GUIDELINES FOR EVALUATING FOUNDATION PERFORMANCE BY MONITORING

by
The Structural Committee

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PREFACE

This document was written by the Structural Committee and has been peer reviewed by the Foundation Performance Association (FPA). The FPA has published this document as FPA-SC-12 Revision 0 making it 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 at 1, 2, etc.

The Structural Committee is a permanent committee of the Foundation Performance Association. When the writing of this document commenced, Ron Kelm, P.E., chaired the Structural Committee and 25 to 30 members were active on the committee. The committee sanctioned this paper and formed an ad hoc subcommittee to develop the document. The subcommittee chair and members are listed on the cover sheet of this document.

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 will form a new subcommittee to revise this document. If the revised document successfully passes FPA peer review, it will be published on the FPA website and will replace the previous revision.

The intended audiences for the use of this document include engineers, inspectors, foundation warranty companies, foundation repair contractors, builders, owners, attorneys and others that may be involved in the assessment of foundation movement of residential and other low-rise buildings. This document was created with generously donated time in an effort to improve and help establish a standardized basis for the assessment of the performance of foundations. The Foundation Performance Association 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.

It is the desire of the Structural Committee that this document be used not only to inform, but also to establish a sense of uniformity in the industry on monitoring foundations of residential and other low-rise buildings. This paper was written specifically for use in Southeast Texas and should be used with caution if adapted elsewhere.

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1.0 INTRODUCTION

The purpose of this document is to provide guidelines for monitoring foundations over time, which will help in:

- Determining when excessive foundation movement is occurring,
- Evaluating if excessive foundation movement has likely ceased, and
- Understanding why the movement occurred.

When excessive movement has likely ceased, repairs may be made with reduced risk that additional Distress Phenomena will reappear. Monitoring surveys made utilizing these guidelines require site visits made over a period of time. This paper offers a procedure to follow while monitoring a foundation for excessive movement, and provides guidelines to be used in determining when the excessive movement has abated.

These guidelines are written with the assumption that an initial foundation survey has been conducted that includes foundation Elevations and a Distress Phenomena survey. This paper focuses on symptoms (foundation movement) and only briefly addresses the subject of causes, such as lack of code compliance in foundation design, site, preparation, construction, and drainage.

2.0 DEFINITIONS

For the purposes of this paper, the following terms are defined:

Adjusted Elevation Plan is the set of Data Point Elevations that are translated vertically to adjust for changes in floor covering thicknesses and steps. The Adjusted Elevation Plan should include the date the survey was made and be recorded on an architectural floor plan that shows walls, showers, sinks, countertops, etc.

Benchmark is a specially installed Data Point near the foundation and is designed and assumed to have zero or negligible movement for the monitoring activities. A Benchmark may be installed in cases where the direction of foundation movement is not easily diagnosed. If a Benchmark is used, the Elevation of the interior Reference Point is recorded relative to the Benchmark during each site visit. When a specially installed Data Point is not feasible, a Benchmark may be selected as a designated point on a surface convenient to the subject foundation. It should be noted that trees, curbs, light stanchions, manhole covers, etc., have been shown to move significantly relative to foundations and are usually not reliable choices for a Benchmark.

Contours are lines that connect points of equal and consistent elevations. Contours may be drawn on an Adjusted Elevation Plan to determine the vertical deformation of the foundation, or on a Time-change Elevation Plan to determine the direction of movement over a specific time period. Contours should be plotted in equal increments.

Data Point is the location where an Elevation is measured.

Distress Phenomena are the visual manifestation of damage that is likely caused by foundation movement and reflected by the creation of separations, cracks, or other damage. Distress Phenomena may also be referred to as Negative Phenomena. For a discussion of Distress Phenomena not caused by foundation movement see document FPA-SC-03, "Distress Phenomena Often Mistakenly Attributed to Foundation Movement", which is freely available at www.foundationperfomance.org. Distress Phenomena can be categorized into three groups as follows:

> ***Architectural Phenomena*** are defined as cosmetic Distress Phenomena resulting from minor separations in the walls, floors (reflecting cracks and/or excessive curvature in the slab below), ceilings, paving, etc. that are often noticeable by the building's occupants.
>
> ***Functional Phenomena*** are defined as Distress Phenomena affecting the use of the residential or low-rise building. Examples are doors or windows that stick, leak, will not close, or will not latch, and doors which open or close on their own (ghost doors). Some other examples include noticeable floor slopes or wall tilts, tilted countertops, and vertical pavement offsets sufficient to cause tripping.
>
> ***Structural Phenomena*** are defined as Distress Phenomena affecting the stability of the building. This would encompass separations or distortions to structural support members such as studs, columns, beams, foundation, or pavement elements such that the member may no longer support the intended design load.

Elevation of a Data Point is the measured vertical height above or below the Reference Point.

Maximum Differential Elevation is the greatest change in Elevation between all Data Points in the Adjusted Elevation Plan. The Maximum Differential Elevation is a positive number, computed by subtracting the smallest value from the largest value, and this amount is sometimes referred to as "Out-of-Level".

Monitor Period is the time between any two Elevation surveys.

Monitor Point is a Data Point at the top of the floor covering or foundation surface that is easily found again, such as a corner of a room or under a ceiling light fixture. Monitor Points should not be located on a wearing surface, such as a high-traffic carpeted area in a doorway. Monitor Points are normally distributed uniformly throughout the foundation, with a total of approximately one Monitor Point per 75 to 100 square feet of foundation area. It is, however, ultimately the individual's discretion to record an adequate number of Monitor Points.

