized this—particles move to their final position (not just steady-state) at random shear-strains. Because of its origins in the steady state concept, DSSM is sometimes informally called "Harvard soil mechanics."

DSSM provides for very close fits to stress–strain curves, including for sands. Because it tracks conditions on the failure plane, it also provides close fits for the post failure region of sensitive clays and silts something that other theories are not able to do. Additionally DSSM explains key relationships in soil mechanics that to date have simply been taken for granted, for example, why normalized undrained peak shear strengths vary with the log of the overconsolidation ratio and why stress–strain curves normalize with the initial effective confining stress; and why in one-dimensional consolidation the void ratio must vary with the log of the effective vertical stress, why the end-of-primary curve is unique for static load increments, and why the ratio of the creep value  $C_c$  to the compression index  $C_c$  must be approximately constant for a wide range of soils.<sup>[26]</sup>

## See also

[edit]

- Critical state soil mechanics
- Earthquake engineering
- Engineering geology
- Geotechnical centrifuge modeling
- Geotechnical engineering
- Geotechnical engineering (Offshore)
- Geotechnics
- Hydrogeology, aquifer characteristics closely related to soil characteristics
- International Society for Soil Mechanics and Geotechnical Engineering
- Rock mechanics
- Slope stability analysis

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[edit]

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## External links

[edit]

-  Media related to Soil mechanics at Wikimedia Commons

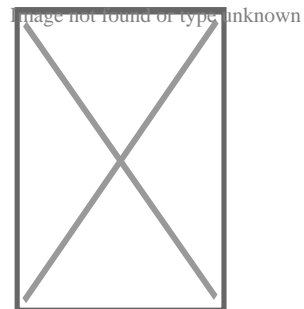
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### Soil science

- History
- Index

## Main fields

- Pedology
- Edaphology
- Soil biology
- Soil microbiology
- Soil zoology
- Soil ecology
- Soil physics
- Soil mechanics
- Soil chemistry
- Environmental soil science
- Agricultural soil science



## **Soil topics**

- Soil
- Pedosphere
  - Soil morphology
  - Pedodiversity
  - Soil formation
- Soil erosion
- Soil contamination
- Soil retrogression and degradation
- Soil compaction
  - Soil compaction (agriculture)
- Soil sealing
- Soil salinity
  - Alkali soil
- Soil pH
  - Soil acidification
- Soil health
- Soil life
- Soil biodiversity
- Soil quality
- Soil value
- Soil fertility
- Soil resilience
- Soil color
- Soil texture
- Soil structure
  - Pore space in soil
  - Pore water pressure
- Soil crust
- Soil horizon
- Soil biomantle
- Soil carbon
- Soil gas
  - Soil respiration
- Soil organic matter
- Soil moisture
  - Soil water (retention)

- **v**
- **t**
- **e**

### **Soil classification**

**World  
Reference  
Base  
for Soil  
Resources  
(1998–)**

- Acrisols
- Alisols
- Andosols
- Anthrosols
- Arenosols
- Calcisols
- Cambisols
- Chernozem
- Cryosols
- Durisols
- Ferralsols
- Fluvisols
- Gleysols
- Gypsisols
- Histosol
- Kastanozems
- Leptosols
- Lixisols
- Luvisols
- Nitisols
- Phaeozems
- Planosols
- Plinthosols
- Podzols
- Regosols
- Retisols
- Solonchaks
- Solonetz
- Stagnosol
- Technosols
- Umbrisols
- Vertisols

**USDA soil  
taxonomy**

- Alfisols
- Andisols
- Aridisols
- Entisols
- Gelisols
- Histosols
- Inceptisols
- Mollisols

## **Applications**

- Soil conservation
- Soil management
- Soil guideline value
- Soil survey
- Soil test
- Soil governance
- Soil value
- Soil salinity control
- Erosion control
- Agroecology
- Liming (soil)

## **Related fields**

- Geology
- Geochemistry
- Petrology
- Geomorphology
- Geotechnical engineering
- Hydrology
- Hydrogeology
- Biogeography
- Earth materials
- Archaeology
- Agricultural science
  - Agrology

