

EXCERPTS FROM

**SPECIFICATION AND APPLICATION OF VOID SPACES
BELOW CONCRETE FOUNDATIONS**

by

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TABLE OF CONTENTS

PREFACE	5
GLOSSARY	7
1.0 INTRODUCTION	14
1.1 GENERAL	14
1.2 CONSIDERATIONS FOR THE USE OF VOID FORMS	15
2.0 VOID SPACE TYPES	16
2.1 DEGRADABLE VOID SPACE PRODUCTS	16
2.1.1 Corrugated Paper Void Forms	16
2.1.2 Molded Pulp Void Forms	18
2.2 COLLAPSIBLE VOID SPACE PRODUCTS	18
2.2.1 Expanded Metal Void Form Systems	19
2.2.2 Plastic Grid Void Form System	19
2.2.3 Foam Type Void Form System (Polystyrene Foam)	20
2.3 TEMPORARY VOID FORM PRODUCTS	21
2.3.1 Wood Void Forms	21
3.0 DESIGN OF VOID SPACE SYSTEMS	22
3.1 VOID SPACE SYSTEMS FOR ISOLATED SLABS	23
3.2 VOID SPACE SYSTEMS FOR ISOLATED GRADE BEAMS	26
3.3 OTHER DESIGN CONSIDERATIONS OF VOID SPACE SYSTEMS ...	28
3.3.1 Below-Ground Grade Beams	28
3.3.1.1 Earth-Formed Grade Beams	28
3.3.1.2 Below-Ground Formed Grade Beams Without Void Spaces	29
3.3.1.3 Below-Ground Formed Grade Beams With Void Spaces	30
3.3.2 Corrugated Paper Void Forms (Under Slab Areas, Grade Beams, And Around Pier Caps)	32
3.3.3 Collapsible Void Space Materials (Under Grade Beams Only)	32
3.3.4 Non-Collapsible Void Space Materials	32
3.4 DESIGN LOADS	33
3.5 FORMS AROUND THE TOPS OF DRILLED PIERS	33
3.5.1 Advantages	33
3.5.2 Disadvantages	33
3.5.3 Other Considerations	33
3.6 DESIGN PROCEDURE	35
3.7 VAPOR RETARDER	35
4.0 CONSIDERATIONS FOR UNDER-SLAB UTILITIES PLUMBING	36

4.1	PIPING CONNECTION AT THE FOUNDATION PERIMETER.....	43
4.1.1	PIPING CONNECTION AT THE FOUNDATION PERIMETER FOR RESIDENTIAL STRUCTURES	48
5.0	RECOMMENDED VOID SPACE MATERIALS.....	49
5.1	RECOMMENDED VOID SPACE MATERIAL TYPES.....	49
5.2	DEGRADABLE CORRUGATED PAPER VOID FORM MATERIALS...	50
5.3	COLLAPSIBLE VOID FORMS.....	51
5.4	NON-COLLAPSIBLE VOID SPACE SYSTEMS	52
5.5	TRAPEZOIDAL CORRUGATED PAPER VOID FORMS.....	53
5.6	PLASTIC VOID FORMS.....	54
5.7	MANUFACTURER TESTING REQUIREMENTS	55
5.8	SUBMITTALS.....	55
6.0	HANDLING AND INSTALLATION OF VOID SPACE SYSTEMS.....	56
6.1	ONSITE VOID SPACE SYSTEMS PROTECTION.....	56
6.2	INSTALLATION	56
7.0	REFERENCES	58

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Some of the methods and devices which are discussed in this document are inventions by various parties and have been PATENTED or are PATENT-PENDING. These methods and devices are referenced in this document 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 without endorsing or disparaging any particular products or manufacturers. This document is not an inducement to patent infringement. Therefore, this statement is hereby providing NOTICE to assume all methods and devices discussed in this document are PATENTED or are PATENT-PENDING unless verified otherwise.

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Grade Beam – a nominally horizontal Foundation component located at or near grade level, typically consisting of reinforced concrete. Grade Beams function to support the contributing loads from the Superstructure and any ground floor slab that is supported by the Grade Beam. The Grade Beam may be either directly supported by bearing on the underlying soils for Shallow Foundation Systems or may be designed to span between the deep Foundation components of a Deep Foundation System. For a Deep Foundation System, Grade Beams may be isolated from the soil by Void Forms or removable formwork.

Heave – the upward movement of an underlying supporting soil stratum due to the addition of moisture to an unsaturated Expansive Soil in the Movement Active Zone. When moisture is added to soil with an expansive clay content, expansion occurs within the Movement Active Zone of the soil. Heave normally only occurs within clayey soils that have a high suction potential and an available moisture source. Lateral movements of expansive soils may also occur due to the addition of moisture and cause a buildup of lateral pressures when the movement is restrained, but horizontal movements are typically not categorized as “Heave”.

Heave, Frost – heaving of soil that can occur when moisture in the soil freezes due to the formation of ice lenses that expand within the soil. This document does not address Frost Heave.