Phenomena Plan is a representation of observed Distress Phenomena, presented on an architectural floor plan. The Phenomena Plan may be presented separately or combined with the Adjusted Elevation Plan or the Survey Elevation Plan. There are many ways to compile a Phenomena Plan and no example is given in this guideline.

Plot Point is a Monitor Point that is graphed over time to show how the Monitor Point has or has not moved vertically. Plot Points usually number between 5 and 8 for a typical residence, or approximately 2 per 1000 square feet for larger structures, and are labeled alphabetically (A, B, C, etc.) on the Survey Elevation Plan. The Reference Point may be chosen as one of the Plot Points. The Benchmark, if available, should be a Plot Point.

Reference Point (Datum) is the location used as a baseline in computing Time-change Elevations over the foundation. The Reference Point may be the Benchmark, or it may be an interior or exterior point that may move up or down but is assigned an arbitrary value such as 0.0”. Typically the Reference Point is located near the center of the foundation.

Stabilized is the condition of the foundation movement when the foundation-soil interaction is small enough, based upon the available data, that repairs to the Distress Phenomena may be made with reduced risk of recurrence of the Distress, assuming current conditions of known influences to foundation performance remain unchanged. Stabilization guidelines are further defined in Section 4.0. For more information regarding factors that influence foundation performance, see document FPA-SC-07, “Foundation Maintenance and Inspection Guide for Residential and Other Low-Rise Buildings”, which is freely available at www.foundationperfomance.org.

Survey Elevation Plan is the set of raw (unmodified) data recorded during an Elevation survey. It should be recorded on an architectural floor plan and include the date the survey was made. The data shown in the Survey Elevation Plan are not adjusted for differences in floor covering thicknesses and steps. The data on the Survey Elevation Plan are as-measured values.

Time-change Elevation is the change in Elevation of a Monitor Point over a Monitor Period. It is determined by subtracting the earlier Elevation from the more current Elevation. Only equivalent plans may be used to calculate the Time-change Elevation, i.e. it is not possible to calculate Time-change Elevations between an Adjusted Elevation Plan and a Survey Plan. The set of Time-change Elevations should be recorded on an architectural floor plan and include the dates of the two sets of data used and the name of the company(s) that recorded the data.

3.0 TESTING TO ASSIST IN THE MONITORING PROCESS

Tests that may be helpful in diagnosing the cause(s) of foundation movement, to predict future movement, and/or to confirm the cessation of movement are discussed below. Results and conclusions based on the tests and procedures detailed below should be noted in subsequent report(s) to the client.

3.1 ELEVATION SURVEYS

Elevation surveys are an intrinsic method of determining foundation movement. Elevation surveys provide information not necessarily visible to the eye, such as direction, location and magnitude of movement. It may be helpful to record all sets of Survey Elevations on the same drawing as illustrated in Section 6.2. All Elevation plans should indicate the type of floor covering in each area.

The Survey Elevation Plan recorded just prior to or just after closing should be considered the initial survey for monitoring purposes. If a survey was not conducted at that time, the oldest Elevation survey available should be considered the initial survey.

Sections 4.0 and 5.0 further discuss this method of investigation.

3.2 GEOTECHNICAL TESTS

When geotechnical testing is obtained, the Potential Vertical Movement (PVM) analysis utilizing soil suction should be used to quantify the amount of potential future movement. Moisture contents, soil strength, water table elevation, and perched water conditions should be included in the geotechnical testing, and these results should be compared to the prior geotechnical report, if available. For a guideline on minimum requirements for geotechnical testing, see document FPA-SC-04, "Recommended Practice for Geotechnical Explorations and Reports", which is freely available at www.foundationperfomance.org .

Soil moisture and soil strength are easily estimated by pushing a plumber's probe or other slender object into the soil in question and noting the insertion pressure required, the depth obtained for a given effort, and the dampness and plasticity of the soil. It is advisable to probe various places around the perimeter of the foundation. In this manner the soil resistance may be estimated at each monitoring event and correlated with the foundation movement.

3.3 CORING

Concrete cores may be extracted and analyzed for thickness, strength and composition to ascertain whether the concrete parameters agree with the original foundation design. Other data from coring include depth of concrete, voids, aggregate size, cold joints, large cracking, and, if the core is drilled through steel, the steel reinforcing size and location may be determined. Care should be exercised to avoid coring through post-tensioned cables and grade beams.

3.4 PETROGRAPHIC ANALYSIS

Petrographic analysis is a microscopic examination of a concrete sample using chemicals and lighting techniques to determine information such as the type of cement used, and the proportions of fly ash, slag, ground limestone or other mineral admixtures, if present. The examination may also determine the aggregate type and whether it is acid soluble, the water-cement ratio, the amount of entrained air, the extent of hydration, the condition of the sample, whether deposits or contaminants are present, and if there is micro-cracking.

3.5 GEOPHYSICAL TESTING

Geophysical tests, such as ground penetrating radar and resistivity measurements, may provide additional information. This information may include the depth of the slab and grade beams, the placement of slab reinforcement, soil moisture and the presence of voids, water pockets and/or other subsurface objects.

3.6 PLUMBING LEAK DETECTION TESTS

Plumbing leak detection tests may be utilized at any time to determine the presence of drain line leaks beneath or near the foundation. Plumbing leak detection tests are often utilized during or after the occurrence of excessive foundation movement to assess if the movement caused below-slab leaks in the plumbing lines. Alternatively, the presence of leaks, and corresponding information regarding the amount of water expelled through the leak(s) may be used to correlate with the foundation movement that has occurred.

Area drains should be checked to insure that water discharges away from the foundation. Sprinkler systems, swimming pools, and other sources of exterior water should be checked if leaks are suspected.

