EVALUATION GUIDELINES FOR THE PERFORMANCE OF SLAB-ON-GROUND FOUNDATIONS

FIRST EDITION 2015

FOREWORD

- The first step in evaluating residential slab-on-ground foundation performance is understanding it's function and what should be expected. Residential foundations serve two primary functions - one is to provide a reasonably level hard surface between the soil and living space and second is to support the structure above.

- Slab-on-ground foundations are designed as floating slabs, much the same as a boat floats on water. They are not designed to resist or control soil movement, but mitigate the effects of anticipated soil movement. Rather, they are subject to the effects of soil movement. A properly performing foundation will act as a semi rigid element that will float on the soil with minimum distress to the structure above.

- One of the most common tools for evaluating foundation performance is a floor levelness or elevation survey. This can be used to evaluate the foundation levelness, deflection and tilt at the time of survey, however, engineering judgment needs to be used to determine if any elevation difference is due to original construction, foundation movement or a combination of both. The only absolute way to measure foundation movement is to compare changes between two surveys.
- The two primary criteria used to measure foundation performance are tilt and flexural deflection. The figures below give examples and descriptions of tilt and deflection. The most common allowable are a tilt of 1% and a deflection of L/360. In other terms, a tilt of up to 1 inch in 100 inches and a deflection of 1 inch in a length of 360 inches are acceptable. The performance deflection criteria cannot be directly compared to the design deflection criteria of the foundation because the foundation is not designed for a certain deflection limit, but is designed for a certain stiffness criteria based on the building materials. The stiffness coefficients are related to deflection, but are not directly comparable to the deflection criteria of L/360.

- Foundations are not constructed perfectly level and normal construction tolerances for levelness are plus or minus 3/4 inch which means there may be a 1-1/2 inch difference in elevation due to original construction and if within this value then the original construction is within acceptable tolerance. When there is a difference in floor elevation and there is no accompanying distress, such as sheetrock and brick cracks, out of square doors or material separations, then, the out-of-level condition is most likely due to original construction and not foundation movement. When the above mentioned criteria are exceeded there needs to be noteworthy distress that can be correlated to the out-of-tolerance conditions, otherwise the situation does not qualify as a deficiency in foundation performance.

FOREWORD, CONT.

- The Texas Residential Construction Commission (TRCC) and the Texas Section of the American Society of Civil Engineers (ASCE) have published criteria and guidelines for evaluating foundation performance and they both use the 1% and L/360 tolerances. Once again, it is important to note that associated distress must accompany the out-of-tolerance conditions. It is not unusual to have minor sheetrock cracking, brick cracking and/or other material separations in a residence supported by a slab-on-ground foundation on expansive soils. It should also be understood that there are other factors not associated to foundation movement that can cause distress in the structure above, such as wind and seismic forces, poor quality in the construction, improper framing ,etc. Also, improper sub grade preparation, improper soil fill retention, abnormal soil conditions, abnormal weather phenomena, improper introduction of landscaping and trees, plumbing line leaks, near foundation excavations, poor long term homeowner maintenance and other factors can have a significant effect on the performance of the foundation and residence.

- The International Building Code states that a foundation "shall be designed to resist differential volume changes and to prevent structural damage to the supported structure. Deflection and racking of the supported structure shall be limited to that which will not interfere with the usability and serviceability of the structure". It is obvious from this statement that some minor to even moderate cracking and distress are not indicative of a foundation failure.

INTRODUCTION

- The purpose of this document is to:
  - Provide guidelines for acquisition of Slab-on Ground Foundation performance data;
  - Provide guidelines to aid in the evaluation of the performance of a Slab-on-ground Foundation;
  - Propose allowable acceptance criteria for Slab-on-ground Foundation Movement.

- This document addresses the foundations of residential and other low-rise buildings that are 4-stories or less. The performance and serviceability of residential and other low-rise building concrete slab foundations has been discussed and analyzed for over 30 years. The foundation system's primary job is to support the superstructure. In areas with active clay soils, the foundation system must also act as a buffer between the active soils and the superstructure.

- A major portion of the residential and other low-rise buildings that are constructed are supported by slab-on-ground foundation systems that are allowed to bend and move with the soils. All foundation systems move. Even with complete and correct geotechnical information, a properly designed and constructed foundation system will still move. Generally, movement begins the day the foundation is placed, and continues throughout the life of the structure.

- To date, foundation movement has been analyzed, categorized, and quantified by various codes, articles, organizations, private groups, and trade standards. However, when viewing the variety of analytical procedures and the problems associated with them, it is apparent that a consensus for analysis of the performance of foundation systems has not been reached. This document attempts to present a more acceptable procedure through the presentation of various definitions, including investigation and data acquisition, including both presentation and methods, and prescriptive criteria for foundation movement, coupled with the method for computation.

DEFINITIONS

- ***Contour Lines*** are lines that connect points of equal elevation on the surface of a foundation and do not cross. Contour lines may be drawn on an adjusted elevation plan to determine the vertical deformation (sometimes called "distortion") of the foundation, or on a time-change elevation plan to determine the direction and magnitude of movement over a specific time period. Contour lines should be plotted in equal vertical intervals.

