Failures of Non-Isolated Plumbing in Expansive Soil

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INTRODUCTION

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ASPE Plumbing Engineering Design Handbook, Vol 4, Chapter 6, "Hanger and Support Conditions", "Natural Environmental Conditions":
[Bold print provided for clarity]

"The susceptibility of a piping system to natural conditions must be accounted for within the piping system and the accompanying hangers, supports, and anchors. The major effect of these natural environmental conditions is on the basic building structure. However, within structures designed to handle extreme natural phenomena, the piping system itself must be hardened or conditioned.

Typical natural phenomena consist of seismic forces and sustained periods of high winds, including hurricanes and typhoons, which create major stresses and loads on a building's structure. For instance, an extreme high-rise building can move 4 to 13 inches (102 to 304 mm) laterally in high winds. In zones of known natural phenomena, such as areas ***susceptible to earth movement****, the plumbing engineer must design the piping and support systems to sustain the shocks, stresses, and loads inherent with and applied by these extreme forces. The engineer must refer to the applicable building codes to determine the seismic design category for any mandated piping system support requirements.*

While a plumbing system may not be expected to survive the complete destruction of a building's structure, it is expected to survive intact and working in the event that the building structure itself survives."

INTRODUCTION

In response to numerous failures of non-isolated plumbing in expansive soil around the country, **the 2024 International Plumbing Code (IPC) has new language explicitly requiring isolation of plumbing from expansive soil under isolated slabs** (over a crawlspace or voidwork). It will not permit buried plumbing. It will also not permit non-isolated void systems that provide various forms of “voids” but do not actually isolate plumbing, hangers and supports under the slab, even though the manufacturers may claim they “isolate” plumbing.

As a consequence of many plumbing failures, lawsuits and the clarifying language in the 2024 IPC, **Mechanical Engineering firms today are interpreting long-standing IPC and UPC requirements (in all published plumbing codes, current and previous) for protection of plumbing to require isolation of plumbing from expansive soil under isolated slabs.** Below isolated slabs, these firms are not allowing buried plumbing and not allowing non-isolated void systems.

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Building Professional Institute (BPI)

The new 2024 IPC language was presented at the North Texas BPI in a 3 hour presentation in July 2022. Furthermore, because all previously published editions of the IPC and UPC require protection of plumbing to avoid overstressing and overstraining pipe material, the BPI presenters recommended Mechanical Engineers "**immediately cease and desist the practice of permitting Non-Isolated Plumbing (Buried Plumbing or Non-Isolated Void Systems) under Slab-On-Voidwork foundations**…". The slides and the video are available for download from BPI.



Building Professional Institute (BPI) Presenters



John Focht, P.E. – Braun Intertec Inc.
Geotechnical Engineer



Don Penn, P.E. – Image Engineering Group, Ltd.
Mechanical Engineer



Michael Lee, P.E. – Wiss, Janney, Elstner Associates, Inc.
Structural Engineer

INTRODUCTION

All 3 presenters of this 2023 ASPE Tech Symposium presentation today agree with the content and recommendations presented at the North Texas BPI Presentation by those 3 engineers. Their 3 hour presentation is the most comprehensive review of this issue in the industry today. Some of that content is shared in today's presentation. We encourage you to download all of that content from the BPI website and evaluate your office policies in consideration of that content. The slides and the video are available for download through BPI online at www.bpi-tx.com

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INTRODUCTION

Overview

Expansive Soil

Construction Approaches

Failures of Non-Isolated Plumbing Under Isolated Slabs

Code History

New Language in the 2024 IPC

Recommendations

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INTRODUCTION

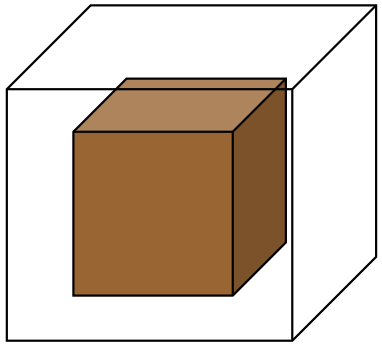
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Intellectual Property Notice

Some of the methods and devices which are discussed in this presentation are inventions by various parties and have been **PATENTED** or are **PATENT-PENDING**. These methods and devices are referenced in this presentation without naming the manufacturers. A primary purpose of referencing these methods and devices is to discuss the relative technical advantages and disadvantages of various approaches used in the industry today. This presentation is not an inducement to patent infringement. Therefore, this slide is hereby providing **NOTICE** to all attendees that attendees should assume all methods and devices discussed in this presentation are **PATENTED** or are **PATENT-PENDING** unless they verify otherwise. Attendees are welcome to contact the Presenters and request more information related to intellectual property for any specific methods and devices referenced, if desired.

EXPANSIVE SOIL

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EXPANSIVE SOIL

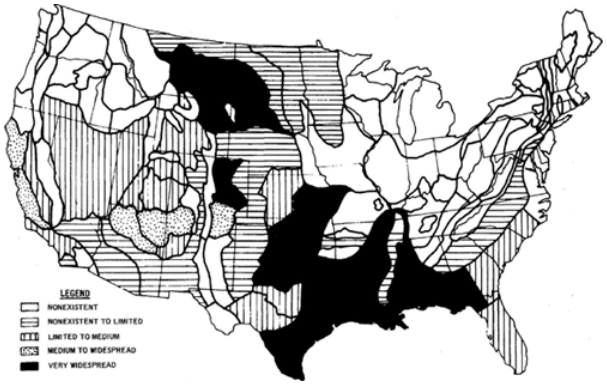


Image from the US Department of Transportation
Federal Highway Administration
Publication No. FHWA NHI-05-037 Chapter 7
May 2006

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Introduction to Expansive Soil

"Expansive Soil" is defined by the IBC (2021 IBC Section 1803.5.3)

Increase in moisture content ➡ Increase in volume (Swelling)
Decrease in moisture content ➡ Decrease in volume (Shrinking)

Soil shrink-swell is a four-dimensional phenomenon

Depth of the "Active Zone" varies from site to site (e.g. 3 ft to 30+ ft)

Expansive soils are the most costly natural hazard in the United States, causing more damage than all other natural hazards combined, including earthquakes, floods, tornadoes and hurricanes

FEMA 1982 Special Statistical Survey:
Data, Injuries and Property Loss by Type of Disaster 1970-1980. Washington D.C.

EXPANSIVE SOIL

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Introduction to Expansive Soil

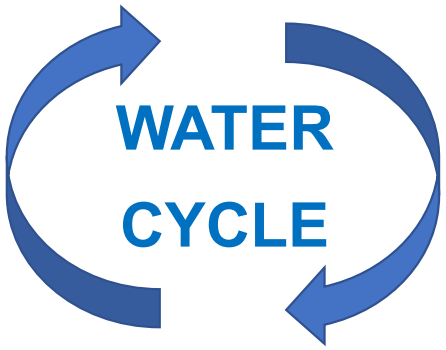
Soil heave can be measured in ***feet***

Swell pressures can exceed ***five tons per square foot***

Soil behavior is almost always ***variable in space and time***



EXPANSIVE SOIL



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Example Causes of Moisture Change

Seasonal variations in rainfall/drought

Irrigation Systems

Adding New Trees/Bushes

Removing Existing Trees/Bushes

Ponding Rainwater

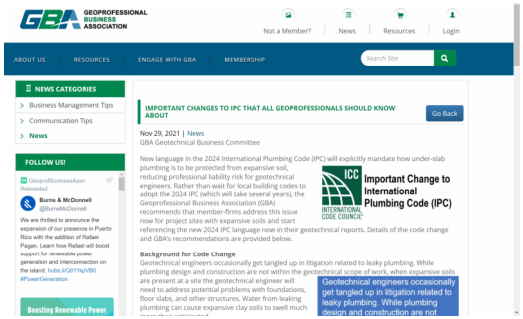
Exterior Plumbing Leaks

Under-Slab Plumbing Leaks

Adding Impervious Flatwork

Removing Impervious Flatwork

EXPANSIVE SOIL



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GBA Recommends Isolation of Plumbing under Isolated Slabs

“For geotechnical reports on projects with expansive soils where the floor slab will be above a crawlspace or void forms, GBA recommends that the reports include recommendations that are consistent with this new section of the 2024 IPC, regardless of whether the IPC or the UPC is locally adopted.”

https://www.geoprofessional.org/news/important-changes-to-ipc-that-all-geoprofessionals-should-know-about/

GEOPROFESSIONAL BUSINESS ASSOCIATION

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Beyond Expansive Soil

Examples of other types of volumetric soil changes:

- Settlement
- Frost Heave
- Collapsible Soils

Strategies that work for expansive soils often work for other geotechnical problems as well.

CONSTRUCTION APPROACHES

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FOUNDATION TYPES

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Non-Isolated Slabs versus Isolated Slabs

Non-Isolated Slabs (where the slab is supported by soil under the slab)

- Stiffened Slab-on-Ground
- Uniform Thickness Slab-on-Ground with Footings or Non-Isolated Grade Beams
- Uniform Thickness Slab-on-Ground with Isolated Grade Beams (bearing on piers/piles)

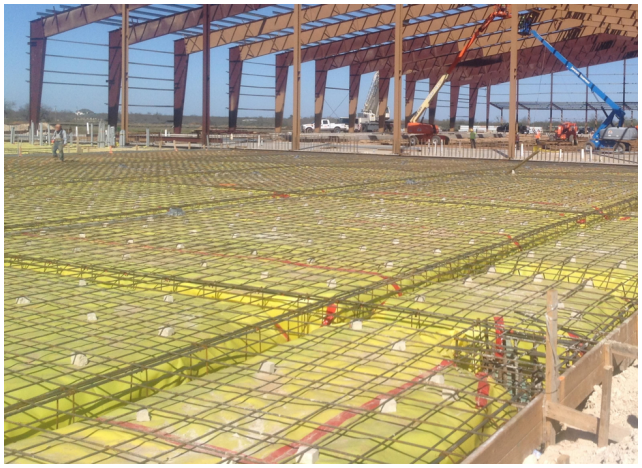
Isolated Slabs (where the slab is not supported by soil under the slab) can be subdivided into:

- Slab-on-Crawlspace
- Slab-on-Voidwork, where the void is created by special forms

FOUNDATION TYPES

Sketches of Non-Isolated Slabs

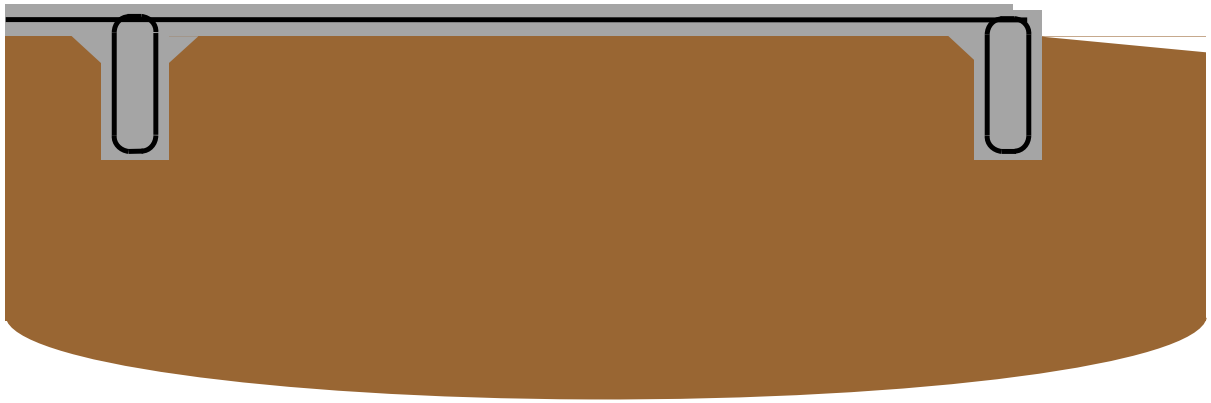
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FOUNDATION TYPES



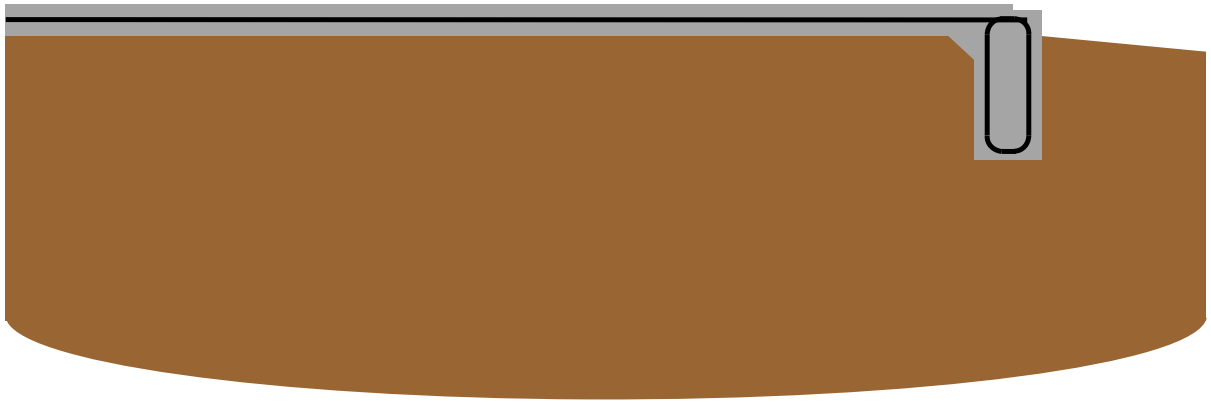
Non-Isolated Slabs:
Stiffened Slab-on-Ground



FOUNDATION TYPES

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Non-Isolated Slabs:
Uniform Thickness Slab-on-Ground
With Footings or Non-Isolated Grade Beams



FOUNDATION TYPES

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Non-Isolated Slabs:
Uniform Thickness Slab-on-Ground
With Isolated Grade Beams



The bottom and sides of grade beams are often formed. Grade beams typically bear on deep foundations (i.e., piers). “Soil Retainers” are retaining walls that prevent soil from entering the voidspace under the grade beams.

FOUNDATION TYPES

Sketches of Isolated Slabs

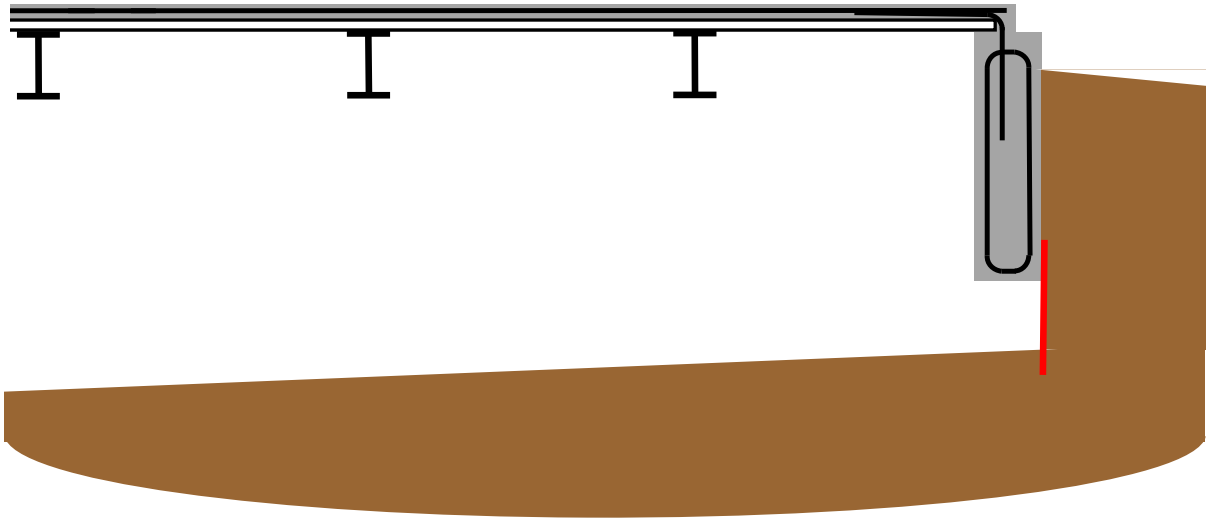
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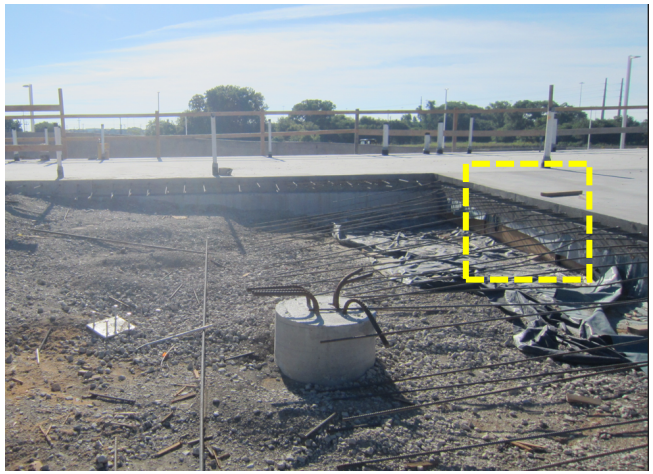
FOUNDATION TYPES



Isolated Slabs:
Slab-on-Crawlspace



Slabs often consist of a composite system of steel beams with slab poured on metal deck, precast concrete (double tees or hollow core planks). Grade beams and girder beams typically bear on deep foundations. “Soil Retainers” are retaining panels or walls that protect the voidspace under the perimeter grade beams.



FOUNDATION TYPES



Isolated Slabs:
Slab-on-Voidwork



When the slab is poured, the slab reinforcement and concrete are supported by a layer of “voidwork”. However, the voidwork is designed to degrade, collapse or otherwise create a space under the slab. Deep foundations support the slab permanently, on a grid about 20 ft each way.

FOUNDATION TYPES

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Isolated Slabs:
Slab-on-Crawlspace vs. Slab-on-Voidwork

The terms “under-floor space” and “crawl space” are used in the IBC but not defined. A crawl space is a type of under-floor space where a person can crawl. The space under a Slab-on-Voidwork is an under-floor space but not a crawl space.

2021 IBC 1202.4 Under-floor ventilation: Requires ventilation requires natural or mechanical ventilation of “crawl spaces”. However, the IBC does not require all under-floor spaces be ventilated.

2021 IBC 1209.1 Crawl spaces: Requires that “crawl spaces” be provided with a minimum 18”x24” access opening. However, this does not require all under-floor spaces have an access opening.

Crawl spaces also typically have a minimum dimension of 18” clear under all slab framing, typically slope to drains, and often have lighting.

Under-floor spaces under Slabs-on-Voidwork rarely have access, ventilation, 18” minimum clear height, drainage or lighting.