Noting the location of leaks on a Phenomena Plan, an Adjusted Elevation Plan or a Time-change Elevation Plan may assist the user in diagnosing the type of foundation movement.

3.7 GROUNDWATER MONITORING

Testing that utilizes a pressure gauge, such as a piezometer, may be used to detect the presence of subsurface free water. Variations in hydrostatic pressure are indicative of changes in ground water elevation. Chemical testing of collected water samples may be useful in determining the water’s age and source.

3.8 SITE RECONNAISSANCE

A variety of site reconnaissance testing and observations that may provide additional information about the type and expected duration of movement are discussed below.

3.8.1 Aerial Photos

Aerial photos provide pre-construction site information, such as if a foundation was built over an old lake, road, ditch or bayou, or if the lot contained trees prior to clearing. Aerial photos may be obtained freely on the internet for limited dates, and photos taken on many specific dates may be purchased. Graphics software may be used to overlay an aerial photo taken prior to subdivision development onto a post-construction aerial photo.

3.8.2 Topographic Maps

For sloped terrain, topographic maps may be helpful to diagnose the cause of excessive foundation movement. For example, comparison of preconstruction and post-construction topographic maps may indicate changes in surficial water flow and/or the placement of fill.

3.8.3 Excavation at the Foundation

Excavation of the soil around the grade beams, slab and/or piers may be helpful in diagnosing the cause of movement. Presence (or lack thereof) of gaps between the grade beam and piers, depth and size of piers, bells and grade beams, presence of water around the grade beam or at the base of the pier, and condition of the soil should be noted. Examination of the soil around the grade beams and/or piers may indicate if the excavated portion of the foundation was constructed in compliance with the building code and the design plans, if available.

A plumber's probe may be used to determine the approximate depth of grade beams, and the presence of piers.

3.8.4 Drainage

The drainage around the entire foundation, and especially the area of the foundation experiencing the excessive movement, should be inspected and corrected if it appears that poor drainage is causing the movement. Examples of poor drainage include, but are not limited to, downspouts that discharge adjacent to the foundation, flat grade or grade that slopes towards the foundation (note that current code requires that finished grade has a minimum 5% slope away from the foundation for the first 10' and a minimum 2% slope elsewhere), graveled areas that allow water easy access to the soil around the foundation, planters adjacent to the foundation that impede water egress, overflow A/C condensate ponding adjacent to a grade beam, and lack of gutters in areas, such as at a roof valley, that concentrate much of the roof's watershed into one location.

Additional water sources, which may increase foundation movement and are exacerbated by poor drainage, are soaker hoses and sprinkler systems. When soaker hoses are present their use should be established and the quantity of water placed around the foundation estimated. When a sprinkler system is installed, observe its operation. If it is a manual system, determine the frequency of use, or if it is an automatic system, examine the system controller to determine the frequency and duration of watering. Watering should not exceed that necessary for grass and plants.

3.8.5 Landscaping

Location of trees and other large vegetation near the foundation should be observed. It is helpful to note the diameter of the tree trunks, their distance from the foundation, and their canopy size. Including significant landscaping and landscaping changes, such as a felled tree, on a Phenomena Plan, an Adjusted Elevation Plan or a Time-change Elevation Plan may assist the user in diagnosing the type of foundation movement.

3.8.6 Rainfall Data

Rainfall data may be useful, is often freely available on the internet and may include historical rainfall data as well. The rainfall (or lack thereof) should be correlated with the degree of movement during a Monitor Period. Historical rainfall data prior to construction may aid in diagnosis of movement and prediction of its abatement.

4.0 STABILIZATION GUIDELINES

Movement of a foundation may be the result of cyclical movement due to trans-evaporation in conjunction with the wet and dry seasons, or non-cyclical movement of the soils below the foundation. The foundation should be monitored for a minimum of one year to assess whether the movement is cyclical or non-cyclical.

Sections 4.1 and 4.2 below discuss Time-change Elevation guidelines and Distress Phenomena guidelines, based on the experience and judgment of this committee, that must be satisfied before the subject foundation will be considered to have Stabilized. Some situations require engineering judgment calls that may negate the results of these guidelines. In addition to Time-change Elevation and Distress Phenomena guidelines, testing and observations that may affect the engineering judgment call are discussed in Section 3.0.

4.1 TIME-CHANGE ELEVATION GUIDELINES

Time-change Elevations should be calculated for all Monitor Points (common to both surveys) and may be noted on a Time-change Elevation Plan. The foundation-soil interaction will be considered to have Stabilized if all of the following have been met:

a) A minimum of three Time-change Elevation Plans is completed over a minimum period of one year. The Elevation measurements are more meaningful when the foundation has experienced a complete set of seasons, i.e. the first and last set of measurements were separated by a minimum of one year and were recorded in the same season. Ideally, Monitor Point Elevations should be recorded every three months for more accurate and expedient diagnosis of the cause of movement.

b) The Maximum Differential Elevation of the Time-change Elevation Plan is 0.3” or less over a three or four month period and 0.4” or less over a six to eight month period.

c) The Distress Phenomena guidelines discussed in Section 4.2 are met.

d) The climatic and seasonal conditions correlate with the amount of movement. See Section 3.8.6 for more information.

e) All drainage, plumbing leaks, and other moisture issues were remedied six months or more prior to the current Monitoring Period.

The foundation-soil interaction may also be considered to have Stabilized when the movement reverses on itself, i.e., moves in the opposite direction such that separations tend to close, as is indicative of cyclical movement, provided that no new significant Distress Phenomena are observed, and the movement correlates with the rainfall data.

