SPECIFICATION AND APPLICATION OF VOID SPACES BELOW CONCRETE FOUNDATIONS

by

The Structural Committee
of
The Foundation Performance Association

Houston, Texas

www.foundationperformance.org

Document # FPA-SC-11-1

Rev. # 1 ISSUE HISTORY (Some internal committee issues omitted)

Rev #	Date	Description	Subcommittee Chair(s)	Subcommittee Members
0A	03 Jan 13	Issued for Committee Review	Michael Skoller Greg Carr	Ron Kelm Larry Lanz Rob Riedel Mike Turner Nicole Wylie
0M	29 Jan 14	Issued for FPA Peer Review 1		
0N	09 Apr 14	Issued for Committee Review		
0O	10 Apr 14	Issued for FPA Peer Review		
0P	11 Jun 14	Issued for Committee Review		
1	18 Jul 14	Issued for Website Publication		

Rev. # 0 ISSUE HISTORY (Some internal committee issues omitted)

Rev #	Date	Description	Subcommittee Chair(s)	Subcommittee Members
A	22 Jun 05	Issued for Committee Review	Michael Skoller	Jim Austin Karl Breckon Mike Turner Ron Kelm Al Maceiras Mari Mes Mohamed Moussaoui
Z	18 Jul 07	Issued for FPA Peer Review		
BB	26 Oct 07	Issued for Committee Review		
0	11 Nov 07	Issued for Website Publication		

TABLE OF CONTENTS

PREFACE

This document was written by the Structural Committee's FPA-SC-11 ad hoc subcommittee and has been peer reviewed by the Foundation Performance Association (FPA). This document was published as FPA-SC-11 Revision 0 (FPA-SC-11-0) on 11 November 2007 and again as Revision 1 (FPA-SC-11-1), superseding the Revision 0 issue, and is made freely available to the public at www.foundationperformance.org so all may have access to the information. To ensure this document remains as current as possible, it may be periodically updated under the same document number but with higher revision numbers such as 2, 3, etc.

The Structural Committee is a standing committee of the Foundation Performance Association. At the time of writing Revision 0 of this document, the Structural Committee was chaired by Ron Kelm, P.E. and 25 to 35 members were active on the committee. During the writing of this Revision 1, the Structural Committee was again chaired by Ron Kelm, P.E. and 45 to 55 members were active on the committee. The committee sanctioned the Rev. 0 version of this paper in May 2005 and this Rev. 1 version in September 2012, and in each case formed an ad hoc subcommittee to write or revise the document. The subcommittee chair(s) and members are listed on the cover sheet(s) of this document and are considered this document's co-authors.

Suggestions for improvement of this document should be directed to the current chair of the Structural Committee. If sufficient comments are received to warrant a revision, the committee may form a new subcommittee to revise this document. If the revised document passes FPA peer review, it will be published on the FPA website, superseding this revision.

The intended audiences for the use of this document are engineers, architects, builders, foundation contractors, owners, and others that may be involved in the design of Foundations in geographical areas with Expansive Soil.

This document was created with generously donated time in an effort to advancing the knowledge, performance, and standards of engineering, construction, and repairs related to foundations, soils, and structures. The text in this document represents the opinions of a majority of the subcommittee members and may not necessarily reflect the opinions of every subcommittee member, committee member or FPA member at the time of, or since, this document’s publication. The FPA and its members make no warranty regarding the accuracy of the information contained herein and will not be liable for any damages, including consequential damages, resulting from the use of this document. Each project should be investigated for its individual characteristics to permit appropriate application of the material contained herein.

Please refer to the FPA’s website at www.foundationperformance.org for other information pertaining to this and other FPA publications.

GLOSSARY

Deep Support Systems, alternatively known as Deep Foundations, are deep components such as drilled piers, driven piles, and helical piles that extend an adequate depth below the movement zone of the Expansive Soil and support Foundations. They are used to transfer the structure load to stronger, non-active and more stable soil layers. Deep Support Systems function to limit the vertical movements of the Foundation by providing support in a non-active soil stratum. For further details, see Document Nos. FPA-SC-01, *Foundation Design Options for Residential and Other Low-Rise Buildings on Expansive Soils* [2] and FPA-SC-16, *Design Procedure for Drilled Concrete Piers in Expansive Soil* [4].

Degrade is the term used to describe the physical breakdown and loss of shape and strength of Corrugated Paper Void Forms after concrete has been placed and set. Corrugated Paper Void Forms, with the exception of the Fully Wax Impregnated type, will ultimately degrade. Corrugated Paper Void Forms are specifically designed to degrade in order to provide the Void Space needed for expanding soil.

Expansive Soil, as defined by the 2012 International Building Code [5] Section 1803.5.3 and 2012 International Residential Code [6] Section R403.1.8.1, is "Soils meeting all four of the following provisions and shall be considered expansive, except that tests to show compliance with Items 1, 2 and 3 shall not be required if the test prescribed in Item 4 is conducted:

1. Plasticity index (PI) of 15 or greater, determined in accordance with ASTM D 4318.

2. More than 10 percent of the soil particles pass a No. 200 sieve (75 μm), determined in accordance with ASTM D 422.

3. More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D 422.

4. Expansion index greater than 20, determined in accordance with ASTM D 4829."

Footing is one type of element of a Foundation used to horizontally distribute the applied load to the soil below.

Foundation is the structure resting on soil on which the Superstructure is supported.

Grade Beams is the term used to describe all structural beams in a Foundation that extend from the top of the Slab Area to the bottom of the Foundation, and that either rest directly on the soil, or are fully or partially isolated from the soil by Void Forms. Examples include:

- An Isolated Slab with monolithically poured stiffening Grade Beams bearing directly on the soil and supported by a Deep Support System.

- An Isolated Slab with monolithically poured stiffening Grade Beams bearing directly on the soil and *not* supported by a Deep Support System.

- An Isolated Slab with monolithically poured stiffening Grade Beams not bearing directly on the soil and supported by a Deep Support System. The Grade Beams and the Slab Area are isolated from contact with the soil by use of a Void Space System.

Heave is upward movement of an underlying supporting soil stratum usually due to the addition of water to an unsaturated Expansive Soil in the active zone. When moisture is added to a soil with clay content, expansion occurs within the structure of the soil, and the corresponding area of the Foundation and Superstructure is moved upward. Heave normally only occurs within clayey soils that have a high suction potential and an available moisture source. See PUM and PVR.

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

Isolated Slab is the Slab Area that utilizes Void Spaces that separate the Slab Area from the surface soil. It is designed to span between Grade Beams resting on finished grade or Deep Support System.

Plasticity Index (PI) is the numeric difference between the liquid limit (LL) and the plastic limit (PL). It can indicate the potential for volume change of Expansive Soil. Soil with a PI less than 15 is considered non-expansive, soil with a PI between 15 and 30 is considered to be moderately expansive, and soil with a PI above 30 is considered highly expansive.

Potential Upward Movement (PUM) and Potential Vertical Rise (PVR) are methods to determine the potential amount of upward movement of the soil directly below the Foundation. PUM or PVR are typically provided in geotechnical reports and are based on moisture changes from dry to saturated conditions as well as from in-situ to saturated conditions. Common methods for determining PUM include the use of suction tests, swell tests, and the potential vertical rise (PVR) method. The PVR method is defined by Texas Department of Transportation document TxDOT 124-E, “Method for Determining the Potential Vertical Rise, PVR”.

Slab Area is the portion of a horizontal concrete Foundation spanning between the Grade Beams or supported directly by a Deep Support System.

Soil Retainers are sheets of material placed vertically or at an angle adjacent to the Void Space that is under the Grade Beams. They are used to resist the lateral volume change of the soil that can fill the Void Space during and after construction. Soil Retainers should be fabricated from materials that are non-degradable and not adversely affected by moisture.

Superstructure is comprised of building components above the Foundation, such as structural and architectural elements.

Void Forms are sacrificial formwork elements designed to provide Void Space between Expansive Soil and the Foundation, while providing a temporary support formwork for the weight of concrete until it has reached a specified strength. Examples of Void Forms are as follows:

- **Corrugated Paper Void Forms** are produced with varying degrees of moisture protection as follows:

    - **Uncoated** describes Corrugated Paper Void Forms that have no protective material used to either coat or impregnate the forms, and therefore are not protected from water, soil, moisture, insects, or micro-organisms.

    - **Wax Coated** describes a process that is used to coat only the exterior liner surface of Corrugated Paper Void Forms. This process temporarily helps maintain structural integrity, should the Corrugated Paper Void Forms come in contact with moisture before or during Foundation construction.