EXPANSIVE SOIL ILLUSTRATION

The following slides illustrate examples of Expansive Soil Behavior under **Isolated Slabs**

Please note that similar types of movement can occur under all foundation types. For non-isolated slabs, the movement will occur to the extent that the slab stiffness (and any resisting elements such as deep foundations) allows the soil movement to occur.

Remember: soil swell pressures can be quite large, measured in tons per square foot

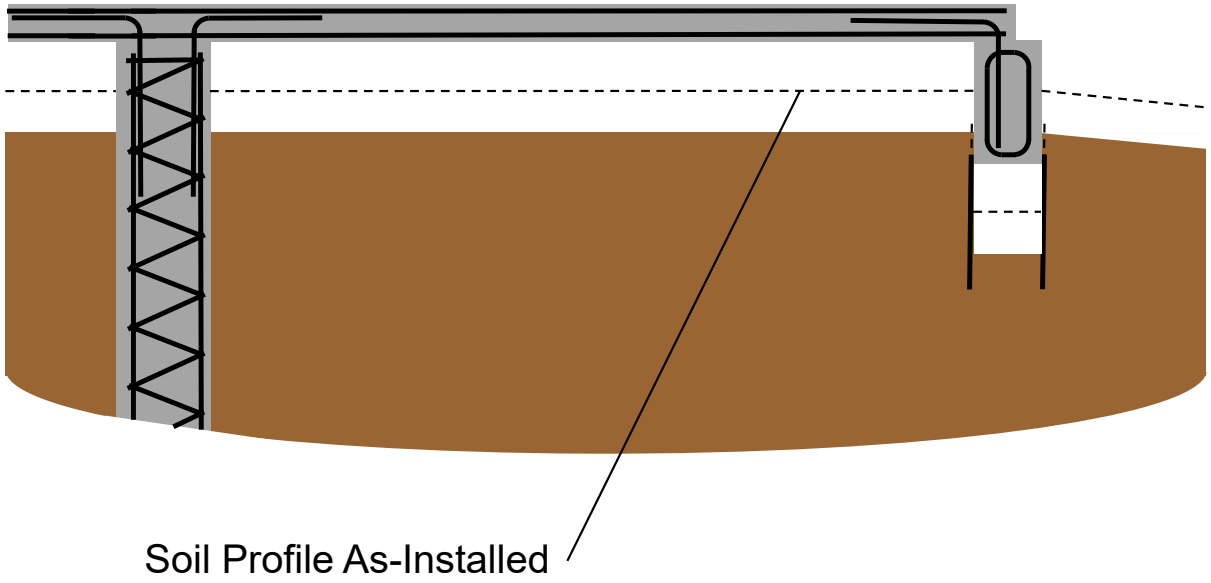
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EXPANSIVE SOIL ILLUSTRATION

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General Under-Slab Settlement

(Examples: Uncompacted Fill Settlement, Overburden Increase Settlement)

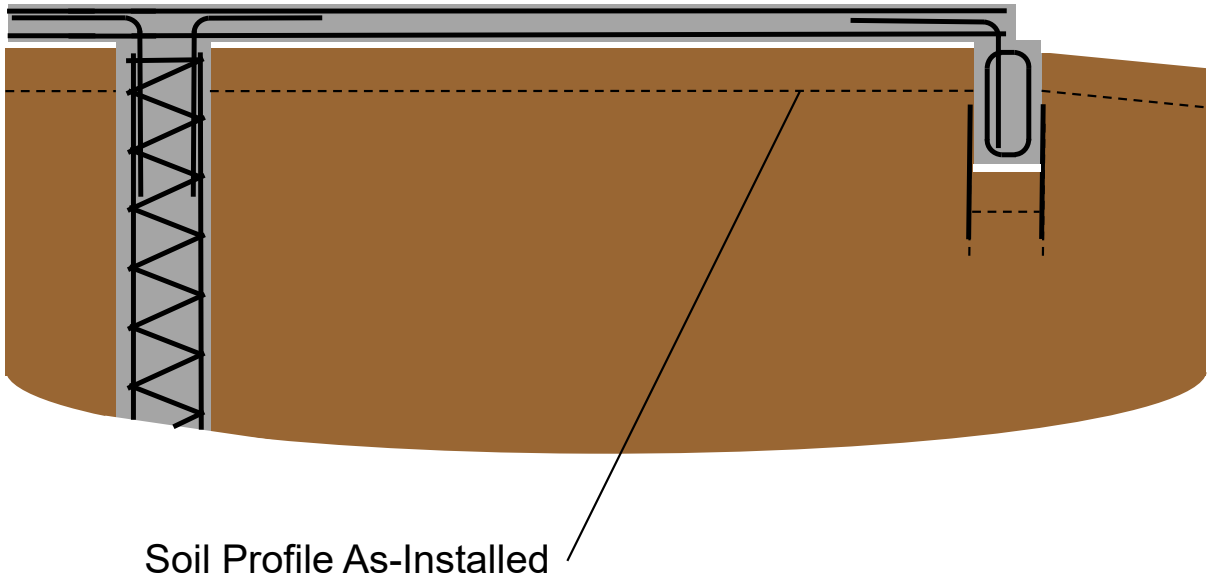


EXPANSIVE SOIL ILLUSTRATION

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General Under-Slab Swelling

(Examples: Secondary Swelling, Unloaded Overburden Swelling, Forest Removal Swelling)

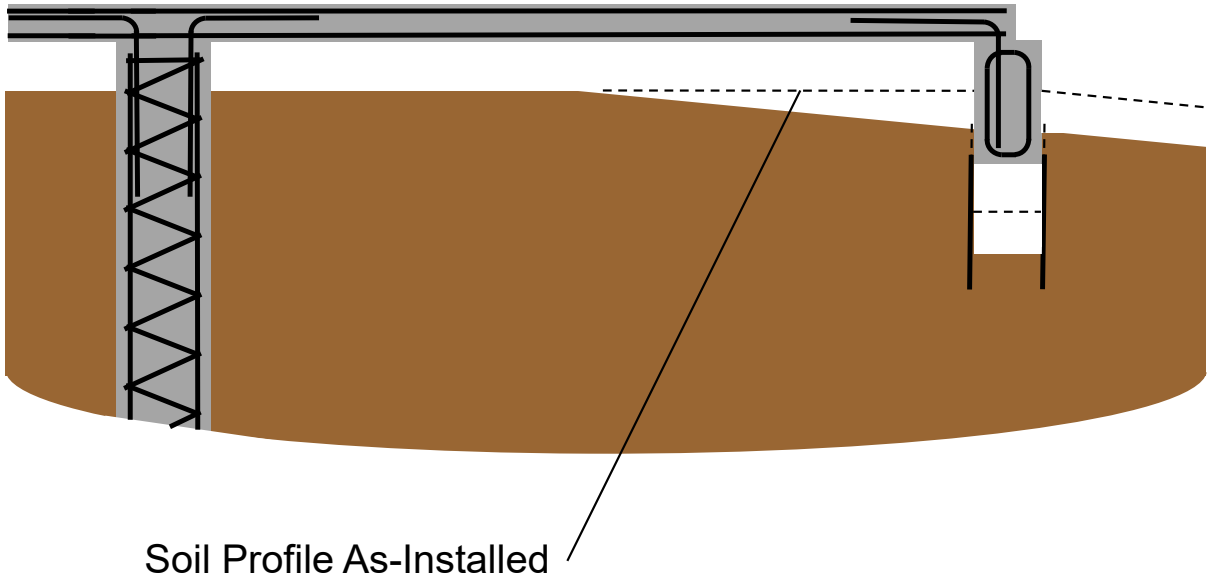


EXPANSIVE SOIL ILLUSTRATION

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Perimeter Under-Slab Shrinkage

(Examples: Seasonal Drying Shrinkage, Root-Induced Shrinkage)

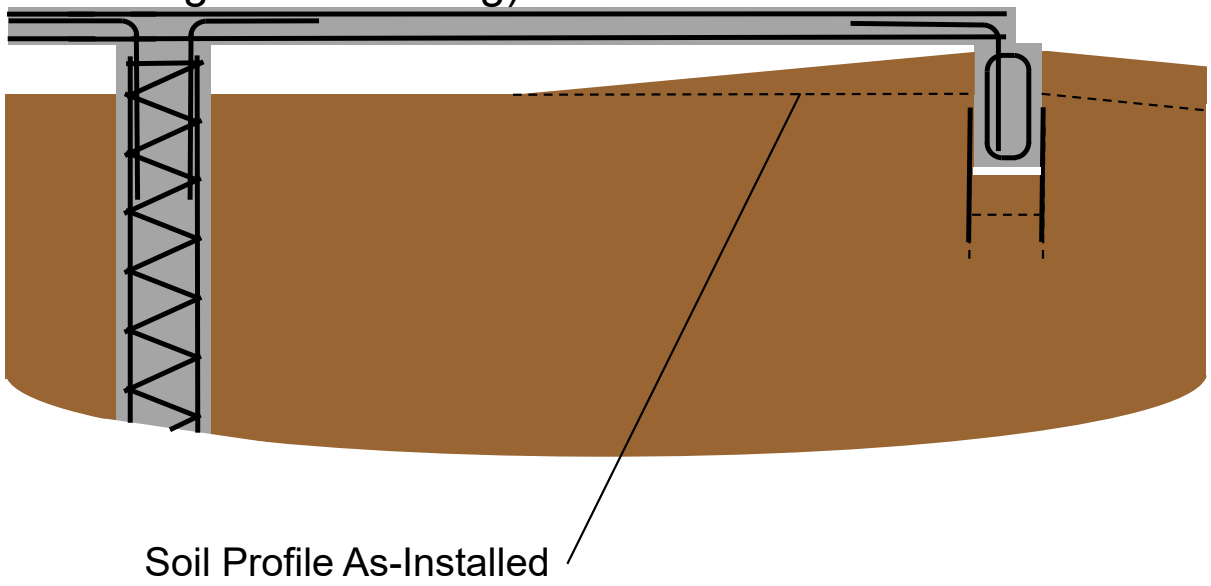


EXPANSIVE SOIL ILLUSTRATION

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Perimeter Under-Slab Swelling

(Examples: Seasonal Wetting Swelling, Over-Irrigation Swelling, Scouring Rainfall Collection Swelling, Post-Construction Tree Removal Swelling, Perimeter Plumbing Leak Swelling)

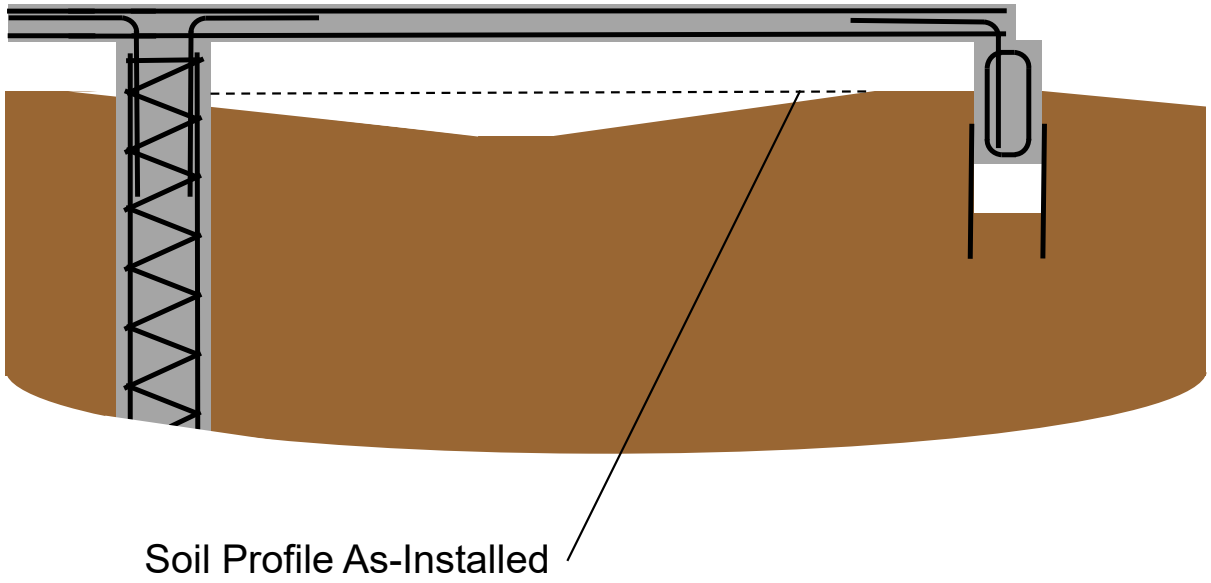


EXPANSIVE SOIL ILLUSTRATION

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Localized Under-Slab Settlement

(Example: Irregular Bedrock Elevations, Poor Fill Compaction, etc.)

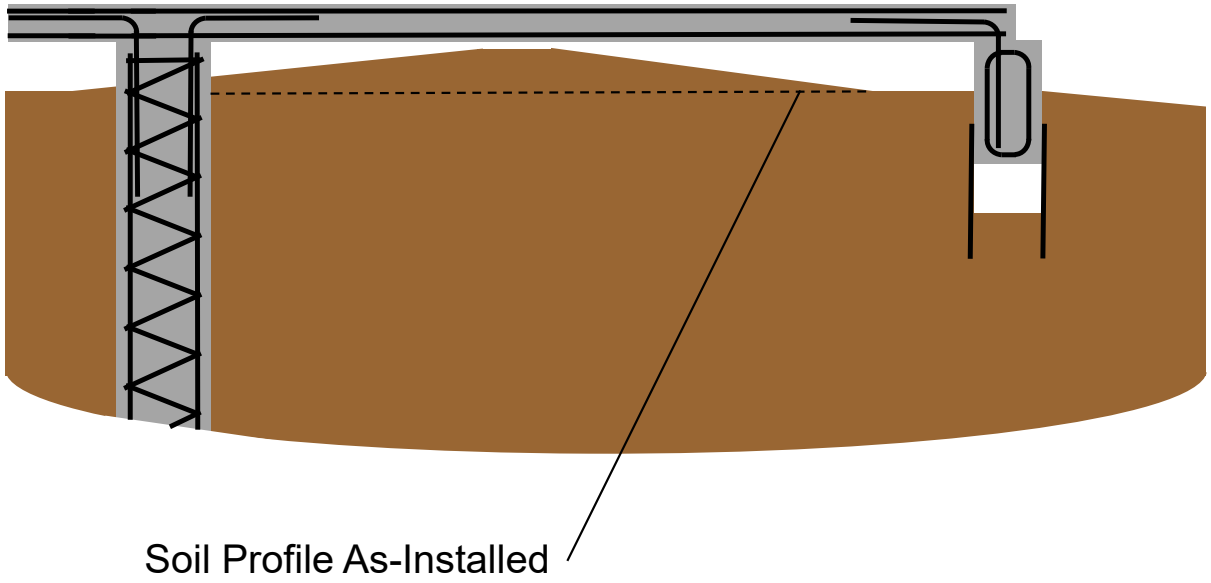


EXPANSIVE SOIL ILLUSTRATION

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Localized Under-Slab Swelling

(Example: Under-Slab Plumbing Leaks, Isolated Pre-Construction Tree Removal without Proper Grubbing)

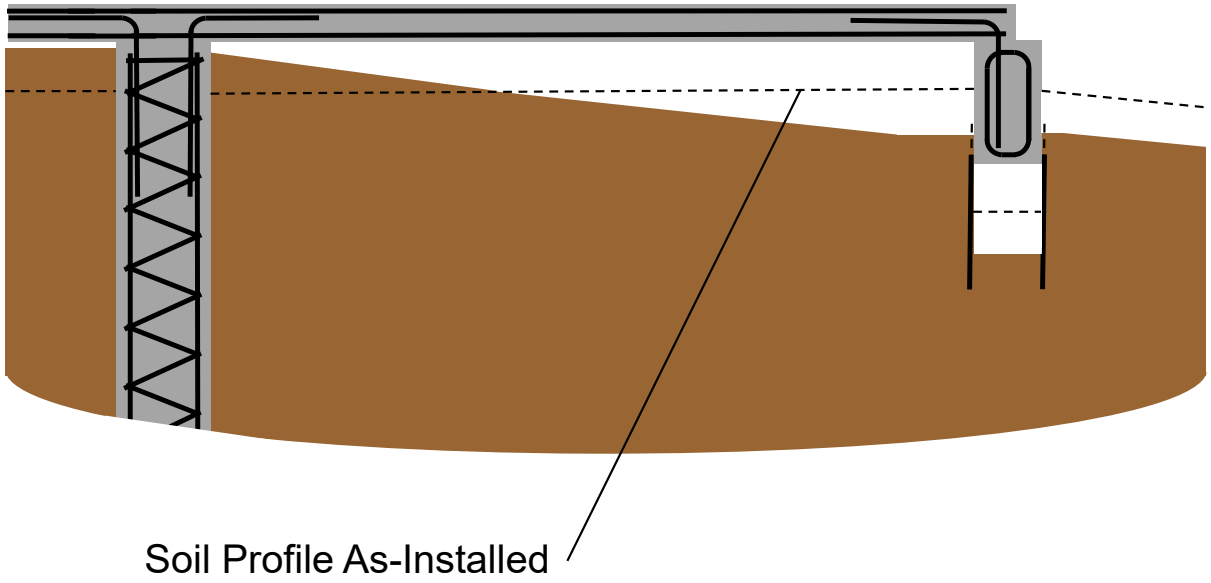


EXPANSIVE SOIL ILLUSTRATION

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Complex Under-Slab Swelling & Shrinking

(Example: Moisture Migration in Partially Saturated Heterogenous Soil Conditions)



PLUMBING APPROACHES

Plumbing Approaches Encountered Today

Non-Isolated Slabs

Non-Isolated Plumbing

Isolated Slabs

Slab-on-Crawlspace

Non-Isolated Plumbing ← **MAJOR LITIGATION**

Isolated Plumbing

Slab-on-Voidwork

Non-Isolated Plumbing ← **MAJOR LITIGATION**

Isolated Plumbing

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PLUMBING APPROACHES

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Non-Isolated Slabs (Slab-on-Ground) With Non-Isolated Plumbing

1. Expansive soil is typically removed or modified to reduce the Potential Vertical Movement (PVM) to 1” or less.

2. Because the plumbing is conventionally buried, the slab and plumbing underneath typically both move together as the soil swells/shrinks.

3. If plumbing becomes damaged by expansive soil movement, the slab can typically be sawcut above the damage and the plumbing can be repaired as feasible maintenance. A Structural Engineer may be involved if it is a post-tensioned slab, to address the cutting of post-tensioning strands and re-retensioning them, but the approach is generally the same.

PLUMBING APPROACHES

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Slab-on-Crawlspace (Isolated Slab) With Non-Isolated Plumbing

1. The crawlspace provides an accessible under-floor space that isolates most of the plumbing from expansive soil damage.

