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Identifying the signs and symptoms of soil heave in residential properties

Soil heave, often caused by the expansion of clay soils when they absorb water, can pose significant problems for residential properties. Uneven floors indicate potential structural problems that may need foundation repair service [foundation repair service areas](#) property. Identifying the signs and symptoms early on is crucial for mitigating damage and ensuring the structural integrity of homes. Here are some key indicators that homeowners should be aware of:

1. **Cracks in Walls and Foundations**: One of the most apparent signs of soil heave is the appearance of cracks in the walls, both interior and exterior. These cracks can vary in size but are usually vertical and may widen over time. Similarly, the foundation might show signs of shifting or cracking, indicating that the soil beneath is expanding.
2. **Uneven Floors**: Soil heave can cause the ground beneath a home to become uneven, leading to sloping or uneven floors. Homeowners might notice doors that no longer close properly or gaps appearing between the floor and the wall.
3. **Sticking Windows and Doors**: As the foundation shifts due to soil expansion, windows and doors may begin to stick or become difficult to open and close. This is a common symptom because the frame of the house is being distorted by the movement beneath it.
4. **Cracks in Driveways and Sidewalks**: Externally, soil heave can cause cracks in driveways, sidewalks, and patios. These cracks are often irregular and can worsen over time, especially after periods of heavy rain.
5. **Bowing or Bulging Walls**: In more severe cases, walls may start to bow or bulge outward. This is a clear sign that the soil beneath is exerting significant pressure on the structure.
6. **Water Pooling Around the Foundation**: If soil heave is causing the ground to become uneven, water may start to pool around the foundation. This can exacerbate the problem by further saturating the soil and leading to more expansion.
7. **Changes in Landscaping**: Homeowners might notice that plants and trees near the house are tilting or showing signs of distress. This can be an indirect indicator that the soil beneath is moving.

Addressing soil heave promptly is essential to prevent further damage. Homeowners should consult with a professional to assess the situation and recommend appropriate solutions,

which may include drainage improvements, soil stabilization techniques, or foundation repairs. Early detection and intervention can save both time and money in the long run, preserving the safety and value of the property.

Understanding the causes and factors contributing to soil heave

Understanding the causes and factors contributing to soil heave is crucial for developing effective techniques to address soil heave issues. Soil heave, also known as frost heave or simply heave, occurs when soil expands due to the freezing of water within it, leading to significant disruptions in structures built on or within the soil. Several primary factors contribute to this phenomenon, and understanding these can help in mitigating its effects.

One of the main causes of soil heave is the presence of water in the soil. When temperatures drop below freezing, the water in the soil starts to freeze and expand. This expansion puts pressure on the surrounding soil particles, causing them to move apart and the soil volume to increase. The extent of heave is directly influenced by the amount of water present in the soil; wetter soils are more susceptible to heave than drier ones.

The type of soil also plays a critical role in the occurrence of soil heave. Fine-grained soils, such as clays and silts, are particularly prone to heave because they have a higher capacity to retain water. These soils have smaller particles that allow water to infiltrate and freeze more readily. In contrast, coarse-grained soils like sands and gravels are less susceptible to heave due to their larger particle size and lower water retention capacity.

Temperature fluctuations are another significant factor. Rapid and repeated freezing and thawing cycles can exacerbate soil heave. When soil freezes and then thaws, the water within it expands and contracts, leading to consistent movement and potential damage to structures above or within the soil. Regions with cold climates and frequent freeze-thaw cycles are more prone to soil heave problems.

The depth of the frost line, or the maximum depth at which the ground freezes in winter, is also a critical consideration. In areas with deep frost lines, soil heave can affect structures more profoundly. Engineers and builders must consider the local frost line depth when designing foundations and other structures to ensure they are built deep enough to avoid the heave zone.

Lastly, human activities can inadvertently contribute to soil heave. Activities such as improper drainage, irrigation practices, and construction can alter the natural water balance in the soil, leading to increased moisture content and heightened susceptibility to heave.

In conclusion, understanding the causes and factors contributing to soil heave—including water content, soil type, temperature fluctuations, frost line depth, and human activities—is essential for developing effective techniques to address soil heave issues. By recognizing these factors, engineers and builders can implement appropriate measures to mitigate the risks associated with soil heave, ensuring the stability and longevity of structures built on or

within the soil.

Assessing the extent of soil heave damage in residential foundations

When it comes to understanding and addressing soil heave issues in residential foundations, one of the critical steps is assessing the extent of the damage caused by soil heave. This process is essential because it helps homeowners and professionals determine the severity of the problem and plan appropriate remedial actions. Soil heave, the upward movement of soil due to the expansion of water-saturated clays, can lead to significant structural issues if not addressed promptly.

To begin with, assessing soil heave damage requires a thorough inspection of the foundation. This typically involves a visual examination by a qualified professional, such as a structural engineer or a geotechnical expert. They will look for common signs of heave, such as cracks in the walls, uneven floors, doors and windows that stick, and gaps between the foundation and the structure above. These visible indicators are often the first clues that soil heave may be occurring.

Beyond visual inspection, more detailed assessments may be necessary. This can include soil sampling and testing to determine the type of soil and its moisture content. Soil tests can reveal the presence of expansive clays, which are a common culprit behind heave issues. Additionally, monitoring equipment such as inclinometers or piezometers may be installed to measure soil movement and water pressure over time, providing valuable data on the extent and progression of heave.

Another crucial aspect of assessing soil heave damage is evaluating the structural integrity of the foundation. This might involve non-destructive testing methods like ground-penetrating radar (GPR) or infrared thermography to detect hidden cracks or weaknesses. In some cases, core samples may be taken from the foundation to assess the depth and nature of the damage.

Once the extent of the soil heave damage is understood, appropriate remediation techniques can be planned. These might include soil stabilization methods, such as chemical treatment or moisture barriers, to prevent further expansion. In more severe cases, structural repairs such as underpinning or piering may be necessary to stabilize the foundation and prevent further damage.

In conclusion, assessing the extent of soil heave damage in residential foundations is a multifaceted process that requires careful inspection, soil testing, and structural evaluation. By understanding the severity of the issue, homeowners and professionals can implement effective solutions to mitigate soil heave and protect the integrity of the foundation. This proactive approach not only preserves the value of the property but also ensures the safety and stability of the home for years to come.