    - **Wax Impregnated** describes the result of a process that saturates individual papers used to manufacture Corrugated Paper Void Forms with wax. Fully Wax Impregnated describes the result of a manufacturing process where all paper components (e.g., liners and mediums) are Wax Impregnated. Fully Wax Impregnated paper is highly resistant to initial moisture contact, is not biodegradable, and holds its shape when wet with no imposed load. (It is not suggested for use in dry conditions or dry climates.)

- **Metal Void Forms** are lightweight metal components, fabricated to configure a Void Space System capable of temporarily supporting a variety of imposed concrete and construction loads, which allow for vertical movement of the Expansive Soil. An example is expanded sheet metal material that is repetitively slit and pulled to expand into diamond shaped open areas leaving connecting strands of metal having an average open space of 75-80%. This material is formed into a configuration of corrugated vertical segments that support the imposed concrete and construction loads. Metal Void Forms may be collapsible or non-collapsible.

- **Molded Paper Void Forms** are made from 100% recovered paper pulp, recycled paper, and recovered Kraft paper slurries that are shaped into a product that has limited strength capacity.

- **Plastic Void Forms** are Foundation forming elements designed to create permanent Void Spaces between the undersides of concrete Foundation slabs and underlying Expansive Soil. Plastic Void Forms do not disintegrate and therefore remain under the slab for the life of the Foundation. They can be made from up to 100% recycled plastic, usually polypropylene. Plastic Void Forms also serve a secondary purpose of providing a long lasting partial moisture barrier under Slab Areas, as they are not affected by water. The weight of wet concrete and other construction loads can be supported by Plastic Void Forms. See Section 2.0 for additional information. Plastic Void Forms may be collapsible or non-collapsible.

- **Styrofoam Void Forms** are components designed to create a waterproof Void Form capable of supporting a variety of imposed concrete loads. Styrofoam can be fabricated to form voids for Heaving soil to expand into. An example is where Styrofoam is molded to form an upside-down box-shaped Void Form that is placed under Grade Beams. This Void Form is designed to have enough strength to support the concrete until it reaches its design strength. Thereafter, it creates a Void Space for Heaving soil to expand into. Alternatively, solid Styrofoam is a compressible product with varying degrees of compressibility that allows for very limited vertical movement of the Heaving soil by compression of the Styrofoam. Extreme care should be taken in the design when utilizing this material. This product, when used as solid blocks of Styrofoam, does not provide a Void Space.

Void Space is a purposely designed void volume used to create a buffer zone or clearance between Expansive Soil and a Foundation, that allows Heave to occur without imposing detrimental uplift pressures on the Foundation.

Void Space System is the complete assembly and use of components specified by the Foundation design engineer in order to create the designed Void Space.

1.0 INTRODUCTION

1.1 GENERAL

The need for this document was prompted by a concern in the building industry about the effectiveness of Void Space Systems in isolating Foundations from Expansive Soil. Void Space Systems are designed to provide a vertical clearance between Expansive Soil and a concrete Foundation, in order to accommodate Heave, while providing a temporary support formwork for the weight of concrete and construction loads.

The scope of this document is to provide guidance in the design, specification, and installation of Void Space Systems under residential, commercial, light industrial, and civil structure Foundations, typically called lightly loaded Foundations, which are built on Expansive Soil. Examples of these structures include houses, swimming pools, bridge abutments, retaining walls, apartments, restaurants, retail stores, machine shops, warehouses, and schools.

The use of Void Forms upon which to place concrete has been common practice for decades. The forms used must either degrade, compress under the upward load of Expansive Soil, or provide a means to allow Expansive Soil under the Foundation to Heave into the Void Space created by the Void Forms. The resultant force from the Foundation gravity load, structure loads, and soil uplift on the parts of the Foundation in contact with the Expansive Soil must be considered in the design. If not considered, the Foundation may move excessively upwards by the force resulting from soil Heave. The intent of using Void Forms is to provide an adequate clearance beneath the Foundation for the Expansive Soil to Heave into the Void Space without applying detrimental upward pressure to the Foundation.

Until the mid-1990s it was customary to use Void Spaces below Grade Beams but not below the Slab Area on designs using Deep Support Systems to support the Slab Area and its Grade Beams. Since that time, many engineers have specified that Void Spaces be installed only under the Slab Area when designing a slab supported by Deep Support Systems. Some performance problems continue to exist on Foundations using Deep Support Systems. This document will clarify possible causes of Foundation problems and present a guideline for the use of Void Space Systems under Isolated Slabs and Isolated Foundations in an effort to improve future performance.

This committee recommends that Void Spaces be provided under both Grade Beams and Slab Areas with Expansive Soil conditions, when using Isolated Foundations supported by Deep Support Systems. The elimination of Void Spaces under the Grade Beams for this type of Foundation design should be considered only when geotechnical investigation and structural calculations demonstrate that doing so is appropriate.

1.2 CONSIDERATIONS FOR THE USE OF VOID FORMS

Expansive Soil will change volume when water is lost or gained within the soil. The amount of expansion and shrinkage is a function of the soil type. The soil PI is an indication of the potential volume change of a given soil; the greater the PI, the greater the PUM of the soil.

Soil will gain and lose moisture during wet and dry seasons, respectively. Changes in the moisture content have little effect on non-cohesive soil (e.g., sand), but can have a great effect on cohesive soil (e.g., clay). Changes in moisture content of cohesive soil are a function of the soil's location and depth, available water, vegetation present, permeability, grain size, and type of soil. Due to suction, Expansive Soil under a Foundation with available water will continue to Heave until its maximum demand for water is reached. Sandy clay and silty clay soil will reach water content equilibrium faster than clay soil.

When selecting and designing a Foundation type, consider the properties of the soil, the surrounding environment, and the requirements of the design. Clay that is dry, cracked, and hard has higher swell potential; clay that is soft and wet has lower swell potential. Clay soil has a demand for water and will take on water until a moisture equilibrium condition is achieved. Heave in Expansive Soil may continue for many years.

An important force to consider when designing a Foundation with Void Space is the uplift force on the bottom of the Grade Beams. Consideration must be given to the PUM/PVR of the soil and the effect on Foundations, including its effect on Slab Areas.

2.0 VOID SPACE SYSTEM TYPES

Several Void Space System types are discussed below. See Section 4.0 for Void Form material specifications.

2.1 DEGRADABLE VOID SPACE SYSTEMS

The Corrugated Paper Void Forms most commonly used are degradable forms fabricated from corrugated paper arranged in an open cell configuration. The exterior surface of the Corrugated Paper Void Forms may be Wax Coated to temporarily resist moisture from the weather, soil, and/or wet concrete. These forms are typically designed to gradually absorb ground moisture and lose strength and shape over a period of time, leaving a Void Space between the Expansive Soil and the Foundation.

If the soil beneath the Foundation expands, and the Corrugated Paper Void Forms have degraded, the Expansive Soil will Heave into the Void Space created by the Corrugated Paper Void Forms without lifting or deforming the Foundation. Granular fill material under Corrugated Paper Void Forms should not be used, because a capillary break occurs at the soil/Void Form interface, which prevents moisture from contacting the degradable Corrugated Paper Void Forms.

Degradable Corrugated Paper Void Forms can be used under Slab Areas. Other types of Corrugated Paper Void Forms should not be used under Slab Areas.

2.2 COLLAPSIBLE VOID SPACE SYSTEMS

Collapsible Void Space Systems incorporate a material designed to collapse under soil Heave pressures that are less than the combined Foundation and Superstructure dead loads, but to *not* collapse during Foundation form setting and concrete placement. Collapsible Void Space Systems may be constructed of plastic, Wax Coated or Wax Impregnated corrugated paper, expanded metal, Styrofoam, or other materials resistant to moisture but designed to collapse under the pressure of Expansive Soil.

Collapsible Void Space Systems should not be used under Slab Areas. The combination of dead load, sustained live load, and inherent low stiffness of the typical Slab Area is usually not sufficient to collapse this type of Void Space System, and would thereby transfer the uplift forces through the non-collapsed Void Space Systems to the Slab Area above.

2.2.1 Expanded Metal Void Form Systems

Expanded metal products offer a non-degradable material to create Void Space. Designs, configurations, and different gauges and types of expanded metal allow these products to lose vertical load resistance due to upward soil pressures. As designed, the soil pressure may mechanically deform and bend the basic expanded metal shapes as the soil expands into the created Void Space. These Void Space Systems are usually covered with materials including wood fiber sheets and geo-fabric that cover the supporting expanded metal in order to prevent the inflow of concrete and soil into the Void Space they create.