2. However, often at the perimeter, where the plumbing transitions to being buried outside of the building, the plumbing becomes non-isolated and damage can occur, but the crawlspace access makes repairs feasible.

PLUMBING APPROACHES

Slab-on-Crawlspace (Isolated Slab)
With Non-Isolated Plumbing



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PLUMBING APPROACHES

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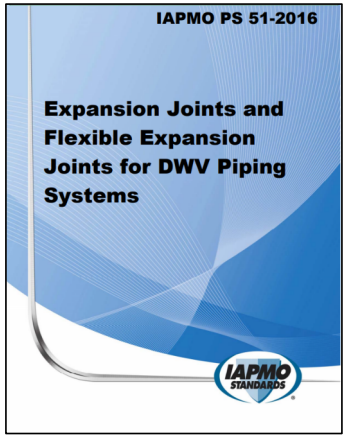
Slab-on-Crawlspace (Isolated Slab) With Isolated Plumbing

1. The crawlspace provides an accessible under-floor space that isolates all of the plumbing, hangers and supports below the slab from expansive soil damage.

2. Where the plumbing transitions to being buried outside of the building, a flexible expansion joint is provided with an initial vertical offset that is sufficient to allow the upward potential vertical movement estimated by the geotechnical engineer. And, the Plumbing Designer selects the flexible expansion joint unit so that it can also allow the downward potential vertical movement estimated by the geotechnical engineer without breaking the plumbing.

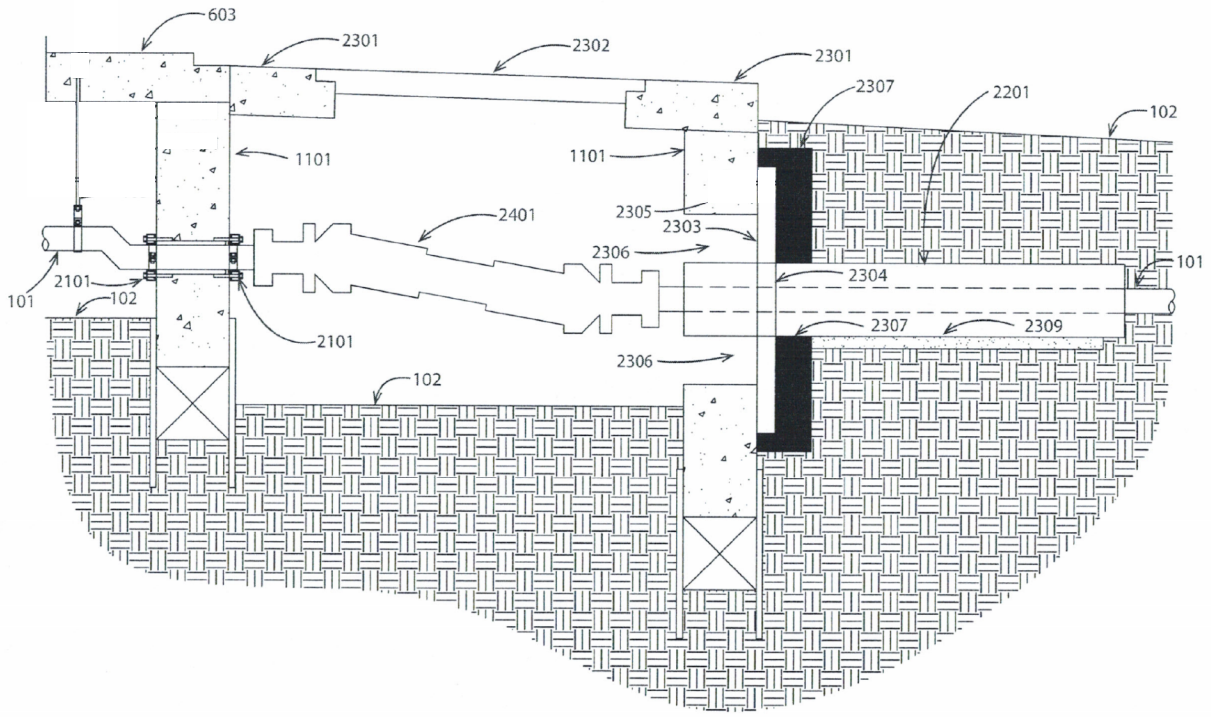


PLUMBING APPROACHES



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Slab-on-Crawlspace (Isolated Slab) With Isolated Plumbing



Note: This is an example of a PATENT-PENDING method.

PLUMBING APPROACHES

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Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

1. Plumbing has to bridge between a moving system (the soil) and a non-moving system (the slab), so re-occurring damage is common.

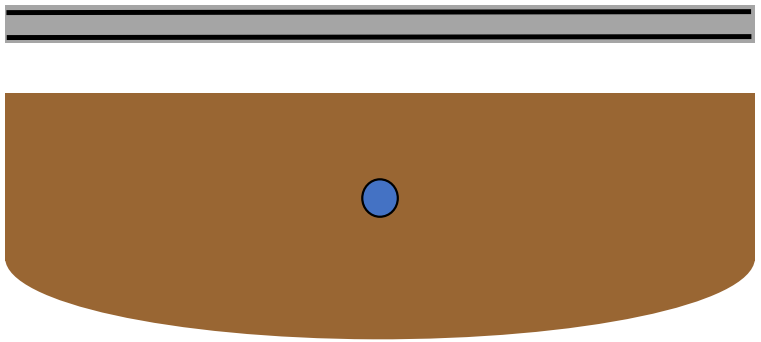
2. Any damage to the plumbing under the slab becomes extremely expensive to repair because there is no access and the slabs typically CANNOT be sawcut immediately over the damaged plumbing because it will structurally weaken the slab, which can and has caused areas of the slab to fall.

3. Small, temporary access openings are typically sawcut in the slab, in between pier lines in both plan directions, and soil is hand excavated (shovel by shovel) and wheelbarrowed out of the building to reach the damaged plumbing. After all this effort, the repairs typically do not isolate the plumbing. Because they do NOT solve the under-lying reason that damage occurred, plumbing damage can reoccur.

PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

Buried Pipe



Non-Isolated
Void Systems

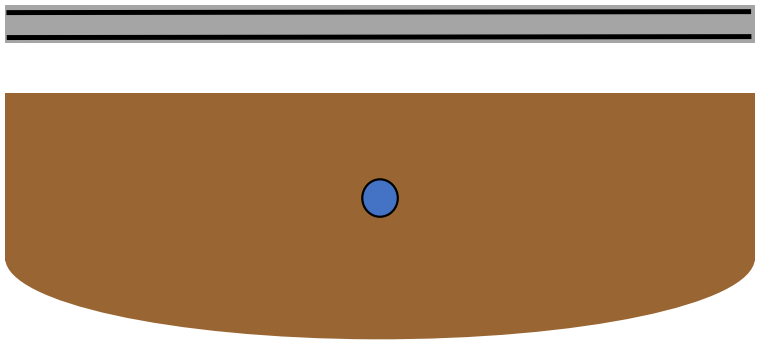


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PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

Buried Pipe



Non-Isolated
Void Systems

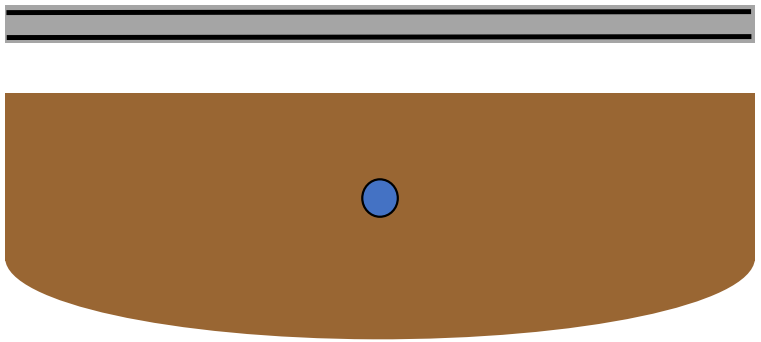


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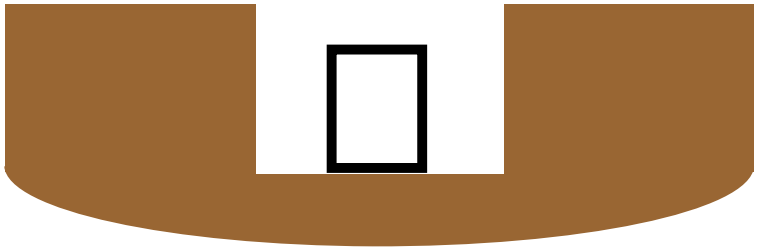
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

Buried Pipe



Non-Isolated
Void Systems



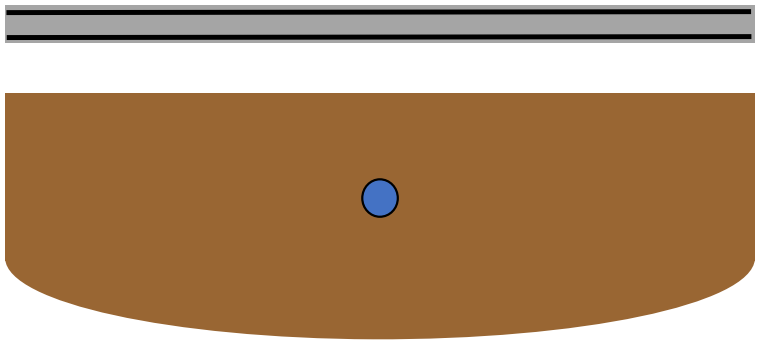
This is a conceptual example.
Product details vary.

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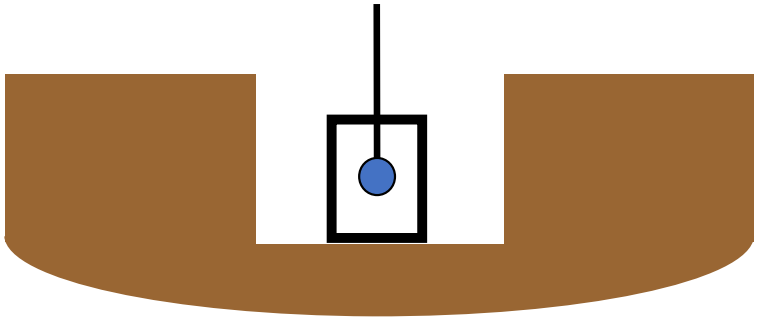
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

Buried Pipe



Non-Isolated
Void Systems

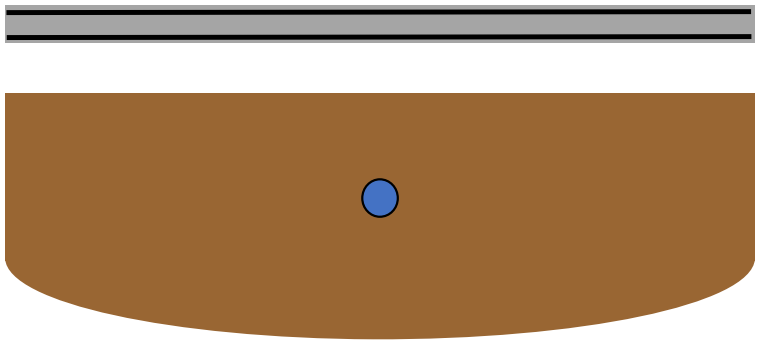


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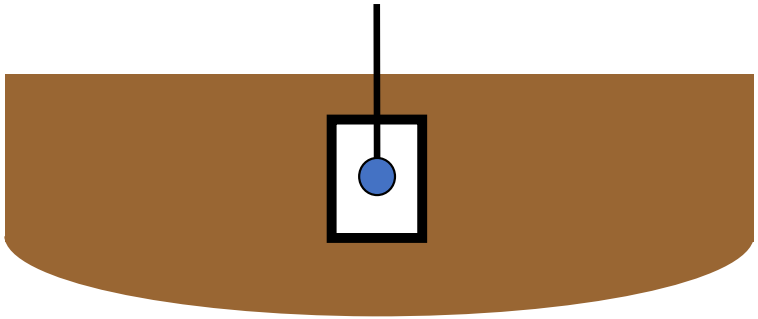
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

Buried Pipe



Non-Isolated
Void Systems

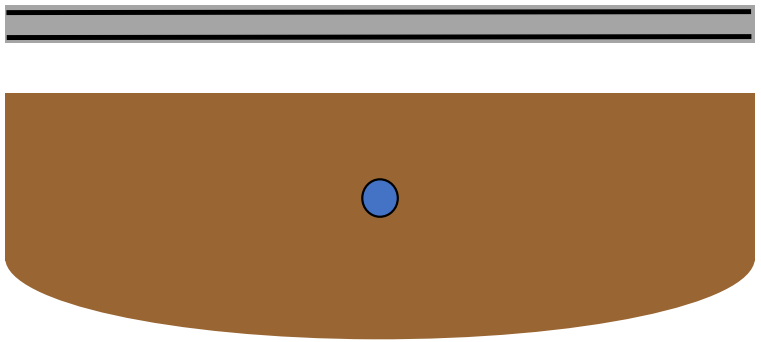


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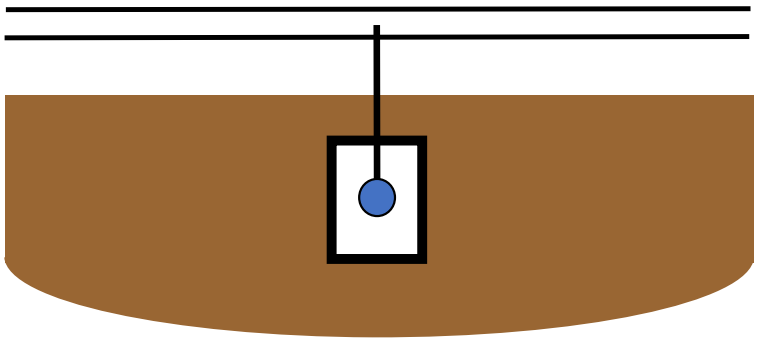
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

Buried Pipe



Non-Isolated Void Systems

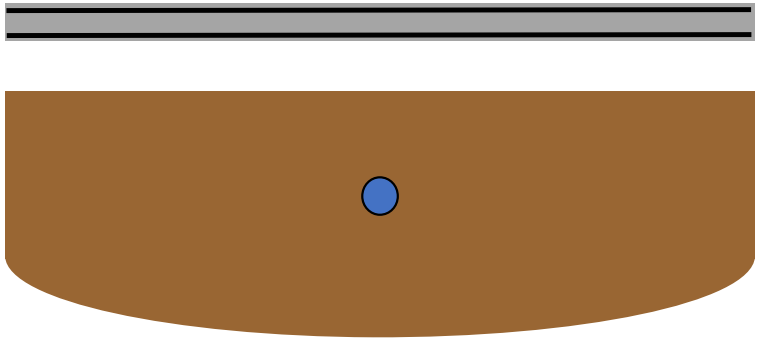


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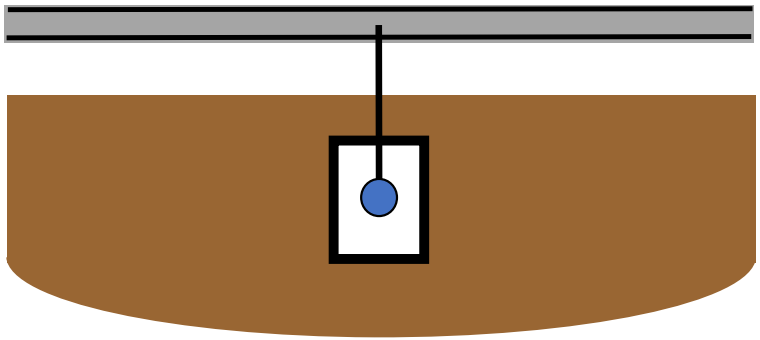
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

Buried Pipe



Non-Isolated Void Systems



Regardless of how the manufacturers may claim that their connection will flex or slip if soil movement occurs, these systems do not isolate the plumbing, hangers and supports below the slab from all soil-induced loads.

BH

PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Non-Isolated Plumbing

Buried Pipe



Examples of Non-Isolated Void Systems





BH

PLUMBING APPROACHES

BH

Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

1. Plumbing, hangers and supports below the slab are not in contact with the subgrade and no assemblage of materials is in contact with both the subgrade and any plumbing, hangers or supports below the slab. This allows the estimated potential vertical movement and the potential horizontal movement to occur without damaging the plumbing.

