SPECIFICATION AND APPLICATION OF VOID SPACES BELOW CONCRETE FOUNDATIONS

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Presented to :	**Foundation Performance Association**
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FOUNDATION PERFORMANCE ASSOCIATION

Specification and Application of Void Spaces Below Concrete Foundations

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VOID SPACES

Gaps designed to provide a buffer zone between expansive soils and a concrete foundation in order that **heave** can occur without imposing detrimental uplift pressures to the foundation

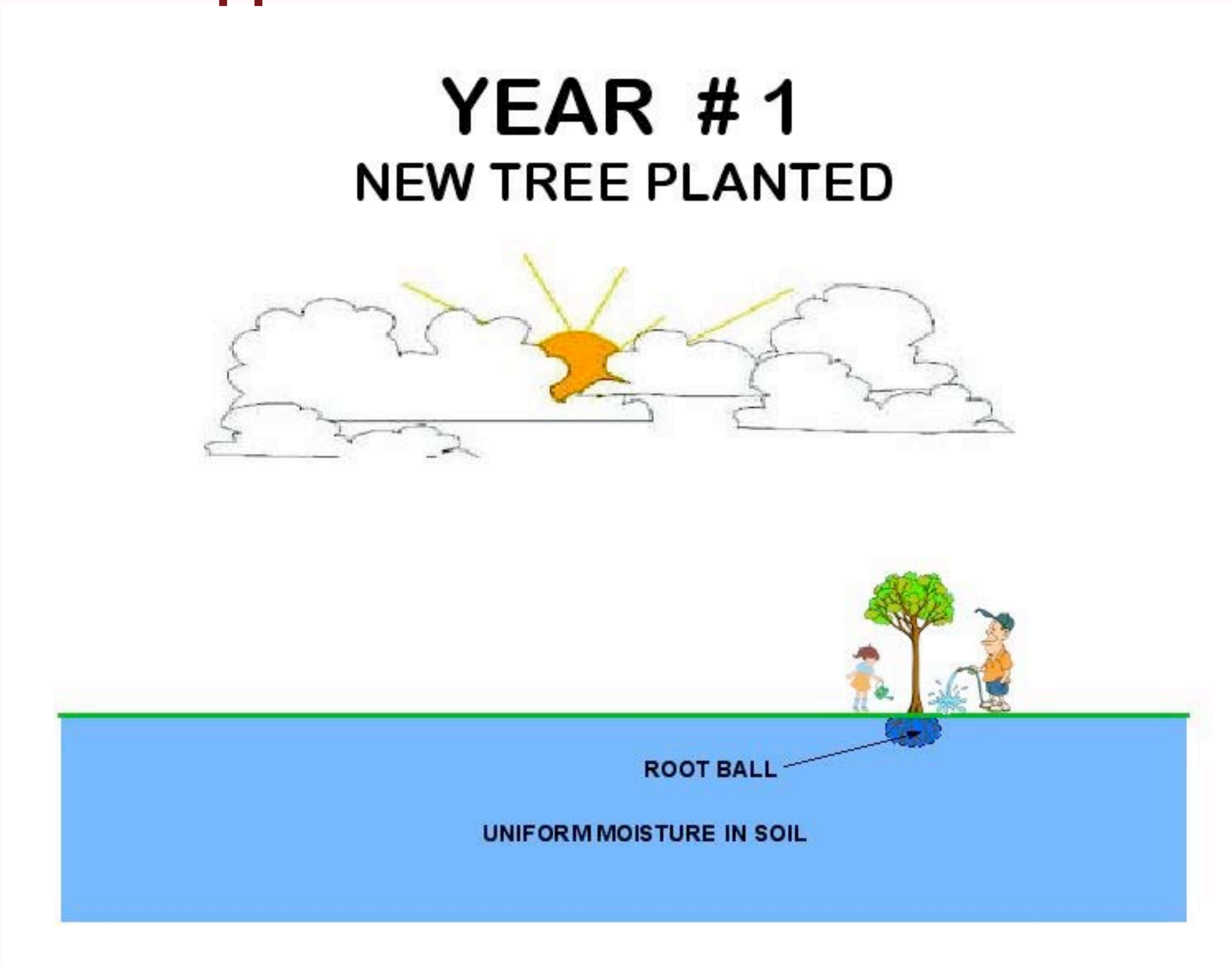
HEAVE….

The upward movement of an underlying supporting soil stratum due to the addition of water to an unsaturated expansive soil within the moisture active zone.

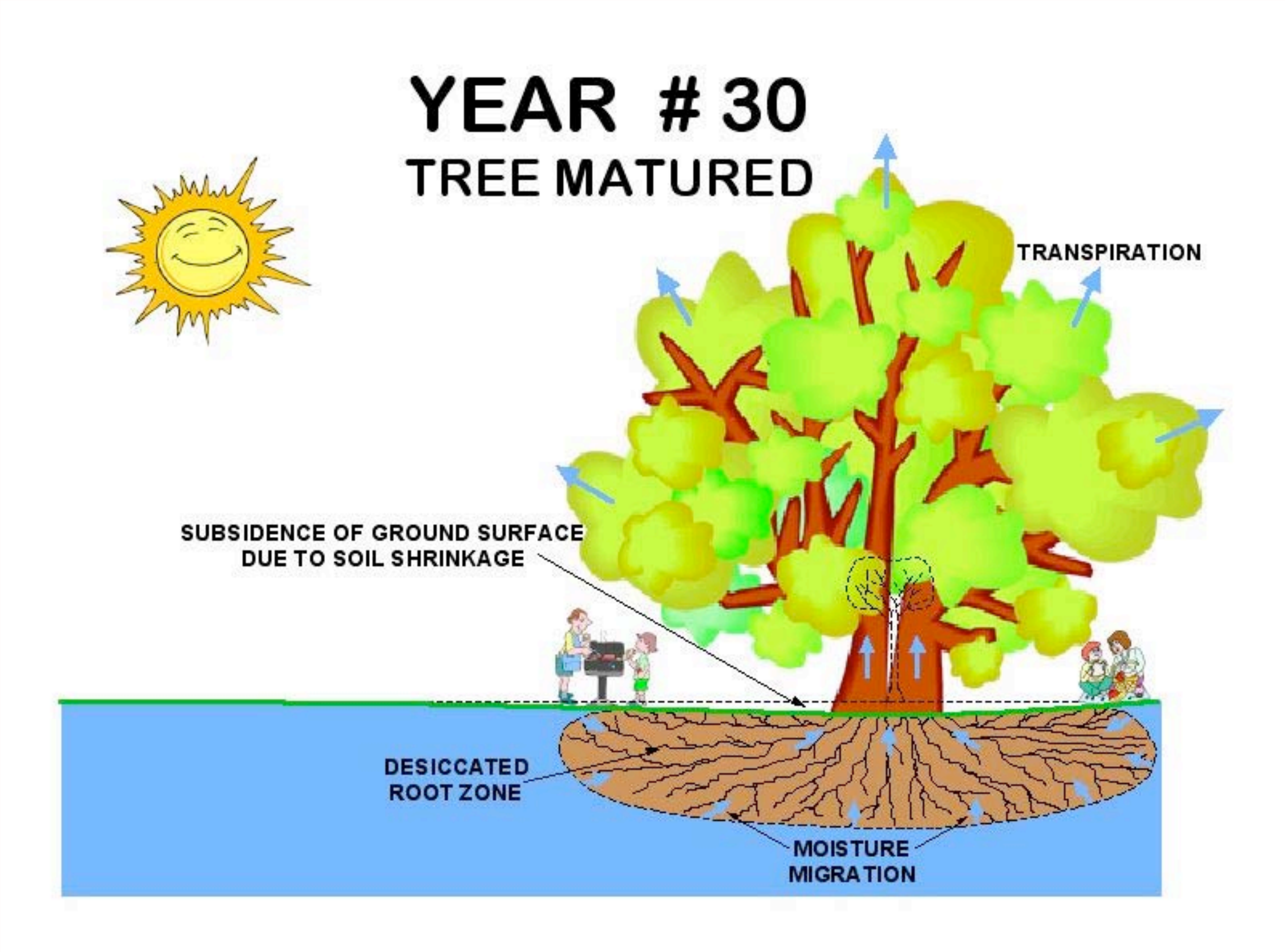
Commonly occurs within clayey soils with an available moisture source.