2.3 NON-COLLAPSIBLE VOID SPACE SYSTEMS

Non-Collapsible Void Space Systems incorporate material designed to maintain its original structural integrity throughout the life of the Foundation. This type of system provides a built-in Void Space that allows Expansive Soil to expand upward into the Void Space immediately after construction. Materials may be comprised of plastic, Styrofoam, or other products.

In Isolated Slabs, Non-Collapsible Void Space Systems may be used under Slab Areas. If the design of the Foundation requires that the Grade Beams rest on finished ground, these systems cannot be used under the Grade Beams.

In Isolated Foundations, Non-Collapsible Void Space Systems may be used under Grade Beams and Slab Areas.

2.3.1 Plastic Void Form Systems

Plastic Void Forms provide a waterproof and long lasting formwork for creating Void Spaces. Foundations designed with Plastic Void Forms create a matrix of Void Spaces under the Slab Area surrounded by more closely spaced bi-directional narrow Grade Beams that sit directly on the Expansive Soil. Non-expansive soil caps are usually not required when using Plastic Void Forms; only the top vegetative layer of the soil needs to be removed and the building pad finish graded, as is commonly done for any Foundation. As the Expansive Soil expands, most of the increased volume change moves upward into the Void Spaces created by the Plastic Void Forms, thereby minimizing uplift forces on the Foundation. Where heavily loaded structures and/or highly Expansive Soil require greater flexural rigidity in the concrete slab, below-ground Grade Beams (similar to those used in the PTI ribbed slab design) can be used. Plastic Void Forms can also be used in Foundation slabs that have moisture cut-off walls around the perimeter of the Foundation.

Plastic Void Forms utilize specially designed rigid plastic boxes to form Void Spaces on the undersides of concrete Slabs Areas, which result in a bi-directional matrix of rigid narrow Grade Beams surrounding the Void Spaces. The narrow Grade Beams sit directly on the Expansive Soil, with a total contact area that is uniformly distributed and designed to not exceed the allowable soil bearing pressure. The area under the Plastic Void Form is open to the soil (i.e., a box with 5 closed sides and one open side down facing the soil). Plastic Void Forms usually do not transmit any Expansive Soil uplift force to the Foundation. Only the narrow concrete Grade Beams in contact with the soil will be minimally affected by soil uplift forces. Plastic Void Forms are specifically designed for use under Slab Areas, but can be used under Grade Beams in Isolated Foundations.

2.3.2 Metal Void Form Systems

Various sheet metal products can be used to create Void Space Systems. Designs, configurations, and different gauges and types of metal allow these products to maintain the vertical load resistance required for construction loads and to lose vertical load resistance due to upward soil pressures.

3.0 DESIGN OF VOID SPACE SYSTEMS

This section includes the design of Void Spaces under various load criteria in conjunction with the Void Space System material type (see Section 2.0 for definitions). This section also includes some advantages and disadvantages of Void Space Systems under Slab Areas, under Grade Beams, and around the top of the Deep Support Systems.

Void Forms under Foundations support uncured concrete during construction and create the Void Space that isolates the Foundation from the underlying Expansive Soil. The depth of the Void Space, which has been known to range from one to twenty-four inches (1"-24"), is a function of the PUM of the underlying soil. Typically, deeper Void Spaces are associated with soil that is more expansive. The Geotechnical Engineer should specify the net depth of the Void Space and the PUM/PVR. In the case of all Void Space Systems, the required Void Space height and volume should be determined by the Foundation design engineer in conjunction with the PUM determined by the Geotechnical Engineer.

When designing an Isolated Foundation, Void Spaces under the Grade Beams should be used when the uplift forces of the Expansive Soil are predicted to be greater than the dead plus sustained live loads of the Foundation and Superstructure that are transferred to the Grade Beams.

When using Void Spaces under the Slab Area, there are three Foundation design methods that are commonly used:

- Isolated Slab supported by Grade Beams bearing on the soil – this design method uses Void Spaces placed under the entire Slab Area between stiffening Grade Beams bearing on the soil. Void Spaces are not placed under the Grade Beams.

- Isolated Slab supported by Deep Support Systems – this design method may have Grade Beams supported by a Deep Support System or the Isolated Slab may be directly supported by a Deep Support System.

- Isolated Foundation supported by Grade Beams and Deep Support Systems – this design method uses Void Spaces placed under both the Slab Area and the Grade Beams resting on Deep Support Systems. This allows the increasing volume change of Expansive Soil to be absorbed under both the Grade Beams and the Slab Area. When the uplift forces of the Expansive Soil on the underside of the Grade Beams are predicted to be less than the dead plus sustained live loads of the Foundation and Superstructure that are transferred to the Grade Beams, the engineer can elect to remove the Void Spaces from under the Grade Beams, but not the Slab Area.

3.1 VOID SPACE SYSTEMS FOR ISOLATED SLAB FOUNDATIONS

One type of Isolated Slab Foundation has Grade Beams that bear on the surface of the soil. If the expansion potential of the underlying soil is significant, Isolated Slab Foundations may require some deeper Grade Beams that are below-ground (placed under the slab but made integral with the slab), formed by trenches dug into the soil at varying design depths and spacing. These Foundations will move as the underlying soil Heaves. Vertical movement of these Foundations is reduced by the Void Forms under the Slab Areas. However, Grade Beams usually neither anchor the slab to the soil nor prevent vertical movement of the Foundation. Void Spaces under the Slab Area provide voids for the increasing volume change of Expansive Soil to expand into, and thereby reduce the uplift forces on the underside of the Foundation.

Another type of Foundation design combines an Isolated Slab Foundation with Deep Support Systems. In one variation, the Isolated Slab is directly supported by the Deep Support System. In another variation, the Isolated Slab is supported by Grade Beams that are supported by Deep Support Systems. Void Spaces for both variations are provided under the Slab Areas and not under the Grade Beams that span between Deep Support Systems, only if the soil uplift forces on those Grade Beams do not exceed the dead loads plus sustained live loads on the Grade Beams.

Note that significantly increasing the depth of the Foundation perimeter beams can help slow moisture flow to areas under a Foundation, thereby reducing the available moisture to Expansive Soil located under interior Foundation slab and interior Grade Beam areas.

Commonly used materials in Void Space Systems for Isolated Slab Foundations include the following:

- Injection molded plastic is used to make Plastic Void Form boxes with the bottoms of the boxes open against the soil. These Plastic Void Forms can be placed under the Slab Area. Any intermediate stiffening Grade Beams under the Slab Areas that are formed by these Void Space Systems, and are in contact with the soil, must be designed so that the soil uplift forces on the underside of these stiffening Grade Beams can be resisted by the slab rigidity.

- Corrugated Paper Void Forms, whether recycled or virgin material, degrade over time when exposed to moisture and thereby create Void Space. In order for the Corrugated Paper Void Forms to degrade, the contractor shall ensure that no subgrade capillary breaks, such as gravel, plastic sheathing, or fill debris, exist below these Void Forms. After the concrete sets, moisture must be present in the underlying soils in order for the Corrugated Paper Void Forms to degrade.

- Expanded metal forms that are covered with a fabric material and/or a wood substrate, as required to retain the wet concrete during the placement, allow the expanding soil to pass through the mesh at the bottom of the form and into the Void Space that it creates. This type of form can also be used under Grade Beams when Deep Support Systems are used in conjunction with an Isolated Slab.

- Other materials such as metal sheet, plywood, molded paper, Styrofoam, etc. can be used in Void Space Systems.

Isolated Slab Foundations, which have Grade Beams in complete contact with the ground and have no Void Space under the Grade Beams, are designed using the same structural design methods and software that are used in the design of slab-on-ground foundations (such as the ribbed slab design that is promoted by the Post-Tensioning Institute). When utilizing Void Forms under the Slab Area only, as in this case, the design with Void Spaces has a reduced area of the foundation that is in contact with the soil and necessitates that calculations be done to ensure that the allowable soil bearing pressure on the soil is not exceeded. The slab should be designed to span the distance between Grade Beams in accordance with ACI 318.