- ***Deflection*** is the measurement of the distorted shape of a structural element due to bending of the foundation. An example of this is when an initially straight beam is loaded with a transverse load, it will distort into a curved shape. The deflection at any point within the span length on the beam is the translation of that point from its initial position (which if not known is assumed to be on a straight line between two points) to its position on the deflection curve. As shown in Figure 6.3.1-1 and in Section 6.3.2, examples A, B and C, deflection is the vertical distance between any point 2 on the surface and a line L_{13} that connects two end points 1 and 3 on that surface. Note: Actual deformations are perpendicular to the chord line L_{13}. The difference between the actual deflections and the measured deformations (i.e., deflection) is inconsequential and not considered.

- ***Elevation*** of a data point is the measured vertical height above (+) or below (-) the reference point.

- ***Foundation*** is defined as a system that is a combination of materials designed to work together to provide a base that supports a superstructure, while transferring loads to and from the soil below.

- ***Reference Point (also, Datum or Reference 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.

DEFINITIONS

- ***Survey Elevation Plan*** is the set of raw (unmodified) data point elevations 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.

- ***Adjusted Elevation Plan*** is the set of data point elevations, some of which are vertically translated to adjust for changes in floor covering thicknesses and steps. The adjusted elevation plan should include the date the survey was made and should be presented on an architectural floor plan that shows walls, showers, sinks, countertops, etc.

- ***Baseline Elevations*** are the first elevation readings of a particular set of points in the structure to which future measurements will be compared.

- ***Initial Elevations*** are the first elevations recorded, and should be taken after floor finishes are installed, preferably just prior to occupancy. If initial elevations are recorded, they are considered baseline elevations. Elevations recorded immediately after foundation placement generally should not be considered as initial elevations since the foundation system will move and adjust as loads and bearing soil conditions will change during the construction period.

- ***Tilt*** is defined as a planar rotation, measured over the full length or full width of the foundation caused by changes in the soil. (See figures in Sections 6.3.1 and 6.3.2)

What we are having to deal with is movement in the bearing soils which support our slab-on ground foundation system and the structure above.

CAUSES OF SOIL AND FOUNDATION MOVEMENT

- Nearly all foundation movement occurs due to soil movement. Soil that is expansive can rise or fall at the surface by comparatively large amounts, sometimes as much as 12 inches. Residential and other relatively light low-rise buildings typically follow the movement of the upper soil. Often movements are not detected or detrimental because they are sufficiently uniform throughout the building pad. However, the soil movement can be non-uniform such that differential movement of the soil supporting the Foundation occurs. If the anticipated differential movement was properly reported in the geotechnical report, a properly engineered Foundation will have been sufficiently stiffened and reinforced to resist a portion of the differential soil movement so that the negative phenomena that occurs is minimal.

- There are many types of soil movement that cause foundation movement. Several of the more common types of movement causing negative phenomena in residential and other low-rise structures include settlement, subsidence, and heave.

- The most logical way to stop distress in the superstructure due to foundation movement is to eliminate movement in the soils. Soil movement can be controlled using proper earth work and preparation procedures. However outside of completely controlling the soil's movement, the next most logical option is to allow for some soil movement and to design a foundation that will perform within allowable parameters and standards for those movements.

TYPES OF SOIL MOVEMENT

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

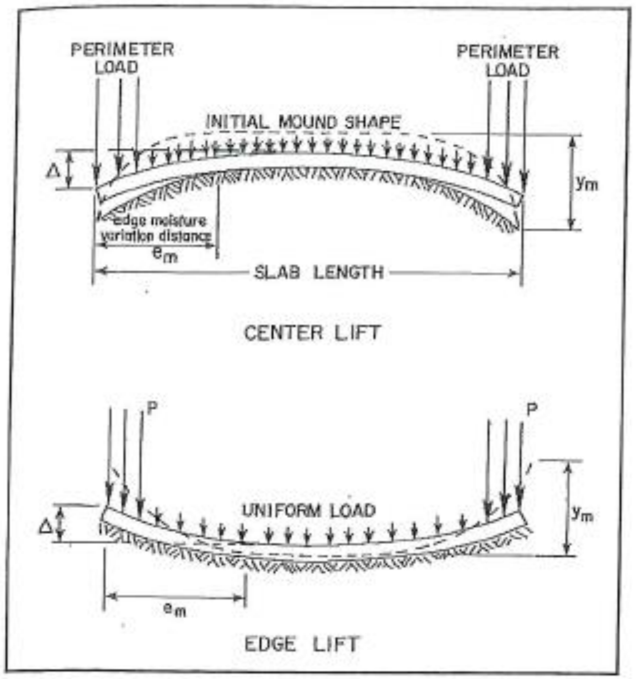
- ***Settlement*** is downward movement of an underlying supporting soil stratum due to loading in excess of the bearing capacity of the soil below or loss of moisture. Encompassed in settlement area) the immediate elastic consolidation and distortion of granular or clay soil particles, b) slope instability, and c) the long-term consolidation resulting from gradual expulsion of excess pore water pressure from voids between saturated clay soil particles or long term settlement generated by secondary compression. Settlement may occur in all types of soils.