Without a void space, this movement may be detrimental to foundations and superstructures.

How Heave Happens:



How Heave Happens:



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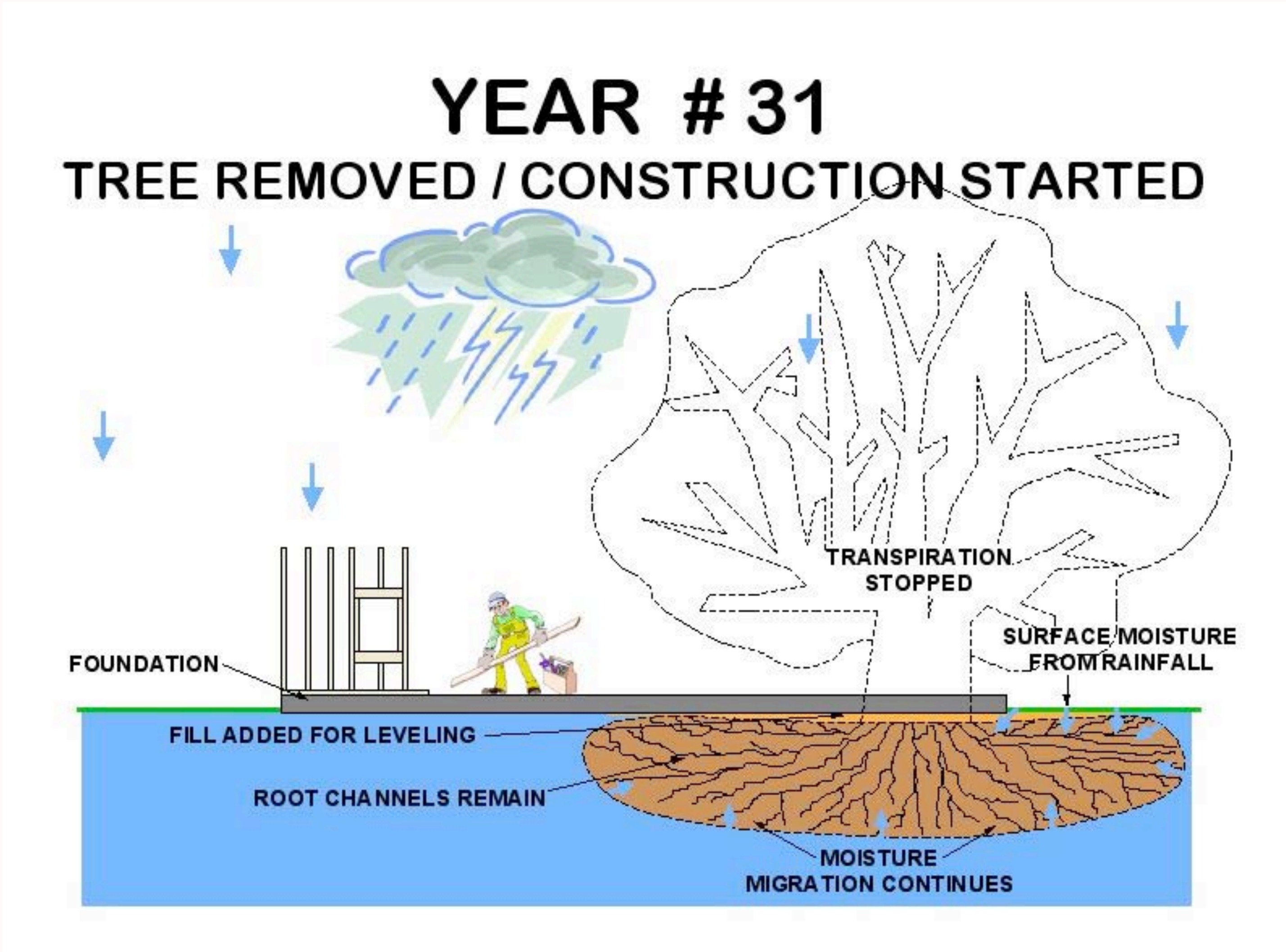
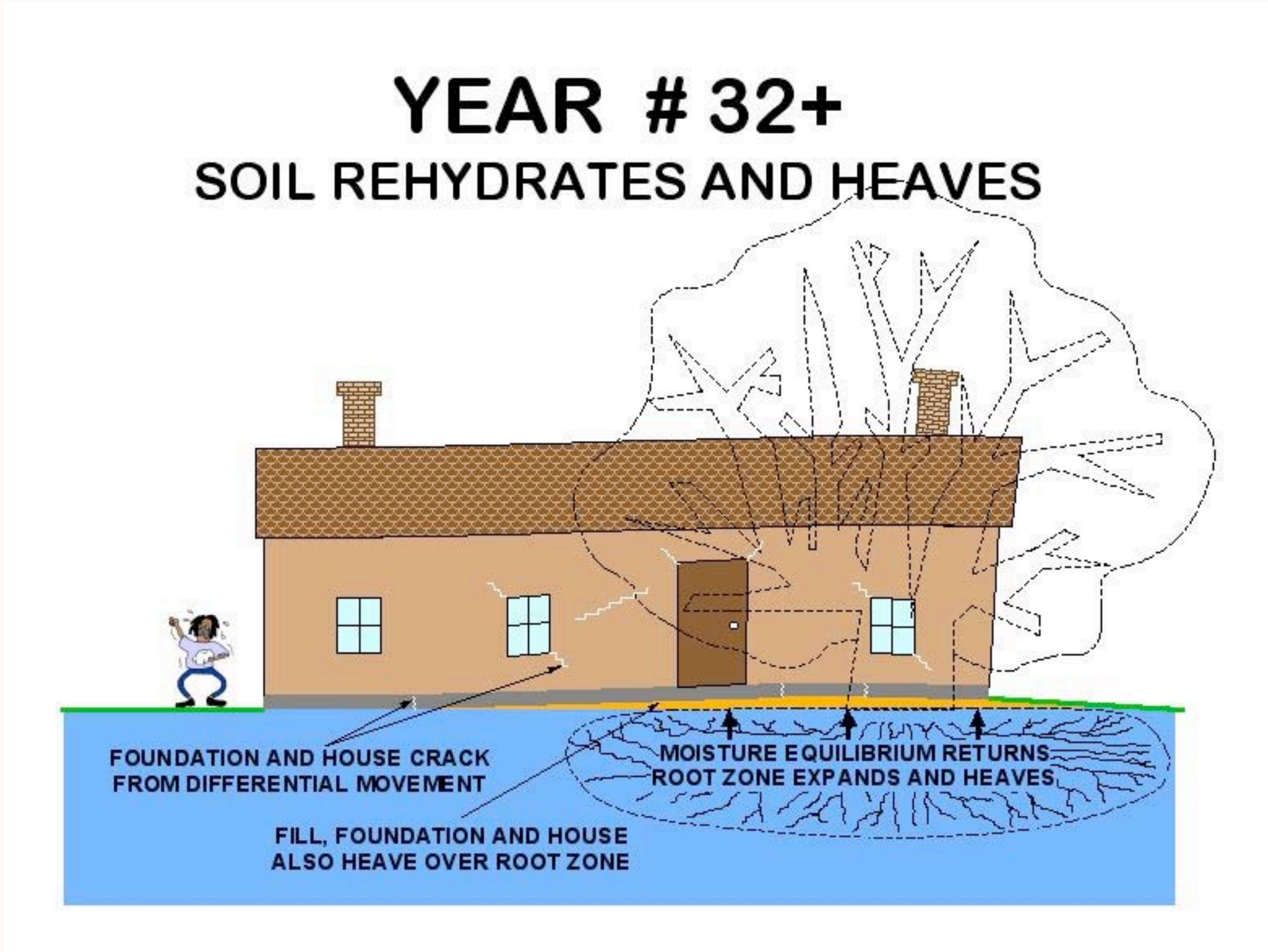