Table 3.1 itemizes the advantages and disadvantages of utilizing different Void Space materials under the Slab Area:

Table 3.1
Use of Void Space Systems Under Slab Areas

Characteristics		Void Space System Material						
		Corrugated Paper	Expanded Metal	Metal Sheet	Molded Plastic	Molded Paper	Styrofoam Sheet	Wood
		A	B	C	D	E	F	G
Advantages								
1	Void Space created under Slab Areas allows increasing volume change of Expansive Soil under the Slab Areas to dissipate into the Void Space.	●	●	●	●	●	●	●
2	The underside of Slab Areas is typically well above surrounding grade and less affected by adjacent surface water.	●	●	●	●	●	●	●
3	Can be walked on by construction workers during installation and concrete pour.	●	●	●	●	●	●	●
4	Can be installed during rain and in standing water.		●	●	●		●	●
5	Allows immediate expansion of soil.		●	●	●	●	●	●

Table 3.1
Use of Void Space Systems Under Slab Areas

Characteristics		Void Space System Material						
		Corrugated Paper	Expanded Metal	Metal Sheet	Molded Plastic	Molded Paper	Styrofoam Sheet	Wood
		A	B	C	D	E	F	G
6	Creates permanent moisture barrier under majority of Slab Area.				●		●	
Disadvantages								
1	Allows surface water to get under Slab Area, if no deep moisture cut-off walls are used around the Foundation perimeter.	●	●	●	●	●	●	●
2	Additional cost compared to Slab Area placed directly on ground.	●	●	●	●	●	●	●
3	Must first Degrade in order to create Void Space.	●						
4	Termites and other organisms may be attracted to Void Space System material.	●				●		●
5	Soil moisture or other sources of water may affect forms during construction.	●				●		
Other Considerations								
1	Void Space System is sacrificial.	●	●	●	●	●	●	●
2	Cover material required for walking on forms.					●		
3	Forms can be treated to resist mold and termites, if a concern.	●				●		●
4	The height of the Void Space must be accurately determined by the Geotechnical Engineer to provide for anticipated PUM.	●	●	●	●	●	●	●

3.2 VOID SPACE SYSTEMS FOR ISOLATED FOUNDATIONS

Isolated Foundations utilize Deep Support Systems to support the Grade Beams. The concrete slab, or other type of design that is used to create the floor of the Foundation, rests entirely on the Grade Beams, all of which do not come in contact with the soil. An alternative is to have the concrete slab supported directly by the Deep Support System, with the Slab Area elevated above the soil. These allow the Expansive Soil to increase in volume as it Heaves without touching the underside of the Grade Beams and Slab Area.

Grade Beams in this type of foundation must have Void Spaces installed under them so that the expanding soil does not push up on the underside of the Grade Beams. Expanding soil in contact with Grade Beams can cause the Grade Beams to lift off the top of the Deep Support System, unless the sustained loads from the Superstructure and Foundation exceed the uplift force of the expanding soil.

The design of Isolated Foundations must ensure that the Grade Beams (or Slab Area) are designed to span between the Deep Support Systems without any soil support. The design must also ensure that the undersides of the Grade Beams and Slab Areas are high enough above the top of the soil so as to not be in contact with the soil at its maximum Heave. The Slab Areas must be designed for their unsupported lengths as they span between Grade Beams, other intermediate stiffening beams, and/or Deep Support Systems, per applicable design codes.

Table 3.2 itemizes the advantages and disadvantages of utilizing different Void Space System materials under Grade Beams:

Table 3.2
Use of Void Space Systems Under Grade Beams

Characteristics		Void Space System Material						
		Corrugated Paper	Expanded Metal	Metal Sheet	Molded Plastic	Molded Paper	Styrofoam Sheet	Wood
		A	B	C	D	E	F	G
Advantages								
1	Void Space created under Grade Beams allows increasing volume change of Expansive Soil under the Grade Beams to dissipate into the Void Spaces.	●	●	●	●	●	●	●

Table 3.2 Use of Void Space Systems Under Grade Beams								
Characteristics		Void Space System Material						
		Corrugated Paper	Expanded Metal	Metal Sheet	Molded Plastic	Molded Paper	Styrofoam Sheet	Wood
		A	B	C	D	E	F	G
2	If sufficient Void Space is maintained under the Grade Beams, the Slab Area is not in contact with the ground, and the Deep Support Systems are properly anchored below the movement zone of the underlying soil, upward Foundation movement will be almost completely eliminated.	●	●	●	●	●	●	●
Disadvantages								
1	The bottoms of some Grade Beams are typically placed below ground and thereby allow water to collect in the Void Spaces under the Grade Beams during construction and the life of the Foundation.	●	●	●	●	●	●	●
2	Additional cost compared to Grade Beams placed directly on ground.	●	●	●	●	●	●	●
3	Must first Degrade or crush to function.	●						
4	Termites and other organisms may be attracted to Void Space System material.	●				●		●
5	Soil moisture or other sources of water may affect forms during construction.	●				●		
Other Considerations								
1	Void Space System is sacrificial.	●	●	●	●	●	●	●

Table 3.2
Use of Void Space Systems Under Grade Beams

Characteristics		Void Space System Material						
		Corrugated Paper	Expanded Metal	Metal Sheet	Molded Plastic	Molded Paper	Styrofoam Sheet	Wood
		A	B	C	D	E	F	G
2	Void Forms can be treated to resist mold and termites, if a concern.	●				●		●
3	The height of the Void Space System must be accurately determined by the Foundation design engineer to provide for the design PUM.	●	●	●	●	●	●	●
4	Additional soil testing should be done by the Geotechnical Engineer to determine anticipated soil uplift pressures.	●						
5	A friction reducing material can be used on both vertical sides of below-ground Grade Beams to reduce the friction uplift force of expanding soil in contact with those surfaces. Common materials are rolled plastic sheeting and corrugated plastic sheets.	●	●	●	●	●	●	●

3.3 OTHER DESIGN CONSIDERATIONS OF VOID SPACE SYSTEMS

3.3.1 Below-Ground Grade Beams

Below-ground beams are embedded in the ground. Grade Beams below ground have two uplift forces caused by expanding soil acting upon them: (1) under the Grade Beam where it is in contact with the soil, and (2) on the two sides of the Grade Beam where the soil is pushing up and engaging the sides of the Grade Beam by friction. The actual determination of these forces is not in the scope of this document.

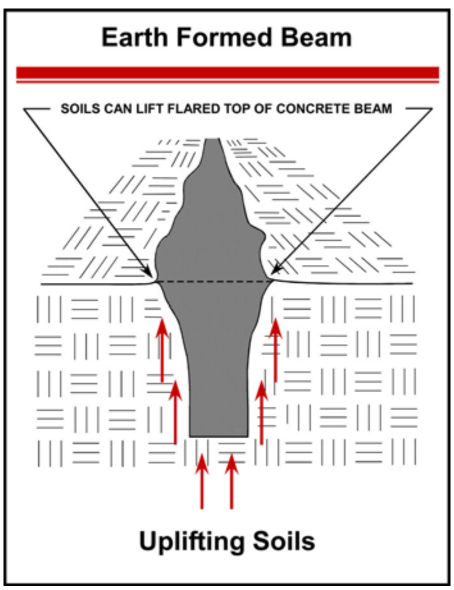
3.3.1.1 Earth Formed Below-Ground Grade Beams

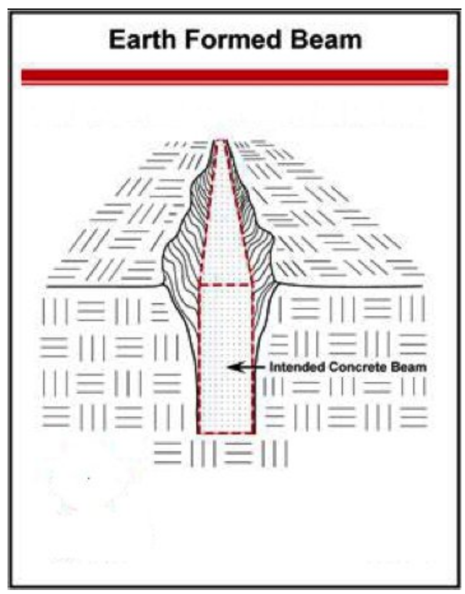
Earth formed below-ground Grade Beams are embedded in the ground and formed by the soil on the two sides and by the top of the Void Forms or bottom of the trenches that have been dug to form the Grade Beams.

The following design considerations should be accounted for with these types of beams:

- Isolated Slab Foundations may or may not require integral Grade Beams to be formed below grade. This is a function of the required rigidity of the Foundation.
- If the total uplift force on the Grade Beams caused by the expanding soil is less than the total dead load and sustained live loads on the top of the Grade Beams, the elimination of the use of Void Spaces can be considered in Isolated Foundations.
- Construction plans must include requirements for the bottoms of the trenches to be cleaned out and compacted per specifications before concrete is placed.
- Earth formed Grade Beams typically use more concrete than below-ground formed Grade Beams, because trench sides are rough and the tops are flared.