## **Societies, Initiatives**



- Australian Society of Soil Science Incorporated
- Canadian Society of Soil Science
- Central Soil Salinity Research Institute (India)
- German Soil Science Society
- Indian Institute of Soil Science
- International Union of Soil Sciences
- International Year of Soil
- National Society of Consulting Soil Scientists (US)
- OPAL Soil Centre (UK)
- Soil Science Society of Poland
- Soil and Water Conservation Society (US)
- Soil Science Society of America
- World Congress of Soil Science

**Scientific journals**

- *Acta Agriculturae Scandinavica B*
- *Journal of Soil and Water Conservation*
- *Plant and Soil*
- *Pochvovedenie*
- *Soil Research*
- *Soil Science Society of America Journal*

**See also**

- Land use
- Land conversion
- Land management
- Vegetation
- Infiltration (hydrology)
- Groundwater
- Crust (geology)
- Impervious surface/Surface runoff
- Petrichor

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-  [Category soil](#)
- [Category soil science](#)
-  [List of soil scientists](#)





















- **v**
- **t**
- **e**

Geotechnical engineering

Offshore geotechnical engineering

## Investigation and instrumentation

### Field (*in situ*)

-  Core drill
-  Cone penetration test
-  Geo-electrical sounding
-  Permeability test
-  Load test
  - Static
  - Dynamic
  - Statnamic
-  Pore pressure measurement
  - Piezometer
  - Well
-  Ram sounding
-  Rock control drilling
-  Rotary-pressure sounding
-  Rotary weight sounding
-  Sample series
-  Screw plate test
- Deformation monitoring
  -  Inclinator
  -  Settlement recordings
-  Shear vane test
-  Simple sounding
-  Standard penetration test
-  Total sounding
-  Trial pit
-  Visible bedrock
- Nuclear densometer test
- Exploration geophysics
- Crosshole sonic logging
- Pile integrity test



## Soil

### Types

- Clay
- Silt
- Sand
- Gravel
- Peat
- Loam
- Loess

### Properties

- Hydraulic conductivity
- Water content
- Void ratio
- Bulk density
- Thixotropy
- Reynolds' dilatancy
- Angle of repose
- Friction angle
- Cohesion
- Porosity
- Permeability
- Specific storage
- Shear strength
- Sensitivity

**Structures  
(Interaction)**

Natural features

- Topography
- Vegetation
- Terrain
- Topsoil
- Water table
- Bedrock
- Subgrade
- Subsoil

Earthworks

- Shoring structures
  - Retaining walls
  - Gabion
  - Ground freezing
  - Mechanically stabilized earth
  - Pressure grouting
  - Slurry wall
  - Soil nailing
  - Tieback
- Land development
- Landfill
- Excavation
- Trench
- Embankment
- Cut
- Causeway
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- Erosion control
- Earth structure
- Expanded clay aggregate
- Crushed stone
- Geosynthetics
  - Geotextile
  - Geomembrane
  - Geosynthetic clay liner
  - Cellular confinement
- Infiltration

Foundations

- Shallow
- Deep

## Mechanics

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- Pore water pressure
- Lateral earth pressure
- Overburden pressure
- Preconsolidation pressure

### Phenomena/ problems

- Permafrost
- Frost heaving
- Consolidation
- Compaction
- Earthquake
  - Response spectrum
  - Seismic hazard
  - Shear wave
- Landslide analysis
  - Stability analysis
  - Mitigation
  - Classification
  - Sliding criterion
  - Slab stabilisation
- Bearing capacity \* Stress distribution in soil

## Numerical analysis software

- SEEP2D
- STABL
- SVFlux
- SVSlope
- UTEXAS
- Plaxis

## Related fields

- Geology
- Geochemistry
- Petrology
- Earthquake engineering
- Geomorphology
- Soil science
- Hydrology
- Hydrogeology
- Biogeography
- Earth materials
- Archaeology
- Agricultural science
  - Agrology

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## About Cook County

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## Things To Do in Cook County

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### Photo

**Sand Ridge Nature Center**

**4.8 (96)**

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**River Trail Nature Center**

**4.6 (235)**

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**Palmisano (Henry) Park**

**4.7 (1262)**

**Driving Directions in Cook County**

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**Driving Directions From Palmisano (Henry) Park to**

## Driving Directions From Lake Katherine Nature Center and Botanic Gardens to

## Driving Directions From Navy Pier to

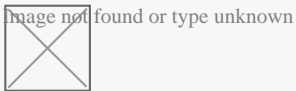
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## Reviews for

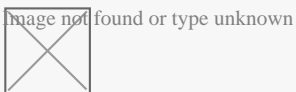
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**Jeffery James**

**(5)**

Very happy with my experience. They were prompt and followed through, and very helpful in fixing the crack in my foundation.

