FOUNDATION PERFORMANCE ASSOCIATION
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12 July 2002

American Society of Civil Engineers – Texas Section
3501 Manor Road
Austin, TX 78723
(Via Email: office@texasce.org)

Ref: Recommended Practice for the Design of Residential Foundations

Subject: Comments by the Foundation Performance Association

Dear: Philip King, PE, Chair - Residential Foundation Investigation and Design Subcommittee

On behalf of the Foundation Performance Association, I hereby submit our attached comments to the referenced document.

An ad hoc committee was formed to produce the attached comments. This committee was chaired by the undersigned and co-chaired by David Eastwood, P.E. This committee consisted of the following individuals, all of which are involved in the design, construction, inspection, warranty, forensic assessment, repair or litigation of residential foundations in Texas. Most are members of ASCE, most are professional engineers and several are members of the ASCE committee that drafted the paper that was reviewed.

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In compliance with the ASCE review rules at: http://www.texasce.org/DocumentReview1.cfm , we hereby submit the following information:

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Are you a Texas licensed engineer? *Yes, also see above table*

Do you practice residential foundation engineering? *Yes, also, see above table*

Comment: *See attached*

I propose the following alternative language and I am including Engineering calculations and justifications as needed: *See attached*

Yours truly,
FOUNDATION PERFORMANCE ASSOCIATION

RLKelm

Ron Kelm, P.E.
Secretary, Chair of Committees, Chair of Structural Committee

Attached: FPA Comments to ASCE Residential Design Document
(in both Word and Acrobat Formats with changes and comments highlighted)

****COMMENT: FPA COMMENTS BELOW. ORIGINAL DOCUMENT TAKEN FROM HTTP://WWW.TEXASCE.ORG/DR.HTM . FPA COMMENTS ARE HIGHLIGHTED IN THIS COLOR**-**

FINAL DRAFT DOCUMENT
(Developed at the 01-Feb-02 Meeting held in San Antonio, Texas)

American Society of Civil Engineers
Texas Section
Recommended Practice for the
Design of Residential Foundations

Table of Contents

Section 1. Introduction

The function of a residential foundation is to support the superincumbent structure. The majority of foundations constructed in Texas consist of shallow, stiffened and reinforced slab-on-ground foundations. Many are placed on expansive clays and/or fills. Foundations placed on expansive clays and/or fills have an increased potential for movement and resulting distress.

National building codes have general guidelines which may not be sufficient for the soil conditions and construction methods in the State of Texas. The purpose of this document is to present recommended practice for the design of residential foundations to augment current building codes to help reduce foundation related problems. Where the recommendations in this document vary from published methods or codes, the differences represent the experience and judgment of the majority of the committee members.

On sites having expansive clay, fill, and/or other adverse conditions, residential foundations shall be designed by licensed engineers utilizing the provisions of this document. Expansive clay is defined as soil having a weighted plasticity index greater than 15 as defined by Building Research Advisory Board (BRAB) or a maximum potential ~~swell~~ volume change greater than 1 percent. ~~We propose that local and state governing bodies adopt this recommended practice.~~ ****COMMENT: THIS BELONGS IN THE COVER LETTER TO THE BOARD OF PROFESSIONAL ENGINEERS****

Section 2. Definition of "Engineered Foundation"

An engineered foundation is defined as one for which design is based on three phases:

a. geotechnical engineering information

b. the design of the foundation is performed by a licensed engineer

c. construction is observed with written documentation

These phases are described herein.

Section 3. Design Professionals' Roles and Responsibilities

3.1 Geotechnical Services

The geotechnical investigation and report shall be conducted prior to foundation design under the supervision of and sealed by a geotechnical engineer of record ("geotechnical engineer").