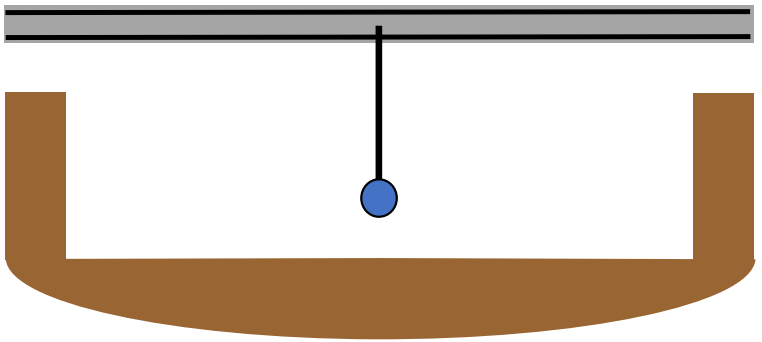
2. Flexible expansion joints are installed in concrete vaults at the building perimeter to allow access for routine inspection, maintenance and replacement of flexible expansion joints. (Similar to that shown for flexible expansion joints for Slab-on-Crawlspace with isolated plumbing,

PLUMBING APPROACHES

BH

Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



Pre-Installed

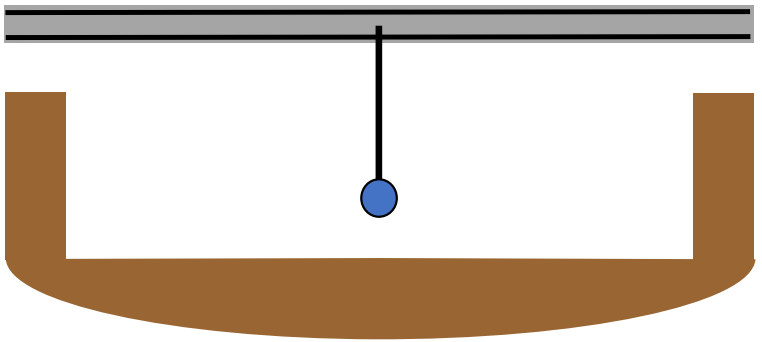


PLUMBING APPROACHES

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Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



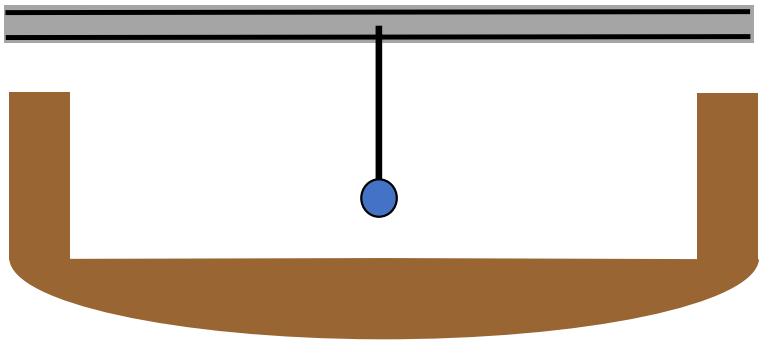
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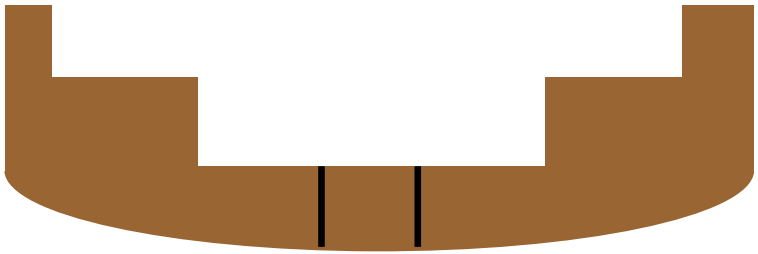
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



Pre-Installed



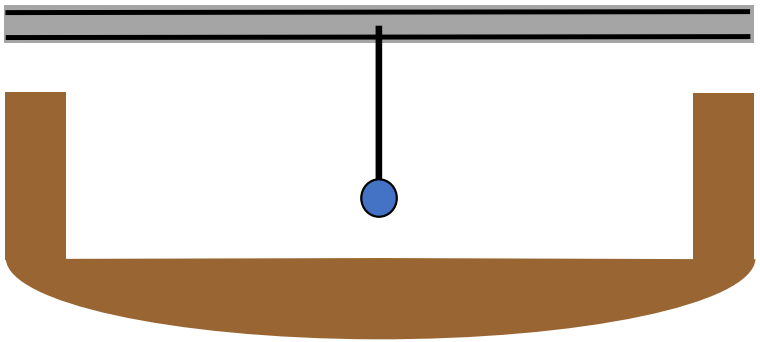
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PLUMBING APPROACHES

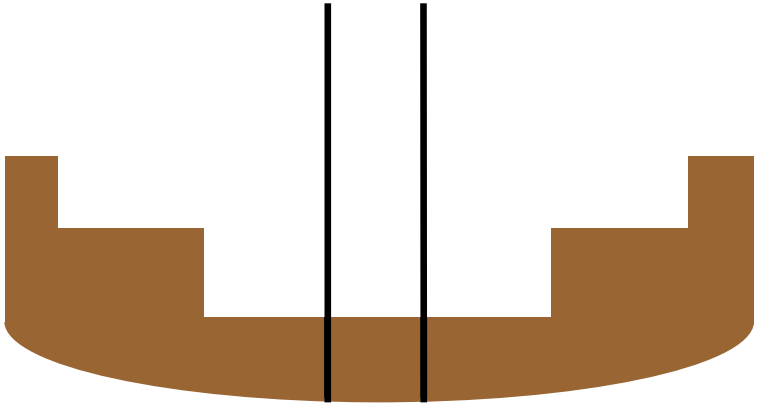
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Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



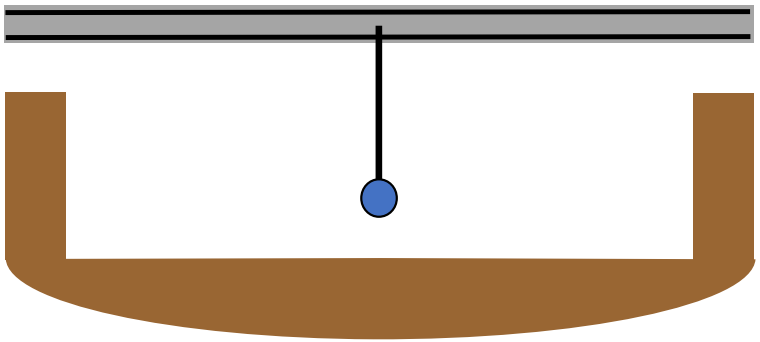
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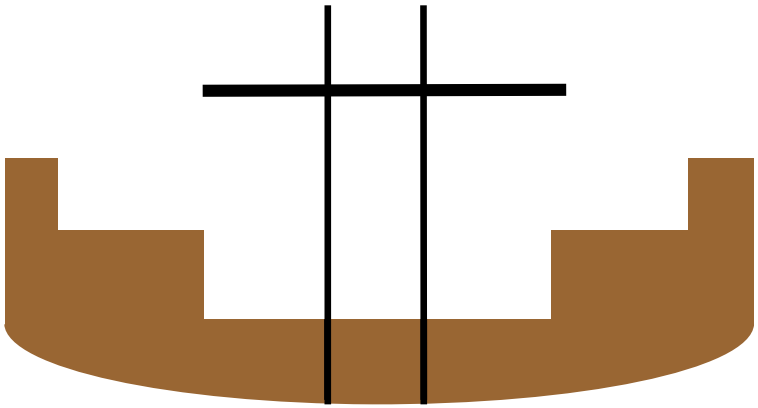
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



Pre-Installed

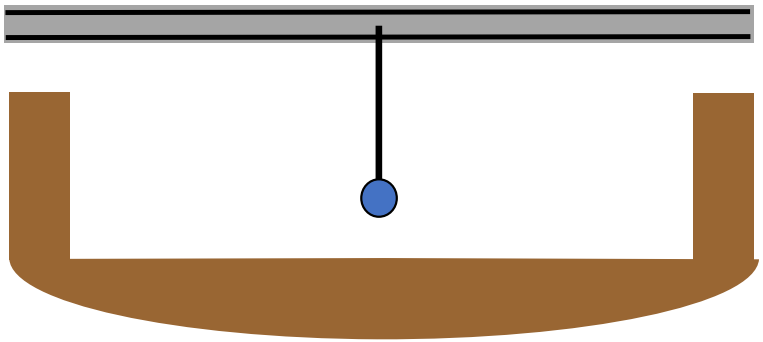


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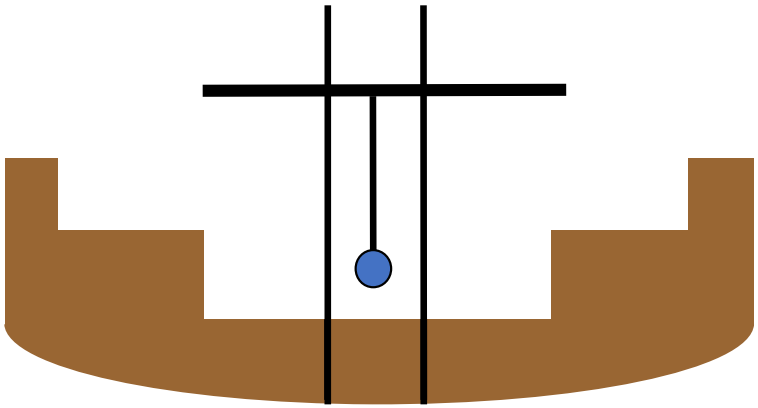
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



Pre-Installed



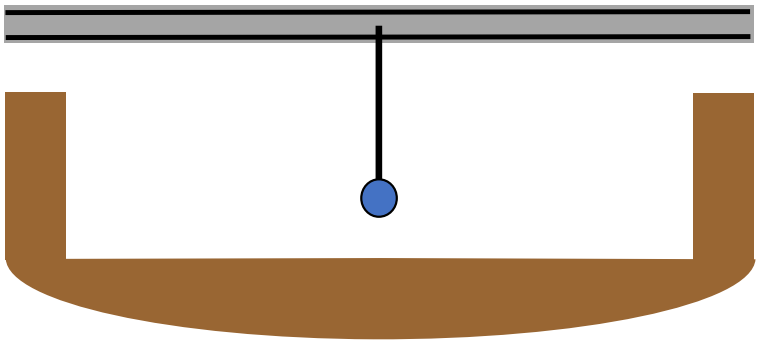
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PLUMBING APPROACHES

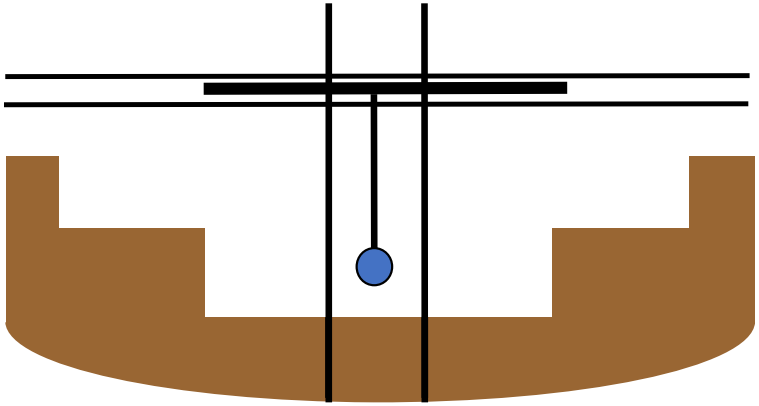
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Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



Pre-Installed

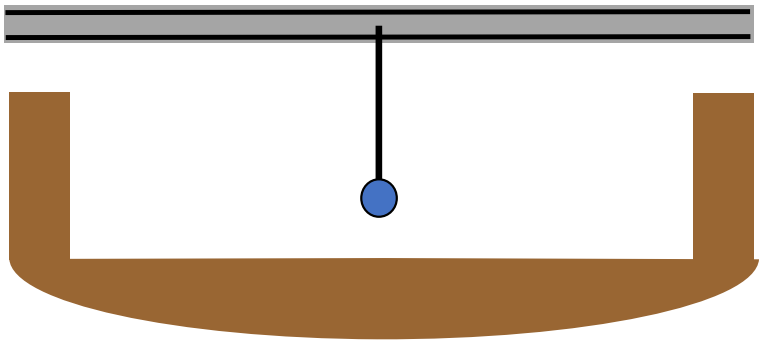


PLUMBING APPROACHES

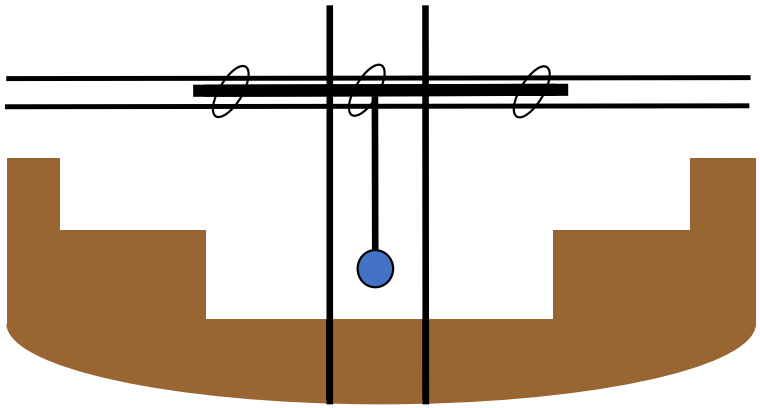
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Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



Pre-Installed

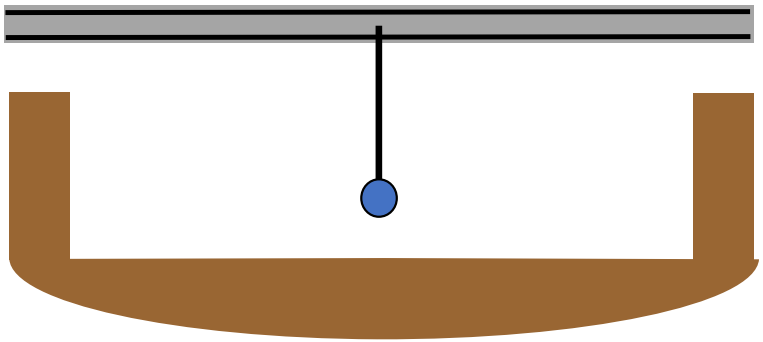


PLUMBING APPROACHES

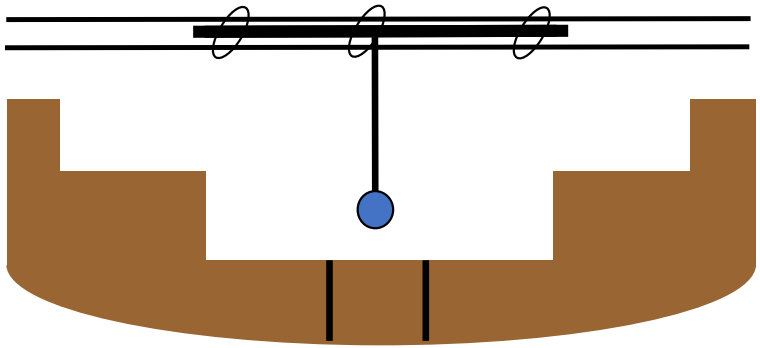
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Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



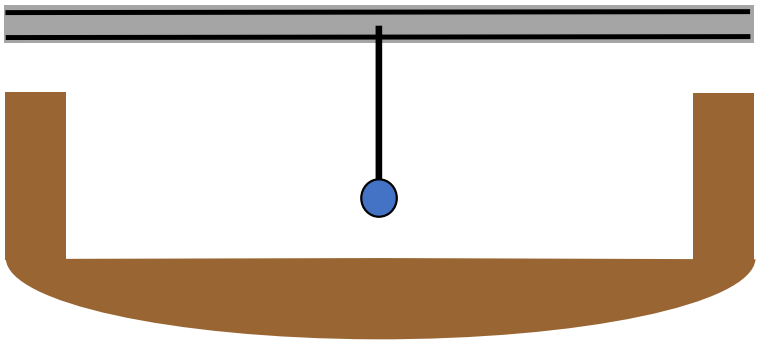
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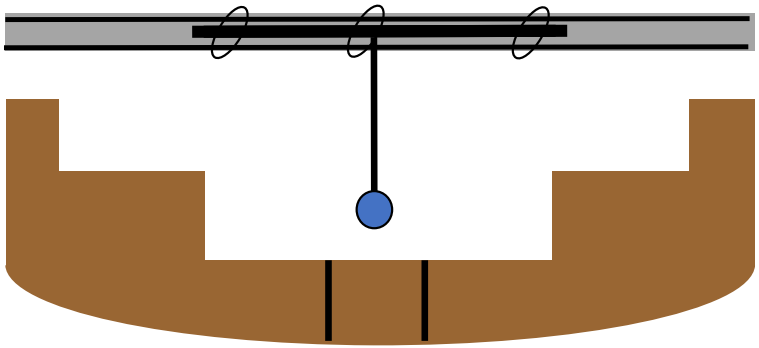
PLUMBING APPROACHES

Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed



Pre-Installed



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PLUMBING APPROACHES

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Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing

Post-Installed

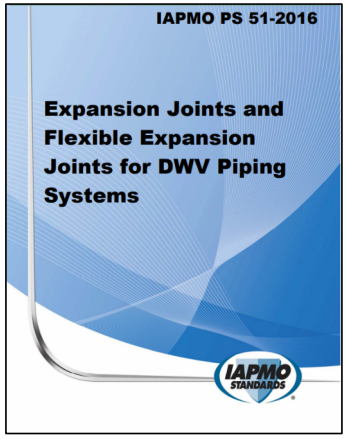


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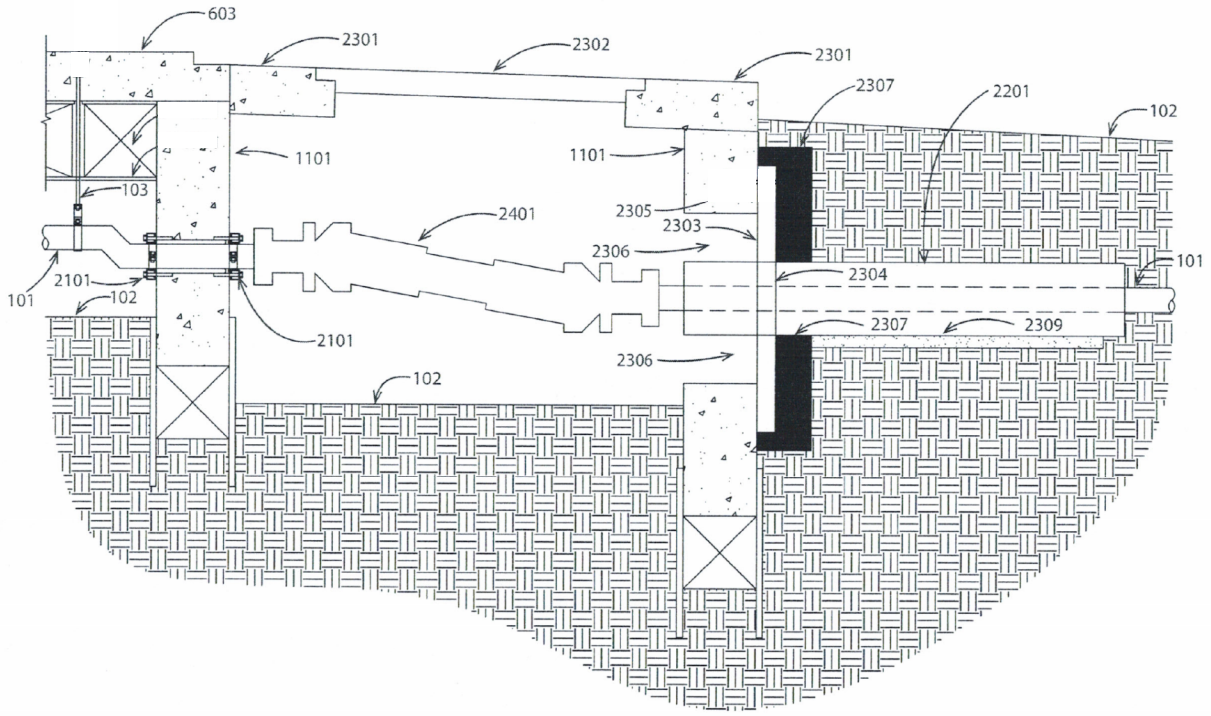


PLUMBING APPROACHES



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Slab-on-Voidwork (Isolated Slab) With Isolated Plumbing



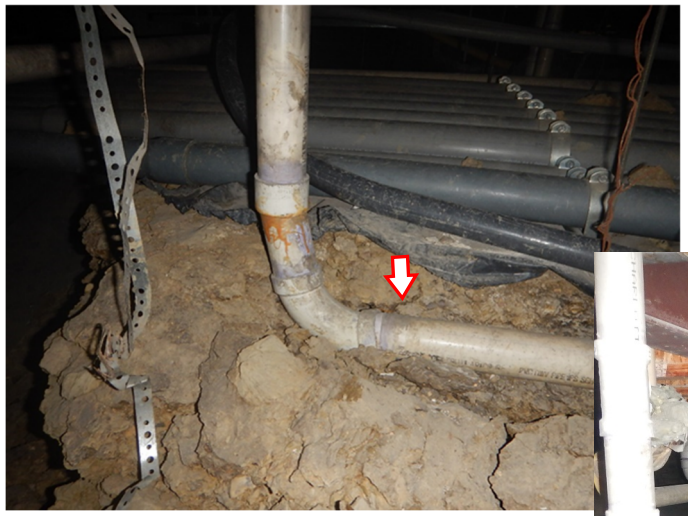
FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

BH

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

BH

Example where Non-Isolated Plumbing was Installed under Slab-on-Crawlspace and Plumbing Damage Occurred



Cracked Plumbing

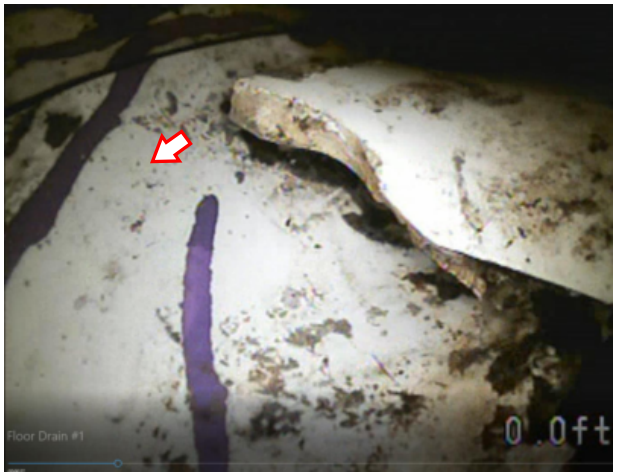


Backdraining Plumbing

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

BH

Example where Buried Plumbing was Installed under Slab-on-Voidwork and Plumbing Damage Occurred



Cracked P-Traps Under Floor Drains
(No Trap Seal Due to Cracks)

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

BH

Example where a Non-Isolated Void System was Installed under Slab-on-Voidwork and Plumbing Damage Occurred



Steel Mesh and Plywood Non-Isolated Void System



Hanger Rods Buckled and Displaced Plumbing

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

Example where a Non-Isolated Void System was Installed under Slab-on-Voidwork and Plumbing Damage Occurred



Plastic Panel Non-Isolated Void System and Cracked Plumbing

BH

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

BH

Example of Damage to Non-Isolated Plumbing under Slab-on-Voidwork after only 1/2” Vertical Movement



>$1M Repairs to Damaged Plumbing at a High School after 1/2” movement

Damage to Non-Isolated Plumbing under Slab-on-Voidwork is likely much more common that realized.