Overview of common techniques for addressing soil heave issues

Certainly! Here's a short essay on the overview of common techniques for addressing soil heave issues:

Soil heave, the upward movement of soil due to moisture expansion or frost action, poses significant challenges to construction projects and infrastructure stability. Addressing soil heave effectively requires a multifaceted approach, incorporating various techniques tailored to specific soil conditions and environmental factors. Here's an overview of common techniques used to mitigate soil heave issues:

1. **Soil Stabilization**: This technique involves modifying the soil's properties to enhance its stability and reduce susceptibility to heave. Methods include adding chemicals like lime or cement to bind soil particles, or using mechanical compaction to densify the soil. Stabilization aims to create a more uniform and stable soil profile, minimizing heave potential.
2. **Drainage Improvement**: Effective drainage is crucial in managing soil moisture levels, a primary cause of heave. Installing drainage systems such as french drains, perforated pipes, or permeable surfaces allows excess water to dissipate, reducing hydrostatic pressure and soil saturation. Proper grading and slope design also facilitate surface water runoff, preventing water accumulation around foundations.
3. **Moisture Barriers**: In areas prone to frost heave, installing moisture barriers can prevent water from infiltrating the soil and freezing. These barriers, often made of geosynthetic materials like polyethylene or bentonite, are placed beneath slabs or pavements to create a barrier against moisture migration. This technique is particularly effective in cold regions where freeze-thaw cycles are prevalent.
4. **Foundation Design Modifications**: Adjusting foundation design to accommodate potential soil movement is a proactive approach. Techniques such as using deeper footings, incorporating flexible foundation systems like raft or mat foundations, or employing pier and beam construction can distribute loads more evenly and accommodate soil expansion without compromising structural integrity.
5. **Vegetation Management**: Vegetation, particularly tree roots, can exacerbate soil heave by extracting moisture and causing soil desiccation. Managing vegetation, especially near structures, involves selective planting of species with non-invasive root systems and maintaining adequate spacing to minimize moisture extraction. Regular monitoring and maintenance of vegetation are essential to prevent heave-related issues.
6. **Geotextiles and Geogrids**: These synthetic materials provide reinforcement and stabilization to soil layers. Geotextiles are permeable fabrics that separate soil layers, while

geogrids are mesh-like structures that enhance soil strength and stability. Incorporating these materials into soil profiles can mitigate heave by improving load distribution and reducing soil movement.

In conclusion, addressing soil heave requires a comprehensive understanding of soil behavior, environmental conditions, and engineering principles. By employing a combination of soil stabilization, drainage improvement, moisture barriers, foundation design modifications, vegetation management, and geosynthetic reinforcements, engineers and construction professionals can effectively mitigate soil heave issues, ensuring the stability and longevity of built structures. Each technique offers unique advantages and should be selected based on site-specific conditions and project requirements to achieve optimal results.

Soil stabilization methods to mitigate soil heave effects

Soil heave, the upward movement of soil due to swelling or frost action, can significantly impact the structural integrity of buildings and infrastructure. To address this challenge, various soil stabilization methods have been developed to mitigate soil heave effects. These techniques aim to enhance soil properties, reduce its susceptibility to swelling, and ensure long-term stability.

One common method is chemical stabilization, which involves adding chemicals to the soil to alter its properties. Lime and cement are frequently used agents. Lime reacts with clay minerals to form stable compounds, reducing the soil's plasticity and swelling potential. Cement, on the other hand, binds soil particles together, creating a stronger, more cohesive matrix that is less prone to heave. These chemical treatments can be applied through mixing, injection, or surface application, depending on the specific site conditions and requirements.

Another effective technique is mechanical stabilization, which includes methods like compaction and reinforcement. Compaction involves increasing the soil's density by applying mechanical force, which reduces pore space and minimizes the potential for water infiltration and subsequent swelling. Reinforcement techniques, such as the addition of geosynthetic materials like geogrids or geotextiles, help distribute loads more evenly across the soil, reducing the impact of heave on structures above.

Thermal stabilization is also employed in regions prone to frost heave. This method involves controlling the soil temperature to prevent freezing. Insulating layers, such as polystyrene boards, can be placed beneath foundations to maintain a consistent temperature and prevent the formation of ice lenses. Additionally, ground heating systems can be installed to warm the soil, ensuring it remains unfrozen throughout the winter months.

Biological stabilization leverages natural processes to enhance soil stability. This can include the use of vegetation to bind soil particles together through root systems, which not only improves soil structure but also reduces erosion and water infiltration. Certain types of

bacteria and microorganisms can also be introduced to the soil to promote the formation of stable aggregates, further mitigating heave effects.

In summary, soil stabilization methods to mitigate soil heave effects are diverse and can be tailored to specific site conditions and project requirements. By employing chemical, mechanical, thermal, and biological techniques, engineers and geotechnical professionals can effectively address soil heave issues, ensuring the longevity and safety of structures built on expansive or frost-susceptible soils.

Drainage system improvements to prevent soil saturation and heave

Certainly!

When it comes to addressing soil heave issues, one of the most effective strategies involves making improvements to the drainage system. Soil heave, which occurs when soil expands due to moisture absorption, can lead to significant structural problems for buildings and infrastructure. By enhancing the drainage system, we can prevent soil saturation, thereby mitigating the risk of heave.

Firstly, it's important to understand that proper drainage ensures excess water is efficiently diverted away from the foundation of structures. This can be achieved through the installation of French drains, which are trenches filled with gravel or rock that channel water away from the building's base. These drains are typically connected to a sump pump system that expels water far from the structure, ensuring the soil remains dry.

Another effective method is the use of permeable pavements. Unlike traditional concrete, permeable pavements allow water to seep through, reducing surface runoff and facilitating better groundwater recharge. This not only helps in preventing soil saturation but also reduces the likelihood of heave.

Additionally, grading the land properly is crucial. Ensuring that the ground slopes away from the building helps in directing water flow away from the foundation. This simple yet effective measure can significantly reduce the amount of water that accumulates around the structure.

Incorporating rain gardens and bioswales into the landscape design is another innovative approach. These features are designed to capture and filter rainwater, allowing it to infiltrate the ground slowly. This reduces the immediate impact of heavy rainfall on the soil and helps maintain a balanced moisture level.