- ***Shrinkage*** is downward movement of an underlying supporting soil stratum due to the withdrawal of moisture. When moisture is extracted from the soil, shrinkage occurs within the structure of the soil, and the corresponding area of the foundation and superstructure move downward. Shrinkage normally occurs within clayey soils and is often the result of soil desiccation that is caused by trees or other large vegetation.

- ***Subsidence*** is defined as regional settlement over a large area, most frequently caused by groundwater mining/withdrawal; but could also be generated by oil and gas extraction, mining, filling of a dam (often triggering minor seismic events), sinkholes in karst areas, collapsing soils (due to raising groundwater), drainage of organic soils, natural compaction, thawing permafrost, etc.

PTI Design For Slabs –on-Ground

Figure 3.5 - Soil-structure interaction models



- This one sketch sums up the general design assumptions and objectives of the current PTI S.O.G. design procedure. It assumes that Ym will occur symmetrically on both sides of the slab and be consistent around the entire slab perimeter, and that the foundation system will dampen and mitigate some of this soil movement. It does this by requiring a certain amount of strength and stiffness be built into the foundation system. There is nothing here that deals with the Ym values (differential soil movements) being different from one side to the other.

To insure a certain level of stiffness in the design we have:

Differential foundation deflection is controlled by providing minimum foundation stiffness in accordance with the following equation, which is applicable to both edge lift and center lift swell modes:

$$E_{cr} I_{L \text{ or } S} \geq 12{,}000\, M_{L \text{ or } S}\, L_{S \text{ or } L}\, C_{\Delta}\, z_{L \text{ or } S} \quad (6\text{-}22)$$

The coefficient C_{Δ} is a function of the type of superstructure material and the swelling condition (center or edge lift). Recommended values of C_{Δ} for both swelling conditions and various superstructure materials are shown in Table 6.2. Smaller values of C_{Δ} may be used for superstructure materials listed in Table 6.2 if effective jointing details are used to minimize cracking, such as closely spaced control joints in brick or stucco walls. See 4.5.6 for a discussion of the C_{Δ} coefficients for prefabricated roof trusses.

Table 6.2 - Recommended Values of Stiffness Coefficient C_{Δ}

Material	Center Lift	Edge Lift
Wood Frame	240	480
Stucco or Plaster	360	720
Brick Veneer	480	960
Concrete Masonry Units	960	1920
Prefab Roof Trusses*	1000	2000

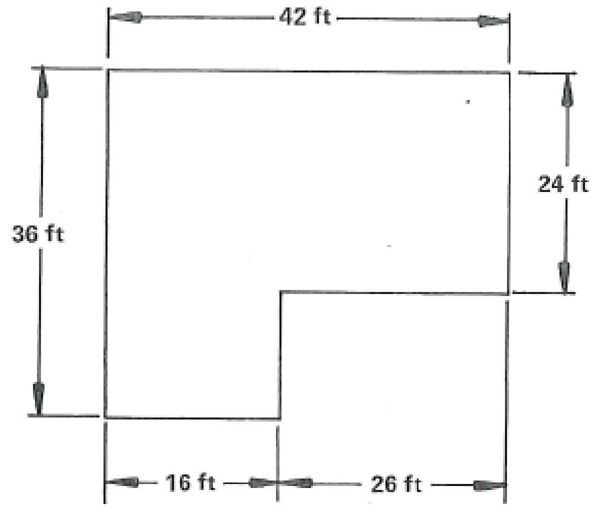
*Trusses which clearspan the full length or width of the foundation from edge to edge.

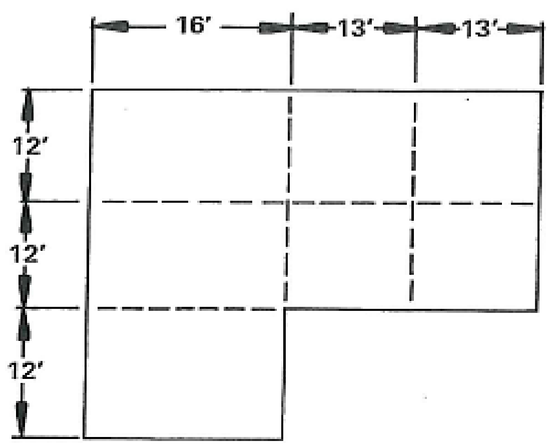
Shape Factor :