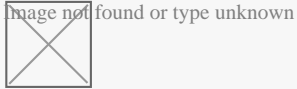


**Sarah McNeily**

**(5)**

USS was excellent. They are honest, straightforward, trustworthy, and conscientious. They thoughtfully removed the flowers and flower bulbs to dig where they needed in the yard, replanted said flowers and spread the extra dirt to fill in an area of the yard. We've had other services from different companies and our yard was really a mess after. They

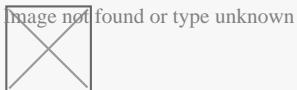
kept the job site meticulously clean. The crew was on time and friendly. I'd recommend them any day! Thanks to Jessie and crew.



**Jim de Leon**

**(5)**

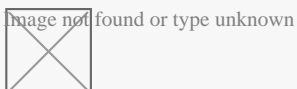
It was a pleasure to work with Rick and his crew. From the beginning, Rick listened to my concerns and what I wished to accomplish. Out of the 6 contractors that quoted the project, Rick seemed the MOST willing to accommodate my wishes. His pricing was definitely more than fair as well. I had 10 push piers installed to stabilize and lift an addition of my house. The project commenced at the date that Rick had disclosed initially and it was completed within the same time period expected (based on Rick's original assessment). The crew was well informed, courteous, and hard working. They were not loud (even while equipment was being utilized) and were well spoken. My neighbors were very impressed on how polite they were when they entered / exited my property (saying hello or good morning each day when they crossed paths). You can tell they care about the customer concerns. They ensured that the property would be put back as clean as possible by placing MANY sheets of plywood down prior to excavating. They compacted the dirt back in the holes extremely well to avoid large stock piles of soils. All the while, the main office was calling me to discuss updates and expectations of completion. They provided waivers of lien, certificates of insurance, properly acquired permits, and JULIE locates. From a construction background, I can tell you that I did not see any flaws in the way they operated and this an extremely professional company. The pictures attached show the push piers added to the foundation (pictures 1, 2 & 3), the amount of excavation (picture 4), and the restoration after dirt was placed back in the pits and compacted (pictures 5, 6 & 7). Please notice that they also sealed two large cracks and steel plated these cracks from expanding further (which you can see under my sliding glass door). I, as well as my wife, are extremely happy that we chose United Structural Systems for our contractor. I would happily tell any of my friends and family to use this contractor should the opportunity arise!



**Chris Abplanalp**

**(5)**

USS did an amazing job on my underpinning on my house, they were also very courteous to the proximity of my property line next to my neighbor. They kept things in order with all the dirt/mud they had to excavate. They were done exactly in the timeframe they indicated, and the contract was very details oriented with drawings of what would be done. Only thing that would have been nice, is they left my concrete a little muddy with boot prints but again, all-in-all a great job



**Dave Kari**

**(5)**

What a fantastic experience! Owner Rick Thomas is a trustworthy professional. Nick and the crew are hard working, knowledgeable and experienced. I interviewed every company in the area, big and small. A homeowner never wants to hear that they have foundation issues. Out of every company, I trusted USS the most, and it paid off in the end. Highly recommend.

Check our other pages :

- [Considering Add On Insurance for Extended Protection](#)
- [Interpreting Detailed Reports from Third Party Engineers](#)
- [Reviewing Contractor Backed Warranty Provisions](#)
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## Frequently Asked Questions

What is the process for making a warranty claim?\*

Knowing how easy it is to file and uphold your warranty claim will give you confidence – but knowing what could void your warranty is equally important. Ask about who maintains ownership over service claims, whether there are any fees associated with claiming your warranty servicing work done, how quickly claims are typically resolved.

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