How Heave Happens:



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VOID SPACE SYSTEM TYPES

DEGRADABLE VOID SPACE SYSTEMS

- **Only** type to be used under slab areas
- Wax coated; will gradually absorb ground moisture and lose strength or degrade over a period of time
- Soil can heave into the resulting void space
- Material, such as gravel or plastic sheathing, under carton forms should not be used because a capillary break may occur preventing moisture migration to the degradable carton forms.

COLLAPSIBLE VOID SPACE SYSTEMS

NON-COLLAPSIBLE VOID SPACE SYSTEMS

VOID SPACE SYSTEM TYPES

DEGRADABLE VOID SPACE SYSTEMS

COLLAPSIBLE VOID SPACE SYSTEMS

- Non-degradable material designed to collapse under heave pressures greater than the weight of the foundation and superstructure dead loads
- Will not collapse during foundation make-up and placement
- Not to be used under slab areas.

NON-COLLAPSIBLE VOID SPACE SYSTEMS

VOID SPACE SYSTEM TYPES

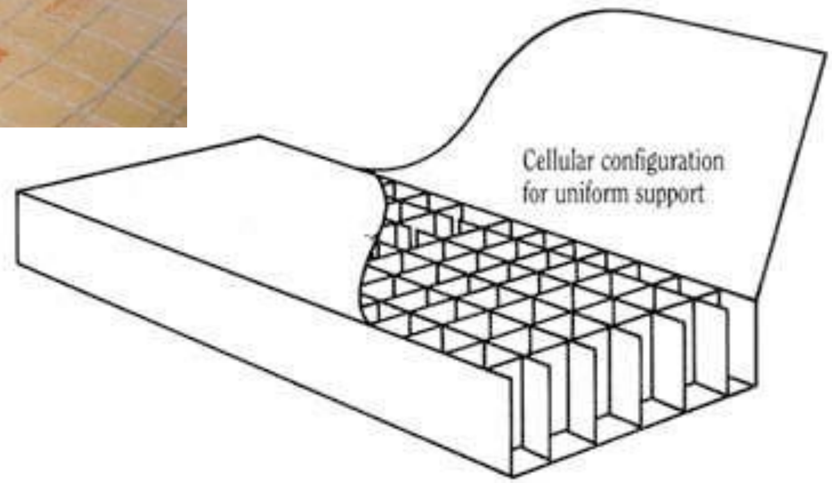
DEGRADABLE VOID SPACE SYSTEMS

COLLAPSIBLE VOID SPACE SYSTEMS

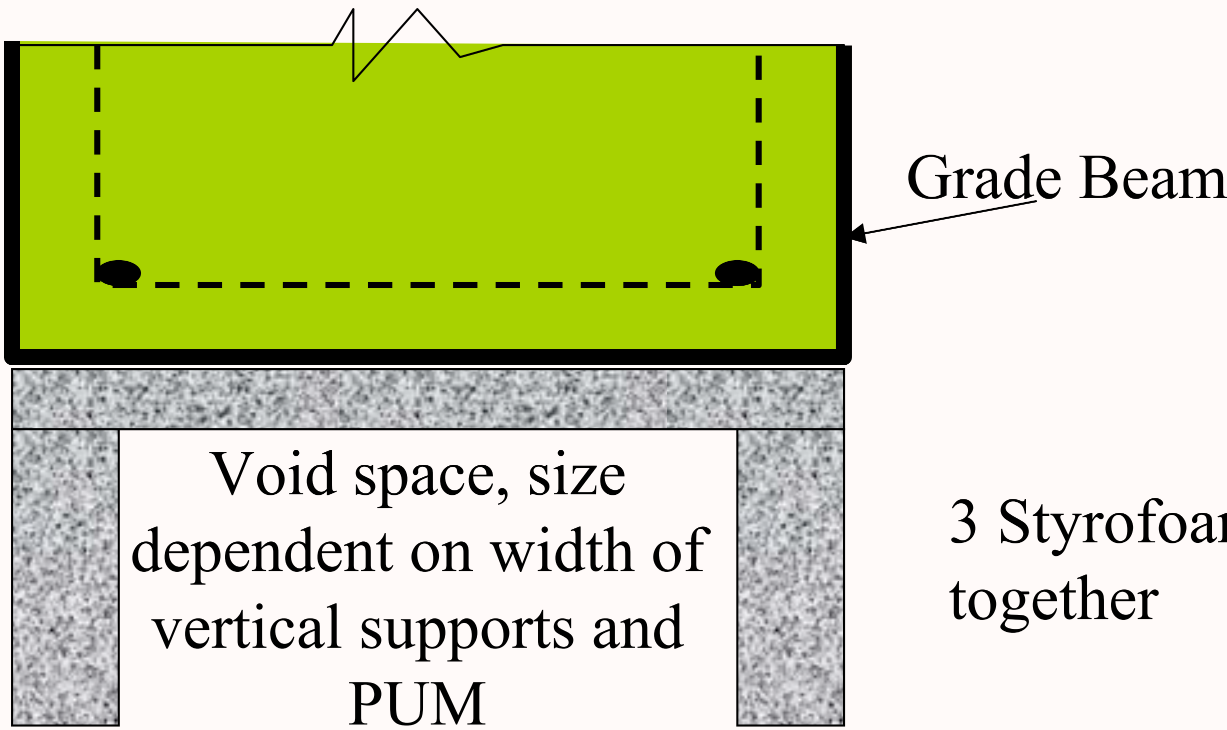
NON-COLLAPSIBLE VOID SPACE SYSTEMS

- Non-collapsible material designed to maintain its original structural integrity throughout life of the foundation
- Built-in void space
- Materials include fully wax impregnated corrugated paper, Styrofoam, plastics and other non-degradable products
- Use under grade beams only