Lastly, regular maintenance of the drainage system is essential. Clogged gutters, broken pipes, and compacted soil can all impede the effectiveness of a drainage system. Routine checks and cleaning can prevent these issues from arising, ensuring the system continues to function optimally.

In conclusion, drainage system improvements play a vital role in preventing soil saturation and subsequent heave. By implementing strategies such as French drains, permeable pavements, proper grading, rain gardens, and consistent maintenance, we can create a more stable environment for structures, safeguarding them against the detrimental effects of soil heave.

Structural repairs and reinforcements for residential foundations affected by soil heave

When it comes to maintaining the integrity of residential foundations, addressing soil heave is crucial. Soil heave, which is the upward movement of the ground due to the expansion of soil, can cause significant damage to the structural integrity of homes. To mitigate these issues, structural repairs and reinforcements are often necessary. Techniques for addressing soil heave involve a combination of assessment, repair, and ongoing maintenance to ensure the longevity and stability of the foundation.

Firstly, a thorough assessment of the affected area is essential. This involves identifying the extent of the soil heave and understanding the underlying causes, such as changes in moisture content or the presence of expansive soils. Professional engineers or geotechnical experts typically conduct this assessment to determine the best course of action.

Once the assessment is complete, repairs can begin. Common techniques include underpinning, where additional support is added beneath the foundation to stabilize it. This can be done through methods like installing helical piers or push piers, which extend deep into the stable soil layers below the heave-affected zone. Another approach is slab jacking, where a mixture of materials is injected beneath the foundation to lift and level it.

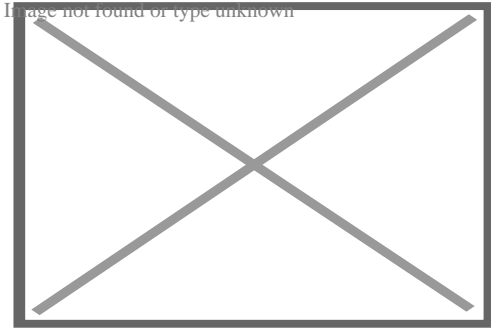
Reinforcements are also critical in preventing future issues. This might involve installing drainage systems to manage water around the foundation, thus reducing the likelihood of soil expansion. Additionally, adding moisture barriers can help maintain consistent soil conditions, minimizing the risk of heave.

In some cases, modifications to the landscaping or the addition of retaining walls may be necessary to further protect the foundation. Regular monitoring and maintenance are also vital, as soil conditions can change over time. Homeowners should be vigilant about signs of distress, such as cracks in walls or floors, and seek professional advice if they notice any issues.

In conclusion, addressing soil heave in residential foundations requires a comprehensive approach that includes assessment, targeted repairs, and ongoing reinforcement strategies. By taking these steps, homeowners can protect their investments and ensure the structural integrity of their homes for years to come.

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Not to be confused with Zoning laws.



Code Violation: This fire-rated concrete block wall is penetrated by cable trays and electrical cables. The hole should be firestopped to restore the fire-resistance rating of the wall. Instead, it is filled with flammable polyurethane foam.

A **building code** (also **building control** or **building regulations**) is a set of rules that specify the standards for construction objects such as buildings and non-building structures. Buildings must conform to the code to obtain planning permission, usually from a local council. The main purpose of building codes is to protect public health, safety and general welfare as they relate to the construction and occupancy of buildings and structures—*for example*, the building codes in many countries require engineers to consider the effects of soil liquefaction in the design of new buildings.^[1] The building code becomes law of a particular jurisdiction when formally enacted by the appropriate governmental or private authority.^[2]

Building codes are generally intended to be applied by architects, engineers, interior designers, constructors and regulators but are also used for various purposes by safety inspectors, environmental scientists, real estate developers, subcontractors, manufacturers of building products and materials, insurance companies, facility managers, tenants, and others. Codes regulate the design and construction of structures where adopted into law.

Examples of building codes began in ancient times.^[3] In the USA the main codes are the International Building Code or International Residential Code [IBC/IRC], electrical codes and plumbing, mechanical codes. Fifty states and the District of Columbia have adopted the I-Codes at the state or jurisdictional level.^[4] In Canada, national model codes are published by the National Research Council of Canada.^[5] In the United Kingdom, compliance with Building Regulations is monitored by building control bodies, either Approved Inspectors or Local Authority Building Control departments. Building Control regularisation charges apply in case work is undertaken which should have had been inspected at the time of the work if this was not done.^[6]

Types

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The practice of developing, approving, and enforcing building codes varies considerably among nations. In some countries building codes are developed by the government agencies or quasi-governmental standards organizations and then enforced across the country by the central government. Such codes are known as the **national building codes** (in a sense they enjoy a mandatory nationwide application).

In other countries, where the power of regulating construction and fire safety is vested in local authorities, a system of model building codes is used. Model building codes have no legal status unless adopted or adapted by an authority having jurisdiction. The developers of model codes urge public authorities to reference model codes in their laws, ordinances, regulations, and administrative orders. When referenced in any of these legal instruments, a particular model code becomes law. This practice is known as 'adoption by reference'. When an adopting authority decides to delete, add, or revise any portions of the model code adopted, it is usually required by the model code developer to follow a formal adoption procedure in which those modifications can be documented for legal purposes.

There are instances when some local jurisdictions choose to develop their own building codes. At some point in time all major cities in the United States had their own building codes. However, due to ever increasing complexity and cost of developing building regulations, virtually all municipalities in the country have chosen to adopt model codes instead. For example, in 2008 New York City abandoned its proprietary *1968 New York City Building Code* in favor of a customized version of the International Building Code.^[7] The City of Chicago remains the only municipality in America that continues to use a building code the city developed on its own as part of the *Municipal Code of Chicago*.

In Europe, the Eurocode: Basis of structural design, is a pan-European building code that has superseded the older national building codes. Each country now has National Annexes to localize the contents of the Eurocodes.

Similarly, in India, each municipality and urban development authority has its own building code, which is mandatory for all construction within their jurisdiction. All these local building codes are variants of a National Building Code,^[8] which serves as model code providing guidelines for regulating building construction activity.