See the following drawings for examples of the above:

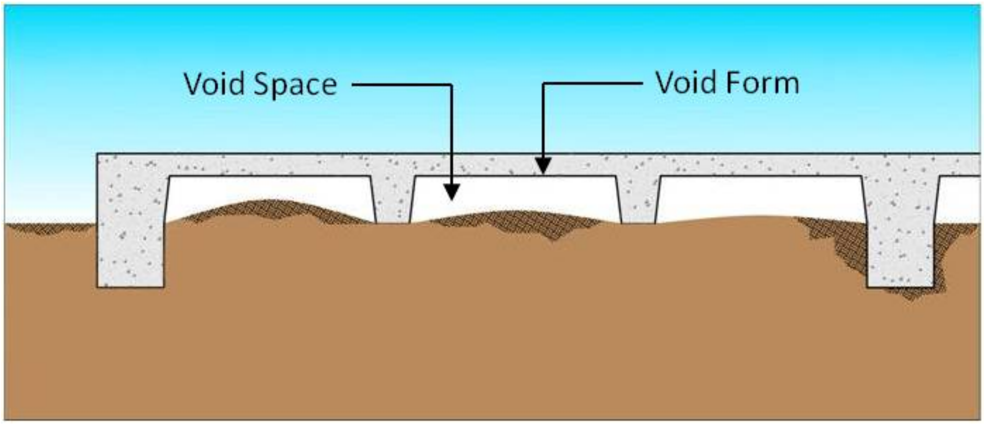




3.3.1.2 Below-Ground Formed Grade Beams Without Void Spaces

The following design considerations should be accounted for with below-ground formed Grade Beams without Void Spaces:

- Care should be taken to minimize the width of the Grade Beams and intermediate stiffening beams that are in contact with Expansive Soil, in order to minimize vertical uplift forces. Limiting the maximum width of grade beams reduces vertical uplift forces. Note, a minimum width of 6 inches allows for adequate cover for reinforcement.



Void Space Below Slab Area and No Void Space Below Grade Beams

- Depending upon the characteristics of the soil, trenches for below-ground Grade Beams can be dug cleanly in the soil, especially in stiff clays. However, the soil may dry at the top corners of the trench and fall into the trench. This creates a rounding at the top of the trench that, from the standpoint of expanding soil, creates an effectively wider beam between Void Forms than shown in the design drawings. This will result in greater uplifting forces on the Grade Beams and should be minimized.

- When designing a Foundation with Void Spaces, below-ground formed Grade Beams may be required to provide additional slab rigidity to resist high structural loads and high soil uplift forces. This type of Foundation “floats” on the soil, just like the standard ribbed slab Foundation design, with the notable exception that it absorbs expanding soil volumes. The ribbed slab Foundation without Void Spaces does not allow for absorbing expanding soil volumes. The use of Void Spaces under the Slab Area allows dissipation of the soil expansive force, and thereby reduces the uplift forces. The Grade Beams formed by the Void Forms under the Slab Area provide the required slab rigidity, by acting as a series of interlocking “T” beams in two directions. There are no Void Spaces under these Grade Beams.

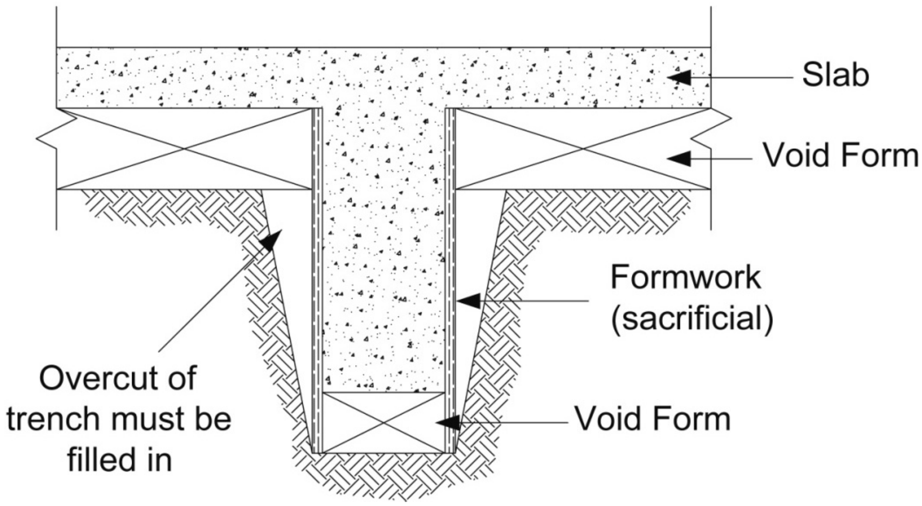
3.3.1.3 Below-Ground Formed Grade Beams With Void Spaces

The following design considerations should be accounted for with below-ground formed Grade Beams with Void Spaces:

- Below-ground Grade Beams should only have Void Spaces placed under the beams if Deep Support Systems are used.

- Intermittent Void Space segments can be used on low PUM soil.

- Check with the supplier of below-ground Grade Beam formwork for details of specific components.
- The drawing below shows an example of a below-ground Grade Beam that rests on a Void Form and has forms on the two vertical sides:



Monolithic In-Ground Forming System

Formwork for Below-Ground Formed Grade Beam

Void Forms Under Slab Area and Between Below-Ground Formed Grade Beams

3.3.2 Corrugated Paper Void Forms (Under Slab Areas, Grade Beams, And Around Pier Caps)

The degraded height of the Corrugated Paper Void Form materials is important for the design of the gross vertical height of the Void Space. The gross vertical height of the Void Space should include the degraded height plus the required Void Space height determined by the Geotechnical Engineer.

3.3.3 Collapsible Void Space Materials (Under Grade Beams Only)

The Void Space height dictated by the Geotechnical Engineer should be increased by the collapsed height of the Void Space material. The combination of the dead plus sustained live loads of the Foundation and Superstructure and inherent stiffness of the Foundation must be sufficient to resist the uplifting forces of the Expansive Soil as it collapses these types of Void Space Systems. Materials must be able to collapse without causing excessive movement of the Foundation.

3.3.4 Non-Collapsible Void Space Materials

When using non-collapsible Void Space Systems, the excavation of Grade Beams must be adequately sized to compensate for the height and thickness of the permanent Void Space Systems materials. The net volume of the Void Space should be sufficient to accept the volume change of the Expansive Soil. The Void Space System in contact with the soil should be able to support the weight of the wet concrete in the Grade Beams above, but should not be required to support the dead plus sustained live loads of the rest of the Foundation and Superstructure.

3.3.5 Plastic Void Forms (under Slab Areas)

Plastic Void Forms are specifically designed to work under Foundation Slab Areas. Rigid bi-directional Grade Beams, which sit directly on the Expansive Soil, are formed on the underside of the Slab Areas by the Plastic Void Forms. Design tools and methodologies commonly used in the design of a PTI ribbed slab (per PTI *Design of Post-Tensioned Slabs-on-Ground*) are used in the design of Foundations with Plastic Void Forms, in combination with two-way slab span calculations. Soil remediation, such as replacement of Expansive Soil with non-expansive soil, is usually not required. See Plastic Void Forms in Figure below:

3.4 DESIGN LOADS

All Void Space System products shall be capable of supporting the construction loads until the concrete sets and becomes self-supporting, while maintaining the design Void Space as indicated on the Foundation design drawings. In addition to the weight of the wet concrete, construction loads should include, as a minimum, the weight of personnel and equipment during the construction process and the concentrated loads from reinforcing steel chairs.

Consult with the Void Form manufacturer for maximum allowable concrete slab thickness and beam depth during the concrete pour. For Corrugated Paper Void Form systems, provide Table 3.4 to the supplier.

Table 3.4
Required Design Loads for Corrugated Paper Void Form Systems[1]

Criterion	Condition[2,4]	Void Space System Material Type		
		Degradable	Non-Degradable	
			Collapsible[3]	Non-Collapsible
Minimum *Initial* Ultimate Uniform Load Collapse Pressure (as shipped, dry) [PSF]	Slabs with t ≤12” thick	600	Do not use	Do not use
	Slabs with t > 12”	456 + 12t	Do not use	Do not use
	Beams with d ≤ 36”	1000	600	600
	Beams with d > 36”	568 + 12d	168 + 12d	168 + 12d
Maximum *Initial* Ultimate Uniform Collapse Pressure (as shipped, dry) [PSF]	Slabs with t ≤12” thick	1500	Do not use	Do not use
	Slabs with t > 12”	1356 + 12t	Do not use	Do not use
	Beams with d ≤ 36”	1500	1000	No limit
	Beams with d > 36”	1068 + 12d	568 + 12d	No limit
Maximum *Final* Ultimate Uniform Collapse Pressure (at 100% humidity for 14 days) [PSF][5]	Slabs with t ≤12” thick	12t	Do not use	Do not use
	Slabs with t > 12”	12t	Do not use	Do not use
	Beams with d ≤ 36”	12d	1000	No limit
	Beams with d > 36”	12d	568 + 12d	No limit

Notes:
1. This table is provided for the use of the Foundation designer and the manufacturer of the Corrugated Paper Void Form System.
2. t = slab thickness [inches]; d = grade beam depth [inches], measured from the top of the slab to the bottom of the beam.
3. The Foundation design engineer should verify the maximum ultimate collapse pressure.
4. The slab values may also be used for pier caps.
5. Placed in a 100% humidity test chamber.