3.2 Design Services

The foundation design engineer shall prepare the plans and specifications for the foundation, and shall be the foundation engineer of record ("foundation engineer"). The foundation shall be built in accordance with the design. The engineer of record shall approve any design modifications. The geotechnical and foundation design engineering may be performed by the same individual~~, provided that individual is sufficiently qualified in both disciplines~~. ****COMMENT: IN A COURT CASE "SUFFICIENTLY QUALIFIED" IS NEVER ENOUGH**

3.3 Construction Phase Services

****COMMENT - THE ENGINEER CANNOT BE FORCED TO PROVIDE INSPECTION SERVICES IF THE CLIENT IS NOT PREPARED TO PAY FOR HIS SERVICES. PLEASE CONSIDER REWRITING AND MAKING THIS SECTION A NON-MANDATORY APPENDIX, BUT IN CASE WITH THE FOLLOWING CHANGES**** ~~The engineer of record shall specify on the plans that construction phase observations shall be incorporated into the foundation construction. These activities shall be performed by: the engineer of record or a qualified delegate. The qualified delegate may be a staff member under his/her direct supervision, or outside agent approved by the engineer of record. The observation reports shall be provided to the engineer of record.~~ It will be specified on the plans that construction phase observations shall be incorporated into the foundation construction inspection report. These activities should be performed by the engineer of record, or a qualified delegate. The qualified delegate may be a staff member under his/her direct supervision, or outside agent approved by the appropriate engineer. The observation reports shall be provided to the engineer of record. The engineer of record shall issue a compliance letter as described in Section 6.3.

Section 4. Geotechnical Investigation

4.1 Minimum Field Investigation Program

The geotechnical engineer~~, in consultation with the engineer of record, if available,~~ shall lay out the proposed exploration program. ~~.~~ A minimum exploration program for subdivisions shall cover the geographic and topographic limits of the subdivision, and shall examine believed differences in geology in sufficient detail to provide information and guidance for secondary investigations, if any. The geotechnical exploration program should take into account site conditions, such as vegetation, depth of fill, drainage, seepage areas, slopes, fence lines, old roads or trails, man made constructions and other conditions that may affect the foundation performance.

As a minimum for unknown but believed to be uniform subsurface conditions, borings ~~shall~~ should be placed at maximum ~~300~~ 200 foot centers across a subdivision. Non-uniform subsurface conditions may require additional borings. A single lot investigated in isolation shall have a minimum of two borings. Borings ~~shall~~ should be a minimum of 20~~15~~ feet in depth unless confirmed rock stratum is encountered at less depth. Borings shall extend through any known fill or potentially compressible materials even if greater depths are required.

All borings shall be sampled at a minimum interval of one per two feet of boring in the upper 10 feet and at 5-foot intervals below that. In clayey soil conditions, relatively undisturbed tube samples should be obtained. In granular soils, samples using Standard Penetration Tests should be obtained. Borings shall be sampled and logged in the field. ~~by a geotechnically trained individual and a~~All borings shall be sampled such that a geotechnical engineer may examine and confirm the driller's logs in the laboratory. ****COMMENT: WHAT IS A"GEOTECHNICALLY TRAINED INDIVIDUAL? THIS NEEDS TO BE DEFINED IF ALLOWED TO REMAIN****

Exploration may either be by drill rig or by test pit provided the depth requirements are satisfied. Sites, which are obviously rock with outcrops showing or easily discoverable by shallow test pits, may be investigated and reported without resorting to drilled borings.

Field logs shall note inclusions, such as roots, organics, fill, calcareous nodules, gravel and man made materials. - The presence or absence of free water in the borehole shall be noted. If encountered, the depth to free water shall be logged. Additional measurements shall be taken at the direction of the geotechnical engineer.

4.2 Minimum Laboratory Testing Program

The geotechnical engineer~~, in consultation with the engineer of record, if available,~~ shall develop the laboratory-testing program. Sufficient laboratory testing shall be performed to identify significant strata and soil properties found in the borings across the site. Such tests may include:

a. Dry Density
b. Moisture Content
c. Atterberg Limits
d. Pocket Penetrometer Estimates of Cohesive Strength
e. Torvane
f. Strength tests
g. Swell and/or Shrinkage Tests
h. Hydrometer Testing
i. Sieve Size Percentage
j. Soil Suction
k. Consolidation

All laboratory testing shall be performed in general accordance with the American Society for Testing and Materials (ASTM) or other recognized standards.