Scope

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The purpose of building codes is to provide minimum standards for safety, health, and general welfare including structural integrity, mechanical integrity (including sanitation, water supply, light, and ventilation), means of egress, fire prevention and control, and energy conservation.^[9]
[[¹⁰]] Building codes generally include:

- Standards for structure, placement, size, usage, wall assemblies, fenestration size/locations, egress rules, size/location of rooms, foundations, floor assemblies, roof structures/assemblies, energy efficiency, stairs and halls, mechanical, electrical, plumbing, site drainage & storage, appliance, lighting, fixtures standards, occupancy rules, and swimming pool regulations
- Rules regarding parking and traffic impact
- Fire code rules to minimize the risk of a fire and to ensure safe evacuation in the event of such an emergency^[citation needed]
- Requirements for earthquake (seismic code), hurricane, flood, and tsunami resistance, especially in disaster prone areas or for very large buildings where a failure would be catastrophic^[citation needed]
- Requirements for specific building uses (for example, storage of flammable substances, or housing a large number of people)
- Energy provisions and consumption
- Grandfather clauses: Unless the building is being renovated, the building code usually does not apply to existing buildings.
- Specifications on components
- Allowable installation methodologies
- Minimum and maximum room ceiling heights, exit sizes and location
- Qualification of individuals or corporations doing the work
- For high structures, anti-collision markers for the benefit of aircraft

Building codes are generally separate from zoning ordinances, but exterior restrictions (such as setbacks) may fall into either category.

Designers use building code standards out of substantial reference books during design. Building departments review plans submitted to them before construction, issue permits [or not] and inspectors verify compliance to these standards at the site during construction.

There are often additional codes or sections of the same building code that have more specific requirements that apply to dwellings or places of business and special construction objects such as canopies, signs, pedestrian walkways, parking lots, and radio and television antennas.

Criticism

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Building codes have been criticized for contributing to housing crisis and increasing the cost of new housing to some extent, including through conflicting code between different administrators.^[11] Proposed improvements include regular review and cost-benefit analysis of building codes,^[12] promotion of low-cost construction materials and building codes suitable to mass production,^[11] reducing bureaucracy, and promoting transparency.^[13]

History

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Antiquity

[edit]

Building codes have a long history. The earliest known written building code is included in the Code of Hammurabi,^[3] which dates from circa 1772 BC.

The book of Deuteronomy in the Hebrew Bible stipulated that parapets must be constructed on all houses to prevent people from falling off.^[14]

In the Chinese book of rites it mentions that ancestral temples and houses should be a certain standard length in ancient China they measured land in the chu or well field system so it was important to be precise though most of the actual lengths are lost or obscure.^{[15][16]}

In ancient Japan a certain official destroyed a courtiers house because the size was above his rank.^[17]

Modern era

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France

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In Paris, under the reconstruction of much of the city under the Second Empire (1852–70), great blocks of apartments were erected^[18] and the height of buildings was limited by law to five or six stories at most.

United Kingdom

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After the Great Fire of London in 1666, which had been able to spread so rapidly through the densely built timber housing of the city, the Rebuilding of London Act 1666 was passed in the same year as the first significant building regulation.^[19] Drawn up by Sir Matthew Hale, the act regulated the rebuilding of the city, required housing to have some fire resistance capacity and authorised the City of London Corporation to reopen and widen roads.^[20] The Laws of the Indies were passed in the 1680s by the Spanish Crown to regulate the urban planning for colonies throughout Spain's worldwide imperial possessions.

The first systematic national building standard was established with the Metropolitan Buildings Act 1844. Among the provisions, builders were required to give the district surveyor two days' notice before building, regulations regarding the thickness of walls, height of rooms, the materials used in repairs, the dividing of existing buildings and the placing and design of chimneys, fireplaces and drains were to be enforced and streets had to be built to minimum requirements.^[21]

The Metropolitan Buildings Office was formed to regulate the construction and use of buildings throughout London. Surveyors were empowered to enforce building regulations, which sought to improve the standard of houses and business premises, and to regulate activities that might threaten public health. In 1855 the assets, powers and responsibilities of the office passed to the Metropolitan Board of Works.

United States

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The City of Baltimore passed its first building code in 1891.^[22] The Great Baltimore Fire occurred in February 1904. Subsequent changes were made that matched other cities.^[23] In 1904, a Handbook of the Baltimore City Building Laws was published. It served as the building code for four years. Very soon, a formal building code was drafted and eventually adopted in 1908.

The structural failure of the tank that caused the Great Molasses Flood of 1919 prompted the Boston Building Department to require engineering and architectural calculations be filed and signed. U.S. cities and states soon began requiring sign-off by registered professional engineers for the plans of major buildings.^[24]

More recently, the 2015 Berkeley balcony collapse has prompted updates to California's balcony building codes, set for 2025, which include stricter material requirements, enhanced

load-bearing standards, and mandatory inspections which known as SB326 and SB721.^[25] These laws mandate regular inspections every six years for multifamily buildings. Property owners and HOAs are required to address any structural or waterproofing issues identified during inspections to ensure compliance and safety. Failure to comply can result in fines, increased liability, and legal consequences. The updates aim to prevent tragedies like the Berkeley collapse, which was caused by dry rot and structural failure, by ensuring the long-term safety and durability of elevated structures.^[26]

Energy codes

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The current energy codes^[*clarification needed*] of the United States are adopted at the state and municipal levels and are based on the International Energy Conservation Code (IECC). Previously, they were based on the Model Energy Code (MEC). As of March 2017, the following residential codes have been partially or fully adopted by states:^[27]

- 2015 IECC or equivalent (California, Illinois, Maryland, Massachusetts, Michigan, Pennsylvania, New Jersey, New York, Vermont, Washington)
- 2012 IECC or equivalent (Alabama, Connecticut, Delaware, District of Columbia, Florida, Iowa, Minnesota, Nevada, Rhode Island, Texas)
- 2009 IECC or equivalent (Arkansas, Georgia, Idaho, Indiana, Kentucky, Louisiana, Montana, Nebraska, New Hampshire, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, South Carolina, Tennessee, Virginia, West Virginia, Wisconsin)
- 2006 IECC or equivalent (Utah)
- 2006 IECC or no statewide code (Alaska, Arizona, Colorado, Kansas, Maine, Mississippi, Missouri, North Dakota, South Dakota, Wyoming)

Australia

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Australia uses the National Construction Code.