Isolated Foundation – a Foundation that utilizes Void Spaces that separate the Slab Area and Grade Beams from the soil below. It is supported by a Deep Foundation System.

Isolated Plumbing – Plumbing system installed under an Isolated Slab, including pipes, fittings, hangers, and supports, that are fully suspended to avoid contact with the subgrade or any assemblage of materials in contact with the subgrade after the slab is installed. This applies only to plumbing within the footprint of the Isolated Slab, as plumbing outside this footprint may require alternative protection in accordance with applicable codes.

Isolated (Structural) Slab – the Slab Area that utilizes Void Spaces that separate the Slab Area from the soil below. It is designed to span between Grade Beams resting on finished grade or Deep Foundation System.

Non-Isolated Plumbing – Plumbing components, including pipes, fittings, hangers, or supports, installed under a slab where any portion of these components is in contact with the subgrade or any assemblage of materials in contact with the subgrade after the slab is installed, particularly in expansive soil conditions. This includes systems that incorporate voids adjacent to or near some plumbing components but do not fully isolate them from subgrade contact or from materials in contact with the subgrade.

Perms (Permeance) – a ratio of material porosity or resistance to water passage, defined as a water mass flowing through 1 sf of material at a defined pressure differential. A U.S. (Imperial) Perm equals 1 grain (0.0001428 lbs, 0.00229 ounces, 0.068 grams) of water passing through 1 square foot pushed at a pressure of one inch (25.4 mm) of mercury.

flooring materials and their adhesives. Membranes are available in various types and thicknesses depending on the protection required.

Poly Vapor Barriers/retarders are tested per ASTM F1249 (*Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor*) and then typically puncture performance specified based on ASTM E1745 (*Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs*) standards and classes, with specific ASTM E1643 (*Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs*) installation requirements. Please note that ASTM E1745 and ASTM E1643 refer to Vapor Barriers/retarders that are in contact with soil [for ASTM documents see [\[3\]](#)].

Vapor Retarders should be connected to the bottom of the slab by using a designed system such as tape or felt products, or by other means.

4.0 CONSIDERATIONS FOR UNDER-SLAB UTILITIES PLUMBING

Plumbing systems for commercial buildings, multifamily structures, and other non-residential construction are typically regulated by a jurisdiction's adopted plumbing code, most commonly the International Plumbing Code (IPC) or the Uniform Plumbing Code (UPC). Designers should verify the plumbing code adopted by the local authority having jurisdiction when applying the guidance in this section.

Protection of plumbing is a health, safety and welfare issue. Although the protection of piping from the effects of Expansive Soil may not be explicitly mentioned in some provisions of some plumbing codes, the expectation of plumbing codes by relevant provisions in each code is clearly that plumbing must be protected from Expansive Soil which may cause stresses and strains on plumbing.

- The 2024 International Plumbing Code (IPC) [\[12\]](#) requires in Section 305.2 that, "Piping in a plumbing system shall be installed so as to prevent strains and stresses that exceed the structural strength of the pipe".
- Section 1601.1 of the 2024 International Building Code (IBC), and earlier editions, states "The provisions of this chapter shall govern the structural design of *buildings, structures* and portions thereof." The interpretation of this committee is that plumbing is a portion of a building.
- Section 101.4 of the IBC states that referenced codes, including the IPC, are considered part of the requirements of the IBC.
- Section 1610.2 of the 2024 IBC states "...approximately horizontal elements below grade shall be designed to resist uplift *loads* where applicable." and requires that, "The design for upward *loads* caused by expansive soils shall comply with Section 1808.6."
- Section 1803.6 of the 2024 IBC states that, where geotechnical investigations are required, the report shall include "...provisions to mitigate the effects of expansive soils..." and "Special design and construction provisions for foundations of *structures* founded on expansive soils, as necessary."

- Similar to the IPC, the 2024 Uniform Plumbing Code (UPC) requires in Section 312.2 that, “Piping in connection with a plumbing system shall be so installed that piping or connections will not be subject to undue strains or stresses, and provisions shall be made for expansion, contraction, and structural settlement.” [14].

The American Society of Plumbing Engineers (ASPE) Plumbing Engineering Design Handbook, Vol 4, Chapter 6 states, in a section titled "Natural Environmental Conditions" under a broader section titled "HANGER AND SUPPORTS AS PART OF THE PIPING SYSTEM": "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." Slabs-on-Void Forms are designed to be isolated from the extreme natural phenomena of expansive soil. Therefore, the ASPE Handbook expects Mechanical Engineers to strengthen or isolate plumbing from Expansive Soil where slabs-on-Void Forms are specified by Structural Engineers. Because it is often not feasible to strengthen plumbing to resist the extreme loads of expansive soil, this committee recommends that contractor/builder, plumbing contractor and/or the plumbing engineer specify that the plumbing be isolated from Expansive Soil and not allow Non-Isolated Plumbing under Isolated Foundations.