3.5 FORMS AROUND THE TOPS OF DEEP SUPPORT SYSTEMS

In order to reduce the uplift pressures on the top of Deep Support Systems, most commonly on drilled piers, the top two-foot portion (or as otherwise determined by the Foundation design engineer) of each drilled pier should be formed to the specified shaft diameter. The advantages, disadvantages and comments of using forms around the tops of piers are shown in Table 3.5.

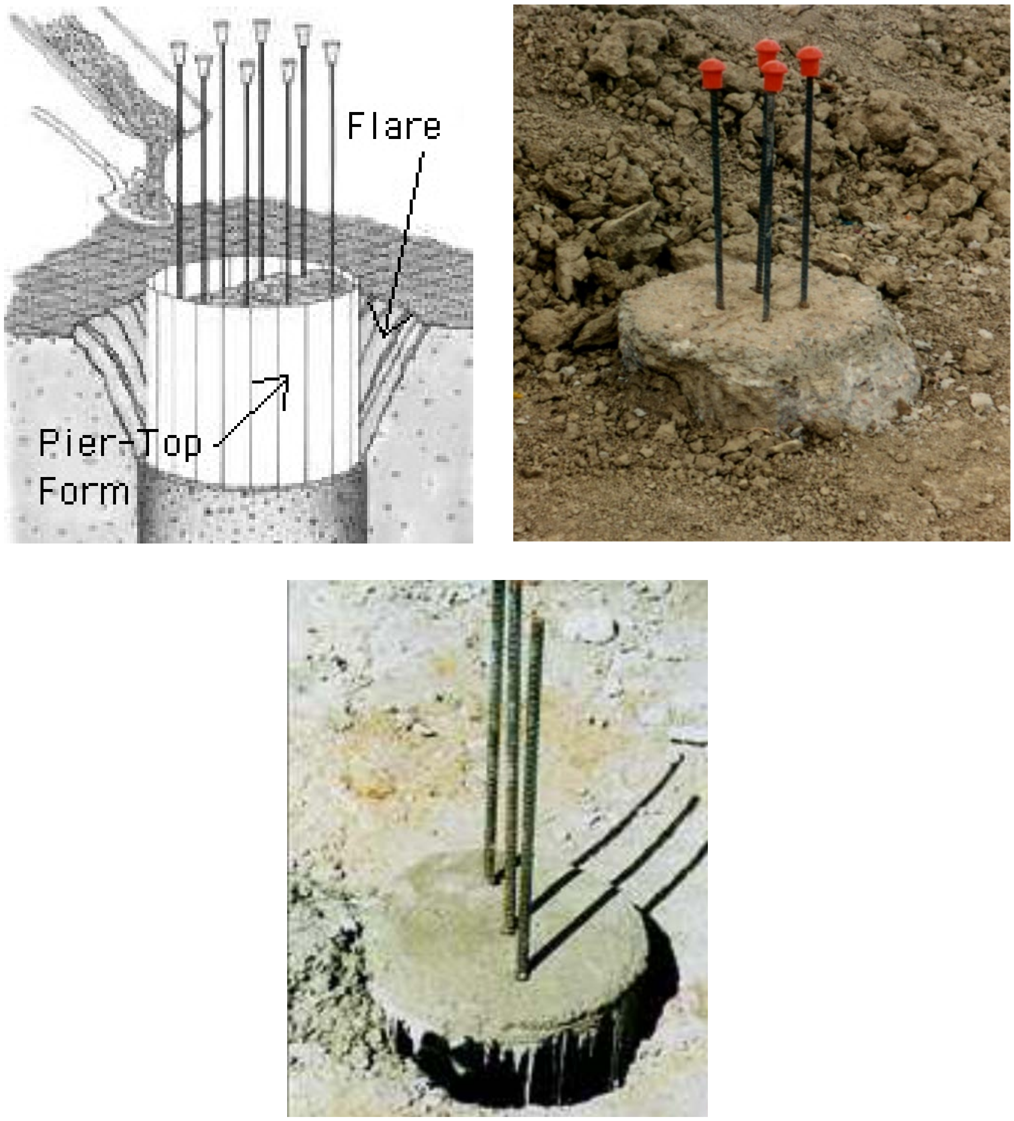
Table 3.5
Forms Around the Tops of the Piers

Characteristics		Corrugated Paper	Expanded Metal	Metal Sheet	Molded Plastic	Molded Paper	Styrofoam Sheet	Wood
		Void Space System Material						
		A	B	C	D	E	F	G
Advantages								
1	By eliminating the "flare", the horizontal contact area between the soil and the pier will be reduced, thereby reducing potential uplift pressures.	●	N/A	●	N/A	N/A	N/A	●
2	By eliminating the "flare" at the top of the pier, concrete waste is eliminated.	●	N/A	●	N/A	N/A	N/A	●
3	Eliminates structural repairs to Foundation caused by uplifting forces of Expansive Soil at pier tops.	●	N/A	●	N/A	N/A	N/A	●
Disadvantages								
1	Additional cost of materials.	●	N/A	●	N/A	N/A	N/A	●
2	Additional labor to install.	●	N/A	●	N/A	N/A	N/A	●
Other								
1	If pier-top forms are not specified, then the uplift pressures on the "flare" should be accounted for in the uplift design calculations.	●	N/A	●	N/A	N/A	N/A	●
2	Forms around the tops of piers are typically used when the elevation at the top of the pier is within 2 feet of the ground surface.	●	N/A	●	N/A	N/A	N/A	●

N/A = Not Applicable

NOTE: "Flare", as used in the table above, is where the top portion of the pier is poured against the soil and the pier at the surface has an actual diameter greater than the pier design diameter.

Figures utilizing the application of forms at the top of piers are shown below:



Forms around the upper portion of piers eliminate flaring

The intersection of the Grade Beam and pier correctly isolated by using pre-manufactured, non-field cut, vertically supported, sealed radial edge, Corrugated Paper Void Forms adjacent to the top of the pier.

Piers within uniform thickness Isolated Slabs can be isolated from the soil by using pre-manufactured, non-field cut, vertically supported, sealed radial edge, Corrugated Paper Void Forms adjacent to the top of the pier.

3.6 DESIGN PROCEDURE

Following is an example procedure to design a Void Space System:

- A geotechnical investigation and report should be performed in accordance with the requirements of Document No. FPA-SC-04, *Recommended Practice for Geotechnical Explorations and Reports* [3] and/or other guidelines acceptable to the Foundation design engineer and in accordance with local building code requirements.

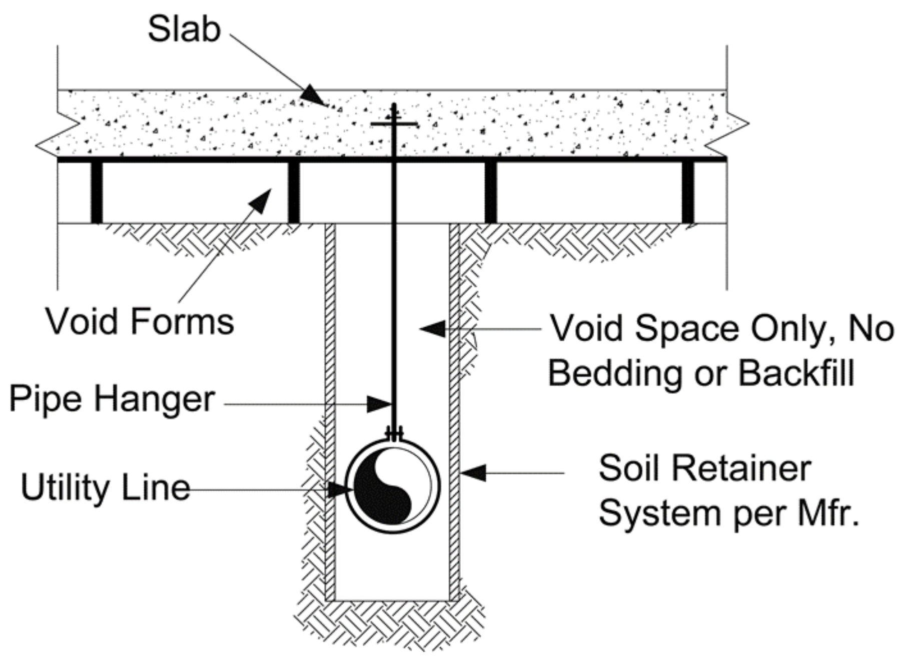
- The Foundation design engineer decides whether or not to utilize a Void Space System based on recommendations from the geotechnical report and discussions with the client.

