FOUNDATION MAINTENANCE AND INSPECTION GUIDE

FOR

RESIDENTIAL AND OTHER LOW-RISE BUILDINGS

by

The Structural Committee

of

The Foundation Performance Association

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PREFACE

This document has been developed by a group of foundation design engineers in Southeast Texas with the goal to educate homeowners, low-rise building owners, and tenants of their duties to maintain their foundations. Foundations, like other parts of a home or building, require a certain amount of maintenance to avoid premature deterioration.

The need for this document has been prompted by a large number of residential and low-rise building foundation problems in Southeast Texas, some of which might have been avoided had owners and tenants properly understood the foundation engineer's design basis and provided the required foundation maintenance. As a result, this document has been prepared and made freely available to the public through the Foundation Performance Association at www.foundationperformance.org so that owners, tenants, realtors, builders, inspectors, engineers, architects, repair contractors, and others involved with residential and other low-rise building foundations may benefit from the information it contains.

A properly engineered foundation will be designed to support its superstructure and buffer it from ground movements and other loadings so that the structural and architectural components do not show significant distress. As with any engineering design, there will be design assumptions made which limit the scope of design so that a foundation can be constructed which is not only strong, meeting the requirements of the Building Code and accepted standard engineering practice, but is also affordable.

The foundation design engineers will want building owners to be satisfied with the performance of the foundations for their buildings. However, building owners must be practical about the nature of the area in which they have built. They must expect and accept a certain amount of foundation movement. With proper maintenance, this movement can be minimized. This document details the responsibilities that foundation design engineers need and expect from the owners and tenants. By following the recommendations contained within this document, the maintainer can greatly increase the probability that the foundation will perform as originally designed.

This document was written specifically for use in the southeast region of the state of Texas and primarily within the City of Houston and the surrounding metropolitan area. Therefore, it should be used with caution if used elsewhere, or if adapted for foundations other than those supporting residential or low-rise structures. The Foundation Performance Association and its members make no warranty regarding the information contained herein and will not be liable for any damages, including consequential damages, resulting from the use of this document.

DEFINITIONS

For the purposes of this guide, certain terms are defined as follows:

Foundation is defined as a composite of soil, concrete, steel, wood, plastic, and other materials that are designed to work together to provide a stable base that supports a superstructure.

Superstructure is defined as the building components above the foundation such as the structural framing and the architectural coverings for the floor, walls, ceilings, and roof.

Foundation Design Engineer is defined as a licensed professional engineer that designs foundations (also called Engineer of Record).

Maintainer is defined as the person or group responsible for monitoring and maintaining the condition of the foundation, usually the owner or tenant.

Sand is defined as soil particles that are at least 0.06 millimeters but less than 2.0 millimeters in diameter. (Note: 1 millimeter = 0.039 inch)

Silt is defined as soil particles that are at least 0.002 millimeters (2 microns) but less than 0.06 millimeters in diameter.

Clay is defined as microscopic soil particles measuring less than 0.002 millimeters (2 microns) in diameter.

Non-Expansive is defined as a property of soil, indicating the soil particles have little potential to swell when moisture is absorbed by them and little potential to shrink when moisture is extracted from them.

Expansive is defined as a property of soil, usually clay, indicating the soil particles have a potential to swell when moisture is absorbed by them and to shrink when moisture is extracted from them. The shrink-swell movements can be in all six directions but the directions of most concern in this guide are the vertical upward (heave) and the vertical downward (subsidence) movements, as defined below.

Settlement is defined as downward movement of underlying supporting soils under load, taking with it the foundation and superstructure, and is due to the immediate elastic compression and distortion of granular or clay soil particles, and the long-term consolidation resulting from gradual expulsion of pore water from voids between saturated clay soil particles. Settlement may occur in all types of soils.

Subsidence is defined as downward movement of underlying supporting expansive soils, taking with it the foundation and superstructure, and is due to the extraction of moisture from the expansive soil particles, and consequently, shrinkage of the expansive soil particles.