DEGRADABLE AND COLLAPSIBLE VOID SPACE SYSTEMS



NON-COLLAPSIBLE VOID SPACE SYSTEMS



3 Styrofoam pieces glued together

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VOID SPACE SYSTEM (DEGRADABLE CARTON FORMS) UNDER SLAB AREAS

Advantages

- Reduces foundation heave
- Elevated slab areas are less affected by surface water prior to concrete placement

VOID SPACE SYSTEM (DEGRADABLE CARTON FORMS) UNDER SLAB AREAS

Disadvantages

- Creates path for water to migrate below slab
- Termites may be attracted to carton forms when paper products are used
- Increases design and construction cost
- Concrete may enter carton form during placement if grade stakes are driven through carton forms

VOID SPACE SYSTEMS UNDER GRADE BEAMS

Advantages

- Allows total isolation of the upper foundation from the active soils
- Potential Upward Movement of foundation will be reduced, assuming sufficient void space is maintained and deeply supported foundations are founded below the moisture active zone.

VOID SPACE SYSTEMS UNDER GRADE BEAMS

Disadvantages

- Void space below beams usually collect water
- Prolongs installation time
- Increases cost of design and construction
- Due to inclement weather conditions, the entire foundation makeup may need to be removed in order to replace damaged or wet carton forms

NO VOID SPACE UNDER GRADE BEAMS

Design procedure:

a) Determine the maximum uplift forces of the soil and compare the capacity of the grade beams with that force applied to the bottom of the grade beams. If the dead load on the beam is equal to or greater than the uplift force, no additional design is necessary. If the uplift force is greater, the grade beams need to be designed for this upward force minus the dead load, and the piers should then be designed for the proper depth below the moisture active zone to resist this uplift.

NO VOID SPACE UNDER GRADE BEAMS

b) There are two uplift forces to be considered: bearing on the bottom of the grade beams and side friction between the soil and sides of the beam. One method of determining these forces is to provide swell tests to determine the surcharge needed for zero swell and use the shear capacity of the soil for the side friction. The actual determination of these forces is not in the scope of this document.

c) It would be a reasonable assumption that, if the above items were accounted for and the actual forces are the same or lower than dead loads, a void space would not be necessary under the grade beams.

NO VOID SPACE UNDER GRADE BEAMS

d) If the net uplift pressures on the grade beams are greater than the dead weight of the foundation and superstructure one of two design choices should be made:
   1) Design the foundation as a stiffened slab per PTI, BRAB or WRI. Movement may occur.
   2) Use a void space under the grade beams in conjunction with a void space under the slab area.

DESIGN CONSIDERATIONS

- **In order to determine the design height for degradable Carton Forms & Collapsible Void Space Materials:**

  deformed/collapsed height of carton form

  \+ void space height required by geotech engineer

  Design Height of Void Space

- **Non-Collapsible Void Space Materials:** Excavated void space should be large enough to compensate for the volume of the permanent void space material and the heaved soil

<table>
<tr><th>TABLE 3.4-1</th><th colspan="4">REQUIRED DESIGN LOADS FOR VOID SPACE SYSTEMS</th></tr>
<tr><th rowspan="3">CRITERION</th><th rowspan="3">CONDITION[1, 3]</th><th colspan="3">VOID SPACE SYSTEM MATERIAL TYPE[1]</th></tr>
<tr><th rowspan="2">DEGRADABLE</th><th colspan="2">NON-DEGRADABLE</th></tr>
<tr><th>COLLAPSIBLE[2]</th><th>NON-COLLAPSIBLE</th></tr>
<tr><td>Minimum Initial Ultimate Uniform Load Collapse Pressure (as shipped, dry) [PSF]</td><td>Slabs with t ≤12” thick
Slabs with t > 12”
Beams with d ≤ 36”
Beams with d > 36”</td><td>600
456 + 12t
1000
568 + 12d</td><td>Do not use
Do not use
600
168 + 12d</td><td>Do not use
Do not use
600
168 + 12d</td></tr>
<tr><td>Maximum Initial Ultimate Uniform Collapse Pressure (as shipped, dry) [PSF]</td><td>Slabs with t ≤12” thick
Slabs with t > 12”
Beams with d ≤ 36”
Beams with d > 36”</td><td>1500
1356 + 12t
1500
1068 + 12d</td><td>Do not use
Do not use
1000
568 + 12d</td><td>Do not use
Do not use
No limit
No limit</td></tr>
<tr><td>Maximum Final Ultimate Uniform Collapse Pressure (at 100% humidity for 7 days) [PSF]</td><td>Slabs with t ≤12” thick
Slabs with t > 12”
Beams with d ≤ 36”
Beams with d > 36”</td><td>12t
12t
12d
12d</td><td>Do not use
Do not use
1000
568 + 12d</td><td>Do not use
Do not use
No limit
No limit</td></tr>
<tr><td colspan="5">Notes:
1. t = slab thickness [inches]; d = grade beam depth [inches], measured from the top of the slab to the bottom of the beam
2. The foundation design engineer should verify the maximum ultimate collapse pressure.
3. The slab values should also be used for pier caps.</td></tr>
</table>

DESIGN CONSIDERATIONS FOR THE FORMS AROUND THE TOPS OF PIERS

FORMS AROUND THE TOPS OF PIERS

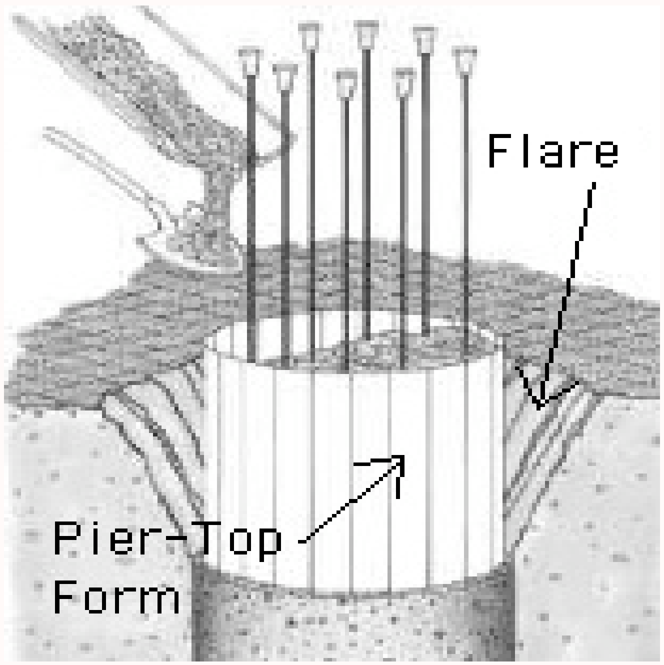
Advantages

- Reducing contact area between top of pier and soil reduces potential uplift pressures
- Less concrete waste