4.3 Geotechnical Report

4.3.1 Report Contents

Geotechnical reports shall contain, as a minimum:
a. purpose and scope, authorization and limitations of services
b. project description, including design assumptions
c. investigative procedures
d. laboratory testing procedures
e. laboratory testing results
f. logs of borings and plan(s) showing boring locations
g. site characterization
h. foundation design information and recommendations
i. color site photos
ji. Professional Engineer's Seal

~~The following sections address site characterization and foundation design information and recommendations.~~ (this is redundant)

4.3.2 Site Characterization

The geotechnical engineer shall characterize the site for design purposes. The report shall comment on site conditions which may affect the foundation design, such as:
a. topography including drainage features and slopes
b. trees and other vegetation
c. seeps
d. stock tanks ~~and other man made features~~
e. fence lines or other linear features
f. geologic conditions
g. surface faults, if applicable
h. subsurface water conditions
i. areas of fill detected at the time of the investigation
j. other man-made features

4.3.3 Foundation Design Information and Recommendations

Reports shall contain ~~the~~ applicable design information and recommendations ~~requested by the engineer of record~~ for each lot in the project. ~~If the engineer of record is not known at the time of the geotechnical report, t~~The following design information should be presented, if applicable:

4.3.3.1 Soil movement potential as determined by the estimated depth of the active zone in combination with ~~at least two~~one or more of the following methods (identify ~~each~~ the method(s) used):

a. Potential Vertical Rise as determined by the Texas Department of Transportation Method 124-E, dry conditions
b. Swell tests
c. Suction and hydrometer tests
d. Linear Shrinkage tests
e. Any other method in accordance with ~~which can be documented and defended as~~ good engineering practice regarding ~~in accordance with~~ the principles of ~~unsaturated~~ soil mechanics

4.3.3.2 Post-Tensioning Institute (PTI) parameters (using their ~~most~~ latest approved~~current~~ design manual and technical notes, unless otherwise prescribed by governmental regulations) including:

a. em and ym for edge lift and center lift modes. Em and ym are based on average climate controlled soil movements and the effect of trees and other environmental effects, as noted in the PTI design manual, should be considered in their derivations. ~~(The em and ym in the PTI design manual are based on average climate controlled soil movements and the design recommendations should take into account the added effect of trees and other environmental effects, as noted in the PTI design manual.); and~~
b. Bearing capacity of the soil, including bearing capacity variation with moisture content.
~~c. If suction values are used to determine the depth and value of suction equilibrium or evaluate special conditions such as trees, the values shall be determined using laboratory suction tests. ym determination shall be based on suction profile change and laboratory determined values of suction-compression index.~~
~~d. em and ym shall be reported for design conditions for suction profile varying from equilibrium, and for probable extreme suction conditions.~~

4.3.3.3 Wire Reinforcing Institute parameters including:

a. Climatic Rating (Cw) of the site
b. Weighted Plasticity Index
c. Slope Correction Coefficient (Cs)
d. Consolidation Correction Coefficient (Co)

4.3.3.4 BRAB design information including:

a. Climatic Rating (Cw) of the site
b. Weighted Plasticity Index
c. Bearing capacity of the soil, including bearing capacity variation with moisture content

4.3.3.5 Finite Element Design Information including:

a. subgrade modulus of the foundation soils

****COMMENT: IF NOT PROVIDED, THE ENGINEER HAS TO GUESS****

4.3.3.6~~5~~ Deep Foundation (pier/pile) design information including:
a. Bearing capacity and skin friction along the pier length
b. Pier types and depths, and bearing strata
c. Uplift pressures on the pier and estimated depth of active zone ~~(pier depth must be below the active zone and provide proper anchorage to resist the uplift pressures)~~
d. Down drag effects on the piers
e. Pier depth below the active zone required to provide proper anchorage to resist the uplift pressures

4.3.3.~~6~~ 7 Shallow foundations (including post and beam footings) design parameters.
a. Bearing capacity, including bearing capacity variation with moisture content ~~and footing depth~~
b. Minimum bearing dimension
c. Footing depth

4.3.3.~~7~~ 8 Soil treatment method(s) to reduce the soil movement potential and the corresponding reduction in predicted movement.

4.3.3.~~8~~ 8 Lateral pressures on any retaining structures or on piers undergoing lateral forces.

4.3.3.~~9~~10 Trees and other site environment concerns that may affect the foundation design. Information useful for design and construction of residential foundations is presented in Appendix A.

4.3.3.11~~0~~ Moisture control procedures to help reduce soil movement.

4.3.3.12~~1~~ Surface drainage recommendations to help reduce soil movement caused by high or changing moisture content.