Heave is defined as upward movement of underlying supporting expansive soils, taking with it the foundation and superstructure, and is due to the addition of moisture to the expansive soil particles, and consequently, swelling of the expansive soil particles.

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APPENDICES (CHECKLISTS)

1.0 INTRODUCTION

This foundation maintenance guide is divided into several parts, summarized as follows. In Section 2, initial survey requirements are discussed. These initial survey requirements are targeted for use by the maintainer. The intent is that they will be implemented upon initial occupation, whether the structure is new or used. In Section 3, the regular maintenance requirements are summarized, and the requirements for maintenance of the foundation are detailed. In Section 4, a foundation design philosophy is presented, giving the user an understanding of typical assumptions made by the foundation design engineer to design a foundation. Finally, the appendices contain checklists for maintainers to print and use in surveying and maintaining their foundations.

2.0 INITIAL SURVEY REQUIREMENTS

2.1 General

Soon after the initial purchase of the structure is complete, the maintainer may use the checklists in Appendices A and B to determine what action may be required to help ensure that the original foundation design philosophy will not be compromised. The items in the checklists apply whether the purchase is for a new or a used structure.

If there are any signs of distress, the maintainer should employ an experienced consultant, such as a licensed structural inspector to determine if the distress is indicative of a foundation movement problem. It the structure is newly built, the original builder and or foundation design engineer of record should be contacted since they will already be familiar with the structure and usually have some responsibility to ensure its performance.

If the distress is found to be the result of foundation movement, the inspector/builder/engineer of record may recommend that a forensic engineer or other forensic consultant then be hired to investigate the cause of movement. The inspector/builder/engineer of record should also provide a level distortion survey of the foundation. Even if they do not find a cause for concern, the level distortion survey and other documentation provided will be a valuable baseline for a forensic engineer or other consultant to use in case there is foundation movement in the future.

If there are signs of distress for which the maintainer is unsure if they are attributable to foundation movement, it may be helpful to refer to the Foundation Performance Association's technical paper # FPA-SC-03, *Distress Phenomena often Mistaken for Foundation Movement*, freely available to the public at www.foundationperformance.org.

Since foundations on expansive soils have maintenance requirements that differ from or are additional to those for foundations on non-expansive soils, the maintainer should determine if the building is located in an area where expansive soils exist or are likely to exist. One sure way to make this determination is to engage a geotechnical engineer to sample and test the soils at the building site, but this method may cost more than the maintainer is willing to spend. A less expensive but less accurate method is to obtain the soil survey booklet from the U.S. Department of Agriculture for the county where the building is located. Alternately, the maintainer may contact the applicable City or County engineering office and question the building inspectors about their knowledge of expansive soils in the area.

2.2 Exterior Survey

Soon after the initial purchase of the structure is complete, the maintainer should make a reconnaissance-type survey of the site and exterior of the structure for evidence of problems affecting the foundation design. Photographs or other documentation should be made of any obvious or suspected distress or other anomalies observed. For later comparison purposes, it is also recommended to take photographs of all exterior perimeter walls to document their initial condition. A typical checklist that may be followed for this survey is shown in Appendix A.

2.3 Interior Survey

Soon after initial occupation, the maintainer should make a reconnaissance-type survey of the interior of the structure for evidence of problems that are indicative of past unusual movement of the foundation. Photographs or other documentation should be made of any obvious or suspected distress or other anomalies observed. A typical checklist that may be followed for this survey is shown in Appendix B.

3.0 REGULAR MAINTENANCE REQUIREMENTS

3.1 General

During the entire period of ownership, the maintainer should regularly provide maintenance in accordance with the checklists in Appendices C and D to help ensure that the foundation performance and original foundation design philosophy will not be compromised. An interval of twice per year is recommended to monitor the site and structure for required maintenance. The best time is after extreme dry or wet weather periods.

During the surveys outlined in the following subsections, the maintainer should review initial survey photographs and other documentation for changes that have occurred. If there are any new signs of obvious or suspected distress, the maintainer should, after first referring to technical document # FPA-SC-03 (see Section 2.1), seek the services of a forensic engineer or other forensic consultant to determine the cause of distress.