Experience has shown that some irregular shapes cannot properly resist bending as calculated by the method of overlapping rectangles, due to torsion effects. It is recommended that a "Shape Factor" calculation be applied to test this condition in the form of:

$$SF = \frac{\text{Foundation Perimeter}^2}{\text{Foundation Area}}$$

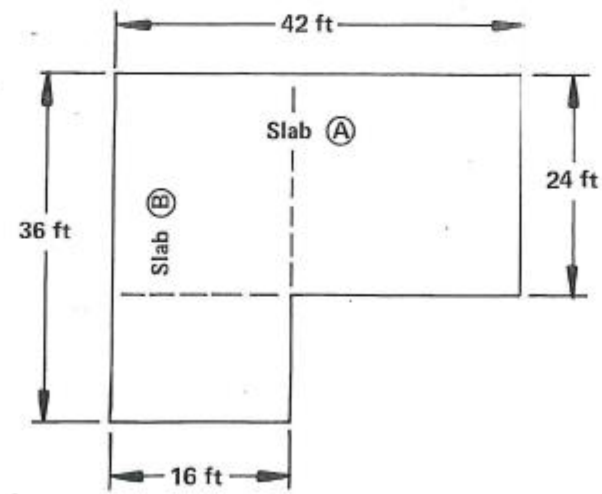
If SF exceeds 24, the designer should consider modifications to foundation foot print, strengthened foundation systems, soil treatment to reduce swell or the use of additional non-prestressed reinforcement and/or additional ribs in areas of high torsional stresses. Analysis by finite element procedures may also be used in the case of $SF > 24$.





b. Slab Geometry Suggests Stiffening Beam Locations as shown; Take Average Beam Spacing as 14 ft For Short Dimension of Slab Ⓐ.

Fig. A.6.1 Assumed overlapping design rectangles and stiffening beam spacing



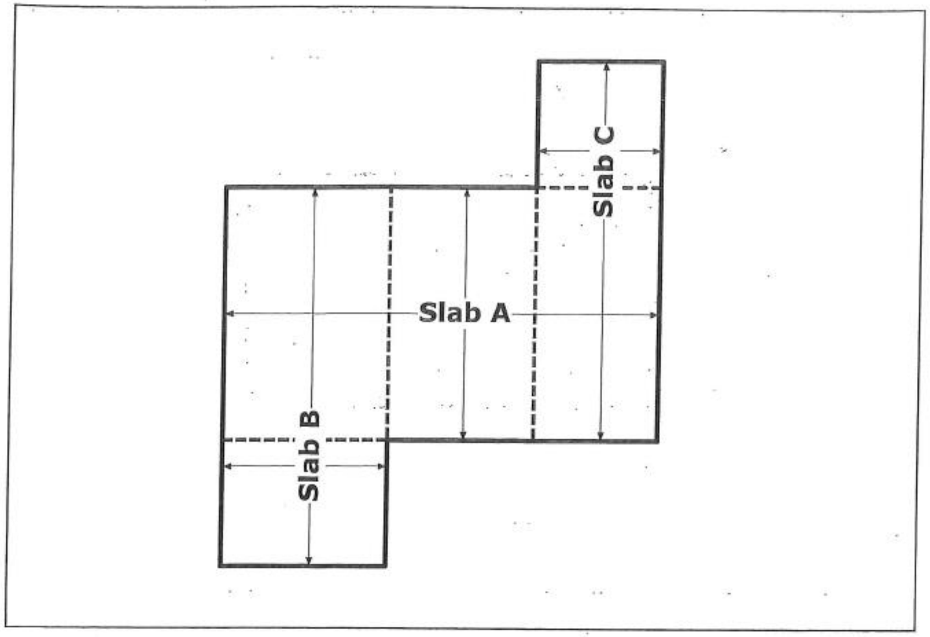
a. Divide Plan Area Into Two Overlapping Rectangles.

IN the First and Second editions of the PTI design Manual this was the shape of our example foundation.

A typical house shape for volume home builders from the 1970’s.

In the Third edition we stepped it up a notch

Figure A.3.5 Overlapping rectangles



The foundation plan satisfies the Shape Factor requirement $SF \leq 24$. This design example will be based only on Slab A for illustrative purposes.

Slab geometry suggests stiffening rib locations as shown in Figure A.3.6.

For short direction:

$14 / 8 = 1.75 > 1.5$ therefore $S = 0.85 \times 14 = 11.9$ ft

D) Approximate Depth of Stiffening Rib

1. Long Direction

As a first approximation, use $\beta = 8$ ft

$L = 42$ ft $< 6\beta = 6\ (8) = 48$ ft

therefore $Z = 42$ ft

For center lift (Use $C_\Delta = 360$)

$$h = \left(\frac{(\gamma_m L)^{0.205} S^{1.059} P^{0.523} e_m^{1.296} C_\Delta}{4560(z)} \right)^{0.824} \quad \textit{Eqn } \boldsymbol{(6\text{-}1)}$$

$$h = \left(\frac{(0.07x42)^{0.205} (12)^{1.059} (695)^{0.523} (9)^{1.296} (360)}{4,560(42)} \right)^{0.824}$$

$h = 10.4$ in.