See also

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- Building officials
- Construction law
- Earthquake-resistant structures
- Energy Efficiency and Conservation Block Grants

- Outline of construction
- Seismic code
- Uniform Mechanical Code
- Variance (land use) – permission to vary zoning and sometimes building to code

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[edit]

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Construction

Types

- Home construction
- Offshore construction
- Underground construction
 - Tunnel construction

History

- Architecture
- Construction
- Structural engineering
- Timeline of architecture
- Water supply and sanitation

Professions

- Architect
- Building engineer
- Building estimator
- Building officials
- Chartered Building Surveyor
- Civil engineer
- Civil estimator
- Clerk of works
- Project manager
- Quantity surveyor
- Site manager
- Structural engineer
- Superintendent

Trades workers (List)

- Banksman
- Boilermaker
- Bricklayer
- Carpenter
- Concrete finisher
- Construction foreman
- Construction worker
- Electrician
- Glazier
- Ironworker
- Millwright
- Plasterer
- Plumber
- Roofer
- Steel fixer
- Welder

Organizations	<ul style="list-style-type: none"> ○ American Institute of Constructors (AIC) ○ American Society of Civil Engineers (ASCE) ○ Asbestos Testing and Consultancy Association (ATAC) ○ Associated General Contractors of America (AGC) ○ Association of Plumbing and Heating Contractors (APHC) ○ Build UK ○ Construction History Society ○ Chartered Institution of Civil Engineering Surveyors (CICES) ○ Chartered Institute of Plumbing and Heating Engineering (CIPHE) ○ Civil Engineering Contractors Association (CECA) ○ The Concrete Society ○ Construction Management Association of America (CMAA) ○ Construction Specifications Institute (CSI) ○ FIDIC ○ Home Builders Federation (HBF) ○ Lighting Association ○ National Association of Home Builders (NAHB) ○ National Association of Women in Construction (NAWIC) ○ National Fire Protection Association (NFPA) ○ National Kitchen & Bath Association (NKBA) ○ National Railroad Construction and Maintenance Association (NRC) ○ National Tile Contractors Association (NTCA) ○ Railway Tie Association (RTA) ○ Royal Institution of Chartered Surveyors (RICS) ○ Scottish Building Federation (SBF) ○ Society of Construction Arbitrators
By country	<ul style="list-style-type: none"> ○ India ○ Iran ○ Japan ○ Romania ○ Turkey ○ United Kingdom ○ United States
Regulation	<ul style="list-style-type: none"> ○ Building code ○ Construction law ○ Site safety ○ Zoning

Architecture

- Style
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- Industrial architecture
 - British
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- Interior architecture
- Landscape architecture
- Vernacular architecture

Engineering

- Architectural engineering
- Building services engineering
- Civil engineering
 - Coastal engineering
 - Construction engineering
 - Structural engineering
- Earthquake engineering
- Environmental engineering
- Geotechnical engineering

Methods

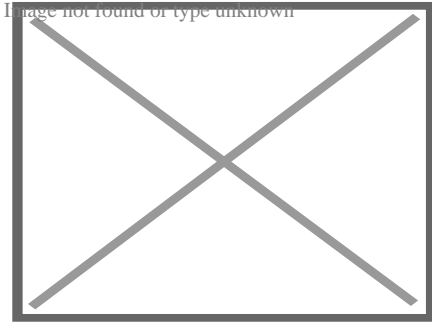
- List
- Earthbag construction
- Modern methods of construction
- Monocrete construction
- Slip forming

- Building material
 - List of building materials
 - Millwork
- Construction bidding
- Construction delay
- Construction equipment theft
- Construction loan
- Construction management
- Construction waste
- Demolition
- Design–build
- Design–bid–build
- DfMA
- Heavy equipment
- Interior design
- Lists of buildings and structures
 - List of tallest buildings and structures
- Megaproject
- Megastructure
- Plasterwork
 - Damp
 - Proofing
 - Parge coat
 - Roughcast
 - Harling
- Real estate development
- Stonemasonry
- Sustainability in construction
- Unfinished building
- Urban design
- Urban planning

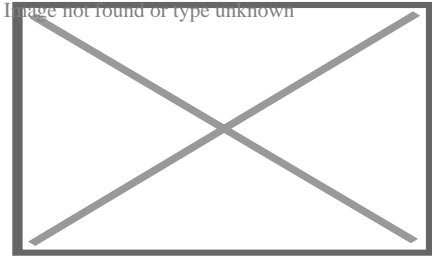
Other topics

 Outline  Category

About concrete slab



Suspended slab under construction, with the formwork still in place



Suspended slab formwork and rebar in place, ready for concrete pour.

A **concrete slab** is a common structural element of modern buildings, consisting of a flat, horizontal surface made of cast concrete. Steel-reinforced slabs, typically between 100 and 500 mm thick, are most often used to construct floors and ceilings, while thinner *mud slabs* may be used for exterior paving (see below).[¹][²]

In many domestic and industrial buildings, a thick concrete slab supported on foundations or directly on the subsoil, is used to construct the ground floor. These slabs are generally classified as *ground-bearing* or *suspended*. A slab is ground-bearing if it rests directly on the foundation, otherwise the slab is suspended.[³] For multi-story buildings, there are several common slab designs (

see § Design for more types):

- Beam and block, also referred to as *rib and block*, is mostly used in residential and industrial applications. This slab type is made up of pre-stressed beams and hollow blocks and are temporarily propped until set, typically after 21 days.[⁴]
- A hollow core slab which is precast and installed on site with a crane
- In high rise buildings and skyscrapers, thinner, pre-cast concrete slabs are slung between the steel frames to form the floors and ceilings on each level. Cast in-situ slabs are used in high rise buildings and large shopping complexes as well as houses. These in-situ slabs are cast on site using shutters and reinforced steel.

On technical drawings, reinforced concrete slabs are often abbreviated to "r.c.c. slab" or simply "r.c.". Calculations and drawings are often done by structural engineers in CAD software.

Thermal performance

[edit]

Energy efficiency has become a primary concern for the construction of new buildings, and the prevalence of concrete slabs calls for careful consideration of its thermal properties in order to minimise wasted energy.^[5] Concrete has similar thermal properties to masonry products, in that it has a relatively high thermal mass and is a good conductor of heat.