3.2 Exterior Maintenance

Approximately every six months, the maintainer should make a reconnaissance-type survey of the site and exterior of the structure for evidence of new or reoccurring problems affecting the foundation performance. More photographs should be taken or other documentation should be made of any new obvious or suspected distress or other new anomalies that are observed. A checklist that may be used for this survey is shown in Appendix C.

3.3 Interior Maintenance

Approximately every six months, the maintainer should make a reconnaissance-type survey of the interior of the structure for evidence of new or reoccurring problems affecting the foundation performance. If any new phenomena have developed, do not repair them without first having a forensic engineer or a forensic consultant investigate the cause of the distress. More photographs or other documentation should be made of any new distress observed. A checklist that may be followed for this survey is shown in Appendix D.

4.0 FOUNDATION DESIGN CONSIDERATIONS

4.1 General

Depending on its type, location, and the year in which it was constructed, the foundation for the home or low-rise building may have been engineered by a professional engineer who was licensed by the state. In the cases where this was done, the foundation design engineer would most probably have required that a soil exploration be carried out and reported by a geotechnical engineer, also licensed by the state. However, even if it was not an engineered foundation, this section should still give the user insight to the typical foundation design philosophy so that the reasons for providing the maintenance discussed above may become apparent.

4.2 Foundation Types

The foundation's primary function is to provide a stable support for the superstructure, keeping superstructure distress to a minimum. A description of the types of foundations commonly used in the Southeast Texas area follows:

A. **Slab-on-Grade**: This foundation type is the most commonly used and consists of cast-in-place concrete slabs stiffened with grade beams and supported by the surface soils (includes both post-tensioned and conventionally reinforced foundations).

B. **Slab-on-Piers**: This foundation is similar to Slab-on-Grade with a soil-supported slab, except the grade beams are supported on drilled cast-in-place concrete piers. The grade beams are designed to span between the piers, but the slab is normally not designed to span between the grade beams.

C. **Structural Slab on Piers**: This foundation consists of cast-in-place reinforced concrete slabs and beams supported on drilled cast-in-place concrete piers, and that is *not* supported by, but rather usually spans a few inches above, the surface soils.

D. **Pier-and-Beam**: The first floor framing system for this type of foundation is built well above the ground, creating what is commonly called a "crawl space". Typically, there is no concrete slab in this system, and the first floor is framed with wood. The "beam" is part of the framed first floor and spans from pier to pier. The "pier" in this case is an aboveground support, typically cast-in-place concrete or reinforced masonry columns. The aboveground piers are in turn typically supported on drilled cast-in-place concrete piers or cast-in-place concrete spread footings.

   Following are some variations of Pier-and-Beam:

   1) **Crawl Space on Grade Beam**: This foundation system consists of a framed first floor supported on framed walls, which are supported on cast-in-place concrete grade beams.

   2) **Crawl Space on Piers**: This foundation system is similar to Crawl Space on Grade Beams, except the grade beams are in turn supported on drilled and cast-in-place concrete piers.

For a more complete listing of foundation types and their various components, and the reasons for using or not using each, please see the Foundation Performance Association's technical paper # FPA-SC-01, *Foundation Design Options for Residential and Other Low-Rise Buildings on Expansive Soils*, at www.foundationperformance.org (scheduled to be published and freely available late 2003).

4.3 Superstructure Types

The superstructure or framing scheme is the "skeleton" that supports the building enclosure and finishes. The most common types of superstructures used in the area are:

A. **Beam and Column**: This framing system concentrates the building weight to the foundation in small areas or "points" located at the bases of the columns. Typically, a drilled and underreamed cast-in-place concrete pier or cast-in-place concrete spread footing is placed at this point load. The rest of the foundation carries less load than do these points.

B. **Joist and Wall**: This framing system spreads the building weight more uniformly on the foundation, and this affects the location of grade beams and piers or spread footings. The walls may be wood stud, cold-formed steel stud, masonry, or concrete.

4.4 Architectural Coverings

Different types of finishes respond differently to movement. Brittle surfaces, such as stucco, masonry, gypsum board (drywall), glass, and tile, cannot tolerate as much movement as flexible surfaces, such as carpet, wood, and vinyl. This affects the design of the superstructure as well as the foundation.