2. Short Direction

$6\beta = 6\ (8) = 48$ ft > 24 ft ... therefore $Z = 24$ ft

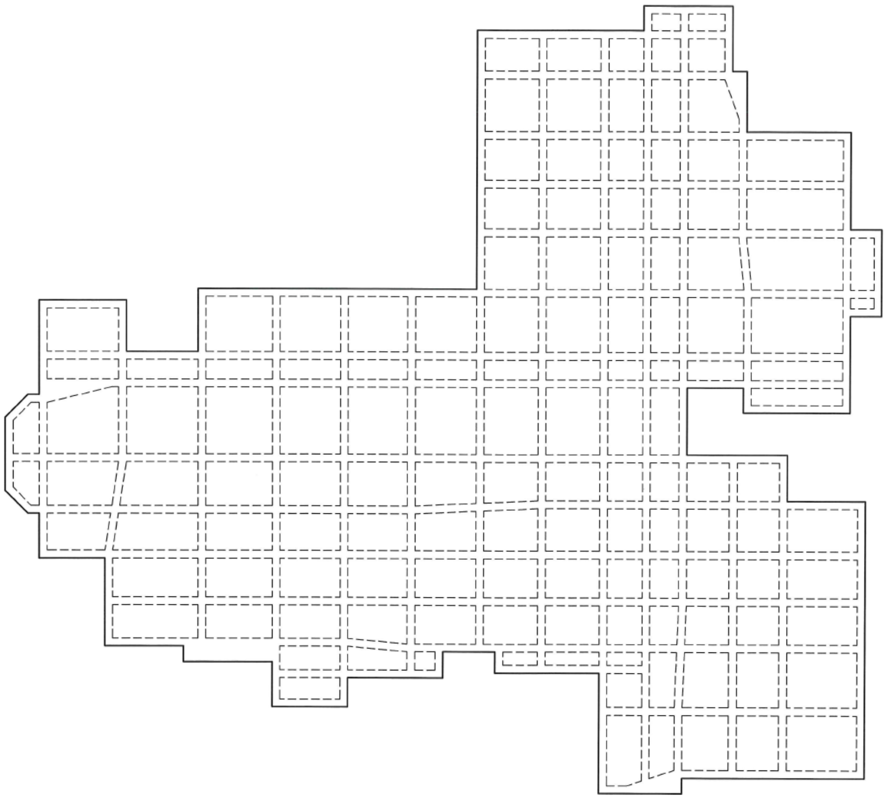
$h = 14.9$ in.

$$h = \left(\frac{(0.07x24)^{0.205} (11.9)^{1.059} (695)^{0.523} (9)^{1.263} (360)}{4,560(24)} \right)^{0.824}$$

Try $h = 14.5$ in.

$b = 12$ in.