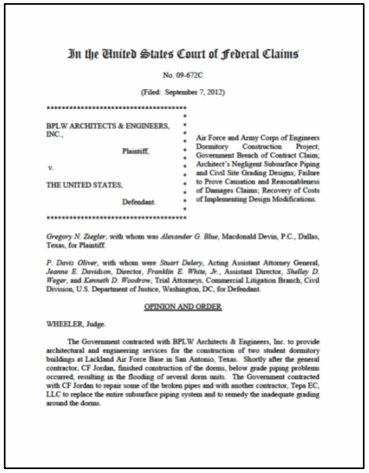
FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

JM

Example of Repairing Non-Isolated Plumbing under Slab-on-Voidwork



This repair simply replaced cracked plumbing in a non-isolated condition, so damage is expected to occur again.



In the United States Court of Federal Claims

No. 09-672C

(Filed: September 7, 2012)

BPLW ARCHITECTS & ENGINEERS, INC.,

Plaintiff,

v.

THE UNITED STATES,

Defendant.

Air Force and Army Corps of Engineers Dormitory Construction Project; Government Breach of Contract Claim; Architect's Negligent Subsurface Piping and Civil Site Grading Designs; Failure to Prove Causation and Reasonableness of Damages Claims; Recovery of Costs of Implementing Design Modifications.

Gregory N. Ziegler, with whom was *Alexander G. Blue*, Macdonald Devin, P.C., Dallas, Texas, for Plaintiff.

P. Davis Oliver, with whom were *Stuart Delery*, Acting Assistant Attorney General, *Jeanne E. Davidson*, Director, *Franklin E. White, Jr.*, Assistant Director, *Shelley D. Weiger*, and *Kenneth D. Woodrow*, Trial Attorneys, Commercial Litigation Branch, Civil Division, U.S. Department of Justice, Washington, DC, for Defendant.

OPINION AND ORDER

WHEELER, Judge.

The Government contracted with BPLW Architects & Engineers, Inc. to provide architectural and engineering services for the construction of two student dormitory buildings at Lackland Air Force Base in San Antonio, Texas. Shortly after the general contractor, CF Jordan, finished construction of the dorms, below grade piping problems occurred, resulting in the flooding of several dorm units. The Government contracted with CF Jordan to repair some of the broken pipes and with another contractor, Tepa EC, LLC to replace the entire subsurface piping system and to remedy the inadequate grading around the dorms.

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

MR

Federal Court Ruling re Isolated Slabs and Non-Isolated Plumbing

"The Government claims that BPLW provided a negligent underfloor piping design, as the design failed to accommodate the "highly expansive" soils in the San Antonio area." "The Government contends that these negligent designs caused the piping problems at the dorms and led it to incur substantial expense to repair broken pipes, replace the underfloor piping system, and remedy the site grading."

"As set forth below, **the Court finds that BPLW did indeed provide negligent underfloor piping and civil site grading designs, as both failed to comply with the contract requirements and the applicable standard of care."**

BPLW ARCHITECTS & ENGINEERS, INC. V. THE UNITED STATES
IN THE UNITED STATES COURT OF FEDERAL CLAIMS
NO. 09-672C (FILED: SEPTEMBER 7, 2012)



GBA GEOPROFESSIONAL BUSINESS ASSOCIATION CASE HISTORY NUMBER 108

PROJECT MANAGEMENT

The Client
A national chain of senior-living facilities

The Project
A five-story senior-living facility to be constructed on an undeveloped lot

Assignment of the GBA Member Firm
Perform a geotechnical-engineering study and provide construction-materials engineering and testing (CoMET) services during construction.

Background

The client – a national chain of senior-living facilities – contacted the GBA Member Firm about a new facility it planned to build. A five-story wood-framed structure with an underground parking garage. The Member Firm assigned the commission to a project manager who prepared an agreement-formatted proposal to perform a geotechnical-engineering study and construction-phase construction-materials engineering and testing (CoMET) services, including earthwork observation and testing, foundation-construction observation, and concrete sampling and testing, most of which was considered

The client accepted the proposal as submitted, including its $50,000-or-fee-whichever-is-higher limitation-of-liability provision.

code-required special inspections. The client's vice president for construction accepted the proposal as submitted, including its $50,000-or-fee-whichever-is-higher limitation-of-liability provision.

Late in the design process, the vice president of construction decided to reduce costs by eliminating the underground parking garage and relying, instead, on a structurally suspended slab with a crawl space beneath it. The owner and architect-led design team decided against a slab-on-grade design because the Member Firm's study revealed that the site was underlain by expansive clay soils. To protect the structurally suspended slab from the expansive soils, the study and the structural engineer specified use of void forms: cardboard forms that would support the slab during placement and then collapse once exposed to subgrade moisture. Based on a recommendation in the Member Firm's geotechnical-engineering report, the structural engineer called for a minimum void space of 12 inches.

Soon after he became aware of the client's decision to eliminate the parking garage, the Member Firm's project manager issued

The project manager issued a report addendum recommending that a particular type of form not be used.

a report addendum that he focused solely on void-form selection, recommending that a particular type of form not be used because of his concerns about its long-term performance. The project manager had to assume the structural engineer adopted his guidance because the architect failed to heed the explicit recommendation – included in the geotechnical-engineering

The architect failed to heed the explicit recommendation that the Member Firm review construction plans and specifications before construction began.

report – that the Member Firm review construction plans and specifications before construction began, especially because of the risks posed by expansive clays.

During construction, the mechanical constructor e-mailed a request for information (RFI) to all design-team members, including the GBA-Member Firm, stating that the sanitary-sewer-pipe design had to be revised because it failed to incorporate local practices for protecting buried pipes from damage caused by swelling clays.

The mechanical-engineering firm [illegible] designed the sewer lines was located in another state and was unfamiliar with local practices. Be that as it may, a month

The mechanical-engineering firm failed to respond to the RFI.

passed and the firm failed to respond to the RFI, causing the mechanical constructor – joined by the constructor-in-charge – to

PAGE 1

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

MR

GBA Case Study re Isolated Slabs and Non-Isolated Plumbing

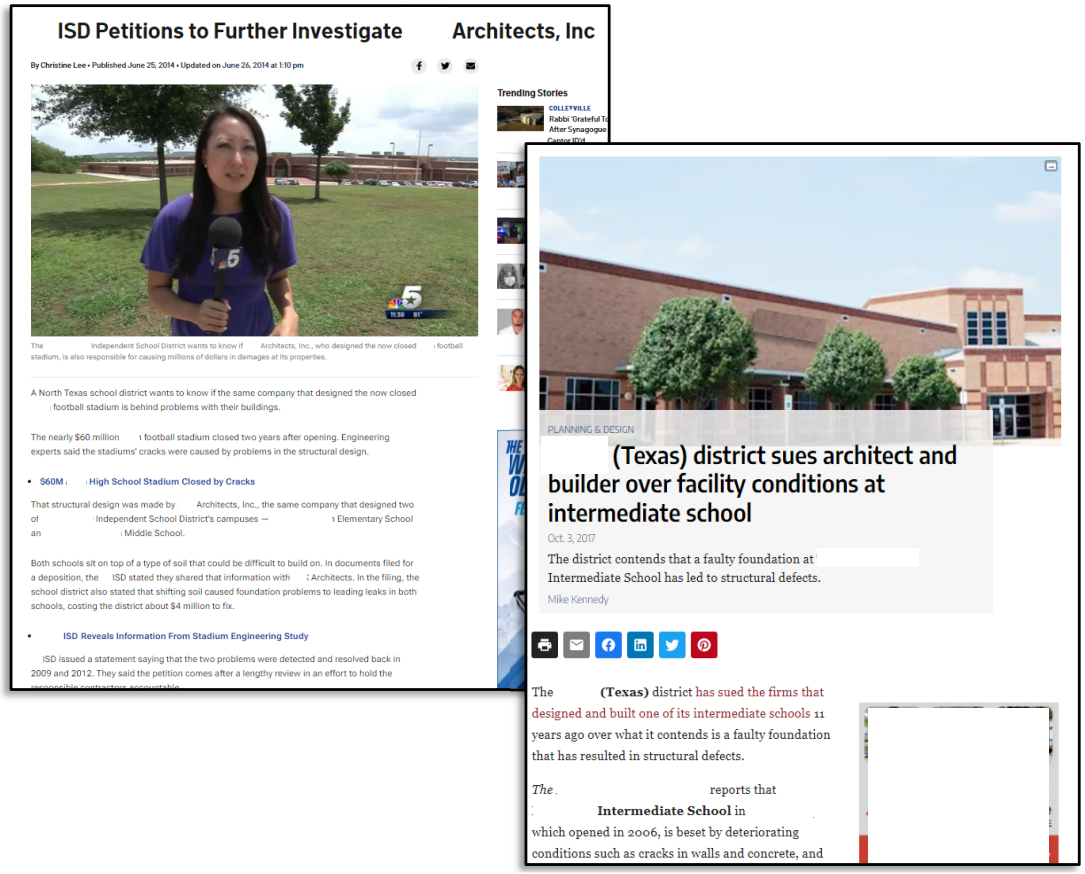
"On the advice of the forensic consultant, the client chose to excavate a deep crawl space under the building floor – essentially a basement – so workers could access the sewer lines and repair them. This labor-intensive effort cost about $8.3 million*. Not surprisingly, the client filed construction-defect claims against all the design firms involved, the constructor-in-charge, and the mechanical constructor. **The client was seeking $25 million to pay for sewer-line repairs, floor-slab repairs, interior repairs, lost revenue from residents, resident-relocation costs, attorney's and expert's fees, and court Costs.**" **All financial factors are reported in 2020 dollars. Foundation approx. 100,000 sf*

"The Member Firm agreed to a settlement two weeks before the trial; seven years after the client initiated the claim; and eleven years after the Member Firm initiated the project."

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

MR

Examples of Litigation reported in the News re Isolated Slabs and Non-Isolated Plumbing



ISD Petitions to Further Investigate Architects, Inc

By Christine Lee • Published June 25, 2014 • Updated on June 26, 2014 at 1:10 pm

Trending Stories

COLLEYVILLE

Rabbi 'Grateful T… After Synagogue …

The Independent School District wants to know if Architects, Inc., who designed the now closed football stadium, is also responsible for causing millions of dollars in damages at its properties.

A North Texas school district wants to know if the same company that designed the now closed football stadium is behind problems with their buildings.

The nearly $60 million football stadium closed two years after opening. Engineering experts said the stadiums' cracks were caused by problems in the structural design.

- $60M … High School Stadium Closed by Cracks

That structural design was made by Architects, Inc., the same company that designed two of Independent School District's campuses — Elementary School an Middle School.

Both schools sit on top of a type of soil that could be difficult to build on. In documents filed for a deposition, the ISD stated they shared that information with Architects. In the filing, the school district also stated that shifting soil caused foundation problems to leading leaks in both schools, costing the district about $4 million to fix.

- ISD Reveals Information From Stadium Engineering Study

ISD issued a statement saying that the two problems were detected and resolved back in 2009 and 2012. They said the petition comes after a lengthy review in an effort to hold the responsible contractors accountable.

PLANNING & DESIGN

(Texas) district sues architect and builder over facility conditions at intermediate school

Oct. 3, 2017

The district contends that a faulty foundation at Intermediate School has led to structural defects.

Mike Kennedy

The **(Texas)** district has sued the firms that designed and built one of its intermediate schools 11 years ago over what it contends is a faulty foundation that has resulted in structural defects.

The reports that **Intermediate School** in which opened in 2006, is beset by deteriorating conditions such as cracks in walls and concrete, and

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

JM

The 160 slides of the BPI Presentation go into great detail on Non-Isolated Plumbing approaches under Isolated Slabs:

- How Non-Expansive Trench In-Fill and/or Vertical Sleeving through an Isolated Slab does not solve the problem.

- How Mechanical Engineers are specifying Retaining Walls in Non-Isolated Void Systems without the Structural Engineering education and experience required.

- How Complex it would be to design a Hanger Rod (partially in expansive soil undergoing volumetric changes) for Expected Uplift.

- How Mechanical Engineers have a false sense of security because they normally specify labelled and listed products but they have been misled by Non-Isolated Void System Manufacturer's claims about their unlabelled and unlisted products.

- How soil-retaining elements are required by the IBC to be designed for expansive soil swell pressures, which can be 100 times the structural limit states capacity of non-isolated void system components.

- How non-isolated plumbing imparts loads onto slabs that the Structural Engineer must account for in the design.

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

JM

The following are some sketches from the BPI Presentation that illustrate some failure modes.