4.5 Soil Types

Of the various materials making up a foundation, the soil is the one of most concern. Because the soil has the ability to expand, contract or settle, it can load the superstructure as well as support it. The area contains various soil types, which include sand, silt, and clay. Much of the clays in the Houston area, especially those south of Interstate 10, are expansive. Movements in these soils may result in loss of support or the exertion of tremendous upward pressure on foundations, causing unsightly distress to the superstructure.

Unless they have been penetrated by tree roots or have widely disseminated fissures and cracks due to desiccation, the clays in the area often have low permeability, and when found a few feet below a granular surface material such as silt and sand, they can cause perched water tables to occur. When this happens, water is trapped in the silts and sands above. This saturation can cause the soil to lose much of its bearing capacity, consequently causing settlement of the foundation and superstructure.

The area also has active faults, which can cause severe foundation and superstructure distress. However, sites with active faults are usually obvious and well defined, so that foundations today are rarely constructed over them. Many other conditions exist that cause foundation movement, such as instability of sloping soil near a bayou or creek, or improper compaction of fill. Their discussion is beyond the scope of this document.

4.6 Soil Moisture

If expansive, the foundation support soils expand and contract due to changes in moisture content. Changes in moisture content can cause very large changes in soil volume when going from a dry to a saturated condition, and vice versa. This movement does not mean the foundation is improperly designed or that it has failed. The foundation design engineer cannot control the moisture content of the soil, but often the owner/tenant can. Uniformity is the key: uniform moisture content in the soil, uniformly maintained in all areas around the foundation.

If changes in moisture content are uniform, then movement of the foundation will be uniform and less distress will be created in the structure. If changes in moisture content are non-uniform, then there may be differential movement in the foundation. Differential movement can cause greater (and more obvious) distress in the structure.

Leaking pools, leaking plumbing lines, leaking drains, dripping faucets, dripping air conditioning condensate lines, and misdirected water from clogged and broken gutters and downspouts can cause local high moisture contents that can result in differential movement in areas of expansive soils. These conditions should be remedied as soon as possible.

Trees in or near the footprint of the foundation, either removed or planted during construction, cause the majority of foundation problems requiring repair in this area. Trees removed during construction tend to cause heave of expansive soils during the first few years, with initial distress often evident at the time of move-in. Trees planted during or after construction tend to cause subsidence of expansive soils. However, significant subsidence distress will usually not occur for ten to twenty years as the trees mature.

4.7 Site Drainage

It is extremely important, particularly in areas of expansive soils, that water drains away from the foundation and not be allowed to pond against or near the foundation. The soil around the foundation should be graded to an obvious slope (two to five percent). Fill in any low spots with select fill (sandy clay) and level off any high spots.

4.8 Site Vegetation

Avoid the use of metal edging or other damming devices within five feet of the foundation, particularly if the soils are expansive. The roots of trees and large plants remove large quantities of water from the soil. If these trees and shrubs are near the foundation and if sufficient water is not supplied, the soils may shrink if expansive, causing subsidence in the foundation. During dry periods, enough water should be supplied to trees to minimize shrinking of expansive soils around them. Most of the irrigation water should be applied well away from the foundation to attract the tree roots in that direction. When trees mature to the point of shading the entire lot, regular pruning will be needed to reduce their water uptake.

Landscaping (plants, shrubs, flowers, etc.) should not trap water against the foundation. Provide a slope in soils below landscape bedding and in the bedding away from the foundation. Alternatively, provide swales around and through the landscaping to drain water away. Provide uniform ground cover around the foundation. This will help keep the moisture evaporation rate uniform. In areas that are not planted, use mulch. Extend the ground cover at least five feet from the foundation.

4.9 Climate

During periods of dry weather, the soil around the foundation should be irrigated if the building is located in an area where expansive soils are known to occur. The most commonly used irrigation system is aboveground timed sprinklers with a manual override so they can be turned off in rainy weather. An automatic belowground irrigation system that senses the moisture content of the soil may also be used.