- For Void Space Systems, the geotechnical report shall include information (such as the PUM) needed by the Foundation design engineer to choose the Void Space System and determine the required height of Void Spaces below the bottom of the Slab Area and Grade Beams, as applicable.

3.7 CONSIDERATIONS FOR UNDER-SLAB UTILITIES

Under-slab utilities should be carefully designed when Void Space is provided between the Slab Area and Grade Beams and the soil. Expansive Soil should not support under-slab utilities below an Isolated Slab on an Isolated Foundation. Under-slab piping must remain stationary with respect to the Slab Area. The distance between the Slab Area and the buried utilities may change as the soil moisture changes. These changes could cause the utility lines to disconnect, start leaking, or otherwise fail. Industry experience indicates that such under-slab problems are costly to repair and tend to develop frequently for locations with PUM values over 4 inches. There are various methods to accommodate such differential movement by using designs that allow the utilities to adjust to the changing conditions. The piping design beneath the Foundation must take into consideration the differential movement between the interior stationary piping and the soil outside the Foundation, and any associated bending stresses.

The following illustration shows an example of how to reduce the likelihood of such utility failures:



Under–Slab Utilities
Section View

4.0 SPECIFICATIONS FOR VOID SPACE MATERIALS

The following specifications should be provided by the purchaser (e.g., general contractor or Foundation contractor), to the Void Form material supplier, and/or to the manufacturer:

4.1 SPECIFICATIONS FOR ALL VOID SPACE MATERIAL TYPES

These general specifications apply to all types of Void Space materials:

- Unless otherwise shown or specified, design, place, and maintain Void Spaces between cast-in-place concrete and the soil in compliance with the American Concrete Institute Standard Guide to Formwork for Concrete, ACI 347 (Table 4.1 and the reference number 4.12) [1]; and for Corrugated Paper Void Forms, Ziverts, G. J., A Study of Cardboard Voids for Prestressed Concrete Box Slabs, PCI Journal, V. 9, No. 3, 1964, pp. 66-93, and V. 9, No. 4, pp. 33-68 [8].

- Manufacturer should submit product data sheets and test information for the Void Form materials to the Foundation design engineer who must verify compliance with the specifications.

- Void Form materials shall be specified by the Foundation design engineer per Table 3.4-1. The Void Form materials shall support all vertical and lateral loads that might be applied during construction until all loads can be supported by the concrete structure. These loads include, but are not limited to, live load, dead load, seismic load, weight of construction workers, weight of wet concrete, effects of the concrete drop, vibration, other concrete placement loads, ambient temperature, and vertical and lateral soil pressures.

- Contractor shall protect the integrity of the Void Forms and related materials prior to concrete placement as required by the manufacturer.

4.2 DEGRADABLE CORRUGATED PAPER VOID FORM MATERIALS

Differences in climate, use, or site conditions may affect the selection of Corrugated Paper Void Form material properties, including strength and moisture response. Following are considerations for their use:

- Fully Wax-Impregnated corrugated fiberboard is not acceptable as a degradable Void Space material due to resistance to deterioration.

- The interior construction of the Corrugated Paper Void Form material should be of a uniform, cellular configuration.

- If the product employs partial Wax Impregnation or Wax Coating, the soil contact area of the Corrugated Paper Void Form should not be Fully Wax Impregnated to ensure that degradation occurs.

- Do not use Polyethylene sheathing under Corrugated Paper Void Forms; degradation of the forms will be affected.

- Soil Retainers can be placed at the sides of Corrugated Paper Void Forms to resist soil and concrete intrusion into the Void Space during the construction process.

Figures showing two applications of Soil Retainers are given below:

Example of a high-density polyethylene (HDPE) Soil Retainer manufactured of materials that are not adversely affected by moisture, designed to be positioned at an angle.

Example of high-density polypropylene (HDPP) Soil Retainers adjacent to Corrugated Paper Void Form placed under Grade Beams, designed to be vertically positioned.

4.3 COLLAPSIBLE VOID FORMS (UNDER GRADE BEAMS ONLY)

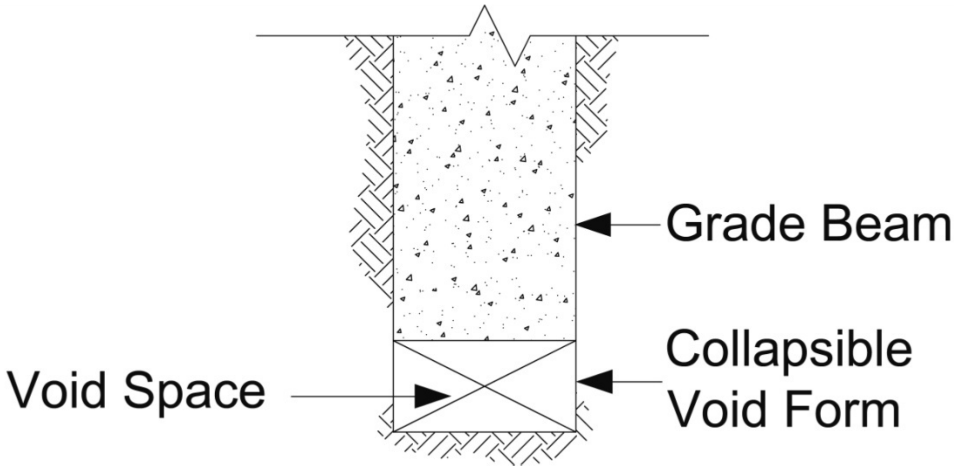
- Materials can be corrugated paper, plastic, metal, or other products. The net volume of the collapsed Void Form should be sufficient to accept the expanding soil. The Void Form materials must collapse under the uplift forces of the soil, but shall be sufficiently stiff to withstand the weight of the concrete and associated construction loads during concrete placement.

- Collapsible Corrugated Paper Void Forms shall be the product of a manufacturer engaged in the commercial production of such Void Forms.

- Corrugated Paper Void Form products shall be treated, if required, with registered Environmental Protection Agency (EPA) biocides and fungicides that resist mold, mildew, spore infestation, and pests.

- Fully Wax Impregnated Corrugated Paper Void Forms are resistant to moisture absorption, and are not considered to be degradable.

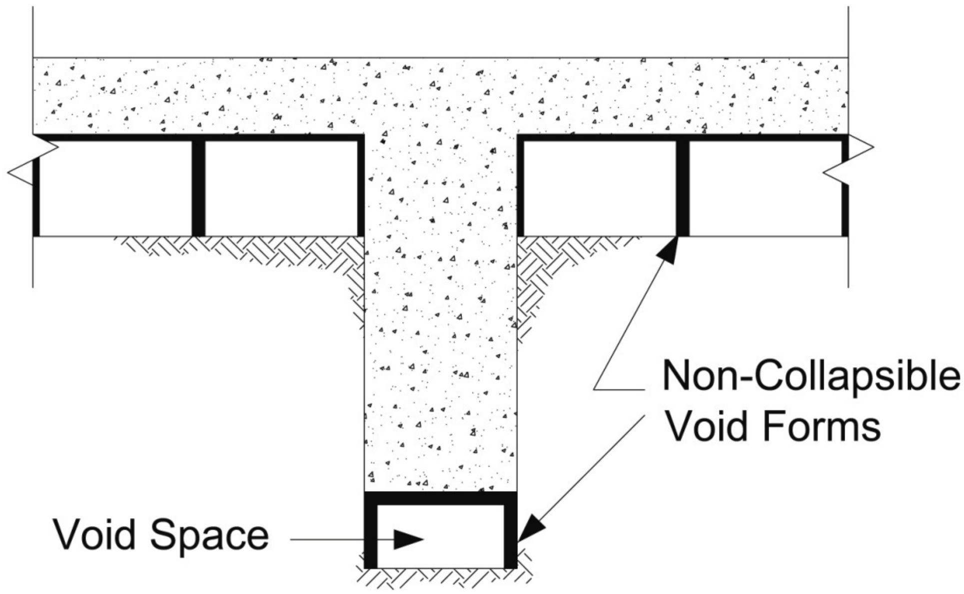
- The following illustration shows the placement of a Collapsible Void Form under a Grade Beam:



Collapsible Void Form Under Grade Beam

4.4 NON-COLLAPSIBLE VOID SPACE SYSTEMS

Non-collapsible Void Space Systems are intended to permanently remain intact, whether under Grade Beams or Slab Areas. They can be made from plastic, Fully Waxed Impregnated corrugated paper, metal, wood, or Styrofoam. The following illustration shows the placement of a Non-Collapsible Void Form below the Slab Area and Grade Beam:



Non-Collapsible Void Forms Under Grade Beam and Slab Area
(Both locations can only be used together with Deep Foundation Systems)

4.5 TRAPEZOIDAL CORRUGATED PAPER VOID FORMS

Trapezoidal Corrugated Paper Void Forms *should not* be specified for the reasons that follow:

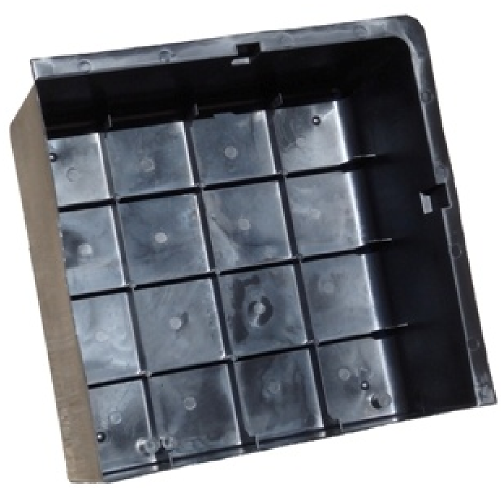
- This shape is designed to form concrete Soil Retainers at the sides of Void Space below a cast-in-place concrete grade beam or wall, but the intended result is difficult to achieve, and therefore may be inappropriate for use as a Void Space System.
- Trapezoidal Corrugated Paper Void Forms are designed to resist lateral pressures from the expanding soil on the concrete grade beam or wall, but the result is seldom achieved due to the concrete on the sides of the Void Space lacking reinforcement and sufficient thickness into the intended retainer area. In practice, this may result in locations that are devoid of concrete.
- Under certain conditions, trapezoidal Corrugated Paper Void Forms do not perform as intended due to the lack of sufficient interior vertical supports [7].

4.6 PLASTIC VOID FORMS

- Plastic Void Form components shall be constructed of plastic materials having a high notch toughness and a shape design capable of supporting workers and steel reinforcement during construction and supporting the wet concrete during the pour.
- The bottoms of the Plastic Void Forms must be open where in contact with the soil.
- Plastic Void Forms shall be the product of a manufacturer engaged in the commercial production of Plastic Void Forms.
- The use of a 6 mil layer of plastic sheeting placed on the ground is recommended to more easily facilitate the installation of Plastic Void Forms and to allow installation during inclement weather. It is also usually required when using post-tensioned cable reinforcement.
- Plastic Void Forms can be used with post-tensioned cables or rebar reinforcement, or a combination thereof.

Examples of Plastic Void Forms:

Plastic Void Form constructed of recycled plastic materials



Bottom of the Plastic Void Form must be open where in contact with the soil

The use of a 6 mil layer of plastic sheeting placed on the ground is recommended.

Plastic Void Forms can be used with post-tensioned cables or rebar reinforcement, or a combination thereof.

4.7 TESTING REQUIREMENTS

An independent testing laboratory shall qualify the strength of Void Space System materials. In order for a Void Space System to be considered acceptable under this document, its materials shall be tested by an independent laboratory in accordance with the following minimum requirements, as applicable to the different types of systems:

- There shall be a minimum of three (3) test samples, randomly selected by the independent laboratory.
- For degradable and collapsible Void Forms only:
    - The test samples shall have a minimum length equal to twice the depth of the test sample.
    - The test samples shall have a repetitive cell pattern of at least two adjacent cells in each horizontal direction.
    - The test pressure at failure shall be the pressure where either the deflection increases without additional pressure, or the total vertical deformation exceeds 5% of the original vertical dimension of the Void Space materials.
- The test pressure at failure applied to each sample shall be within plus or minus 10% of the stated average failure pressure of all the samples.
- The test pressure shall be uniformly applied to the test sample.

4.8 SUBMITTALS

As a minimum for each Void Space System being supplied, the following shall be provided to the foundation design engineer for review:

- Product data sheets describing properties such as, but not limited to, geometry, dimensions, materials, coatings, and test results.

- If requested, certified laboratory test data.

5.0 HANDLING AND INSTALLATION OF VOID SPACE SYSTEMS

This section provides considerations for onsite protection, quality control, and installation concerns of Void Space System materials.

5.1 ONSITE VOID SPACE SYSTEMS PROTECTION

Following are recommendations for proper onsite protection of Void Space System materials to help ensure performance as designed:

- Store Void Space System materials in accordance with manufacturer's recommendations.

- Store moisture sensitive Void Space Systems and accessories on an elevated area, not directly in contact with the ground, and protect from water and the weather.

- Onsite moisture sensitive Void Form materials should be protected against damage prior to installation, preferably in an enclosed transport trailer or other storage container.

- Do not install or use Void Form materials that have been damaged.

5.2 INSTALLATION

Care should be given during the installation of the Void Space System material, in order to ensure that it is installed according to the manufacturer’s recommendations. Below are some specific guidelines, as applicable to the different types of systems:

- Assemble knockdown (unassembled) products as recommended by the manufacturer to develop designed strengths.

- Degradable Corrugated Paper Void Forms should have access to and make contact with moisture after installation, in order to properly deteriorate. The degradable Corrugated Paper Void Forms should not be wrapped in polyethylene. In addition, a moisture retarder (e.g., polyethylene) should not be used under degradable Corrugated Paper Void Forms, because this may not allow deterioration.

- A protective fiberboard may be used as a covering over Corrugated Paper Void Forms as necessary to distribute working load, bridge small gaps, and protect the materials from puncture and other such damage during concrete placement. Protective fiberboard less than 1/8" may curl and is not recommended.

- End caps can be used to seal exposed ends adjacent to pier locations when using Corrugated Paper Void Forms.

- Seam pads, polyethylene sheeting, or protective fiberboard can be used to cover open joints to prevent concrete intrusion when using Corrugated Paper Void Forms.

- Protect degradable Corrugated Paper Void Forms from moisture before concrete is placed. Replace wet or damaged materials before placing concrete.

- Ensure that there is positive drainage away from the Foundation.

- Void Space Systems should be properly placed and anchored to prevent displacement or flotation during placement of concrete.

- The moisture retarder shall only be placed over the top of the Corrugated Paper Void Forms and the protective fiberboard.

- Following are other installation areas of concern for Void Space Systems:

  - Selection of Void Form material type
  - Void Space System minimum and maximum strength (psf)
  - Pre-manufactured Void Space System eliminates field cutting
  - Fiberboard covering is required for Corrugated Paper Void Forms
  - Minimize and cover openings to prevent concrete from flowing into Void Forms
  - Concentrated loads on Void Space System during construction
  - Moisture retarder in wrong location when using Corrugated Paper Void Forms
  - Onsite weather protection
  - Size of concrete pour
  - Labor force (size and skill level)
  - Weather conditions
  - Insufficient soil moisture for degradable Void Forms
  - Construction joints

- See installation photos below:

Protective fiberboard sheets being placed over Corrugated Paper Void Forms

Installation of Plastic Void Forms

6.0 REFERENCES

1. American Concrete Institute Standard *Guide to Formwork for Concrete*, ACI 347 (Table 4.1 and the reference number 4.12).

2. Foundation Performance Association, Document No. FPA-SC-01-0, *Foundation Design Options for Residential and Other Low-Rise Buildings on Expansive Soils*, 30 June 2004.

3. Foundation Performance Association, Document No. FPA-SC-04-0, *Recommended Practice for Geotechnical Explorations and Reports*, 11 April 2001.

4. Foundation Performance Association, Document No. FPA-SC-16, *Design Procedure for Drilled Concrete Piers in Expansive Soil*, date and title pending.

5. *IBC*, *International Building Code*, Country Club Hills, IL, International Code Council, 2012.

6. *IRC*, *International Residential Code for One- and Two-Family Dwellings*, Country Club Hills, IL, International Code Council, 2012.

7. Isbell, David K., *Performance of Cardboard Carton Forms*, presented to the Foundation Performance Association on 21 February 2001.

8. Ziverts, G. J., *A Study of Cardboard Voids for Prestressed Concrete Box Slabs*, PCI Journal, V. 9, No. 3, 1964, pp. 66-93, and V. 9, No. 4, pp. 33-68.