Beginning with the 2024 version of the IPC, where Expansive Soil is identified under buildings and when the Foundation system is an Isolated Foundation (e.g., slab-on-Void Forms or slab-over-crawlspace), Section 305.8.2 states "...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." and "Plumbing, hangers and supports below the slab or framing shall not be permitted to be in contact with the soil or any assemblage of materials that is in contact with soil in the active zone."

Protecting plumbing from Expansive Soil requires coordination among the structural engineer, architect, contractor/builder, plumbing contractor, plumbing engineer, civil engineer and geotechnical engineer. However, the method on how plumbing is protected should come from the contractor/builder, plumbing contractor and/or the plumbing engineer.

Where plumbing, hangers and supports are not isolated from Expansive Soil under Slabs-on-Void Forms Foundations, the plumbing will be forced to bridge between a moving system (the soil) and a non-moving system (the slab or Foundation). This differential movement should be expected to cause the utility lines to disconnect, start leaking, or otherwise fail, requiring repair. Repairs are expensive and time-consuming as there is usually no direct access to the under-floor space. When plumbing must be repaired below slabs-on-Void Form, it is typically necessary to saw-cut temporary access openings in the slab at strategic locations that will not compromise the structural integrity of the slab. Because acceptable access openings typically cannot occur immediately over damaged plumbing, soil is typically hand excavated and wheelbarrowed out of the building to reach the damaged plumbing.

Plumbing systems under Isolated Slabs can be categorized into one of two primary groups: Non-Isolated Plumbing and Isolated Plumbing. See *Protection of Plumbing from Expansive Soils Under Foundations* [17] for more information.

Conventionally buried plumbing is where plumbing and plumbing supports below an Isolated Foundation are in contact with the subgrade (soil), creating an opportunity for plumbing damage. Conventionally buried plumbing is installed and buried directly in the subgrade beneath the slab-on-ground. Conventionally buried plumbing is typically utilized with slab-on-ground Foundations (non-voided Foundations). Under slabs-on-ground the plumbing is installed in the subgrade with little concern of plumbing damage due to soil movement because the slab and plumbing will generally rise and fall together.



Figure 4.0-A Example of a Conventionally Buried Plumbing Installation for a Slab-On-Ground.

Conventionally Buried Plumbing is an example of Non-Isolated Plumbing.

With a Non-Isolated Void System for Plumbing under an Isolated Slab, some portion of the plumbing, plumbing hangers or plumbing supports is either in contact with the subgrade or in contact with an assemblage of materials that is in contact with the subgrade after the concrete slab is installed. These types of systems are therefore capable of imparting soil-induced loads onto pipes, clevises, hangers, drains and slabs, which may damage the plumbing. See *Failures of Non-Isolated Plumbing in Expansive Soil* [18] for more information. Figures 4.0-B through 4.0-E illustrates an example of Non-Isolated Plumbing. If a Non-Isolated Void System for Plumbing is installed, any soil-retaining elements are required to resist lateral soil pressures.

Note that Non-Isolated Plumbing (including conventionally buried plumbing and including plumbing supported by Non-Isolated Void Systems for Plumbing) is explicitly not permitted by the 2024 IPC Section 305.8.2 under Isolated Slabs. Engineering decisions based on calculations should be applied to assess the significance of subgrade contact.