In some special cases, the thermal properties of concrete have been employed, for example as a heatsink in nuclear power plants or a thermal buffer in industrial freezers.^[6]

Thermal conductivity

[edit]

Thermal conductivity of a concrete slab indicates the rate of heat transfer through the solid mass by conduction, usually in regard to heat transfer to or from the ground. The coefficient of thermal conductivity, k , is proportional to density of the concrete, among other factors.^[5] The primary influences on conductivity are moisture content, type of aggregate, type of cement, constituent proportions, and temperature. These various factors complicate the theoretical evaluation of a k -value, since each component has a different conductivity when isolated, and the position and proportion of each components affects the overall conductivity. To simplify this, particles of aggregate may be considered to be suspended in the homogeneous cement. Campbell-Allen and Thorne (1963) derived a formula for the theoretical thermal conductivity of concrete.^[6] In practice this formula is rarely applied, but remains relevant for theoretical use. Subsequently, Valore (1980) developed another formula in terms of overall density.^[7] However, this study concerned hollow concrete blocks and its results are unverified for concrete slabs.

The actual value of k varies significantly in practice, and is usually between 0.8 and 2.0 W m⁻¹ K⁻¹.^[8] This is relatively high when compared to other materials, for example the conductivity of wood may be as low as 0.04 W m⁻¹ K⁻¹. One way of mitigating the effects of thermal conduction is to introduce insulation (

see § Insulation).

Thermal mass

[edit]

The second consideration is the high thermal mass of concrete slabs, which applies similarly to walls and floors, or wherever concrete is used within the thermal envelope. Concrete has a

relatively high thermal mass, meaning that it takes a long time to respond to changes in ambient temperature.^[9] This is a disadvantage when rooms are heated intermittently and require a quick response, as it takes longer to warm the entire building, including the slab. However, the high thermal mass is an advantage in climates with large daily temperature swings, where the slab acts as a regulator, keeping the building cool by day and warm by night.

Typically concrete slabs perform better than implied by their R-value.^[5] The R-value does not consider thermal mass, since it is tested under constant temperature conditions. Thus, when a concrete slab is subjected to fluctuating temperatures, it will respond more slowly to these changes and in many cases increase the efficiency of a building.^[5] In reality, there are many factors which contribute to the effect of thermal mass, including the depth and composition of the slab, as well as other properties of the building such as orientation and windows.

Thermal mass is also related to thermal diffusivity, heat capacity and insulation. Concrete has low thermal diffusivity, high heat capacity, and its thermal mass is negatively affected by insulation (e.g. carpet).^[5]

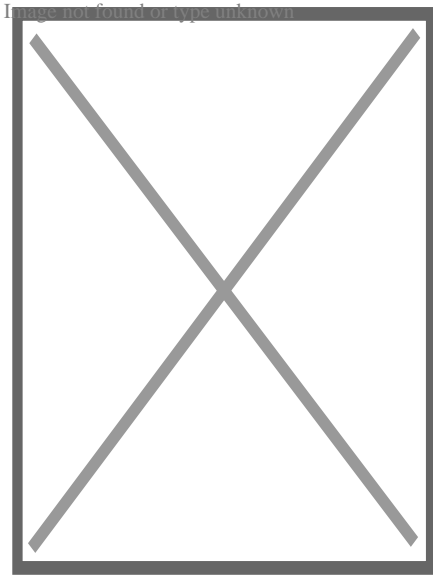
Insulation

[edit]

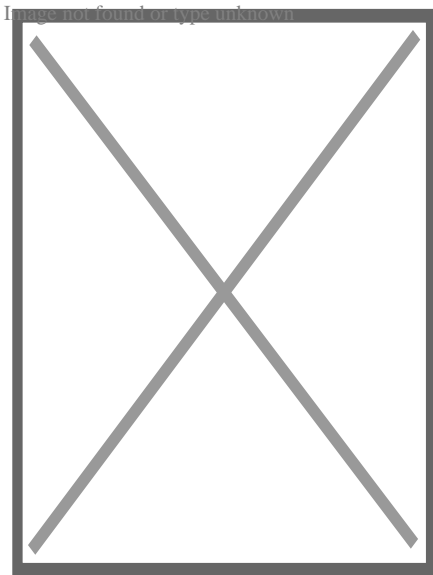
Without insulation, concrete slabs cast directly on the ground can cause a significant amount of extraneous energy transfer by conduction, resulting in either lost heat or unwanted heat. In modern construction, concrete slabs are usually cast above a layer of insulation such as expanded polystyrene, and the slab may contain underfloor heating pipes.^[10] However, there are still uses for a slab that is not insulated, for example in outbuildings which are not heated or cooled to room temperature (

see § Mud slabs). In these cases, casting the slab directly onto a substrate of aggregate will maintain the slab near the temperature of the substrate throughout the year, and can prevent both freezing and overheating.

A common type of insulated slab is the beam and block system (mentioned above) which is modified by replacing concrete blocks with expanded polystyrene blocks.^[11] This not only allows for better insulation but decreases the weight of slab which has a positive effect on load bearing walls and foundations.



Formwork set for concrete pour.



Concrete poured into formwork. This slab is ground-bearing and reinforced with steel rebar.

Design

[edit]

Further information: Marcus' method

Ground-bearing slabs

[edit]

See also: Shallow foundation § Slab on grade

Ground-bearing slabs, also known as "on-ground" or "slab-on-grade", are commonly used for ground floors on domestic and some commercial applications. It is an economical and quick construction method for sites that have non-reactive soil and little slope.^[12]

For ground-bearing slabs, it is important to design the slab around the type of soil, since some soils such as clay are too dynamic to support a slab consistently across its entire area. This results in cracking and deformation, potentially leading to structural failure of any members attached to the floor, such as wall studs.^[12]

Levelling the site before pouring concrete is an important step, as sloping ground will cause the concrete to cure unevenly and will result in differential expansion. In some cases, a naturally sloping site may be levelled simply by removing soil from the uphill site. If a site has a more significant grade, it may be a candidate for the "cut and fill" method, where soil from the higher ground is removed, and the lower ground is built up with fill.^[13]

In addition to filling the downhill side, this area of the slab may be supported on concrete piers which extend into the ground. In this case, the fill material is less important structurally as the dead weight of the slab is supported by the piers. However, the fill material is still necessary to support the curing concrete and its reinforcement.