Tend to keep the irrigation system set on "manual", and only use it in drier periods when wilting of the lawn grasses and other vegetation occurs. The irrigation should be done at least one to two feet away from the foundation, and then lightly so that tree roots are not attracted there. Do not allow sprinklers to spray water against the structure. In extended dry periods, should the soil crack and pull away from the foundation, do not water directly into the gap.

4.10 Initial Soil Movement

Due to the changes in the environment and the load to the soils around a new foundation, the soils have to be allowed to adjust and reach a new equilibrium. This will result in some movement in the soils, foundation, and superstructure. The soils normally stabilize within the first one or two years after construction. However, this initial movement should not cause more than hairline cracking in the superstructure and is usually undetectable to the common building owner that is not looking for distress.

If more than hairline distress is observed, the maintainer should contact the builder/inspector/engineer of record to determine if the distress is due to abnormal foundation movement. If the observed movement is believed to be abnormal, then a forensic engineer or forensic consultant should be contacted to determine the cause of movement.

APPENDIX A - INITIAL EXTERIOR SURVEY	**Date_____**	
Category	**Items to Check (at the time of purchase or move-in)**	√
Cracks & Separations	Check that there are no cracks or separations in the walls if the structure is new.	
	Check that the observed cracks or separations are no more than hairline if the structure is used and is less than 10 years old.	
	Check that the observed wall cracks or separations are no more than 1/8" wide if the structure is more than 10 years old.	
	Check that vertical expansion joints in brick are uniform in width.	
Drainage	Check that water does not pool near the foundation after a heavy rain. If it does, bring in fill and re-grade or add an underground drainage system with area drains.	
	Check that the grade slopes away from the foundation at least 1 inch vertical per foot horizontally for the first 5 feet all around the perimeter (may be less where paving occurs). If necessary, revise the grade with sandy clay (not sand alone) fill or add underground drainage.	
	Check that where paving occurs near the structure, that it positively drains away from the foundation. If not, add underground drainage with area drains or re-pave.	
	Check that downspouts and gutters are clean and water from downspouts is directed away from the foundation.	
	Check that gutters and downspouts exist and that downspouts are tied directly into an underground drainage system or at least have aboveground extensions (e.g. flexible plastic pipe or long concrete splash block) to carry the water at least five to ten feet away from the building before it is allowed to run onto the soil. (Does not apply if the soil is known to be predominately non-expansive.)	
Vegetation	Check that there is no broadleaf tree (e.g., oak, ash, tallow, pecan, hackberry, etc.) closer to the foundation than a distance equal to the height of the tree, even if the tree is on an adjacent property. (Does not apply if the soil is known to be predominately non-expansive.)	
	Check that there is no conifer tree (e.g., pine) closer to the foundation than a distance equal to the radius of its canopy, even if the tree is on an adjacent property. (Does not apply if the soil is known to be predominately non-expansive.)	
	Check that there are no trees of any kind and no large shrubs growing next to the foundation. (Does not apply if the soil is known to be predominately non-expansive.)	
Water Leaks	Check that there are no leaks near the foundation, such as a faucet drip or a condensate drip from an air conditioning unit. If found, repair as needed.	
	Check that the automatic sprinkler system (if applicable) is properly functioning. Change settings as required to keep watering uniform but to a minimum (as needed to support the vegetation), particularly around the foundation. Set the cycle times to purposely water trees away from the structure in an effort to establish their roots away from the foundation.	
	Check that swimming pools, ponds, and fountains hold water without leaking.	

APPENDIX B - INITIAL INTERIOR SURVEY	**Date_____**	
Category	**Items to Check (at the time of purchase or move-in)**	√
Cracks & Separations	Check that there are no cracks or separations in the coverings for the walls, ceilings, or floors if the structure is new.	
	Check that the observed cracks or separations in the coverings for the walls, ceilings, or floors are no more than hairline if the structure is used, but is less than 10 years old.	
Water Leaks	Check that all plumbing works properly, and that there is no stoppage or leaks. If a problem is found, repair as needed.	
Miscellaneous	Check that each door hangs properly, i.e., it does not stick, swing open, or shut on its own, and that there is no appreciable gap between the top of the door and its doorframe header above.	
	Check that there are no uncomfortable floor slopes, easily noticed by walking each room.	
	Check that wood rafters (where applicable) in the attic are not pulled away from ridge members.	
	Check that there is no evidence of past drywall or other architectural repairs.	