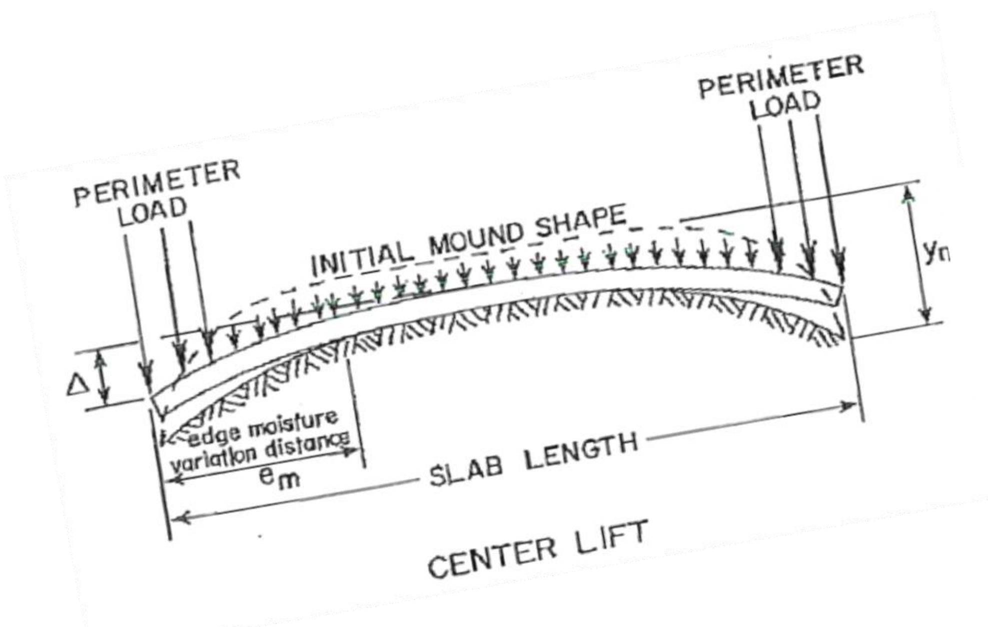
Slab- on Ground Design

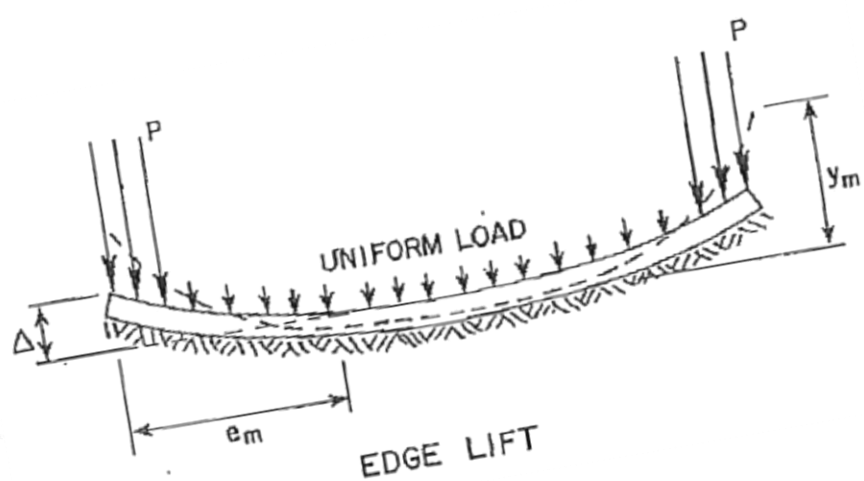


- This is what we design now days using the PTI design procedure.
- Shape factor = Yikes !!!

Performance Guidelines and Criteria

- The following presents a quick summary of what is being checked and how to present the data when checking for this :





PUBLISHED CONSTRUCTION TOLERANCES

- Two authoritative publications concerning the construction tolerances of slab foundations are American Concrete Institute's *ACI 302* [2] and *ACI 117* [1]. However, it is rare that concrete foundations within the scope of this document would be required by the building owner to meet construction levelness or flatness tolerances specified in these two ACI publications. Both of these ACI publications address slab-on-ground foundations as-built level and flatness tolerances, which could be applied if desired by the building owner.

- Because this document addresses performance (rather than construction) of foundations, these two ACI publications are not considered applicable, at least as far as flatness, particularly since residential slabs are typically floated and finished with carpet, wood, tile, etc, such that the peaks and valleys of the cast concrete are not a major concern. However, an overall foundation levelness tolerance of 1.5" (i.e., + or – 0.75"), which *ACI 117* [1] specifies, is widely considered to be an acceptable construction tolerance for Slab-on-ground foundations.

- Past Commission or Agency documents (TRCC) [12], which addressed both construction and performance tolerances from a warranty perspective, had endorsed the 1.5" initial out-of-level tolerance from *ACI 117* [1]. However, an as-built elevation survey was not required and it was unclear on how the construction tolerance should be applied when no as-built elevation survey was required to be performed or retained. The documents were also unclear on whether as-built slab elevations should be recorded on the exposed slab or on the finished flooring materials in order to provide a set of baseline elevations in case of a later performance evaluation or dispute.

- To exemplify the dilemma, when no as-built elevations are recorded or retained, if one corner of a problematic foundation has heaved 2" relative to the rest of the foundation, the building contractor may contend that the foundation could have been cast 1.5" higher at that corner, thereby arguing that the performance deflection is 2" – 1.5" = +0.5". However the building owner may argue that the corner was cast 1.5" lower, meaning the performance deflection is 2" + 1.5" = +3.5", giving a difference in interpretation of 3" (3.5" – 0.5") between the two parties. It will require an experienced Inspector or Forensic Engineer to correlate the distress phenomena in order to determine the more likely initial as-built elevation of the corner.

FOUNDATION STIFFNESS AND FLEXURAL DEFLECTION

- The allowable design bending deflection is characterized by a ratio of the effective length (in inches) divided by a number. This number generally ranges from 240 to 480 for wood frame structures, depending on the type of bending (i.e., edge lift or center lift) and the type of structure. TRCC [12] required computation of a deflection limit using the distance over which the deflection occurred divided by 360. Experience has shown that the onset of excessive distress in the superstructure appears to occur when post construction deflection exceeds the span divided by values between 240 and 480. There are exceptions where this range of deflection is exceeded and the distress in the superstructure is minimal, but the opposite has also been found to occur.

- Foundations may move substantially prior to completion of the architectural finishes. Oftentimes, craftsmen compensate for movement that occurs during construction by leveling the surfaces of the architectural finishes. Therefore distress phenomena may not reflect the total movement measured after construction of the foundation is complete, particularly when the construction schedule is lengthy.

- The PTI guidelines in the subcommittee's draft (preliminary) document recommends a deflection curvature limit or ratio of 1 / 360 = .278 %.