There are two common methods of filling - *controlled fill* and *rolled fill*.^[13]

- **Controlled fill:** Fill material is compacted in several layers by a vibrating plate or roller. Sand fills areas up to around 800 mm deep, and clay may be used to fill areas up to 400 mm deep. However, clay is much more reactive than sand, so it should be used sparingly and carefully. Clay must be moist during compaction to homogenise it.^[13]
- **Rolled fill:** Fill is repeatedly compacted by an excavator, but this method of compaction is less effective than a vibrator or roller. Thus, the regulations on maximum depth are typically stricter.

Proper curing of ground-bearing concrete is necessary to obtain adequate strength. Since these slabs are inevitably poured on-site (rather than precast as some suspended slabs are), it can be difficult to control conditions to optimize the curing process. This is usually aided by a membrane, either plastic (temporary) or a liquid compound (permanent).^[14]

Ground-bearing slabs are usually supplemented with some form of reinforcement, often steel rebar. However, in some cases such as concrete roads, it is acceptable to use an unreinforced slab if it is adequately engineered (

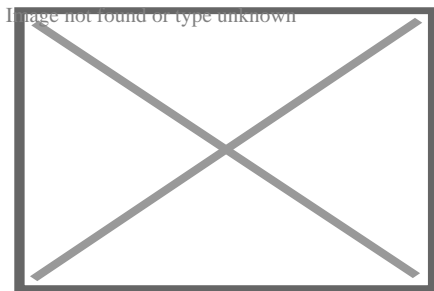
see below).

Suspended slabs

[edit]

For a suspended slab, there are a number of designs to improve the strength-to-weight ratio. In all cases the top surface remains flat, and the underside is modulated:

- A *corrugated slab* is designed when the concrete is poured into a corrugated steel tray, more commonly called decking. This steel tray improves strength of the slab, and prevents the slab from bending under its own weight. The corrugations run in one direction only.
- A *ribbed slab* gives considerably more strength in one direction. This is achieved with concrete beams bearing load between piers or columns, and thinner, integral ribs in the perpendicular direction. An analogy in carpentry would be a subfloor of bearers and joists. Ribbed slabs have higher load ratings than corrugated or flat slabs, but are inferior to waffle slabs.^[15]
- A *waffle slab* gives added strength in both directions using a matrix of recessed segments beneath the slab.^[16] This is the same principle used in the ground-bearing version, the waffle slab foundation. Waffle slabs are usually deeper than ribbed slabs of equivalent strength, and are heavier hence require stronger foundations. However, they provide increased mechanical strength in two dimensions, a characteristic important for vibration resistance and soil movement.^[17]



The exposed underside of a waffle slab used in a multi-storey building

Unreinforced slabs

[edit]

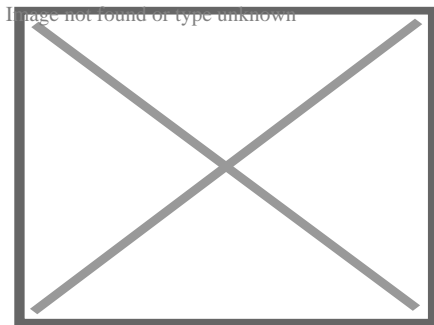
Unreinforced or "plain"^[18] slabs are becoming rare and have limited practical applications, with one exception being the mud slab (

see below). They were once common in the US, but the economic value of reinforced ground-bearing slabs has become more appealing for many engineers.^[10] Without reinforcement, the entire load on these slabs is supported by the strength of the concrete, which becomes a vital factor. As a result, any stress induced by a load, static or dynamic, must be within the limit of the concrete's flexural strength to prevent cracking.^[19] Since unreinforced concrete is relatively very weak in tension, it is important to consider the effects of tensile stress caused by reactive soil, wind uplift, thermal expansion, and cracking.^[20] One of the most common applications for unreinforced slabs is in concrete roads.

Mud slabs

[edit]

Mud slabs, also known as *rat slabs*, are thinner than the more common suspended or ground-bearing slabs (usually 50 to 150 mm), and usually contain no reinforcement.^[21] This makes them economical and easy to install for temporary or low-usage purposes such as subfloors, crawlspaces, pathways, paving, and levelling surfaces.^[22] In general, they may be used for any application which requires a flat, clean surface. This includes use as a base or "sub-slab" for a larger structural slab. On uneven or steep surfaces, this preparatory measure is necessary to provide a flat surface on which to install rebar and waterproofing membranes.^[10] In this application, a mud slab also prevents the plastic bar chairs from sinking into soft topsoil which can cause spalling due to incomplete coverage of the steel. Sometimes a mud slab may be a substitute for coarse aggregate. Mud slabs typically have a moderately rough surface, finished with a float.^[10]



Substrate and rebar prepared for pouring a mud slab

Axes of support

[edit]

One-way slabs

[edit]

A *one-way slab* has moment-resisting reinforcement only in its short axis, and is used when the moment in the long axis is negligible.^[23] Such designs include corrugated slabs and ribbed slabs. Non-reinforced slabs may also be considered one-way if they are supported on only two opposite sides (i.e. they are supported in one axis). A one-way reinforced slab may be stronger than a two-way non-reinforced slab, depending on the type of load.

The calculation of reinforcement requirements for a one-way slab can be extremely tedious and time-consuming, and one can never be completely certain of the best design.^[citation needed] Even minor changes to the project can necessitate recalculation of the reinforcement

requirements. There are many factors to consider during the structural structure design of one-way slabs, including:

- Load calculations
- Bending moment calculation
- Acceptable depth of flexure and deflection
- Type and distribution of reinforcing steel

Two-way slabs

[edit]

A *two-way slab* has moment resisting reinforcement in both directions.^[24] This may be implemented due to application requirements such as heavy loading, vibration resistance, clearance below the slab, or other factors. However, an important characteristic governing the requirement of a two-way slab is the ratio of the two horizontal lengths. If $\frac{L_x}{L_y} \leq 2$, where L_x is the short dimension and L_y is the long dimension, then moment in both directions should be considered in design.^[25] In other words, if the axial ratio is greater than two, a two-way slab is required.

A non-reinforced slab is two-way if it is supported in both horizontal axes.