Disadvantages

- Additional cost of materials
- Additional labor to install

FORMS AROUND THE TOPS OF PIERS

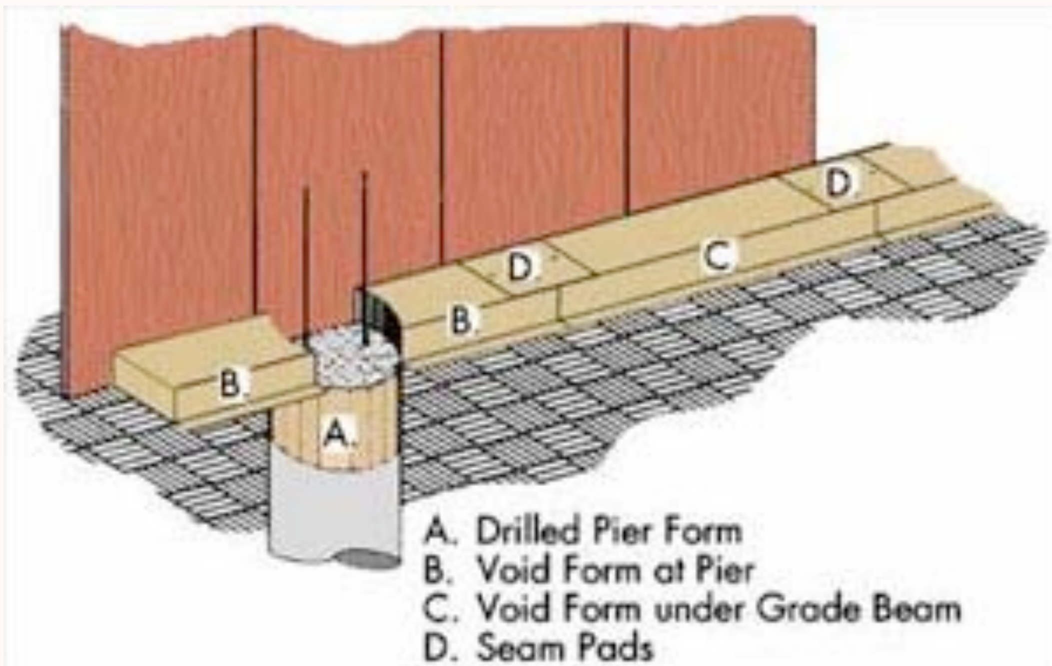


RIGHT WAY

FORMS AROUND THE TOPS OF PIERS

WRONG WAY

FORMS AROUND THE TOPS OF PIERS



VOID SPACE SYSTEM MANUFACTURER TESTING

VOID SPACE SYSTEM TESTING

For a void space system to be considered acceptable under this document, it should be tested by an independent laboratory in accordance with the following minimum requirements:

a) Minimum of 3 randomly selected test samples
b) Minimum length = 2 times depth of test sample
c) Repetitive cell pattern of at least two adjacent cells in each horizontal direction
d) Test pressure at failure is pressure where either deflection increases without additional pressure, or total vertical deformation > 5% of original vertical dimension
e) All samples fail at pressure ±10% of average failure pressure
f) Test pressure shall be uniformly applied to test sample

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VOID SPACE SYSTEM DESIGN PROCEDURE

a) A geotechnical investigation and report should be in accordance with the requirements of Document No. FPA-SC-04, *Recommended Practice for Geotechnical Explorations and Reports* and / or other guidelines acceptable to the foundation design engineer.

b) 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.

VOID SPACE SYSTEM DESIGN PROCEDURE

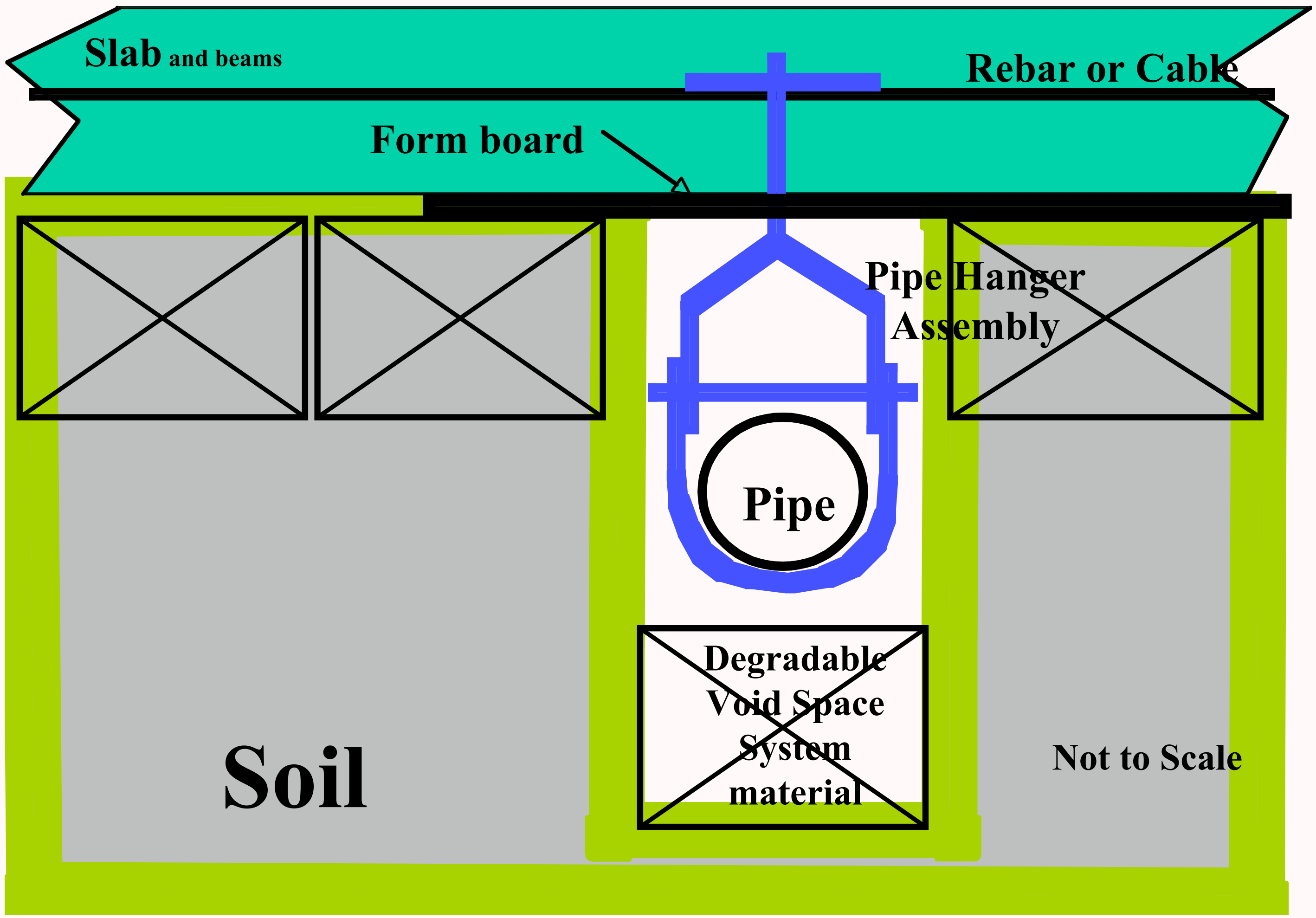
c) The geotechnical report shall include recommendations needed by the foundation design engineer to design the Void Space System, in particular the net height of Void Space (PUM) required below the bottom of the slab and grade beams.