4.3.3.13~~2~~ Potential for load induced settlement.

4.3.3.14~~3~~ On sloping sites, recommend whether a slope stability analysis is required due to possible downhill creep or other instability that may be present.

4.3.3.15~~4~~ The presence and methods of dealing with existing and proposed fill. Fill criteria useful for design and construction of residential foundations is presented in Appendix B.

4.3.3.16~~5~~ Geotechnical considerations related to construction.

4.3.3.17 Uplift forces for use in designing connections between slab and piers.

4.3.3.18 Minimum grade slopes from the foundation (see Appendix A)

Section 5. Design of Foundations

5.1 Design Information

The foundation ~~design~~ engineer shall obtain sufficient information for the design of the foundation. This may include as applicable:
~~a~~g. information gathered by a site visit
~~b~~f. the subdivision plan, site plan or plat
~~c~~b. the topography of the area including original and proposed final grades and slopes for drainage
~~d~~a. the geotechnical report
e. special requirements of the project
f. ~~the project budget~~
~~g~~c. the architectural ~~elevations and floor~~ plans ~~and sufficient additional architectural information to determine the magnitude, construction materials and location of structural loads on the foundation~~
h. ~~exposed or architectural concrete schedule, if applicable~~
d. information obtained from meetings with client

5.2 Design Procedures for Slab on Ground

5.2.1 The foundation engineer shall utilize one of the following methods, with the modifications presented in this section:
a. PTI
b. WRI
c. BRAB
d. Finite Element
e. other methods ~~which can be documented and defended as~~of good engineering practice

5.2.2 Slab-on-ground foundations with piers shall be designed as stiffened soil supported slabs for heave conditions and as structurally suspended foundations with the beams and slabs spanning between piers for shrinkage and settlement conditions. Piers shall not be attached to the slabs or grade beams unless the connections and foundation systems are designed to account for the uplift forces.

5.2.3 ~~Input variables~~Design methodology for residential slab-on-ground foundations ~~shall~~ should be as follows:

5.2.3.1 PTI:

~~a.~~ Use the current design manual and technical notes, and the following design ~~provisions~~modifications:~~.~~
~~b~~a. Provide minimum residual average prestress of 100 psi.
~~c~~b. Maintain the calculated prestress eccentricity within 5.0 inches.
~~d~~c. If the computed concrete tensile stress at service loads, after accounting for prestress losses, exceeds $4\sqrt{f'c}$, provide bonded ~~additional~~ reinforcement at both the top and bottom of the beam, each ~~equal to~~with an area of 0.0033 times the gross beam

section. The transformed area of steel may be used to determine a new stiffness value for the beam.

ed. ~~The em and ym in the PTI design manual are based on average climate controlled soil movements and the design analysis should take into account the added effect of trees and other environmental effects, as noted in the PTI design manual.~~****COMMENT: THIS IS THE JOB OF THE GEOTECHNICAL ENGINEER. PLEASE MOVE IT TO THAT SECTION IF NEEDED IN THIS DOCUMENT****

d. The designer may specify post tensioning cable construction tolerances.

5.2.3.2 WRI:

~~a.~~ Use the current design manual and technical notes, and the following design provisions.

ba. ~~Regardless of the actual beam length, T~~the analysis length should be limited to a maximum of 50 ft regardless of the actual beam length; and

cb. The minimum design length (Lc) shall be increased by a factor of 1.5 with a minimum increased length of 6 ft.

5.2.3.3 BRAB:

~~a.~~ Use the current design manual and technical notes, and the following design provisions.

ba. ~~Regardless of the actual beam length, T~~the analysis length should be limited to a maximum of 50 ft regardless of the actual beam length; and

cb. Use a maximum long term creep factor ~~as provided~~specified in ACI 318, Section 9.5.2.5 ****COMMENT - PLEASE DENOTE TO WHICH EDITION OF ACI 318 THIS SECTION REFERS OR DELETE THE SECTION REFERENCE****.