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

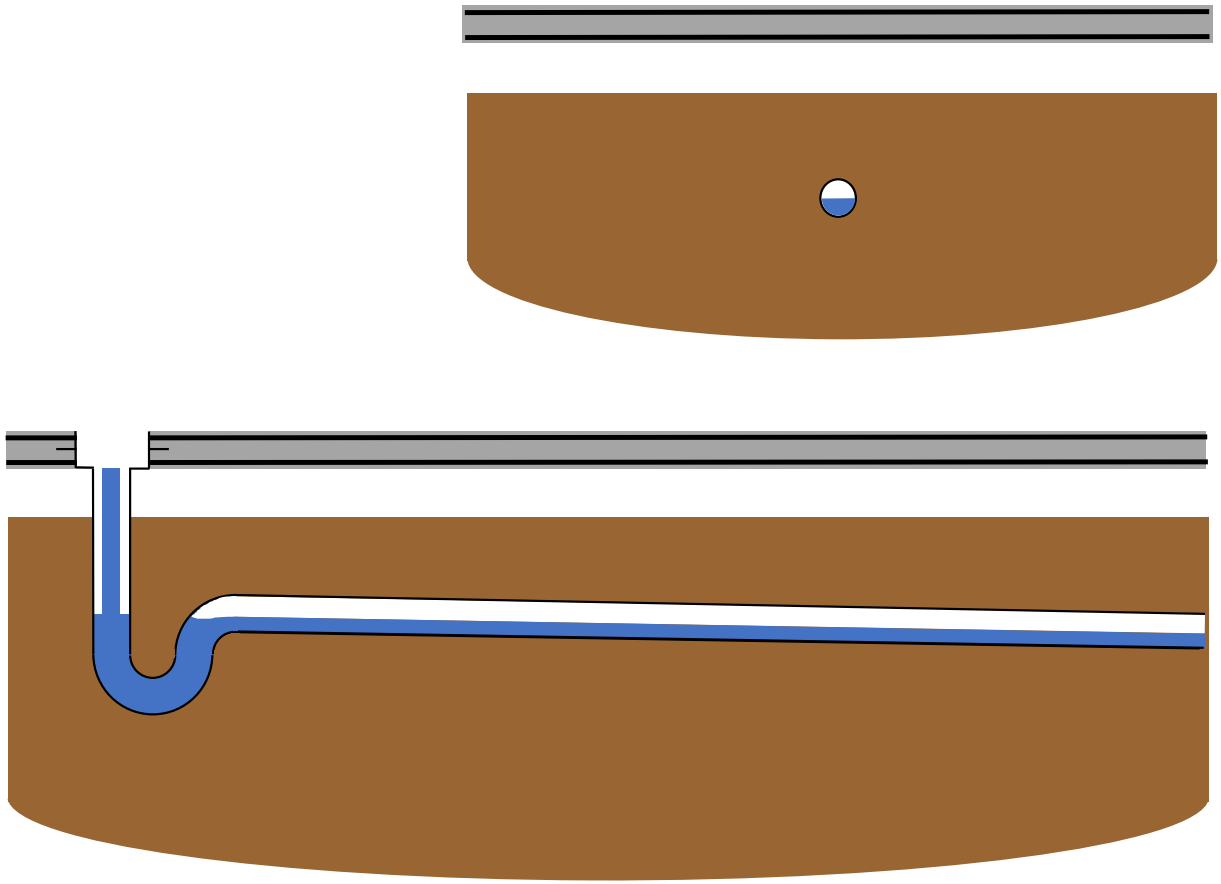
BURIED PLUMBING

JM

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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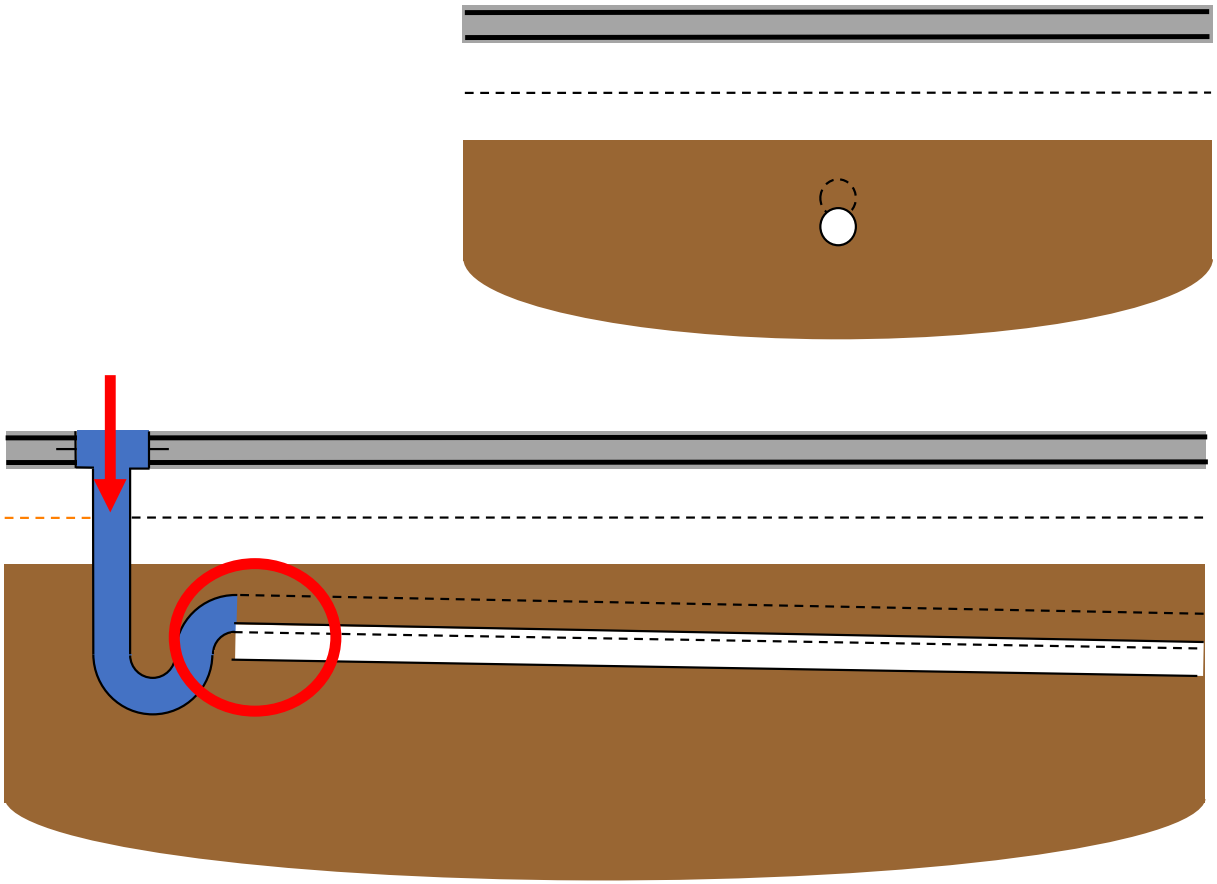
BURIED PLUMBING
Installed Conditions



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

JM

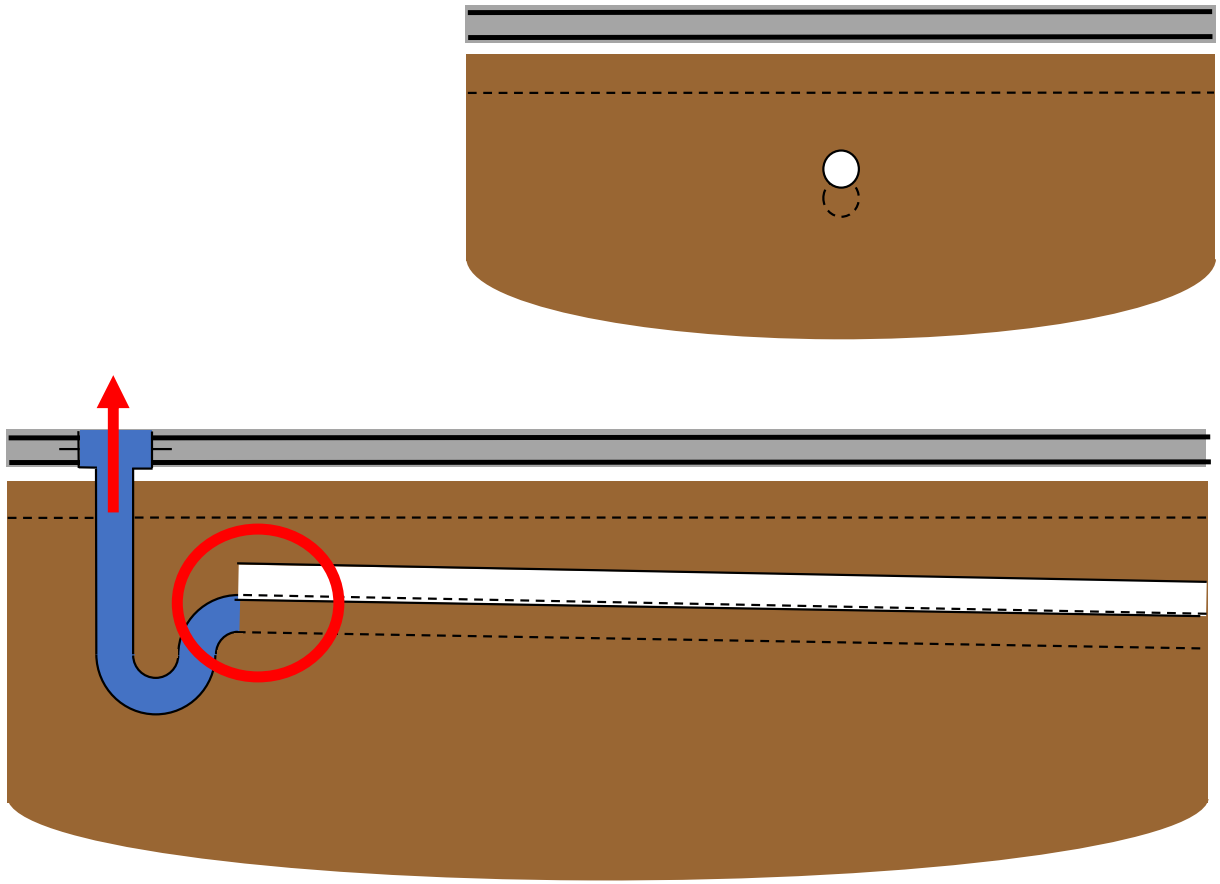
BURIED PLUMBING
General Under-Slab Settlement



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

JM

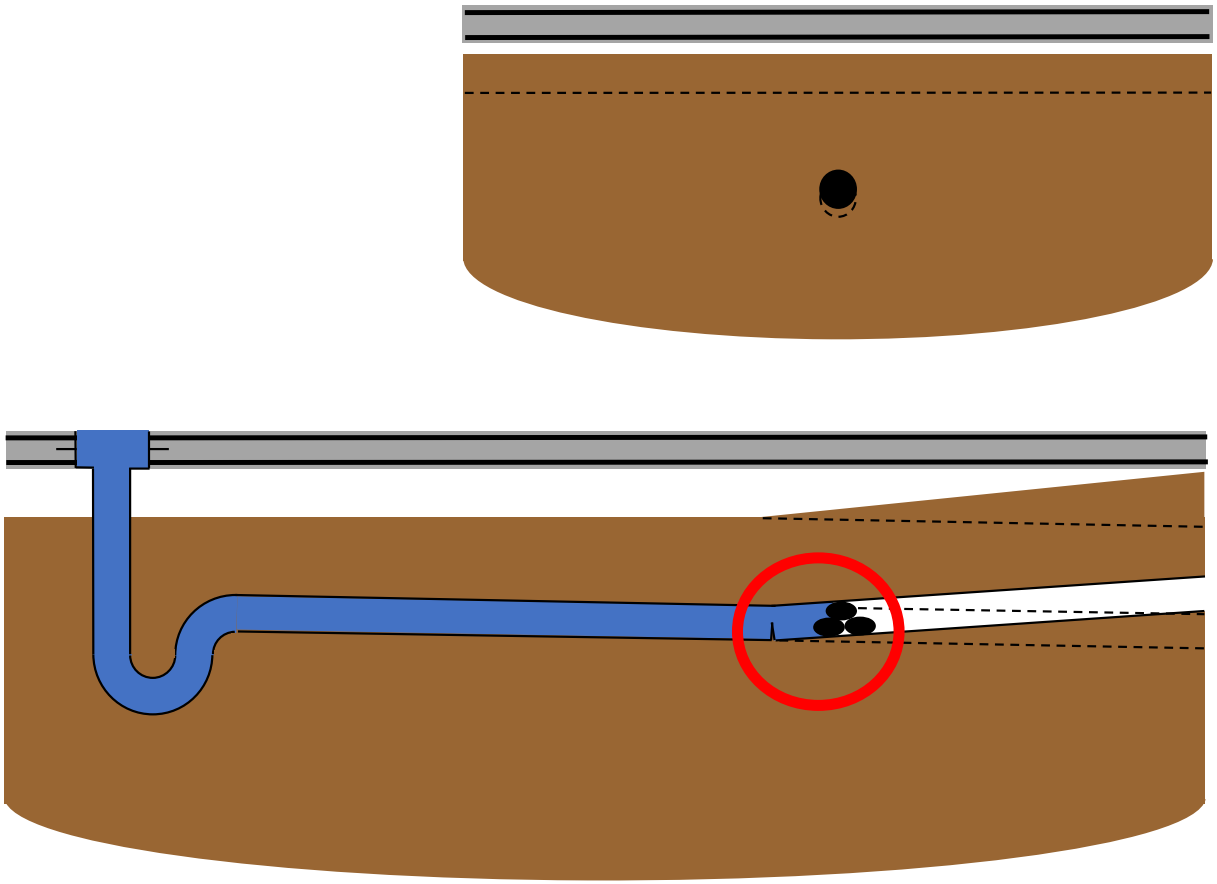
BURIED PLUMBING
General Under-Slab Swelling



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

JM

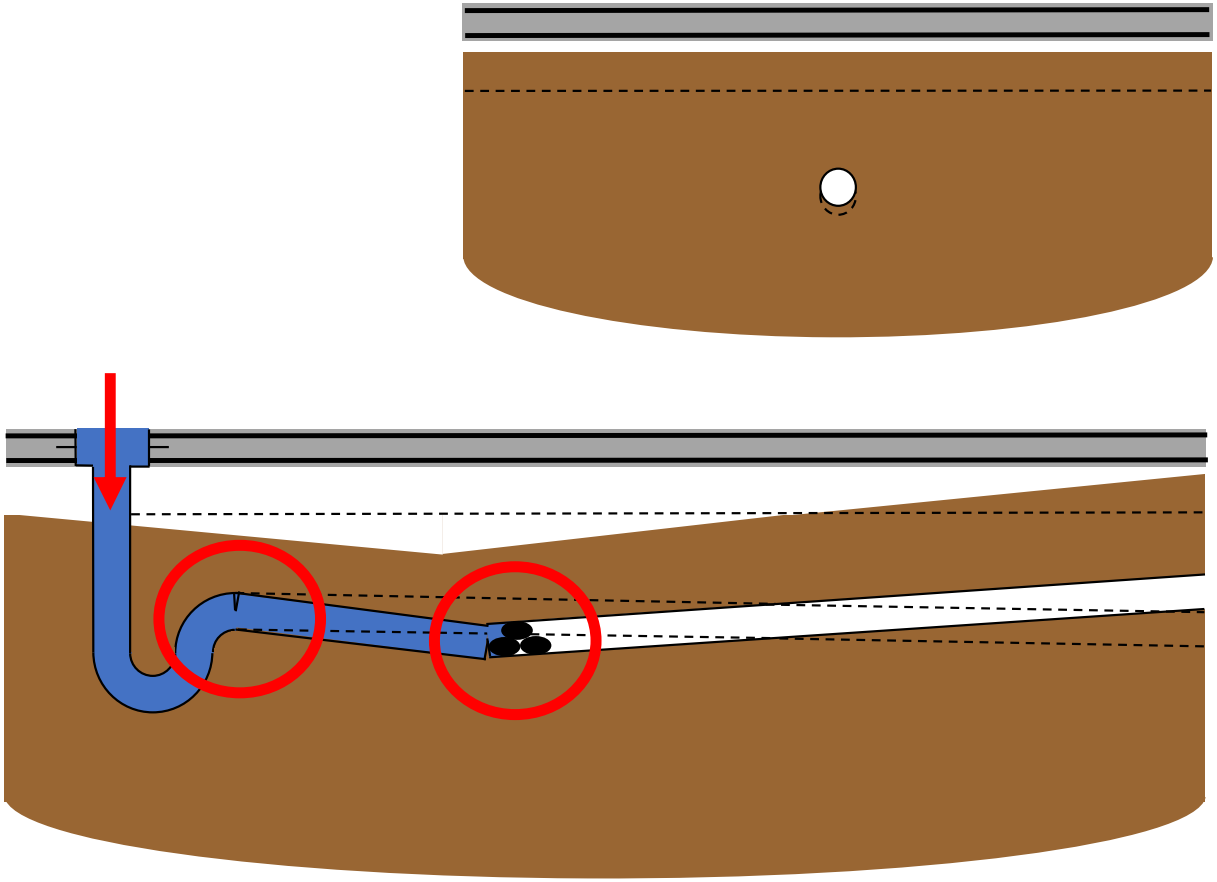
BURIED PLUMBING
Perimeter Under-Slab Swelling



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

JM

BURIED PLUMBING
Complex Under-Slab Swelling & Shrinkage



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

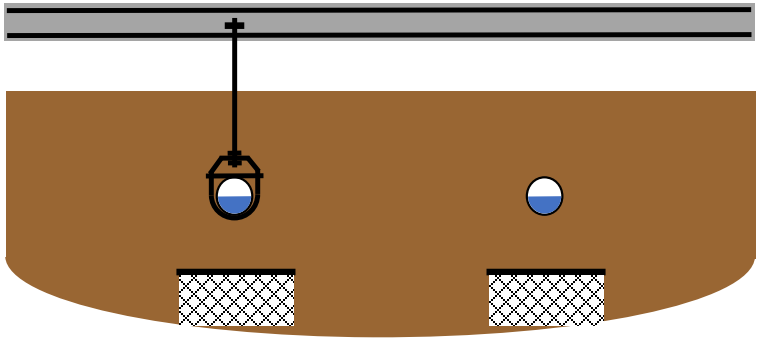
MESH & PLYWOOD UNDER PLUMBING

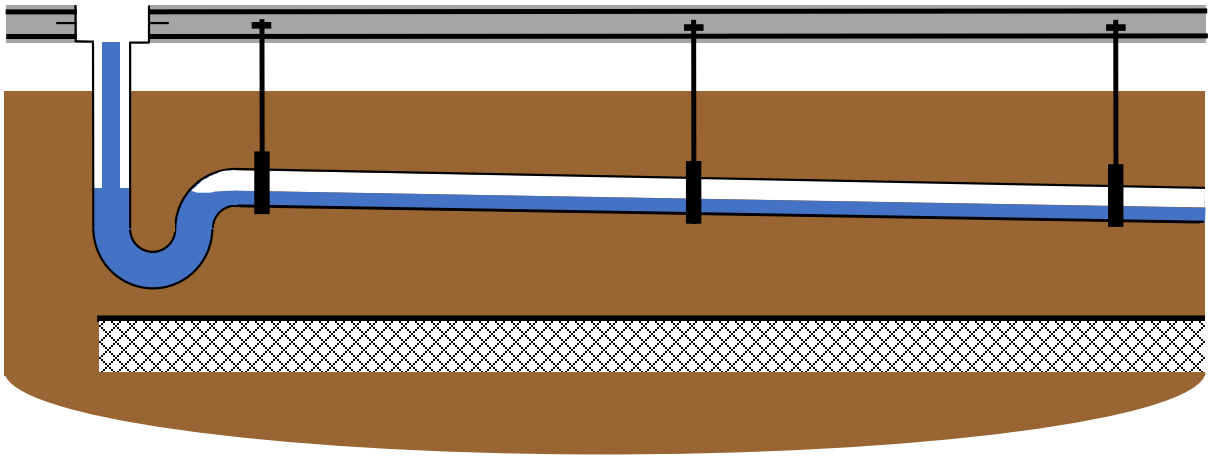
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FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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MESH & PLYWOOD UNDER PLUMBING
Installed Conditions