- (ratios between .3% and .4% are currently being discussed)

TILT & LOCALIZED SLOPE

- Foundation tilt due to ground movement does not normally produce excessive bending stresses in the slab that affect the structural integrity of the foundation. Therefore, even though the differential elevations between the high and low points may be significant, it is oftentimes considered to be acceptable movement of the foundation. Localized slope generally is caused by a combination of overall tilt and the deflected shape due to bending. Floor slopes caused by either tilt and/or localized slope of 1% or greater are usually noticeable to the trained Inspector. Symptoms of excessive tilt or localized slope (i.e. that which creates negative structural phenomena), include:
  - Brick veneer that rotates out of plumb to some degree that it becomes laterally unstable,
  - Studs or other vertical support members of the superstructure that rotate around the horizontal axis and become laterally unstable, and
  - Roof support members of the superstructure that have additional stresses from gravity loads that have increased due to the resulting eccentricity of the loads.
- Although structural phenomena oftentimes will not occur when tilt reaches one percent, the complaint from the building owners is typically one of functionality of the building when this much floor slope occurs. Recognizing excessive tilt conditions as functional phenomena, *the PTI recommends that Tilt be less than or equal to one percent (1%) over the entire length, width, or diagonal of the Foundation*. This limit for tilt is in concurrence with TRCC [12] and ASCE [4] values. See Section 6.3.1 for tilt calculations and Section 6.4 for examples of evaluating tilt and localized slope.

EQUATIONS

- The method presented for computing deflection, localized slope, and tilt is as follows:
- L_{AB} = Overall length or width of foundation for tilt or flexure
- Points 1 & 3 = End points of the span portion being considered for flexure
- Point 2 = a foundation intermediate point between, and vertically coplanar with, points 1 & 3
- $L = L_{13}$ = Horizontal projection of deflected span being considered
- Y_i = Vertical elevation of any point "i" along L_{AB} (relative to datum)
- The foregoing equations use the variables and dimensions shown in Figure 6.3.1-1.

- Please note the following in using these equations:
- Span length (L) and survey elevations (Y_i) are measured in the horizontal and vertical directions, respectively.
- Survey elevations (Y_i) may either be direct survey elevation data or may be extracted from a contour plan.
- Span length (L) may be anywhere along the foundation, whether in orthogonal or skewed directions, provided the span contains three survey elevations (Y_1, Y_2, Y_3).
- Tilt is considered over a span L_{AB} that extends from edge-to-edge of the foundation in any direction.

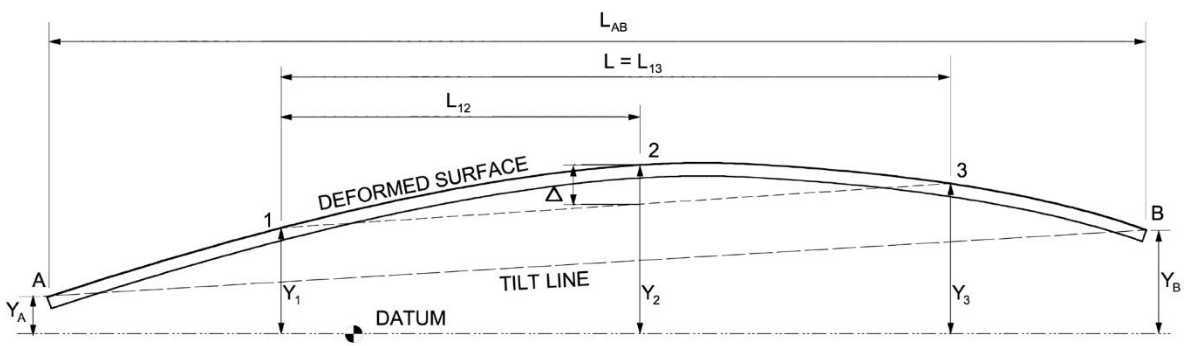
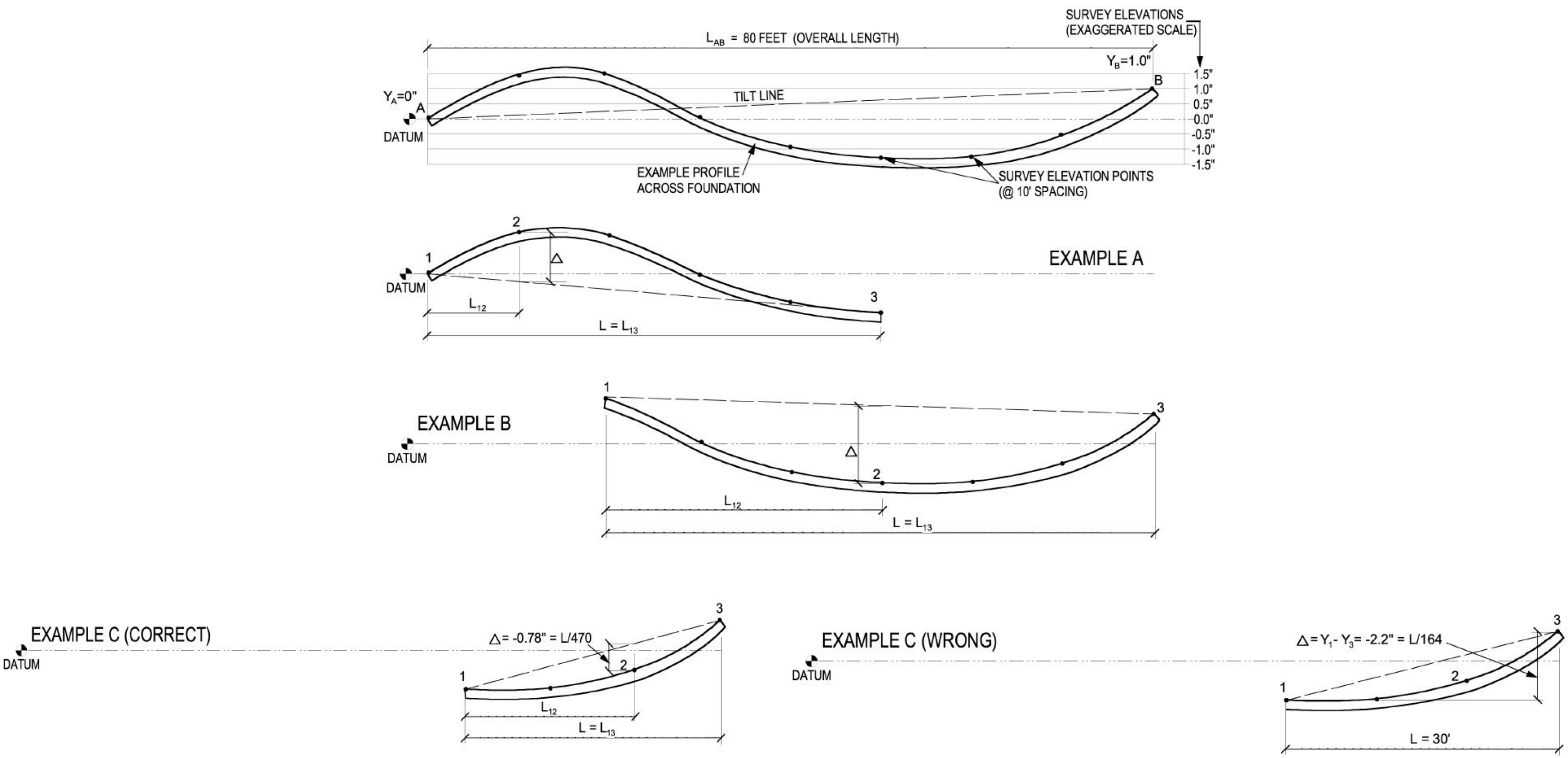