A graph of Plot Points versus Time may be useful in diagnosing the direction of movement and may indicate whether or not the foundation-soil interaction has Stabilized. Two examples follow to provide guidance to the user. See Section 6.4 for more information.

Figure 4-1.1 depicts the Elevations of six Plot Points on a foundation over a period of two years relative to an internal Reference Point. The graph indicates excessive, non-cyclical movement is occurring because the Elevations are random in nature. Overall, these Monitor Points increase over time and do not follow a general cycle. A plot similar to Figure 4-1.1 may indicate that the foundation-soil interaction has not Stabilized.

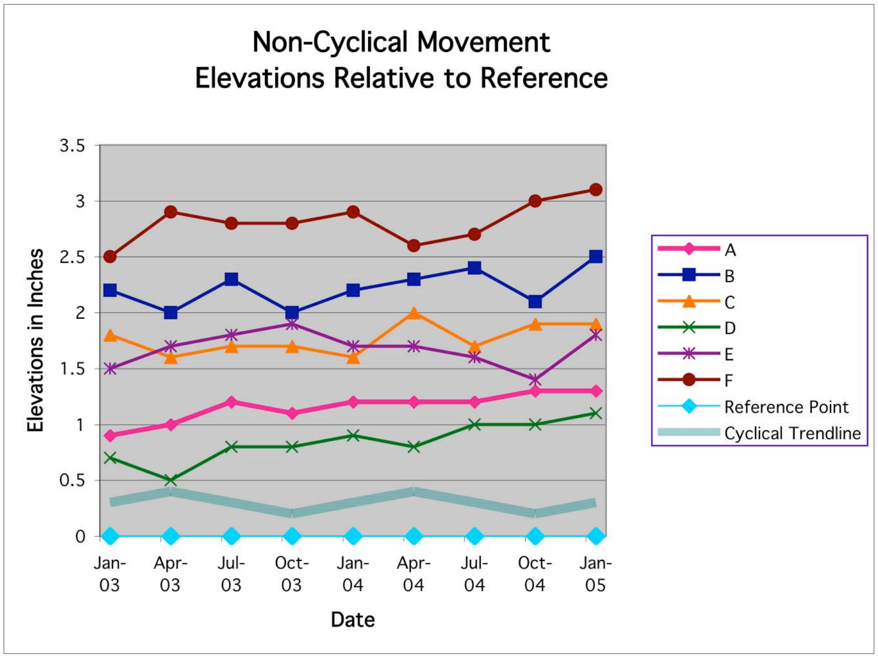

Figure 4-1.1 - Non-cyclical movement

Figure 4-1.2 depicts the Elevations of six Plot Points on a foundation over a period of two years relative to an internal Reference Point. Plots similar to Figure 4-1.2 are common for foundations experiencing normal cyclical movement because the high temperatures and lack of rain in the summer may cause the surrounding soils, if expansive, to dry out and subside, and the low temperatures and rain in the winter may cause the same soils to rehydrate and heave.

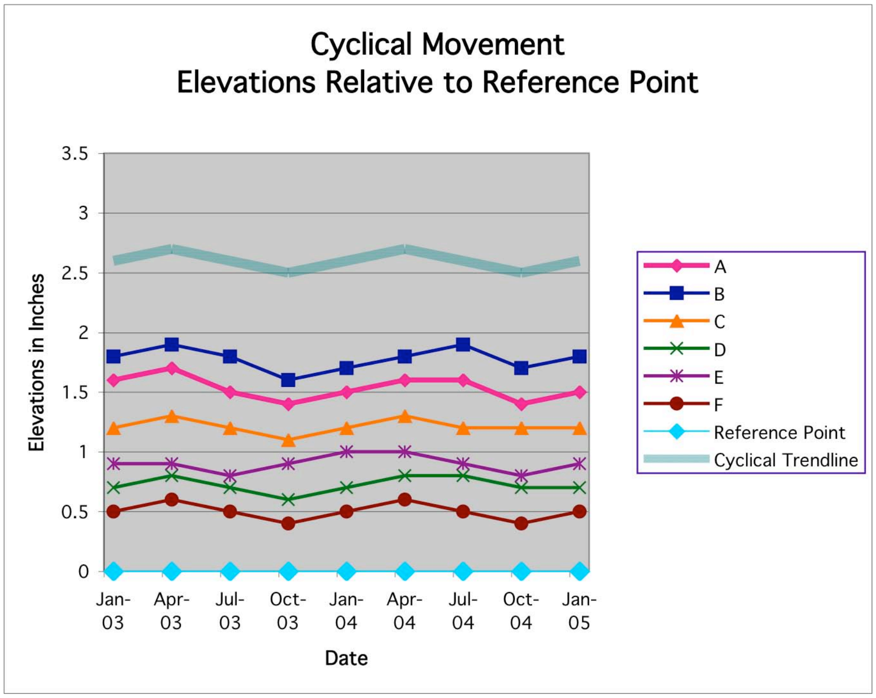

Figure 4-1.2 - Cyclical movement

For slab-on-grade foundations and other foundation systems designed to perform acceptably under cyclical movement, the Time-change Elevation Plan and Plot Points Graph will show cyclical movement when it occurs.

The accuracy of measurement must be taken into account. Normally the accuracy of a manometer based level is 0.2" (i.e., ±0.1") or ±1/8", depending upon the equipment used. The accuracy of operator measurement (i.e., finding the same exact measuring point, taking a reading prior to equilibration, or a change in the ambient temperature in the measurement area) may be an additional ±0.1". Thus, some isolated Time-change Elevation measurements of ±0.2" may be dismissed unless there are other changes that correlate with the observed Time-change Elevation measurement, such as new or increased Distress Phenomena in the area of the measurement.