d) The foundation design engineer specifies the Void Space height and Void Space System on the design drawings and / or specifications based on recommendations of the net height of Void Space (PUM) recommended by the geotechnical engineer.

CONSIDERATIONS FOR UNDER-SLAB UTILITIES

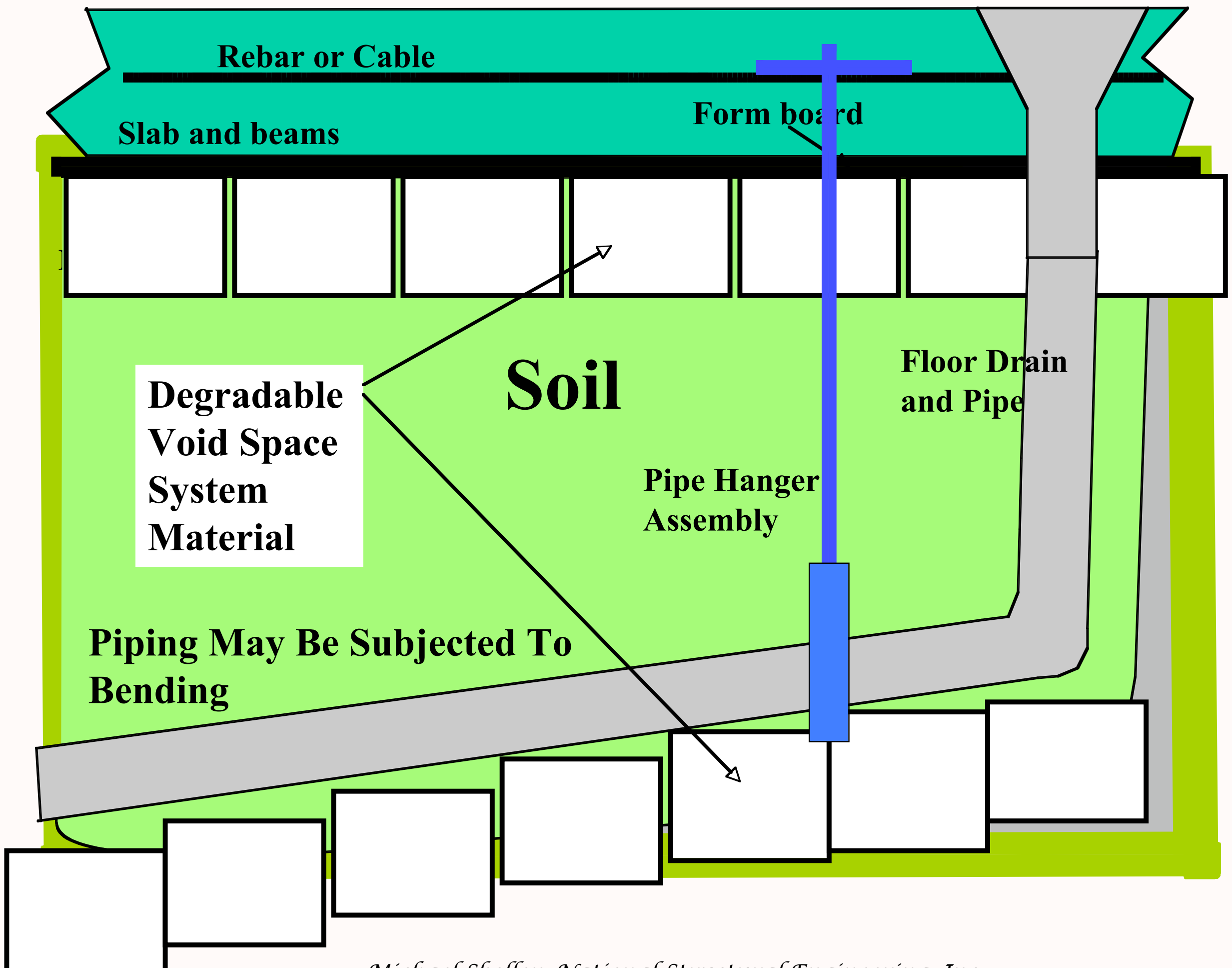
UNDER-SLAB UTILITY CONSIDERATION

--Piping must remain stationary with respect to the slab--



UNDER-SLAB UTILITY CONSIDERATION

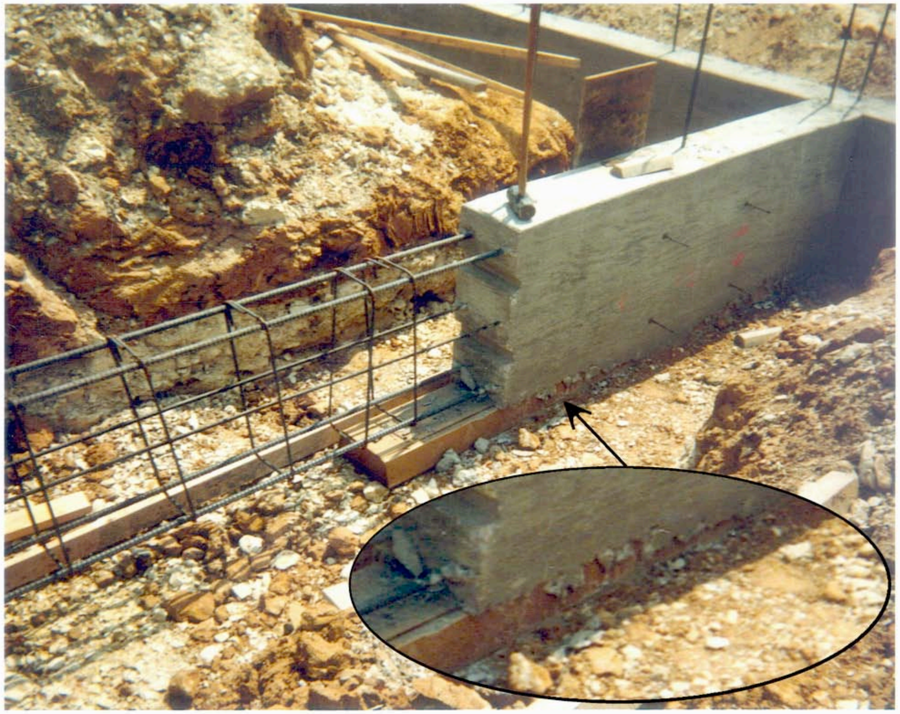
--Piping must remain stationary with respect to the slab--