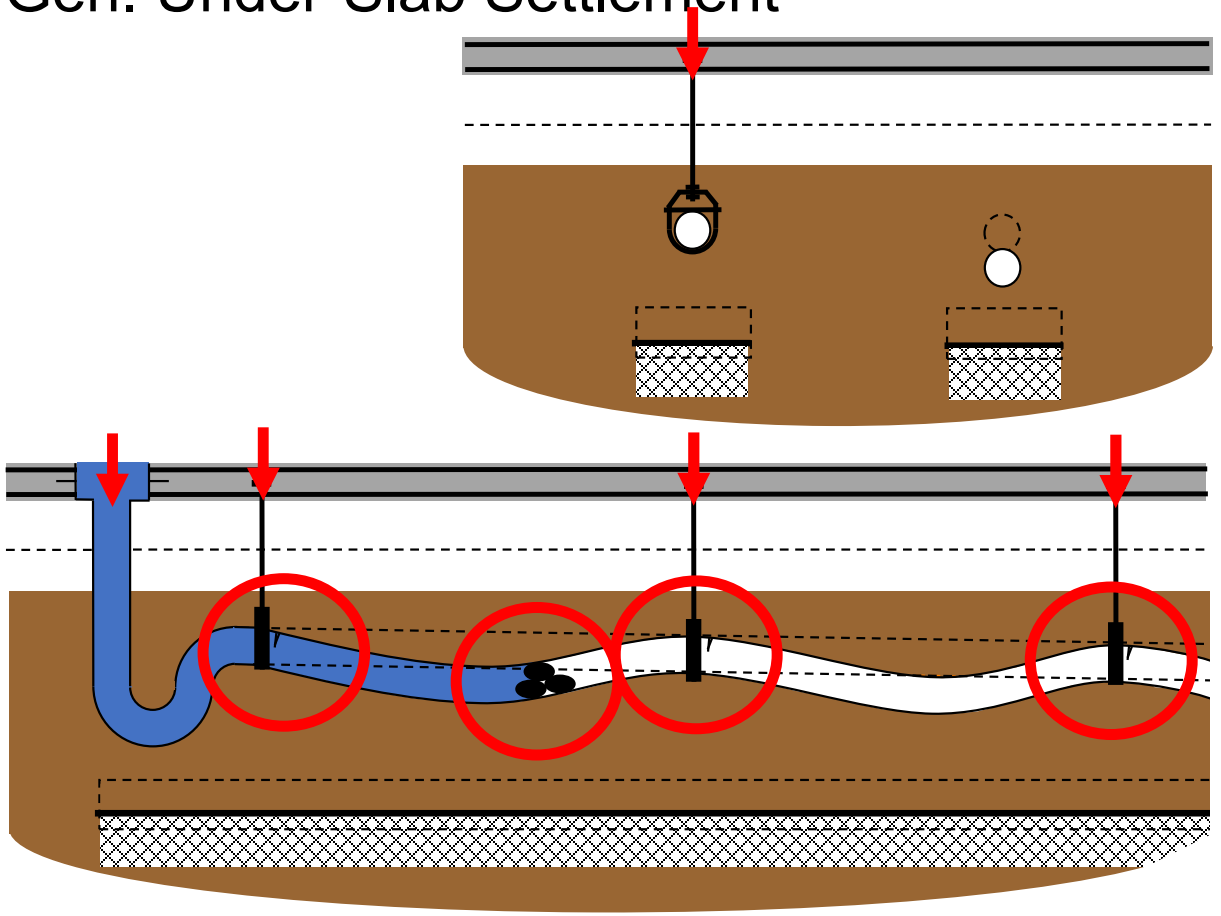




FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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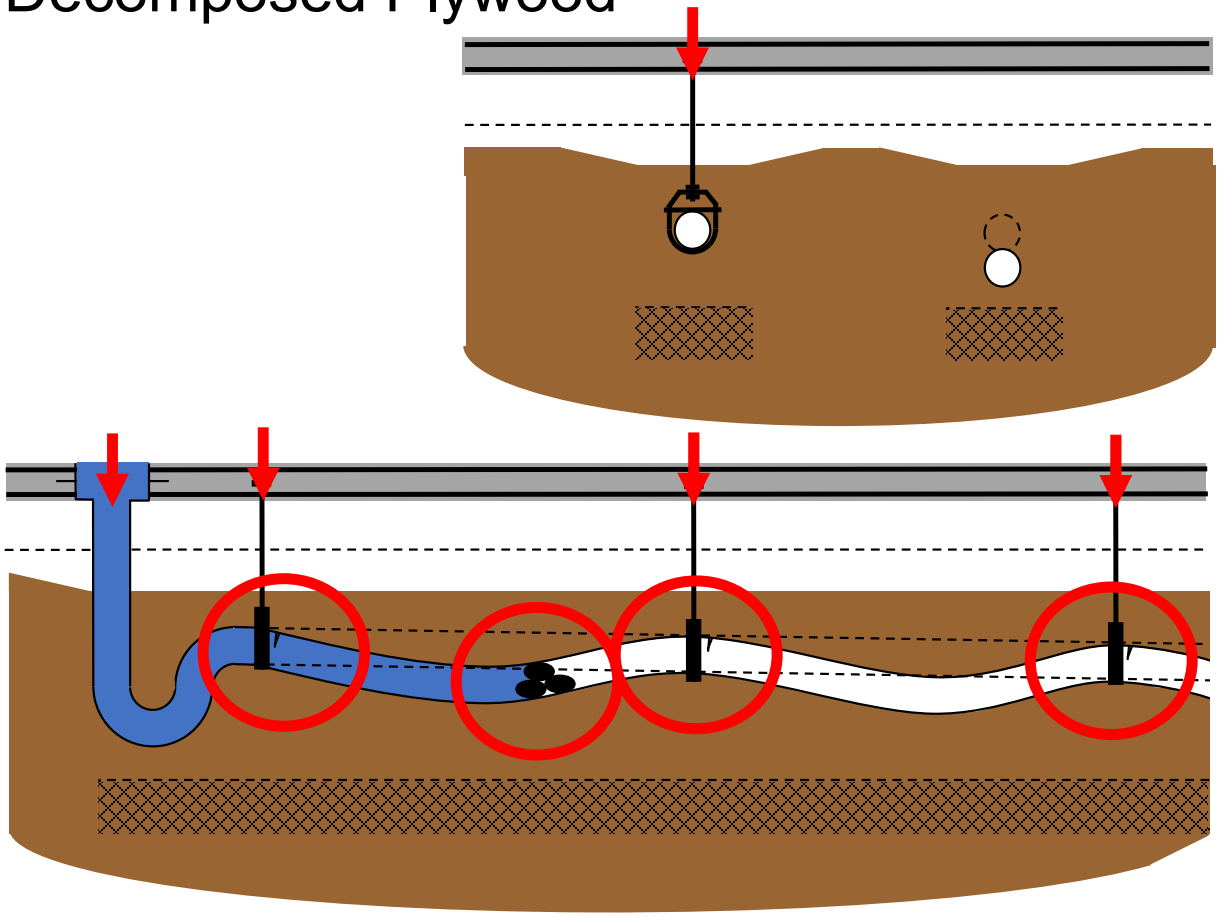
MESH & PLYWOOD UNDER PLUMBING
Gen. Under-Slab Settlement



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

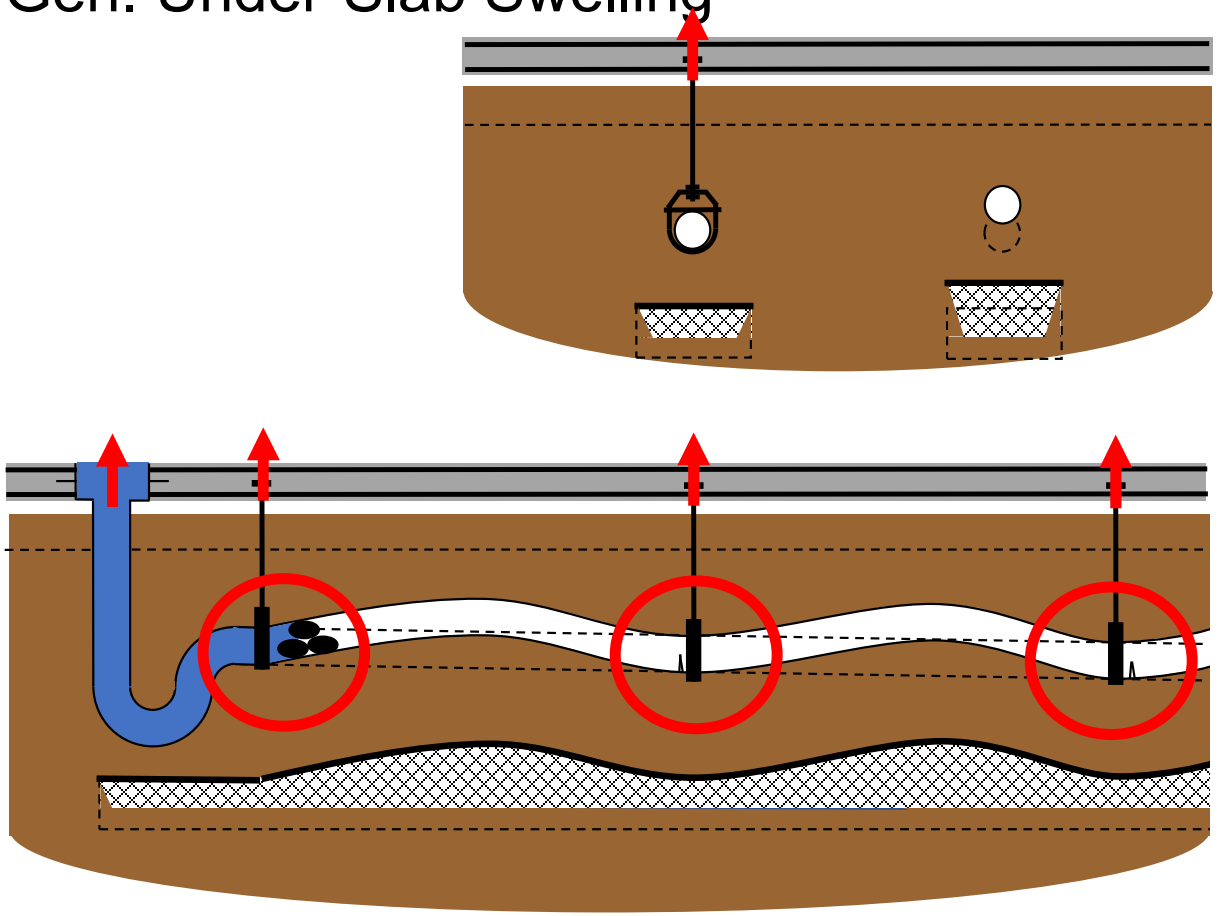
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MESH & PLYWOOD UNDER PLUMBING
Decomposed Plywood



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

MESH & PLYWOOD UNDER PLUMBING
Gen. Under-Slab Swelling

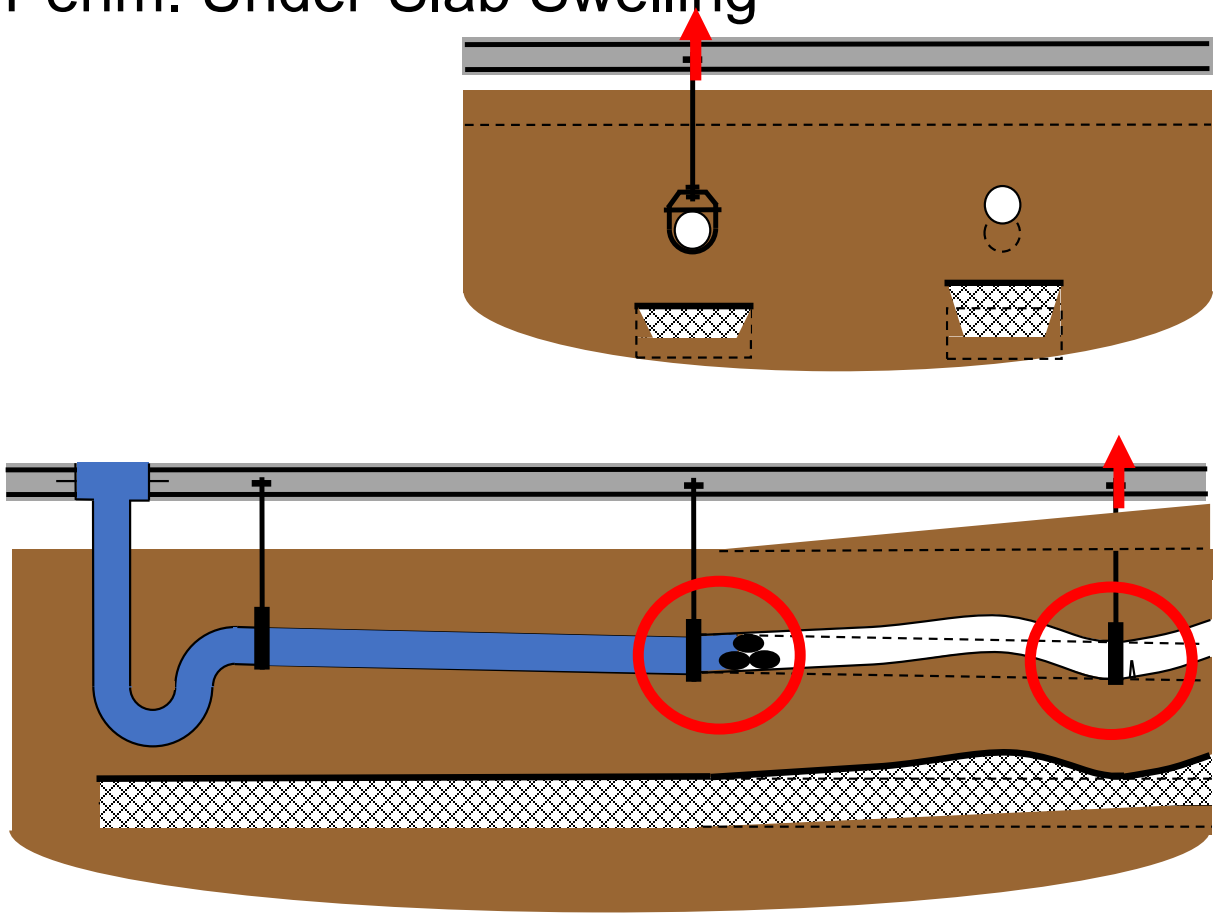


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FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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MESH & PLYWOOD UNDER PLUMBING
Perim. Under-Slab Swelling



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

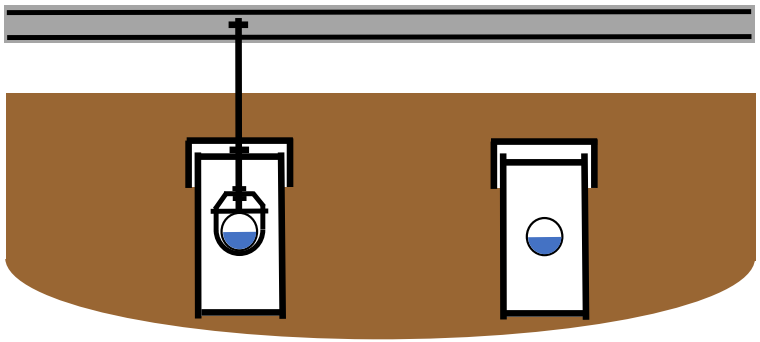
PLASTIC SIDE PANELS AND CROSSBARS

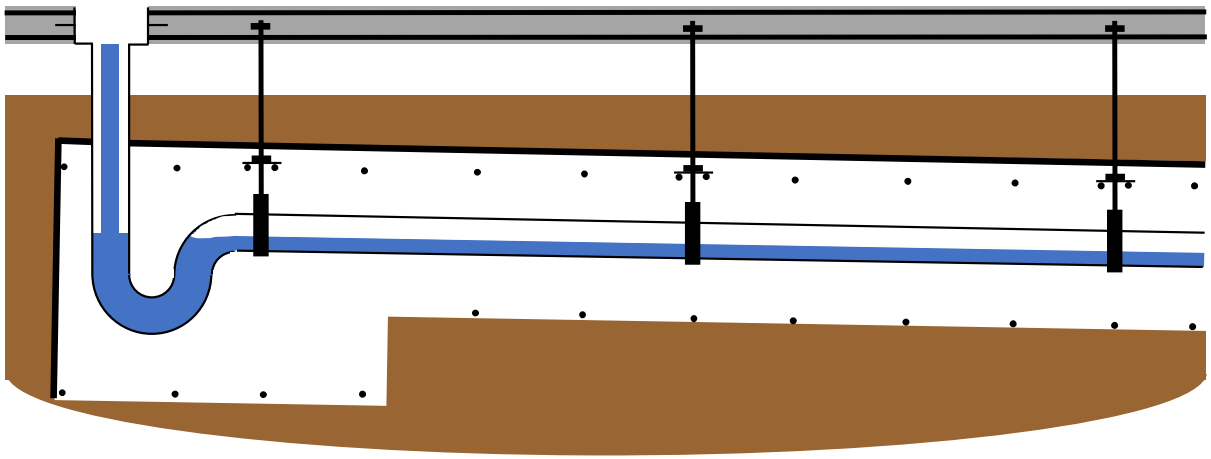
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FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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PLASTIC SIDE PANELS AND CROSSBARS
Installed Conditions

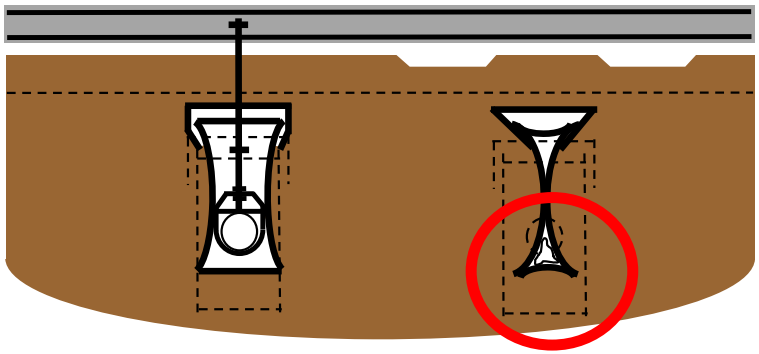


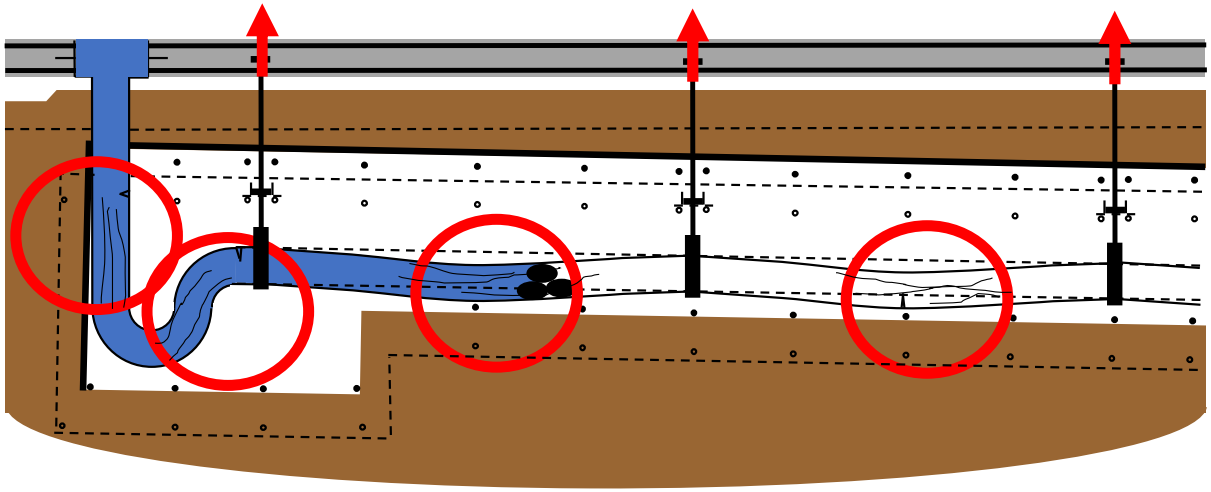


FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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PLASTIC SIDE PANELS AND CROSSBARS
Gen. Swelling, No Rod Buckling