Each Time-change Elevation point should correlate with the surrounding Time-change Elevation points. A Time-change Elevation point that does not correlate with the surrounding points is usually assumed to be a measurement error and may be discounted.

It may be helpful to draw Contours based on the Time-change Elevation plan. See Figure 6-3 for an example. Contours with respect to multiple sets of Time-change Elevation Plans may indicate the direction of the movement during the Monitor Periods. Over the course of several Monitor Periods the locations of the minimum and/or maximum Contour lines may shift.

4.2 DISTRESS PHENOMENA GUIDELINES

New Distress Phenomena, if present, should be noted during each monitoring site visit and recorded on the Phenomena Plan. In general, if a significant Architectural Phenomenon, or if multiple minor Architectural Phenomena, such as short hairline separations, have occurred since the previous site visit, the foundation-soil interaction will not be considered to have Stabilized. If any new Functional or Structural Phenomena are observed, the foundation-soil interaction will not be considered to have Stabilized.

It is common to observe new Architectural Phenomena with only minor differential movement indicated by the Time-change Elevations. This often occurs because architectural finishes are able to withstand a finite amount of movement without any visual manifestation, and it may take only a slight amount of additional movement, often undetectable through the accuracy of most monitoring equipment, to cause these to appear. Therefore, if a minor amount of new Architectural Phenomena are observed and negligible Time-change Elevations are calculated over the prior three months and/or the prior six months, it is at the discretion of the user to determine if the foundation-soil interaction has Stabilized, or if monitoring should continue.

When separations have been repaired, and the separations reoccur in the same or adjacent locations, this typically indicates continuing movement in the same direction, not cyclical movement. Also, during normal cyclical movement, if separations have been repaired, then new separations may occur when the foundation returns toward its initial Elevation.

When few new Distress Phenomena are observed and the Time-change Elevation guidelines discussed in Section 4.1 are satisfied, the foundation-soil interaction will be considered to have Stabilized.

5.0 PROCEDURE

This procedure describes the recommended steps to follow during each monitoring event in order to conduct an Elevation survey, record Distress Phenomena, and analyze the collected data. It is at the discretion of the user to determine which steps are appropriate to the specific case. The frequency of monitoring is discussed in Section 4.1. Each monitoring event should include the following:

5.1 SITE WORK

- Interview the owner or tenant for changes in and around the residence that have occurred since the last site visit, such as replaced flooring surfaces, plumbing leaks, addition of gutters, changes in irrigation habits, tree removal, drainage changes, new Distress Phenomena, etc.

- Walk the exterior and interior of the residence and record changes in Distress Phenomena observed since the last site visit, changes in landscaping, and changes in soil moisture when applicable.

- Record Elevations using the same Reference Point and Monitor Points used in the previous monitoring(s). If a Benchmark is used, record the Elevation of the interior

Reference Point relative to the Benchmark. Recording current Monitor Point Elevations on the previous Survey Elevation Plan may lessen the possibility of operator error, as the operator should notice immediately if an Elevation differs unexpectedly from the previously recorded Elevation.

5.2 DATA EVALUATION

See Section 3.0 for additional testing to help diagnose the causes of foundation movement. The following steps should be completed after every Monitor Period, unless noted otherwise:

1. Compare current Distress Phenomena with previously documented Distress Phenomena. On the Phenomena Plan, new Distress Phenomena should be differentiated from existing Distress Phenomena.

2. Prepare a current Adjusted Elevation Plan.

3. Generate Contours based on the Adjusted Elevation Plan and visually compare the results to previously documented Adjusted Elevation Plans with Contours, if available. The direction, magnitude and rate of foundation movements that occurred during the Monitor Period may be determined from this comparison.

4. Compute Time-change Elevations between the current set of Monitor Points and the Monitor Points recorded at the previous monitoring event (See Figure 6-3) and, if desired, compute Time-change Elevations between the current Monitor Points and any other set(s) of Monitor Points.

5. Graph the Plot Points (Elevation vs. Time, see Figure 6-4) if there are at least three sets of Elevations taken at regular intervals over a time span of at least six months. From this type of plot it is possible to determine the direction, magnitude and rate of the movement.

6. At a maximum of one-year intervals, review and correlate the observed movement to the monthly rainfall data, owner's reported irrigation routine, and any plumbing and drainage issues.

7. Analyze the above data and determine whether the foundation-soil interaction has Stabilized, as discussed in Section 4.0, or if the foundation monitoring should continue.

8. Prepare and issue a monitoring report for the client.

6.0 EXAMPLES

The following are basic examples of the graphs and procedures described in Sections 4.0 and 5.0.

6.1 SURVEY ELEVATION PLAN

The Survey Elevation Plan in Figure 6-1 shows Elevation data for a fictional foundation. An external Benchmark is shown in the backyard and all Elevations are relative to the external Benchmark. In lieu of an external Benchmark, an interior reference point, usually near the center of the residence, may also be used.

Although not shown in Figure 6-1, the Phenomena Plan may be combined with the Survey Elevation Plan.