TRAPEZOIDAL CARTON FORMS

TRAPEZOIDAL CARTON FORMS

- Inappropriate for void space system
- Designed to resist lateral pressures, but as concrete on the sides is often thin and unreinforced, pressures are not resisted
- Lack sufficient interior vertical supports



Trapezoidal carton forms that lack continuous concrete to function as a soil retainer at the bottom of grade beams

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VOID SPACE SYSTEMS ONSITE PROTECTION

- Store materials according to manufacturer's recommendations
- Store degradable Systems in an enclosed container or storage trailer
- Protect Systems against the elements and other means of damage prior to installation
- Do not install or use water sensitive void space materials that have been damaged

VOID SPACE SYSTEMS INSTALLATION

a) Assemble products as recommended by the manufacturer to develop designed strengths.

b) Degradable carton forms should have access to moisture in order to properly deteriorate. Do not wrap degradable forms in polyethylene. A moisture retarder (polyethylene) should not be used below degradable carton forms because this may *not* allow deterioration from the subgrade below.

c) Place a protective covering over Void Space Systems as necessary to distribute working load, bridge small gaps, and protect the materials from puncture and other damage during concrete placement. A protective fiberboard may be used on top of all Void Space Systems, which helps distribute concentrated construction loads from rebar bolsters, personnel, etc. Do not use protective fiberboard less than 1/8”, plywood or OSB board.

VOID SPACE SYSTEMS INSTALLATION

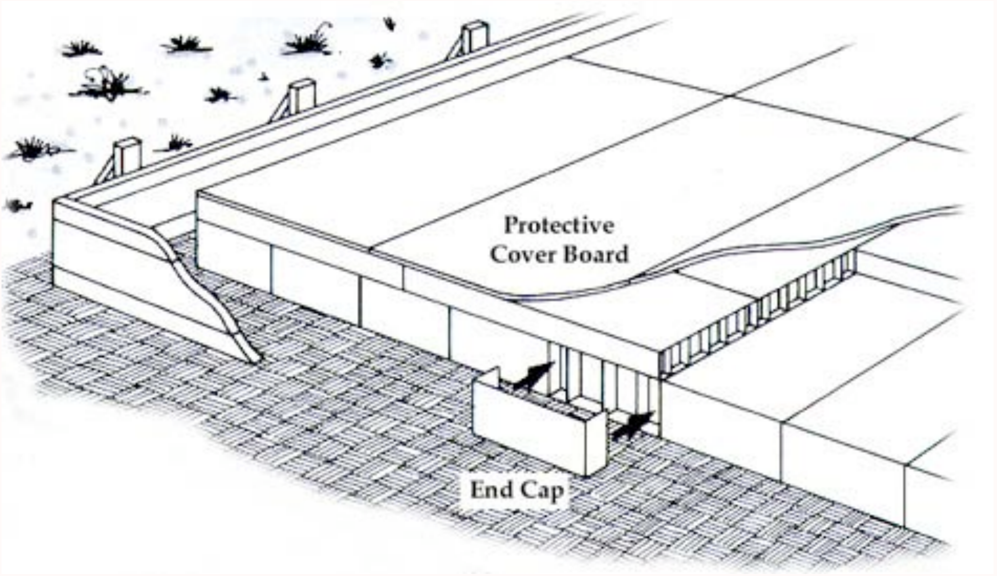
Placement of fiberboard coverings

VOID SPACE SYSTEMS INSTALLATION

d) Foundation design engineer should have an active roll in the construction procedures.

e) Use end caps to seal exposed ends adjacent to piers.

f) Protect degradable systems from moisture. Replace wet or damaged materials before placing concrete.

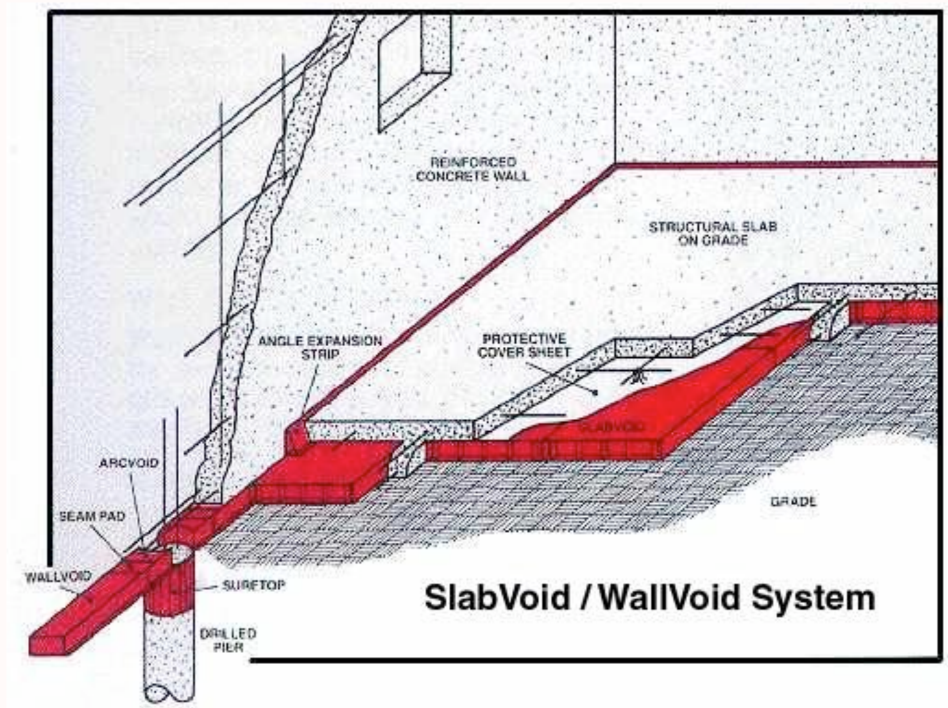


VOID SPACE SYSTEMS INSTALLATION

g) Ensure positive drainage away from the foundation

h) Systems should be properly placed and anchored

i) Moisture retarder may be placed over top of carton forms. Collapsible void systems may be wrapped with moisture retarder as long as the entrapped air has a method of escaping.