5.2.3.4 Finite Element:

a. Use soil support parameters ~~that can be documented and defended as~~of good engineering practice in accordance with the principles of ~~unsaturated~~ soil mechanics recommended in the geotechnical report; ****COMMENT: THE SUBGRADE MODULUS IS TO BE PROVIDED BY THE GEOTECHNICAL ENGINEER****

b. If a design method is used which includes cracking in the concrete then the changes in the moment of inertia due to cracking in the concrete must be considered; and~~Use a cracked moment of inertia for beams that exceed the cracking moment; and~~

c. Use a maximum design deflection ratio ~~of 1 / 360 (deflection ratio is defined as the maximum deviation from a straight line between two points divided by the distance between the two points)~~as specified in PTI, and~~.~~

d. For edge lift design, the soil support may be chosen as a band of width em for edge lift around the periphery of the foundation slab. For center lift design the soil support may be chosen as the area inside of a band of width em for center lift around the periphery of the foundation slab.

5.2.4 Special Design Considerations

The ~~structural~~ foundation engineer should consider the following (deviation ~~shall~~ should be based on generally accepted engineering practice)**:**

5.2.4.1 Exterior corners may require special stiffening. This can be accomplished with diagonal beams, ~~or~~ parallel interior beams near the perimeter beams, or other appropriate methods.

5.2.4.2 Provide continuous beams at reentrant corners.

5.2.4.3 Provide stiffening beams perpendicular to offsets in perimeter beams. ****COMMENT – WE DO NOT UNDERSTAND WHAT THIS MEANS, PLEASE REWORD OR ADD DETAILS TO CLARIFY (DO YOU MEAN DISCONTINUITIES RATHER THAN OFFSETS?)****

5.2.4.4 Provide interior beams at concentrated loads such as fireplaces, columns and heavy interior line loads.

5.2.4.5 ~~Sites with ym exceeding 1.0 inch shall have~~ Sspecial design ~~considerations~~ considerations ~~such as~~ resulting in strengthened sections, revised footprint, site soil treatment, or structurally suspended foundation may be required for sites with ym exceeding 1.0 inch in combination with ~~if any of the following conditions is present:~~
~~a.~~ a shape factor (SF) exceeding 20, (SF = perimeter squared divided by area)
~~b.~~, extensions over 12 ft, or
~~c.~~, concrete lengths exceeding 60 ft

5.3 Design Procedures for Structurally Suspended Foundations

5.3.1 Structurally suspended floors supported by deep foundations shall be designed in accordance with applicable building codes requirements for structural slabs.

5.4 Design Procedures for Footing Supported Foundations

5.4.1 Design in accordance with applicable building codes requirements for footings.

5.4.2 Shallow individual or continuous footing foundations should not be used on expansive soils, unless the superstructure is designed to account for the potential foundation movement.

5.5 Minimum Foundation Plan and Specification Information

5.5.1 Plans shall be signed and sealed by the foundation engineer ~~of record~~, and be specific for each site or lot location. Plans shall include the client's name and engineer's name, address and telephone number; and the source and description of the geotechnical data.

5.5.2 The ~~engineer's~~ drawings shall contain as a minimum:
a. a plan view of the foundation locating all major structural components and reinforcement
b. sufficient information to show details of beams, piers, retaining walls, and drainage details~~, etc.,~~ if such features are integral to the foundation
c. sufficient information for the proper construction and observation by field personnel
d. information or notes addressing minimum perimeter and lot drainage requirements

5.5.3 The ~~engineer's~~ specifications shall include as a minimum:
a. descriptions of the reinforcing and/or pre-stressing cables and hardware;
b. concrete specifications including compressive strengths;
c. site preparation requirements;
d. ~~notes~~ design assumptions used by the foundation engineer concerning nearby ~~existing or future~~ vegetation ~~and the required design features to accommodate these conditions~~; and
e. ~~the schedule of required~~a list of the construction observations and testing required by the foundation engineer.
f. compaction requirements of all structural fill, compaction testing, and reporting by a qualified geotechnical engineer. See Appendix B for more detailed information on fills.