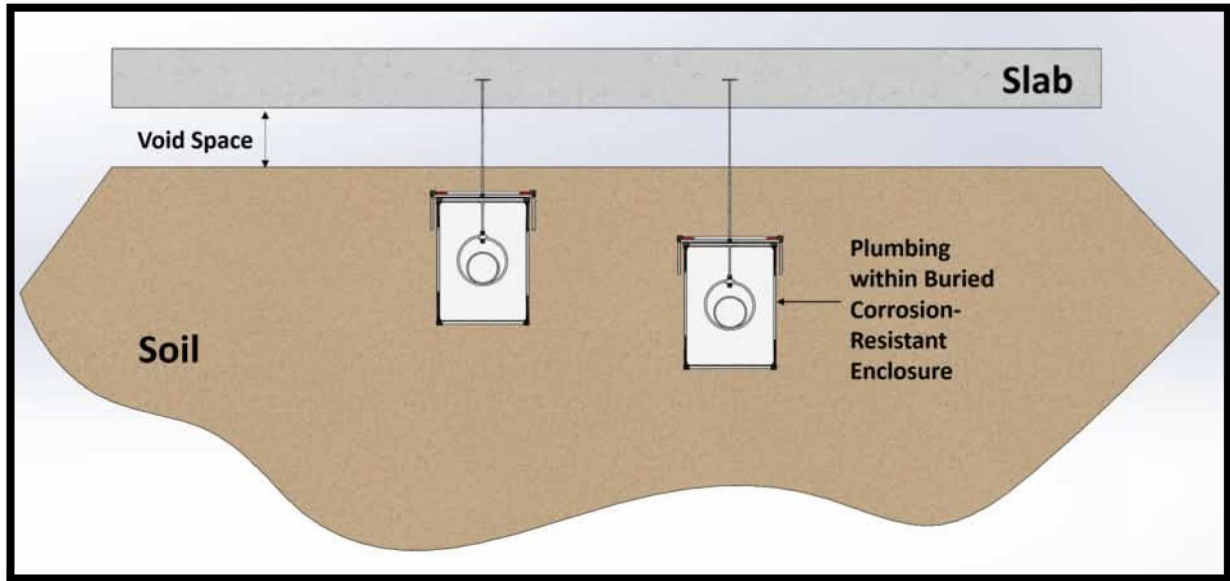


Figure 4.0-B Example of a **Non-Isolated Plumbing** (Buried corrosion-resistant enclosure at varying depths to achieve slope) under an Isolated Slab.

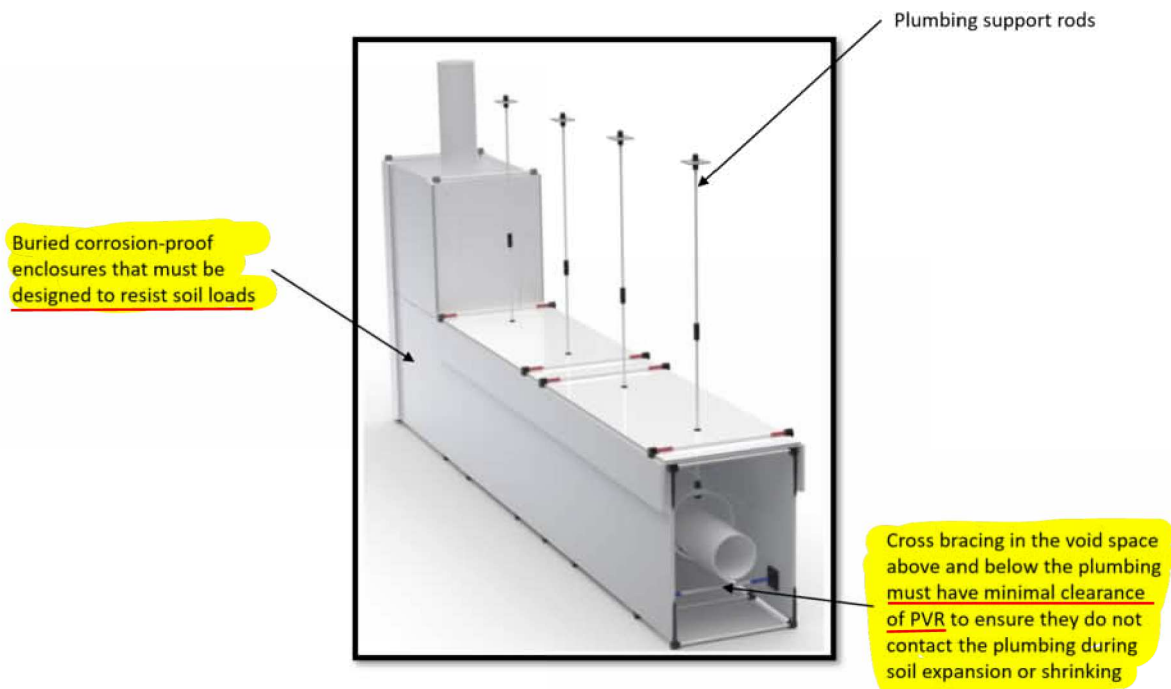


Figure 4.0-C Example of **Non-Isolated Plumbing** (Buried Water Resistant Enclosure).



Figure 4.0-D Example of a **Non-Isolated Plumbing** (Buried Waterproof Enclosure) for an Isolated Foundation.

Per 2024 IPC Section 305.8.2 “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.” Additionally, “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.”

The following illustrations show examples of how to comply with the protection requirements of the IPC and UPC by installing Isolated Plumbing under Isolated Slabs:

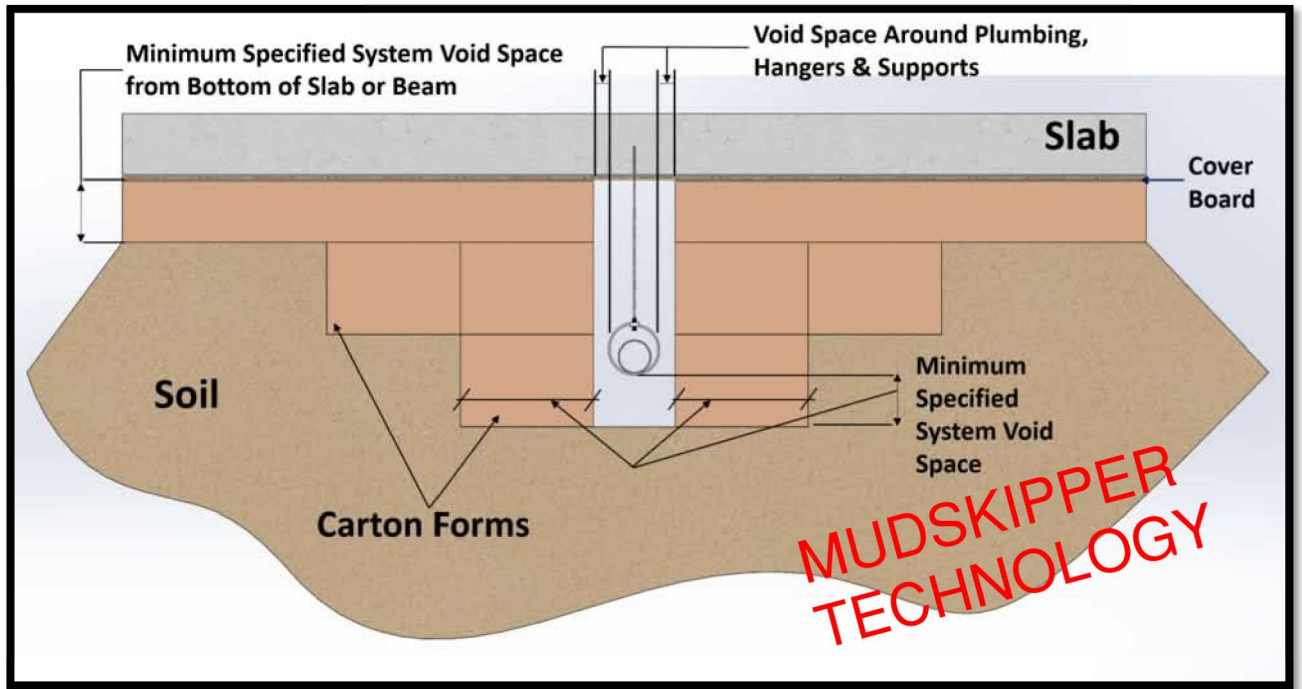


Figure 4.0-F Example of **Isolated Plumbing** Under an Isolated Slab (Sloped Benched Trench with Carton Forms that Degrade) in which plumbing is installed using an initial support system that is removed after transferring support to rebar on carton forms, but before concrete is placed for the slab (pre-installed plumbing).

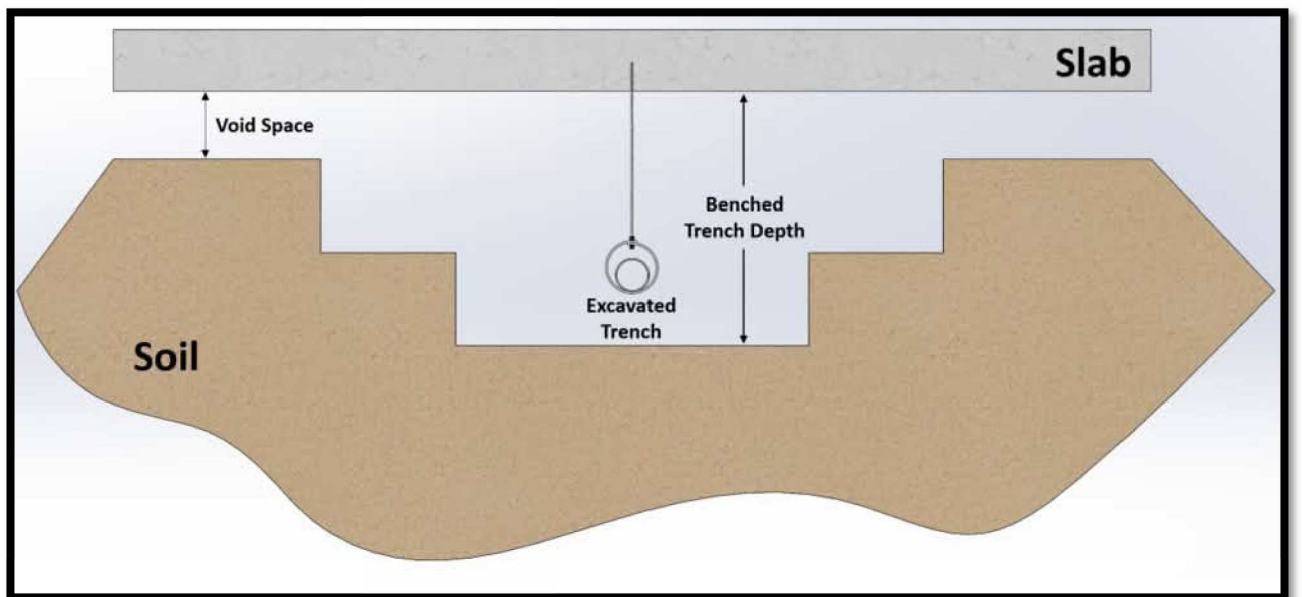


Figure 4.0-G Example of **Isolated Plumbing** Under an Isolated Slab in which plumbing is installed using adhesive anchors after the slab is installed and after any temporary slab supports such as carton forms are removed (post-installed plumbing).