INSTALLATION COMMENTS/CONCERNS

- Selection of paper type
- Void space system minimum/maximum strength (psf)
- Pre-manufactured System eliminates field cutting
- Fiberboard protection for System
- Minimize openings to prevent concrete from flowing into System
- Concentrated loads Systems such as from rebar chairs
- Moisture retarder in wrong location
- Onsite weather protection
- Size of concrete pour
- Labor force (size and skill level)
- Weather conditions
- Insufficient soil moisture for degradable System

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CARTON FORMS BENEATH BEAMS

CARTON FORMS BENEATH BEAMS

CARTON FORMS BENEATH WALL

CARTON FORMS BENEATH SLAB & BEAM

PRE-MANUFACTURED RADIAL CARTON FORM AT PIER INTERSECTION

ONE-PIECE PIER CARTON FORM

TWO-PIECE PIER CARTON FORM

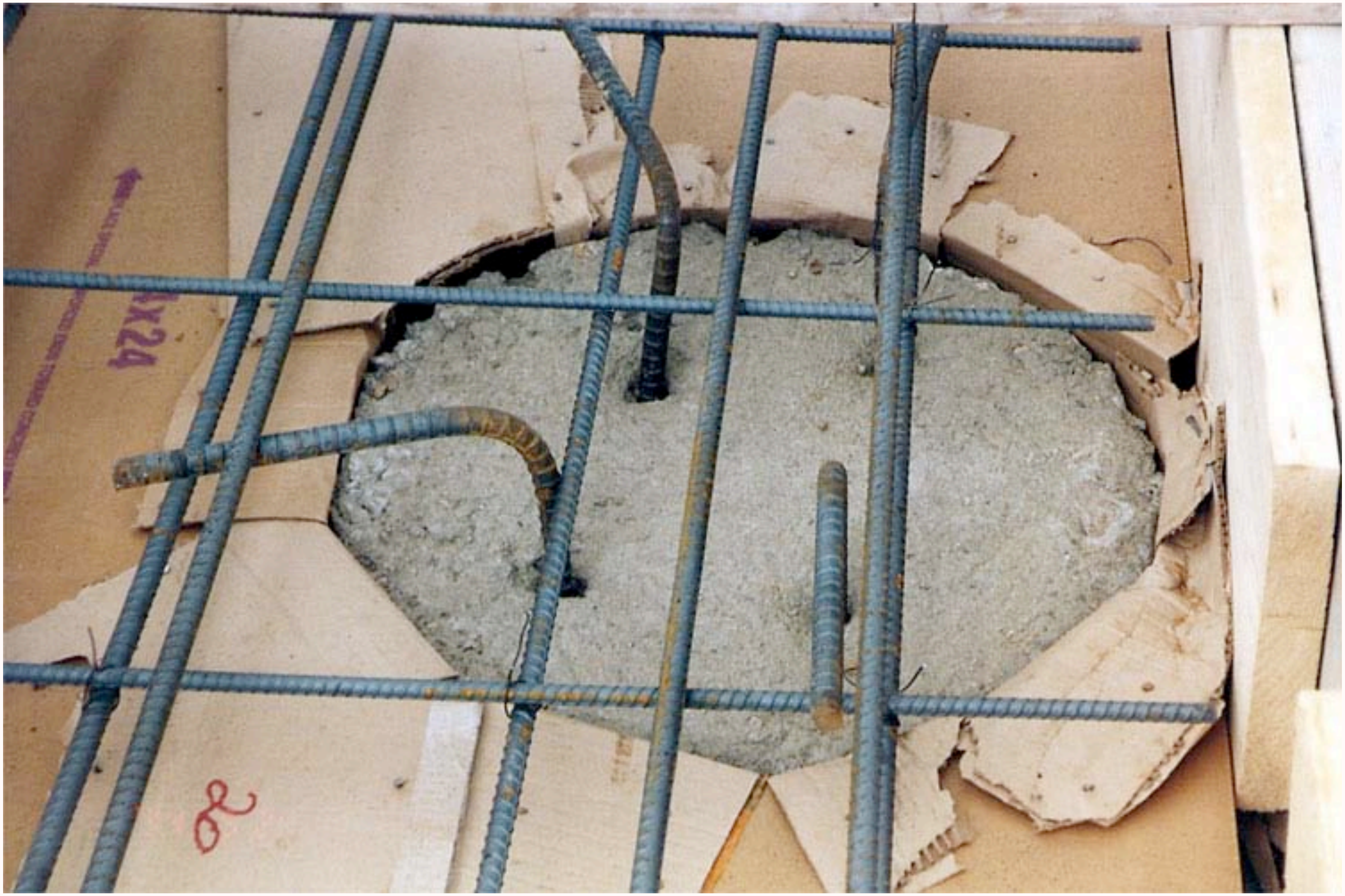
RADIAL SHAPES ARE FIELD-CUT AND PATCHED

EXPOSED CARTON FORM INTERIOR BY FIELD CUTTING

FIELD-CUT PIECES AROUND PIER

WASTED CARTON FORM MATERIAL

FIELD-CUT CARTON FORMS RANDOMLY PLACED AROUND PIER



PIER PERIMETER STUFFED WITH PAPER SCRAP

PRE-MANUFACTURED CARTON FORMS FOR PIERS AND GRADE BEAMS

SLAB AND PIER CARTON FORMS

SLAB AND PIER CARTON FORMS

SLAB AND PIER CARTON FORMS

SLAB AND PIER CARTON FORMS

VOIDED BASEMENT SLAB WITH FIBERBOARD

FIBERBOARD BENEATH POST-TENSION CABLES

FIBERBOARD BENEATH POST-TENSION CABLES

FIBERBOARD BENEATH POST-TENSION CABLES

VOIDED SLAB SECTIONS COVERED WITH FIBERBOARD

VOIDED SLAB SECTIONS COVERED WITH FIBERBOARD AND MOISTURE RETARDER

VOIDED SLAB SECTIONS COVERED WITH MOISTURE RETARDER

RESIDENTIAL VOIDED FOUNDATION SLAB COVERED WITH MOISTURE RETARDER

DEGRADABLE CARTON FORMS AND TRAILER FOR STORAGE OF FORMS PRIOR TO USE

IN CONCLUSION

- USE VOID SPACE SYSTEMS WHEN HEAVE IS A CONCERN
- GEOTECHNICAL AND STRUCTURAL ENGINEERS BOTH RESPONSIBLE FOR THE DESIGN OF VOID SPACE SYSTEMS
- SPECIFY CARTON FORMS THAT HAVE BEEN INDEPENDENTLY TESTED ACCORDING TO THE PROCEDURES IN THIS PAPER
- KEEP DEGRADABLE FORMS DRY AND ALL FORMS PROTECTED UNTIL USE
- REPLACE ANY DEGRADABLE FORMS THAT GET WET PRIOR TO CONCRETE PLACEMENT
- COVER CARTON FORMS WITH A PROTECTIVE BOARD PRIOR TO CONCRETE PLACEMENT

REFERENCES

SAVWAY Carton Forms
http://www.savwaycartonforms.com/

SureVoid Products Inc.
http://www.surevoid.com

VoidForm International Ltd.
http://www.voidforminternational.com/

FPA-SC-12 Presentation
http://www.foundationperformance.org/committee_papers.cfm

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QUESTIONS?

Download “Specification and Application of Void Spaces Below Concrete Foundations” at:
http://www.foundationperformance.org/committee_papers.cfm