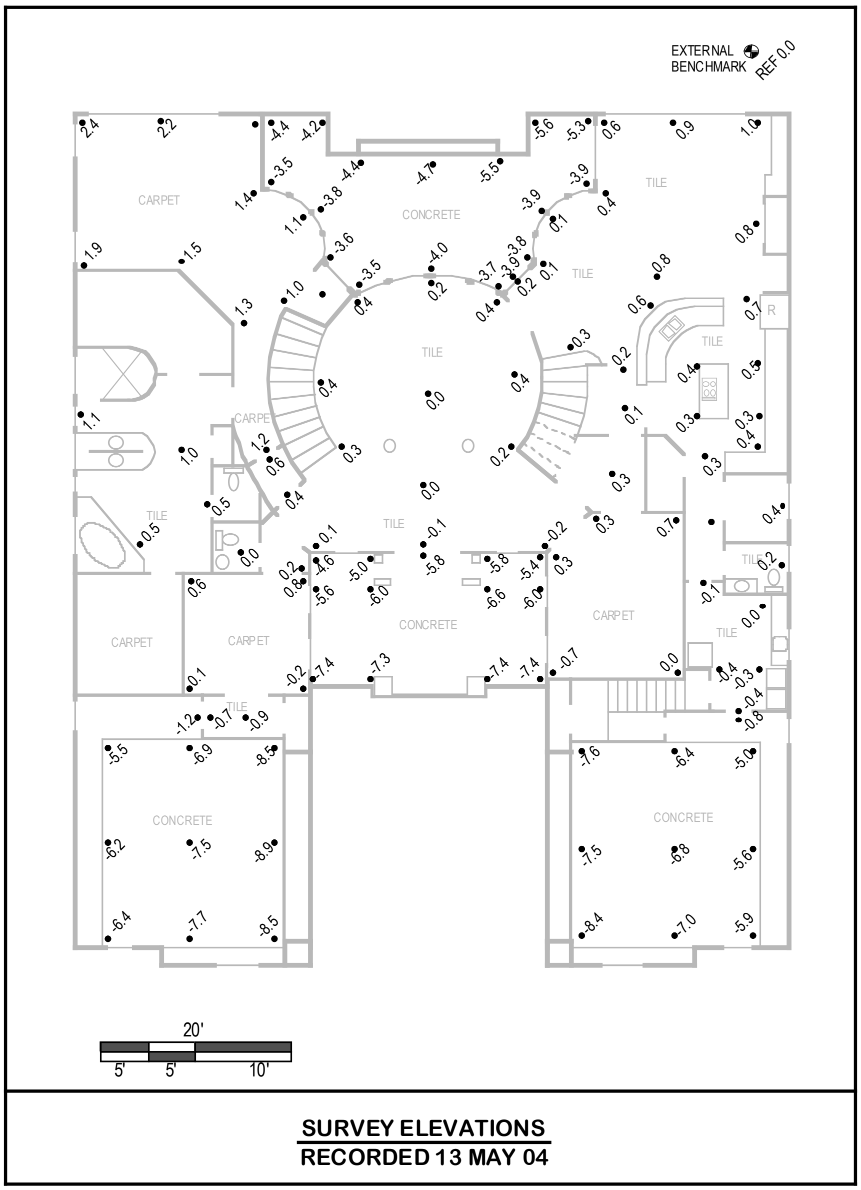

Figure 6-1 – Survey Elevation Plan

6.2 MONITORING ELEVATION PLAN

The plan in Figure 6-2 shows five sets of Survey Elevations recorded for a fictional foundation. For ease of reference and analysis, the data from each Monitor Period are included on one drawing. Note that the number of Monitor Points recorded and shown in Figure 6-2 is less than one-third the number of Elevation Points recorded and shown in Figure 6-1, and that Plot Points are defined and labeled A through H.

An Adjusted Survey Elevation Plan may also be presented, and would appear similar to Figure 6-2, however the data would be adjusted for changes in floor covering thicknesses and steps. Based on Figure 6-2, the user should observe that the movement of the foundation has generally been upward from the initial Elevations. The final survey, taken on 20 Jun 05, indicates minor downward movement.