Figure 4.0-H Example of an in progress installation of Isolated Plumbing before Void Forms are installed. This image displays permanent framing members that will be embedded in slab and permanent plumbing with temporary vertical support rods that are to be removed after transferring support to rebar on carton forms, but before concrete is placed for the slab (pre-installed plumbing).



Figure 4.0-I Example of an Isolated Plumbing Installation under an Isolated Slab (Benched Trench with Carton Forms that Degrade) showing Installing permanent framing members that will be embedded in slab and permanent plumbing with temporary vertical support rods that are to be removed after transferring support to rebar on carton forms but before concrete is placed for the slab (pre-installed plumbing).

In summary, when plumbing is located below a Slab-on-Void Form Isolated Foundation, it is the responsibility of the plumbing engineer to specify code-required isolation of plumbing from the effects of expansive soil.

4.1 PIPING CONNECTION AT THE FOUNDATION PERIMETER

Historically, buildings have been built without isolation of plumbing transitions from expansive soil, transitioning from conditions under a void space of an Isolated Foundation to soil-supported conditions outside of a building. The 2024 and earlier versions of the International Plumbing Code and Uniform Plumbing Code require protection of plumbing under Foundations and a defined distance outside of the buildings.

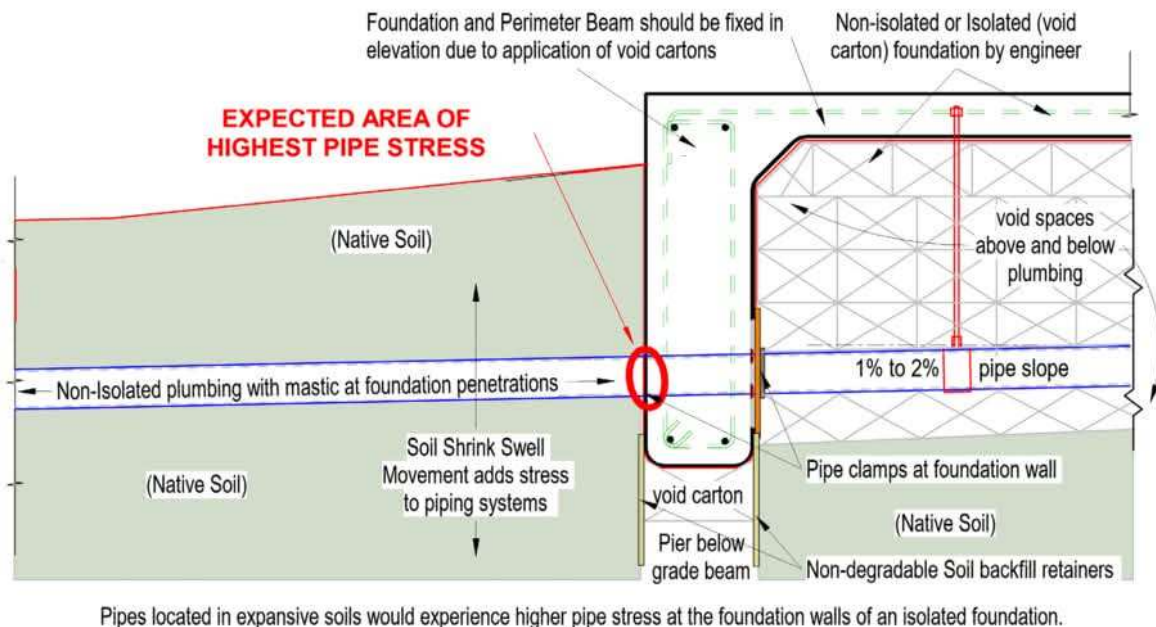


Figure 4.1-A Example of Non-Isolated plumbing at an exterior Foundation Grade Beam

Where isolated plumbing is installed under an Isolated Slab, plumbing must penetrate through a Grade Beam that retains the soil at the perimeter of the Isolated Slab. It is not appropriate to have an oversized sleeve in Grade Beams where plumbing is not designed to accommodate vertical movement. And it is extremely uncommon for plumbing to be designed to accommodate vertical movement from expansive soil. Therefore, plumbing should be restrained from moving vertically where plumbing crosses exterior Grade Beams at transitions. This can be accomplished by grouting a penetration sleeve or by anchoring plumbing to a Grade Beam.