Construction

[edit]

A concrete slab may be prefabricated (precast), or constructed on site.

Prefabricated

[edit]

Prefabricated concrete slabs are built in a factory and transported to the site, ready to be lowered into place between steel or concrete beams. They may be pre-stressed (in the factory), post-stressed (on site), or unstressed.^[10] It is vital that the wall supporting structure is built to the correct dimensions, or the slabs may not fit.

On-site

[edit]

On-site concrete slabs are built on the building site using formwork, a type of boxing into which the wet concrete is poured. If the slab is to be reinforced, the rebars, or metal bars, are positioned within the formwork before the concrete is poured in.^[26] Plastic-tipped metal or plastic bar chairs, are used to hold the rebar away from the bottom and sides of the form-work, so that when the concrete sets it completely envelops the reinforcement. This concept is known as concrete cover. For a ground-bearing slab, the formwork may consist only of side walls pushed into the ground. For a suspended slab, the formwork is shaped like a tray, often supported by a temporary scaffold until the concrete sets.

The formwork is commonly built from wooden planks and boards, plastic, or steel. On commercial building sites, plastic and steel are gaining popularity as they save labour.^[27] On low-budget or small-scale jobs, for instance when laying a concrete garden path, wooden planks are very common. After the concrete has set the wood may be removed.

Formwork can also be permanent, and remain in situ post concrete pour. For large slabs or paths that are poured in sections, this permanent formwork can then also act as isolation joints within concrete slabs to reduce the potential for cracking due to concrete expansion or movement.

In some cases formwork is not necessary. For instance, a ground slab surrounded by dense soil, brick or block foundation walls, where the walls act as the sides of the tray and hardcore (rubble) acts as the base.

See also

[edit]

- Shallow foundation (Commonly used for ground-bearing slabs)
- Hollow-core slab (Voided slab, one-way spanning)
- Beam and block (voided slab, one way spanning)
- Voided biaxial slab (Voided slab, two-way spanning)
- Formwork
- Precast concrete
- Reinforced concrete
- Rebar
- Concrete cover

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[edit]

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External links

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- o *Concrete Basics: A Guide to Concrete Practice*
- o *Super Insulated Slab Foundations*
- o *Design of Slabs on Ground* Archived 2021-05-08 at the Wayback Machine

- o v
- o t
- o e

Concrete

History

- o Ancient Roman architecture
- o Roman architectural revolution
- o Roman concrete
- o Roman engineering
- o Roman technology

Composition	<ul style="list-style-type: none"> ○ Cement <ul style="list-style-type: none"> ○ Calcium aluminate ○ Energetically modified ○ Portland ○ Rosendale ○ Water ○ Water–cement ratio ○ Aggregate ○ Reinforcement ○ Fly ash ○ Ground granulated blast-furnace slag ○ Silica fume ○ Metakaolin
Production	<ul style="list-style-type: none"> ○ Plant ○ Concrete mixer ○ Volumetric mixer ○ Reversing drum mixer ○ Slump test ○ Flow table test ○ Curing ○ Concrete cover ○ Cover meter ○ Rebar
Construction	<ul style="list-style-type: none"> ○ Precast ○ Cast-in-place ○ Formwork ○ Climbing formwork ○ Slip forming ○ Screed ○ Power screed ○ Finisher ○ Grinder ○ Power trowel ○ Pump ○ Float ○ Sealer ○ Tremie

Science

- Properties
- Durability
- Degradation
- Environmental impact
- Recycling
- Segregation
- Alkali–silica reaction

Types

- AstroCrete
- Fiber-reinforced
- Filigree
- Foam
- Lunarcrete
- Mass
- Nanoconcrete
- Pervious
- Polished
- Polymer
- Prestressed
- Ready-mix
- Reinforced
- Roller-compacting
- Self-consolidating
- Self-leveling
- Sulfur
- Tabby
- Translucent
- Waste light
- Aerated
 - AAC
 - RAAC

Applications

- Slab
 - waffle
 - hollow-core
 - voided biaxial
 - slab on grade
- Concrete block
- Step barrier
- Roads
- Columns
- Structures

Organizations

- American Concrete Institute
- Concrete Society
- Institution of Structural Engineers
- Indian Concrete Institute
- Nanocem
- Portland Cement Association
- International Federation for Structural Concrete

Standards

- Eurocode 2
- EN 197-1
- EN 206-1
- EN 10080

See also

- Hempcrete

-  Category:Concrete

About Cook County

Photo

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Things To Do in Cook County

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Sand Ridge Nature Center

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River Trail Nature Center

4.6 (235)

Photo

Palmisano (Henry) Park

4.7 (1262)

Driving Directions in Cook County

Driving Directions From Palmisano (Henry) Park to

Driving Directions From Lake Katherine Nature Center and Botanic Gardens to

Driving Directions From Navy Pier to

<https://www.google.com/maps/dir/Navy+Pier/United+Structural+Systems+of+Illinois%2087.6050944,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sunknown!2m2!1d-87.6050944!2d41.8918633!1m5!1m1!1sChIJ-wSxDtinD4gRiv4kY3RRh9U!2m2!1d-88.1396465!2d42.0637725!3e0>

<https://www.google.com/maps/dir/Lake+Katherine+Nature+Center+and+Botanic+Garden%2087.8010774,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sunknown!2m2!1d-87.8010774!2d41.6776048!1m5!1m1!1sChIJ-wSxDtinD4gRiv4kY3RRh9U!2m2!1d-88.1396465!2d42.0637725!3e2>

<https://www.google.com/maps/dir/Palmisano+%28Henry%29+Park/United+Structural+Systems+of+Illinois%2087.6490151,14z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1sunknown!2m2!1d-87.6490151!2d41.8429903!1m5!1m1!1sChIJ-wSxDtinD4gRiv4kY3RRh9U!2m2!1d-88.1396465!2d42.0637725!3e1>

Reviews for



Jeffery James

(5)

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



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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.



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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!



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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



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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.

Techniques for Addressing Soil Heave Issues [View GBP](#)

United Structural Systems of Illinois, Inc

Phone : +18473822882

City : Hoffman Estates

State : IL

Zip : 60169

Address : 2124 Stonington Ave

Google Business Profile

Company Website : <https://www.unitedstructuralsystems.com/>

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