APPENDIX C - REGULAR EXTERIOR MAINTENANCE Date_____

Category	Items to Check (at six-month intervals)	√
Cracks & Separations	Check for new or changed cracks or separations in the walls. If some have developed, do not repair them without first having a forensic engineer or a forensic consultant investigate the cause of the distress.	
	Check that masonry expansion joints are of uniform width top to bottom and the mortar joints are aligned.	
Drainage	Check that water does not pool near the foundation after a heavy rain. If found, correct the grade slope or add underground drainage.	
	Check the automatic sprinkler system (if applicable) for proper settings to give the site vegetation sufficient moisture to keep it from wilting, but without over-watering it. As part of the check, look inside each underground valve box and in the main water meter valve box to make sure they are dry. If the valves are submerged, suspect over-watering and stop watering in those zones until they are again dry or until the vegetation begins to wilt.	
	Check that patios and flatwork around the structure are providing positive drainage away from the foundation.	
	Check that fences, flowerbeds, or edging are not blocking drainage.	
	Check that downspouts and gutters are clean, and water from downspouts is directed away from the foundation.	
	Check for clogs or leaks in any existing downspout extensions, area drains, or underground drainage pipes, and clean and repair as required.	
Vegetation	Check that there is no broadleaf tree (e.g., oak, ash, tallow, pecan, and hackberry, etc.) closer to the foundation a distance equal to the height of the tree, even if the tree is on an adjacent property. If such is the case, begin a pruning program to keep the tree's canopy at that size for the rest of its life. A reasonable pruning interval would be every 2 - 3 years. (Does not apply if the soil is known to be predominately non-expansive.)	
	Check that there is no conifer tree (e.g., pine) closer to the foundation a distance equal to the radius of its canopy, even if the tree is on the adjacent property. If such is the case, begin a pruning program to keep the tree's canopy at that size for the rest of its life. A reasonable pruning interval would be every 2-3 years. (Does not apply if the soil is known to be predominately non-expansive.)	
	Check that there is no new tree of any kind coming up next to the foundation. If found, remove it.	
	Check that there are no shrubs next to the foundation that have grown to the point where they approach a one story roof in height. If found, cut them back to window height or replace them with a smaller variety. (Does not apply if the soil is known to be predominately non-expansive.)	
Water Leaks	Check that no leaks have developed near the foundation, such as a faucet drip or a condensate drip from an air conditioning unit, particularly from its emergency overflow pipe. If found, repair as needed.	
	Check that the underground drainage system (if applicable) is properly functioning. If it does not drain freely, investigate and clean as needed to achieve normal flow.	
	Check that swimming pools, ponds, fountains, etc. are holding water without leaking. If suspected of losing water below grade, have a pool-leak-detection company investigate, isolate, and repair the leak.	

APPENDIX D – REGULAR INTERIOR MAINTENANCE	**Date_____**	
Category	**Items to Check (at six-month intervals)**	√
Cracks & Separations	Check that there are no new or changed cracks or separations in the coverings for the walls, ceilings, or floors.	
Water Leaks	Check that all plumbing works properly, and that there is no stoppage or leaks. If found, repair as needed.	
Miscellaneous	Check that there are no uncomfortable floor slopes by walking each room. If the maintainer is the tenant, perhaps ask someone else to check this, as it is easy to become accustomed to slopes that have gradually changed over time.	
	Check that wood rafters (where applicable) in the attic are not pulled away from ridge members.	
	Check that each door hangs properly (or as it did before), i.e., it does not stick, or swing open, or shut on its own, and there is no appreciable gap between the top of the door and its doorframe header above.	
	Check interior countertops for levelness, and check cabinet doors and drawers for proper operation.	