~~**5.5.4** The engineer's plan shall address site fill:~~
~~a. The plans shall address fill existing at the time of the design or to be placed during construction of the foundation and shall require any fills which are to support the bearing elements of the foundation to be tested and approved by a geotechnical engineer assisted by a qualified laboratory (Bearing elements of a suitably designed slab-on-ground foundation are defined as the bottoms of exterior or interior stiffener beams.)~~
~~b. The plan shall require that a geotechnical engineer issue a summary report describing the methods, and results of investigation and testing that were used, and a statement that the existing or placed fills are suitable for support of a shallow soil-supported slab-on-ground, or that the foundation elements should penetrate the fill to undisturbed material. See Appendix B for more detailed information on fills.~~****DELETED BECAUSE OF THE ADDITION OF 5.5.3f****

Section 6. Construction Phase Observation

6.1 Responsibility for Observations

Construction phase observations and testing shall be performed in accordance with this document by the engineer of record, his/her representative, or an independent inspector (inspection company) approved by the engineer of record.. ****COMMENT – SEE COMMENTS UNDER 3.3****

6.2 Minimum Program of Observation and Testing

At a minimum, foundations should be observed and tested as applicable to determine whether:

a. see that fill conditions are satisfied in accordance with the plans and specifications;

****COMMENT – THIS NEEDS TO BE DONE BY A GEOTECH****

b. piers are observed constructed according to the plans. for proper placement and depth;

c. observation of all foundation elements, including reinforcement,, are present immediately before concrete placement;

d. observation of concrete meets the strength and physical requirements as specified andduring placement is properly placed; and

e. observation duringeach tendon is stressing stressed to document the elongation and stressing load of each tendonthe design pretension.

6.3 Compliance Letter

****COMMENT - THE ENGINEER CANNOT BE FORCED TO PROVIDE INSPECTION SERVICES IF THE CLIENT IS NOT PREPARED TO PAY FOR HIS SERVICES. PLEASE CONSIDER REWRITING AND MAKING THIS SECTION A NON-MANDATORY APPENDIX****

6.3.1 At the satisfactory accomplishment of all the requirements of the plans and specifications, the engineer of record shall provide a letter to the client indicating, to the best of his knowledge (which may be based on observation reports by a qualified delegate as defined in Section 3.3), the construction of the foundation was in substantial conformance with:

a. the minimum standards of practice presented in this document; and

b. the engineer's plans and specifications including any modifications or alterations authorized.

6.3.2 A non-compliance letter shall be issued if the construction of the foundation did not meet the requirements of Section 6.3.1.

APPENDIX A

IMPACT OF MOISTURE CHANGES ON EXPANSIVE SOILS

Most problems resulting from expansive soils involve swelling or shrinking as evidenced by upward or downward movement of the foundation producing distress to the structure. The difference between the water content at the time of construction and the equilibrium water content is an important consideration. Potential swell increases with lower initial moisture content. Moisture contents and shrink/swell movements may vary seasonally even after equilibrium is reached.

Other problems resulting from expansive soils involve settlement (usually uneven settlement) resulting in loss of soil bearing capacity caused by inadequate drainage. Clay bearing capacity is not a constant, but decreases with increasing moisture content.

Precipitation and evapotranspiration control soil moisture and groundwater levels. A slab will greatly reduce the evapotranspiration rate beneath the slab and partially reduces the inflow due to precipitation or irrigation because of groundwater's ability to migrate laterally. Therefore, soils beneath a slab are normally wetter than soils at the same depth away from the slab. However, an unusually wet season may result in wetter conditions away from the slab than under the slab. With time and normal precipitation patterns, the soil moisture profile will return to its normal condition. Seasonal variations in soil moisture away from the slab will generally occur fairly quickly. Seasonal variations in soil moisture beneath the slab will be slower. In addition roots from trees and large vegetation will seasonally remove moisture from nearby soils.

Wetting of expansive soils beneath slabs can occur as a result of lateral migration or seepage of water from the outside. It can be aggravated by ponded water resulting from poor drainage around the slab or landscape watering. Leaking utility lines and excessive watering of soil adjacent to the structure can also result in foundation heave.

Foundations can experience downward movement as the result of the drying influence of nearby trees. As trees and large bushes grow, they withdraw greater amounts of water from the soil causing downward foundation movement. The area near trees removed shortly before construction may be drier and subject to localized heave.