Adding a buried flexible expansion joint device to the Non-Isolated Plumbing outside of the Foundation may perform better than Non-Isolated Plumbing without any type of flexible joint connection but doing so does not protect the plumbing because it may still require maintenance if expansive soil swelling and shrinking forces are imparted onto the flex joint through the non-expansive fill material. If the plumbing is not clamped to the Foundation perimeter, forces may damage plumbing under the slab. If the plumbing does not have a vertical offset at the foundation perimeter, upward movement of the site utilities outside the building perimeter may require extensive remedial sitework to lower site plumbing and reinstate positive plumbing drainage after the upward expansive soil movement occurs. Install a pipe expansion coupling adjacent to the foundation. Pipes should have sufficient slopes to allow for external soil expansion and provide the minimum code-required slope for positive drainage after upward soil movement has occurred.

To protect the plumbing at the transition from a suspended Void Space System to a soil-supported condition, the following should be considered as a minimum:

1. The transition connecting the grade-supported pipe to the slab-supported must occur outside of the Foundation for easy maintenance and repair.
2. Water ingress at the piping penetrations into the Foundation should be prevented.

3. The plumbing line (plus any appendages) should be capable of handling the vertical motion outside of the foundation without breaking or causing a reverse drainage condition of drain-waste-vent plumbing.
4. Horizontal axial forces caused by the grade-supported plumbing motion should be accommodated.

To protect the plumbing at the transition from a suspended Void Space System to a buried condition, a flexible transition should be utilized. As the plumbing exits from under the foundation, the last fixed location is typical at the perimeter Grade Beam. Clay soil may be installed outside the perimeter Foundation plumbing penetrations to reduce ingress of water under the foundation. The properties of the plug should be specified by the geotechnical engineer. To compensate for vertical soil motion, a flexible expansion joint device should be used. An initial vertical offset should be installed in the plumbing at the foundation perimeter to accommodate the expected upward movement of the soil so that the plumbing will have at least the minimum required functional slope after the expected upward soil movement has occurred. Ideally, this vertical offset occurs over the length of the flexible expansion joint device itself. If this flexible expansion joint device is directly buried in soil, expansive soil swelling and shrinking forces may be imparted onto the plumbing through the sand or gravel, which could cause the plumbing (including the flexible expansion joint device) to break or no longer have the required positive drainage, which would require maintenance. As discussed in Section 4.0, the flexible expansion joint device and plumbing are required by all plumbing codes to be designed not to be overstressed or overstrained, which requires a structural analysis based on expected soil swelling pressures and knowledge of the proprietary plumbing materials. As an alternative to burying this flexible joint, the plumbing can be extended into a vault to house the flexible joint connection and allow for expansive soil swelling and shrinking to occur without damaging the plumbing (including the flexible expansion joint device) as well as allow for routine inspection and maintenance.

Where plumbing transitions from an isolated condition under the building to a soil-supported condition, the connection at this transition should provide adequate flexibility to allow the plumbing to move to accommodate the effects of Expansive Soil swelling and shrinking. This flexibility may be accomplished by providing a flexible expansion joint device where this transition occurs. Flexible expansion joints are available in PVC or epoxy-coated ductile iron. The amount of movement that the flexible expansion joint device should be designed to accommodate will depend on the potential vertical movement of the soil at the location and depth of the flexible expansion joint device. These flexible expansion joints must be restrained by the Foundation at one end in order to provide an adequate reaction force.

Where plumbing exits the building, it should be secured to the Foundation to force movement to occur in the flexible joint. Additionally, the plumbing should be secured to the Foundation to resist lateral and vertical forces that will occur as the external pipe moves. This is necessary so that soil movement outside of the foundation does not transfer loads to the plumbing under the Isolated Slab.

These flexible expansion joint devices can be installed outside of the building footprint. Flexible expansion joint devices have historically been either buried directly in a plumbing trench filled with non-expansive material or in an isolated condition such a vault so that the flexible expansion joint device is not buried in a subgrade. Burying plumbing in a utility

trench filled with non-expansive material, such as pea gravel or granular select fill, will potentially reduce but may not prevent all expansive soil movement from causing movement in the trenched plumbing [17]. Flexible expansion joint devices are not designed to resist expansive soil forces between their rotating ends. The theoretical advantage of burying the flexible expansion joint device (rather than installing it in a vault) would be that this approach may generally costs less to construct but it may cost more in maintenance over the life of the facility because expansive soil movement may damage the flexible expansion joint device or the plumbing adjacent to it. The advantage of the vault is that it permits flexible expansion joint devices to be installed in free air which allows the joint to move without resistance from a subgrade and without exposing the flexible expansion joint device to expansive soil forces. In addition, the vaults allow for easier maintenance of the joint.

Where vaults are utilized, the opening in the vault wall (the penetration farthest away from the building) should be large enough to allow for the piping to move freely as the Expansive Soil shrinks and swells without the pipe interfering with the foundation.

Below are examples of flexible expansion joint devices:



Figure 4.1-B EBAA flexible expansion joint device example



Figure 4.1-C Romac FJ-Restraint flexible expansion joint device example

The 2024 IPC Section 305.8.2 states, regarding Isolated Plumbing under Isolated Slabs, “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.”