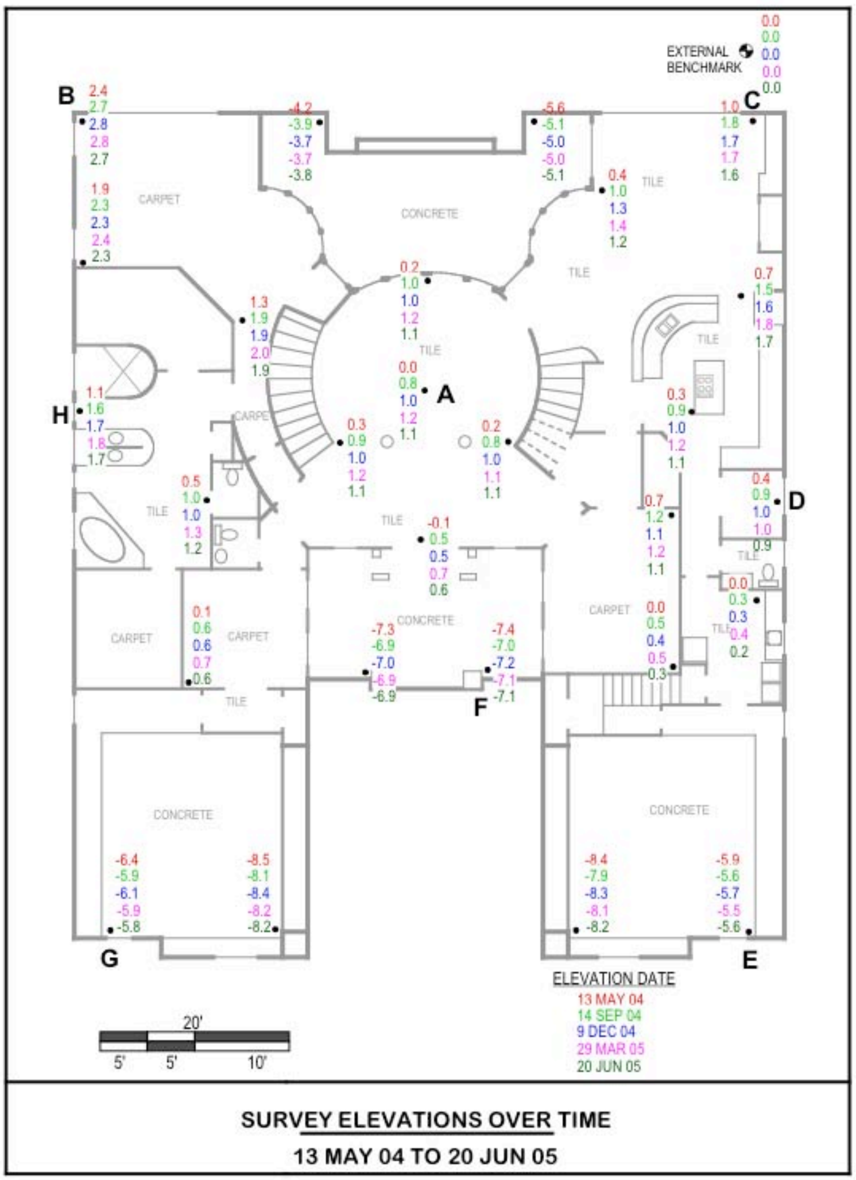

Figure 6-2 – Survey Elevations Recorded Over Time

6.3 TIME-CHANGE ELEVATION PLAN

The Time-change Elevation Plan detailed in Figure 6-3 shows fictional foundation movement recorded during four Monitor Periods. The Time-change Elevations between each Monitor Period are included on one drawing. Although not necessary for stabilization analysis, also included on this drawing, and shown in pink, is the set of Time-change Elevations between the first Monitor Period and the last Monitor Period. Contours representing this set of Time-change Elevations are also shown in pink. Contours may also be provided between other Monitor Periods.

The data in Figure 6-3 show that:

- The Maximum Differential Movement was 0.3" during the most recent Monitor Period, from 29 Mar 05 to 20 Jun 05 (i.e. -0.2" to +0.1" = 0.3", and shown in dark green).

- The Maximum Differential Movement was 0.3" during the Monitor Period from 9 Dec 04 to 29 Mar 05 (i.e. 0.0" to +0.3" = 0.3", and shown in blue).

- The Maximum Differential Movement was 0.9" during the Monitor Period from 13 May 04 to 20 Jun 05 (i.e. +0.2" to +1.1" = 0.9", and shown in pink).

Based on the Time-change Elevation Plan, the movement during the Monitor Period from 29 Mar 05 to 20 Jun 05 exceeds the Time-change Elevation guideline of having less than 0.3" of movement over the most recent Monitor Period. Thus, even if the movement meets the stabilization guideline of 0.4" or less of movement over the previous six to eight months, the foundation has not met the entire stabilization guidelines, and the foundation-soil interaction is not considered Stabilized.

Contours were superimposed on the Time-change Elevation Plan in Figure 6-3. In this example, the Contours provided information on the direction of movement that was not otherwise obvious. The Contours show that the right rear area of the fictional foundation has moved more than the rest over the thirteen-month period from 13 May 04 to 20 Jun 05.