Some construction and maintenance issues include the following:

a. In general, set top of concrete at least eight inches above final adjacent soil grade for damp proofing.
b. Provide adequate drainage away from the foundation (minimum ten percent slope in the first five feet and a minimum two percent slope elsewhere). The bottom of any drainage swale should not be located within four feet of the foundation. Pervious planting beds should slope away from the foundation at least two inches per foot. Planting bed edging shall allow water to drain out of the beds.
c. Gutters or extended roof eaves are recommended, especially under all roof valleys. All extended eaves or gutter down spouts should extend at least two feet away from the foundation and past any adjacent planting beds.
d. Avoid placement of trees and large vegetation near foundations (taking into account the water demands of specific trees and vegetation).

APPENDIX B

IMPACT OF FILL ON FOUNDATIONS

Section B.1 FILL

Fill is frequently a factor in residential foundation construction. Fill may be placed on a site at various times. If the fill has been placed prior to the geotechnical investigation, the geotechnical engineer should note fill in the report. Fill may exist between borings or be undetected during the geotechnical investigation for a variety of reasons. The investigation becomes more accurate if the borings are more closely spaced. Occasionally, fill is placed after the geotechnical investigation is completed, and it may not be detected until foundation excavation is started.

If uncontrolled fill (see discussion below) is discovered later in the construction process, for instance, by the Inspector after the slab is completely set up and awaiting concrete, great expense may be incurred by having to remove reinforcing and forms to provide penetration through the fill. Therefore, it is important to identify such materials and develop a strategy for dealing with them early on in the construction process. Fill can generally be divided into three types: engineered fill, forming fill, and uncontrolled fill. These three types of fill are discussed below.

B.1.1 Engineered Fill

Engineered fill is that which has been designed by an engineer to act as a structural element of a constructed work and has been placed under engineering inspection, usually with density testing. Engineered fill may be of at least two types. One type is "embankment fill," which is composed of the material randomly found on the site, or imported to no particular specification, other than that it be free of debris and trash. Embankment fill can be used for a number of situations if properly placed and compacted. "Select fill" is the second type of engineered fill. The term "select" simply means that the material meets some specification as to gradation and P.I., and possibly some other material specifications. Normally, it is placed under controlled compaction with engineer inspection. Examples of select fill could be crushed limestone, specified sand, or crusher fines which meet the gradation requirements. Select underslab fill is frequently used under shallow foundations for purposes of providing additional support and stiffness to the foundation, and replacing a thickness of expansive soil. Engineered fill should meet specifications prepared by a qualified engineer for a specific project, and includes requirements for placement, geometry, material, compaction and quality control.

B.1.2 Forming Fill

Forming fill is that which is typically used under residential foundation slabs and is variously known as sandy loam, river loam or fill dirt. Forming fill is normally not expected to be heavily compacted, and no wise designer will rely on this material for support. The only requirements are that this material be non-expansive, clean, and that it works easily and stands when cut. If forming fill happened to be properly compacted and inspected in accordance with an engineering specification it could be engineered fill.

B.1.3 Uncontrolled Fill

Uncontrolled fill is fill that has been determined to be unsuitable (or has not been proven suitable) to support a slab-on-groundfoundation. Any fill that has not been approved by a qualified geotechnical engineer in writing shall be considered uncontrolled fill. Uncontrolled fill may contain undesirable materials and/or has not been placed under compaction control. Some problems resulting from uncontrolled fill include gradual settlement, sudden collapse, attraction of wood ants and termites, corrosion of metallic plumbing pipes, and in some rare cases, site contamination with toxic or hazardous wastes.

Section B.2 Building on Non-Engineered (Forming Or Uncontrolled) Fill

Foundations shall not be supported by non-engineered fill. To establish soil supported foundations on non-engineered fill, the typical grid beam stiffened slab foundation is required to penetrate the non-engineered fill with the perimeter and interior beam bottoms forming footings. Penetration will take the load supporting elements of the foundation below the unreliable fill. Penetration could be accomplished by deepened beams, spread footings or piers depending on the depth and the economics of the situation. Generally, piers are most cost effective once the fill to be penetrated exceeds about three feet, but this depends on the foundation engineer's judgment and local practice. Floor systems shall be designed to span between structurally supported foundation elements.

Pre-existing fill may be classified as engineered fill after investigation by the geotechnical engineer. The approval may depend on the fill thickness, existence of trash and debris, the age of the fill, and the results of testing and proof rolling. The geotechnical engineer must be able to expressly state after investigation that the fill is capable of supporting a residential slab-on-ground foundation.