The isolated plumbing transition in the example below uses a flexible expansion joint device selected to be capable of accommodating the expected amount of vertical pipe movement at one end while being connected to the Foundation at the other end. Gravity drainage pipes with a diameter of 4" to 6" (for example) pass through and are connected to an isolated foundation beam. Pipes are clamp-attached to the Foundation. The flexible expansion joint device is located in an open vault with a maintenance vault wall exit sleeve (oversized to accommodate the expected amount of vertical pipe movement) as shown.

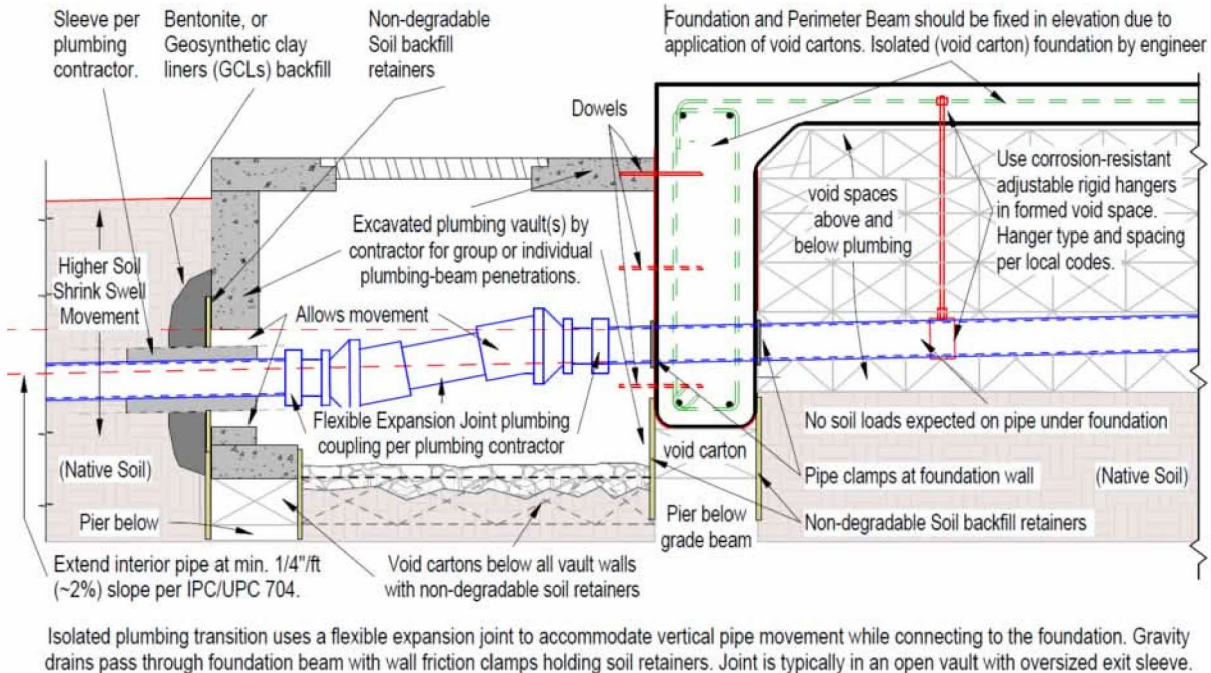


Figure 4.1-D Example of an **isolated transition** from Isolated Plumbing under slab to adjacent grade through a vault

4.1.1 PIPING CONNECTION AT THE FOUNDATION PERIMETER FOR RESIDENTIAL STRUCTURES

For one and two family dwellings construction where applicable plumbing codes do not require plumbing adjacent to the building to be isolated from expansive soil movement, owners may choose to accept the potential maintenance risks associated with buried piping in expansive soils in order to reduce initial construction costs. Designers should verify the plumbing code adopted by the local authority having jurisdiction when applying the guidance in this section.

Figure 4.1.1-A illustrates a plumbing transition from beneath an isolated foundation slab to adjacent exterior grade through a select fill trench. Although this approach can reduce stress at the foundation penetration and potentially avoid repairs beneath the structure, plumbing located in expansive soils outside the foundation may still experience movement-related stress. Where desired, additional measures such as increased pipe slope, soil modification, flexible couplings, or flexible expansion joints may be incorporated to potentially reduce some pipe damage, depending on site-specific geotechnical conditions.

16. AASHTO-93 <https://habib00ugm.wordpress.com/wp-content/uploads/2010/05/aashto1993.pdf>.
17. Focht, John; Penn, Don; and Lee, Michael; *Protection of Plumbing from Expansive Soils Under Foundations*, presented to the North Texas Building Professional Institute on 13 July 2022.
18. Hendrix, Byron; Roland, Michael; and Muhsmann, Jason; *Failures of Non-Isolated Plumbing in Expansive Soil*, presented to the American Society of Plumbing Engineers at the 2023 ASPE Tech Symposium on 29 September 2023. Currently, see the second presentation on this link: <https://www.mudskipper.com/engineers>.