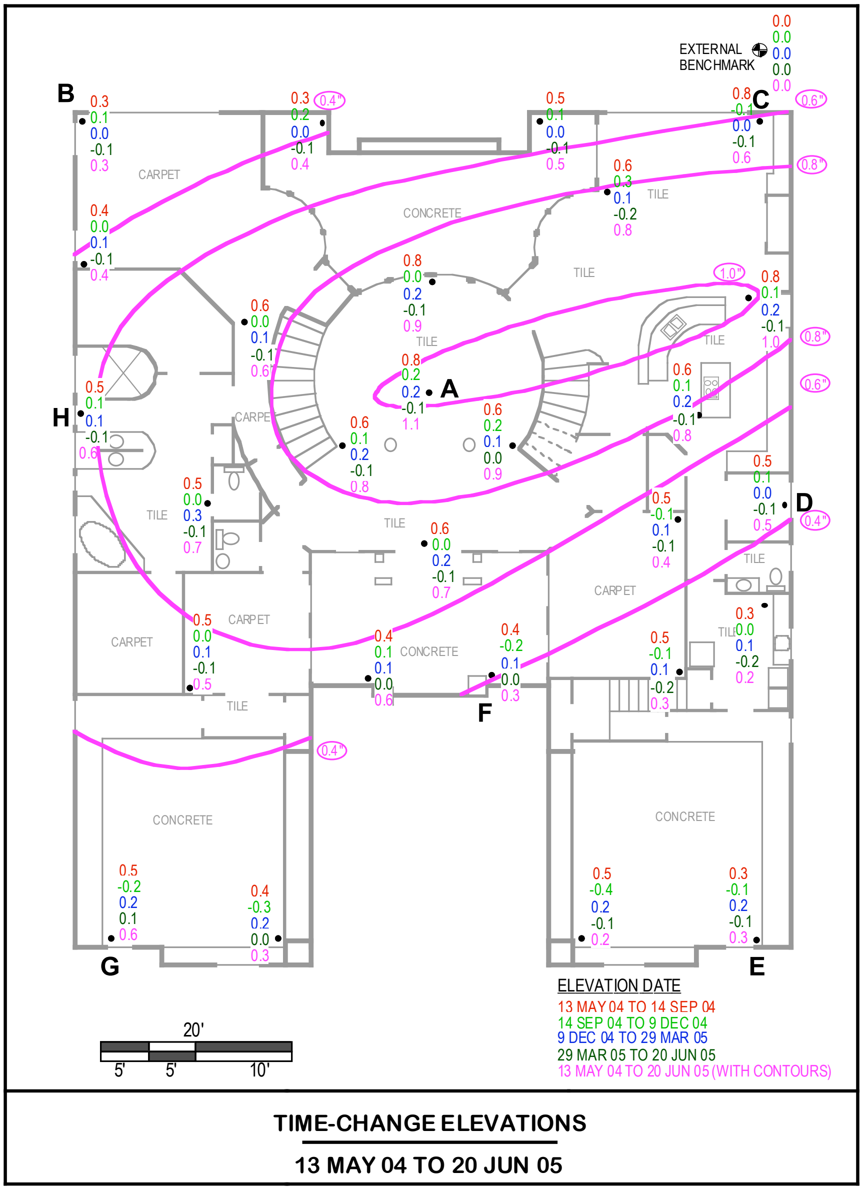

Figure 6-3 – Time-change Elevations with Contours

6.4 GRAPH OF PLOT POINTS (ELEVATION VS. TIME)

Figure 6-4 is a graph of eight Plot Points, A through H, located on the fictional foundation discussed above and an external Benchmark in the backyard. The Benchmark is considered the Reference Point and all Elevations are relative to the Benchmark. The plot gives a quick visual representation of the movement of the Plot Points over a period of time. From this type of plot it is possible to determine the direction and the severity of the movement in the area of and around the Plot Points.

This fictional foundation is located in an area that received much less rainfall than normal during the most recent Monitor Period, however the homeowner's irrigation habits remained unchanged during the dry spell. Based on this information, for a foundation that is not experiencing excessive movement, one might have expected the Elevation of all Plot Points to decrease. However, the plot shows that Plot Point E did not change, and Plot Point G increased in Elevation. Also based on the plot and the knowledge of rainfall data for the prior thirteen months, it may be concluded that Plot Point E is experiencing cyclical movement as well as the heave, indicating that the corresponding area of the foundation will likely no longer experience excessive movement.

From Figure 6-4 it may be concluded that the foundation is experiencing excessive movement due to heave that is more severe in some areas, i.e., near Plot Point A, than in other areas, i.e., near Plot Points B and G.

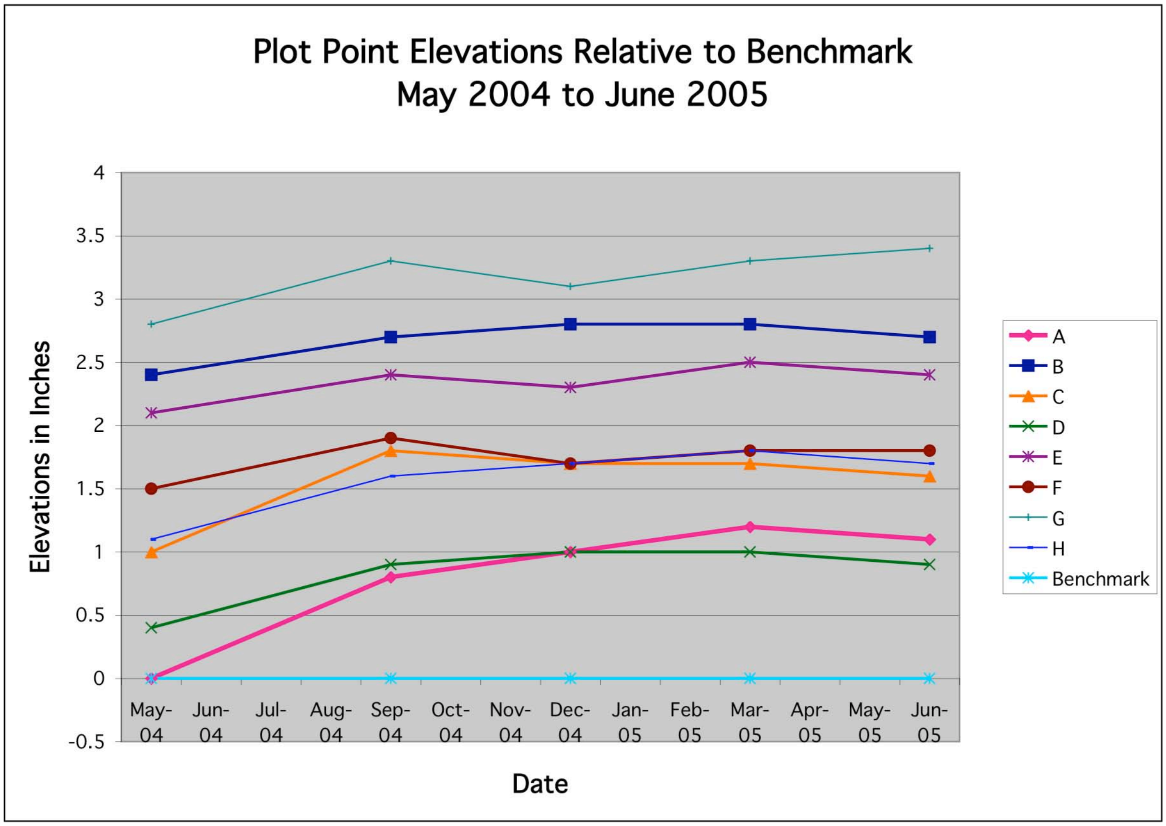

Figure 6-4 – Graph of Plot Point Elevations Relative to a Benchmark