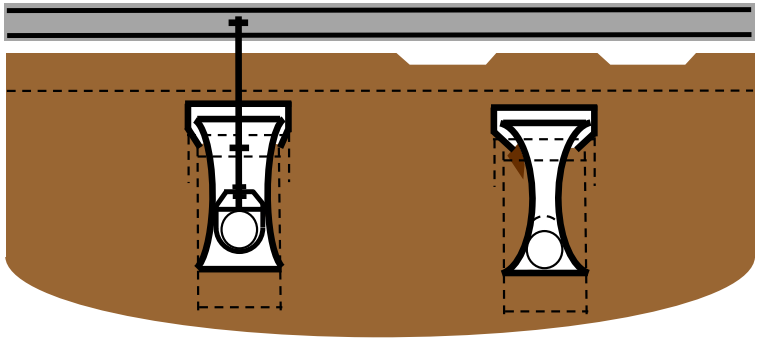


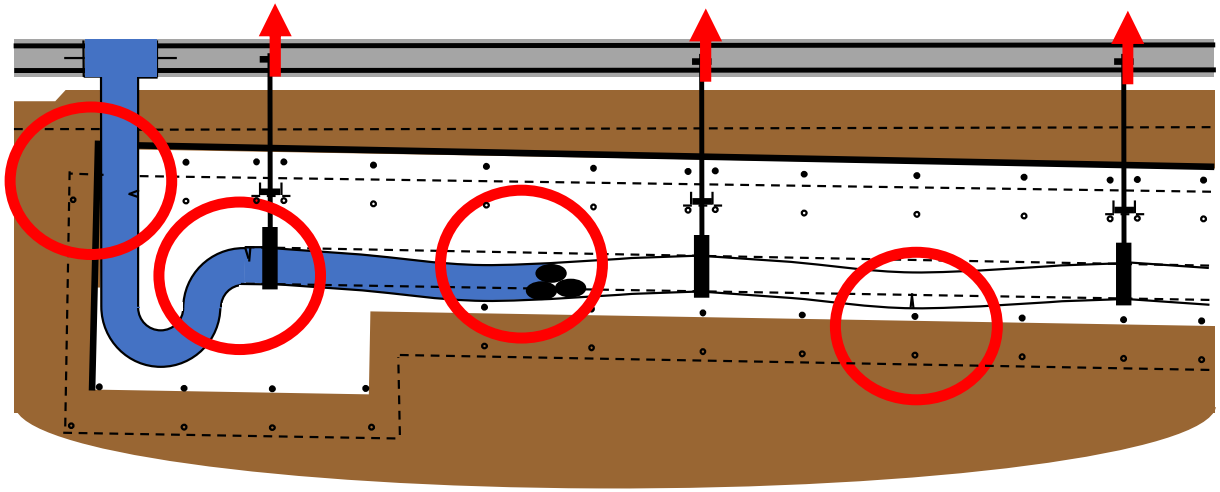


FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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PLASTIC SIDE PANELS AND CROSSBARS
Gen. Swelling, No Rod/Crossbar Buckling

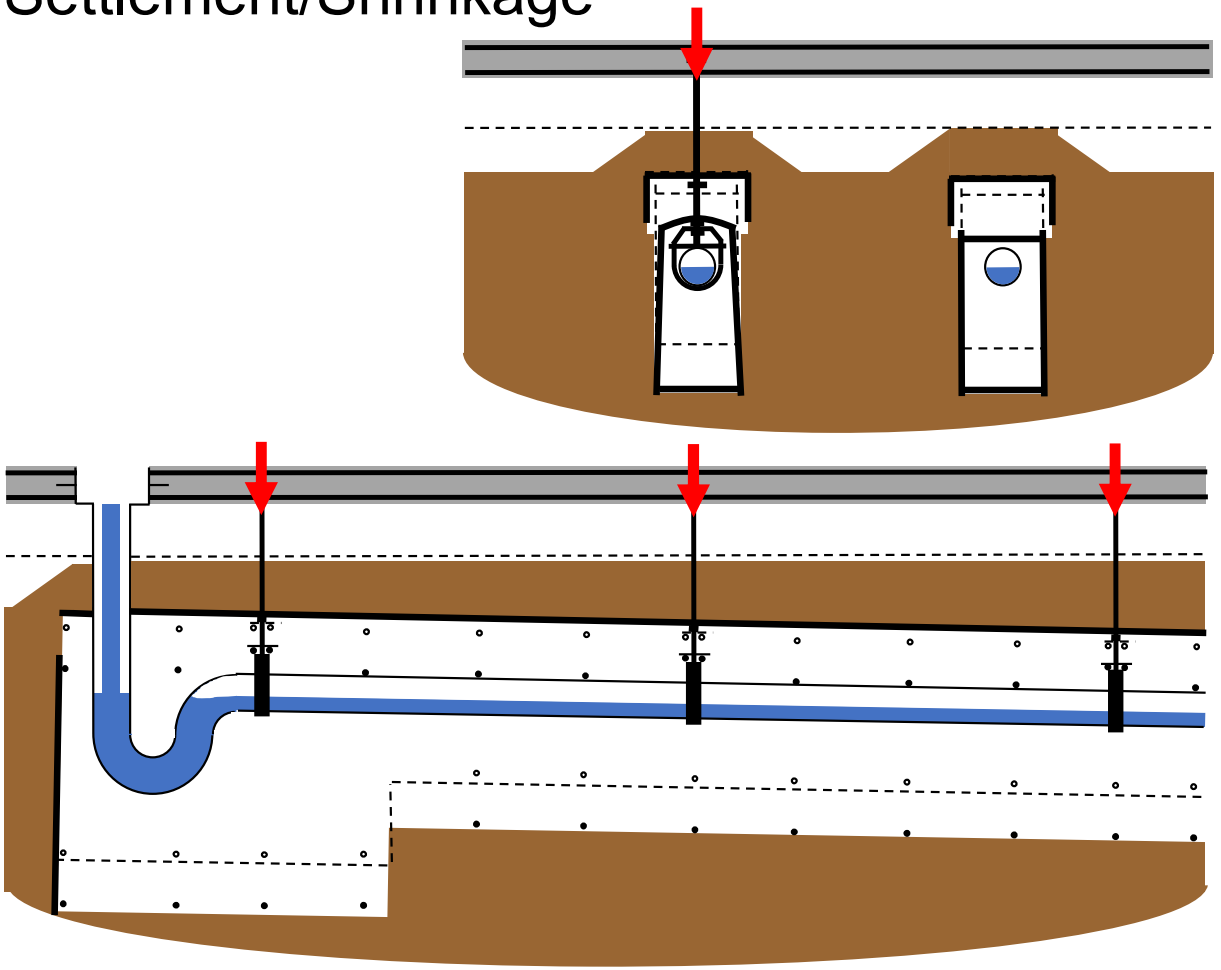




FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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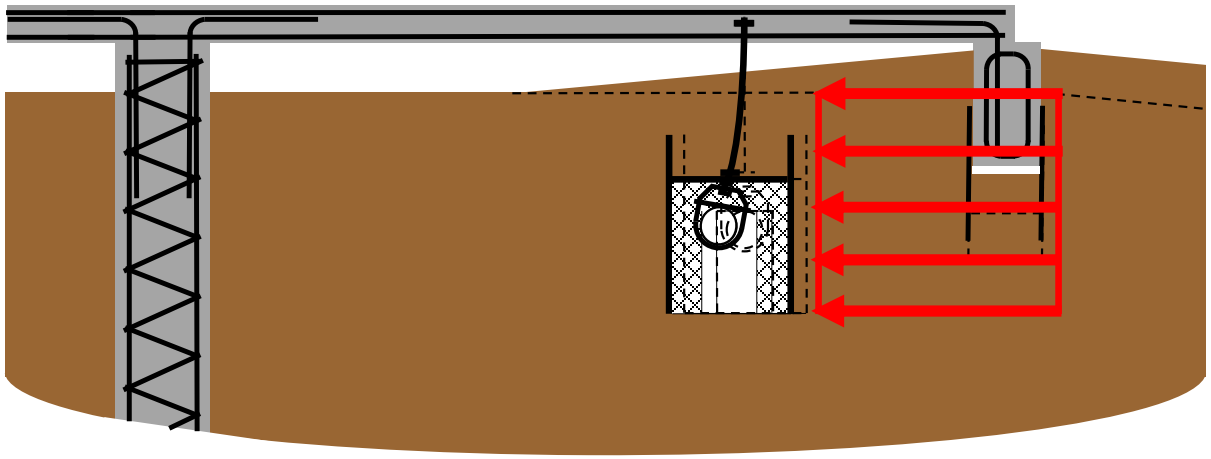
PLASTIC SIDE PANELS AND CROSSBARS
Settlement/Shrinkage



FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

NET HORIZONTAL FORCES

Soil swelling on one side of a Non-Isolated Void System can create net horizontal forces that push Non-Isolated Void Systems and damage plumbing.



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FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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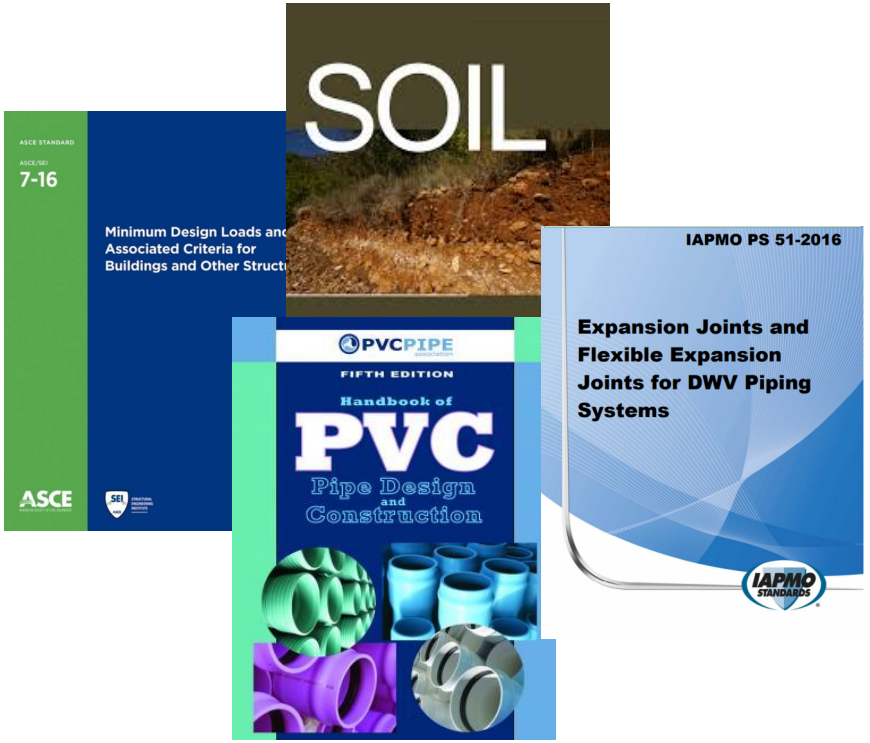
SWELL/SHRINK CYCLE DEFORMATIONS

Designers need to also carefully consider the effects of swell/shrink cycles on the deformed shape of non-isolated void systems.

FAILURES OF NON-ISOLATED PLUMBING UNDER ISOLATED SLABS

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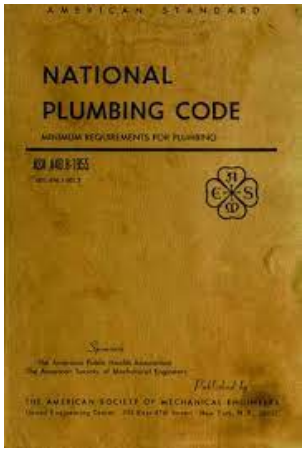
In summary, the problem is that **an unprecedented and possibly unobtainable level of <u>inter-disciplinary testing and design coordination</u>, plan review and plumbing inspection would be required** on each project between the Geotechnical, Mechanical and Structural Engineer to properly protect plumbing **using non-isolated plumbing approaches that have been used**. A Plumbing Inspector does not have the ability to verify this occurred.



CODE HISTORY

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CODE HISTORY

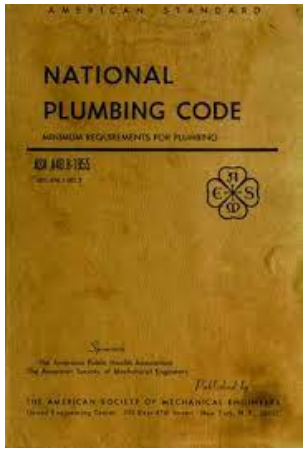


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ASA A40.8 National Plumbing Code 1955 Edition

Some of the relevant “Basic Principles” in this document indicate that protection of plumbing from expansive soil is a health, safety and welfare issue.

CODE HISTORY

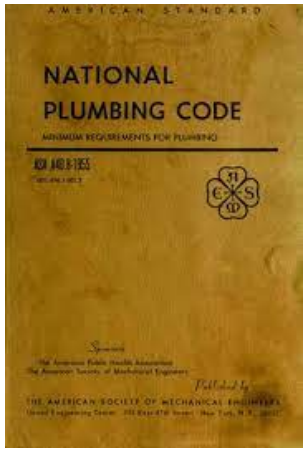


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ASA A40.8 National Plumbing Code 1955 Edition

Principle No. 9: The piping of the plumbing system shall be of durable material, free from defective workmanship, and so designed and constructed as to give satisfactory service for its reasonable expected life.

CODE HISTORY

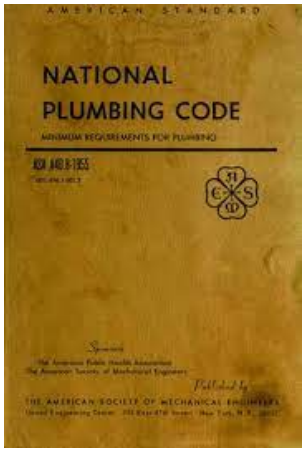


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ASA A40.8 National Plumbing Code 1955 Edition

Principle No. 18: Where a plumbing drainage system may be subjected to backflow of sewage, suitable provision shall be made to prevent its overflow in the building.

CODE HISTORY

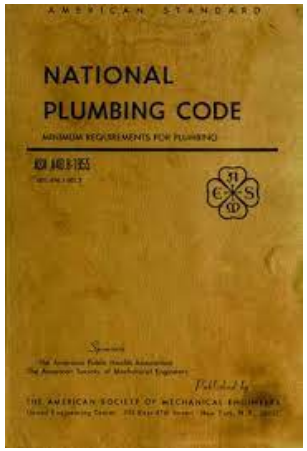


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ASA A40.8 National Plumbing Code 1955 Edition

Principle No. 19: Plumbing systems shall be maintained in a sanitary and serviceable condition.

CODE HISTORY



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ASA A40.8 National Plumbing Code 1955 Edition

Principle No. 22: Sewage or other waste from a plumbing system which may be deleterious to surface or subsurface waters shall not be discharged into the ground or into any waterway unless it has first been rendered innocuous through subjection to some acceptable form of treatment.

NEW LANGUAGE IN THE 2024 IPC

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NEW LANGUAGE IN THE 2024 IPC

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International Plumbing Code
New Language in the 2024 Edition

Explicitly requires protection of plumbing from expansive soil and defines when expansive soil is present.

Allows buried plumbing under Slabs-on-Ground.

Requires complete isolation of plumbing under Slab-on-Crawlspace and Slab-on-Voidwork: "***It shall not be permitted for the plumbing, hangers and supports below the slab or below the framing to be in contact with soil or any assemblage of materials that is in contact with soil within the active zone***."

Exception 1 allows buried pipe for drainage of crawl spaces

Exception 2 allows attachment to piers if the plumbing, hangers and supports are otherwise isolated.

305.8 Expansive Soil. Where expansive soil is identified under buildings in accordance with Section 1803.5.3 of the International Building Code, but not removed in accordance with Section 1808.6.3 of the International Building Code, plumbing shall be protected in accordance with Section 305.8.1 or 305.8.2.

305.8.1 Non-Isolated Foundations. Under foundations with slabs that are structurally supported by a subgrade, it shall be permitted for plumbing to be buried.

305.8.2 Isolated Foundations. Under foundations with a slab or framing that structurally spans over an under-floor space which isolates the slab or framing from the effects of expansive soil swelling and shrinking in accordance with Section 1808.6.1 of the International Building Code, the plumbing shall be suspended so that plumbing, hangers and supports are isolated, by a voidspace, from the effects of expansive soil swelling and shrinking.

Exception: It shall be permitted for plumbing to be buried if the plumbing provides drainage of an under-floor space.

To protect the voidspace, soil shall be sloped, benched or retained in accordance with an approved design methodology.

It shall not be permitted for the plumbing, hangers and supports below the slab or below the framing to be in contact with soil or any assemblage of materials that is in contact with soil within the active zone. It shall not be permitted for a slab and plumbing to be lifted as an assembly to create the voidspace unless the under-floor space is a crawlspace with access to allow inspection of plumbing after lifting.

Exception: It shall be permitted for the piping, fittings, hangers, and supports below the slab or below the framing to be in contact with structural elements of the foundation that are designed to resist the effects of expansive soil swelling and shrinking in accordance with Section 1808.6.1 of the International Building Code.

Organic materials subject to decay shall not be used for hangers, supports and soil retention systems. Materials subject to corrosion shall not be used for hangers, supports and soil retention systems unless protected in an approved manner.

Where plumbing transitions to a buried condition beyond the perimeter of the foundation, an adequately flexible expansion joint shall be provided in the plumbing system to accommodate the effects of expansive soil swelling and shrinking.

RECOMMENDATIONS

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RECOMMENDATIONS

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FOR PLUMBING ENGINEERS

We recommend Mechanical/Plumbing Engineers **immediately cease and desist the practice of allowing Non-Isolated Plumbing (Buried Plumbing or Non-Isolated Void Systems) under Slab-on-Voidwork or Slab-on-Crawlspace** foundations, regardless of whether the IPC or UPC applies or whatever edition applies, whatever the geotechnical engineer estimates to be the probability of movement occurring, whatever the building official will allow, and however hard the owner demands to reduce the initial cost of construction and claims they will accept the risks of damage that would requiring extensive and repeated maintenance.

We recommend Mechanical/Plumbing Engineers **immediately begin complying with the new provisions in the 2024 IPC** (provided in this presentation) for protection of plumbing from expansive soil, which is also recommended by the Geoprofessional Business Association:

Non-Isolated Plumbing is allowed under Non-Isolated Slabs

Isolated Plumbing is required under Isolated Slabs

RECOMMENDATIONS

FOR BUILDING OFFICIALS

In regions where expansive soil is common, we recommend Authorities Having Jurisdiction adopt the new language in the 2024 IPC for the protection of plumbing from expansive soil.

Alternatively, where expansive soil is present and slabs will be isolated from the expansive soil, we recommend Building Officials require a single, comprehensive report be submitted by a combination of a qualified Geotechnical Engineer, Structural Engineer and Mechanical/Plumbing Engineer, providing analytical justification showing how the plumbing will not be over-stressed or over-strained if the possible expansive soil movement and expansive soil swell pressures predicted by the Geotechnical Engineer actually do occur.

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Thank you

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