FIGURE 6.3.1-1

CALCULATION EXAMPLES



NOTE : The minimum effective length to be used when calculating curvature deflection is to be ~ 20’-0”, unless the overall width or length of the foundation rectangle(which is being checked) is less than 20’-0” ,then use the overall dimension.

Note that a common misconception of computing the deflection of an end is exemplified in Example C. This example shows how some may incorrectly compute the Deflection to be L/164, which fails the deflection limit, rather than correctly computing the value of L/470, which passes.

From Section 6.2, the allowable tilt must be less than or equal to 1%. For the 80 ft. profile in Figure 6.3.2-1:

$$\text{Tilt} = \frac{|Y_B - Y_A|}{L_{AB}} \text{ x } 100\% = \frac{|1.0" - 0"|}{80' \text{ x} 12\text{in/ft}} \text{ x } 100\% = 0.10\% < 1.0\%,$$

which means the example profile passes for tilt.

Computations for deflections (Δ) for the above examples are shown in the following Table 6.3.2-1:

Table 6.3.2-1 Deflection Examples

Ex.	L	L_{12}	Y_1	Y_2	Y_3	Δ (inches)	
A	50’	10’	0”	1.4”	-1.2”	1.64	L/366
B	60’	30’	1.4”	-1.2”	1.0”	-2.4	L/300
C	30’	20’	-1.2”	-0.5”	1.0”	-0.78	L/470

For this example, A and C pass the L/360 deflection limit criterion, while B fails. Note that there can be other spans that will also fail if several spans are checked. In fact, for this profile, the maximum actual deflection was found to be L/253.

Site Visit and Data Acquisition

- To give a reasonable assessment of the foundations performance there are several items which are needed and others which are helpful:
- 1. A history of the property ,including any previous
- repairs or inspection reports.
- 2.Architectural plans and /or construction documents
- 3.Visual observations and evidence of distress in the structure and architectural finishes.
- 4. Observing factors influencing the performance of the foundation (i.e. drainage , swimming pools, etc.)
- 5. A determination of the relative foundation elevations, considering floor finishes in sufficient detail to represent the foundation adequately.

Taking the calculations and procedures above , how do you correlate and present the data and information that was obtain during the site visit in a format that is relatively clear and easy to understand.

Data Presentation

- An adjusted elevation plan presents the elevation data, adjusted for changes in floor cover thicknesses and steps. This plan type is useful to present the true level distortion of a foundation.

- It is often advantageous to convert the adjusted elevation data into contours. Contours provide a visual method of rapidly determining foundation levelness, amount of slope and slope direction. Much like a topographic map shows mountains and valleys, a contour plan shows the elevation differences across the foundation. Where the surface is relatively flat, the contour plan can be somewhat meaningless. It is more meaningful in areas where the degree of slope is more pronounced.

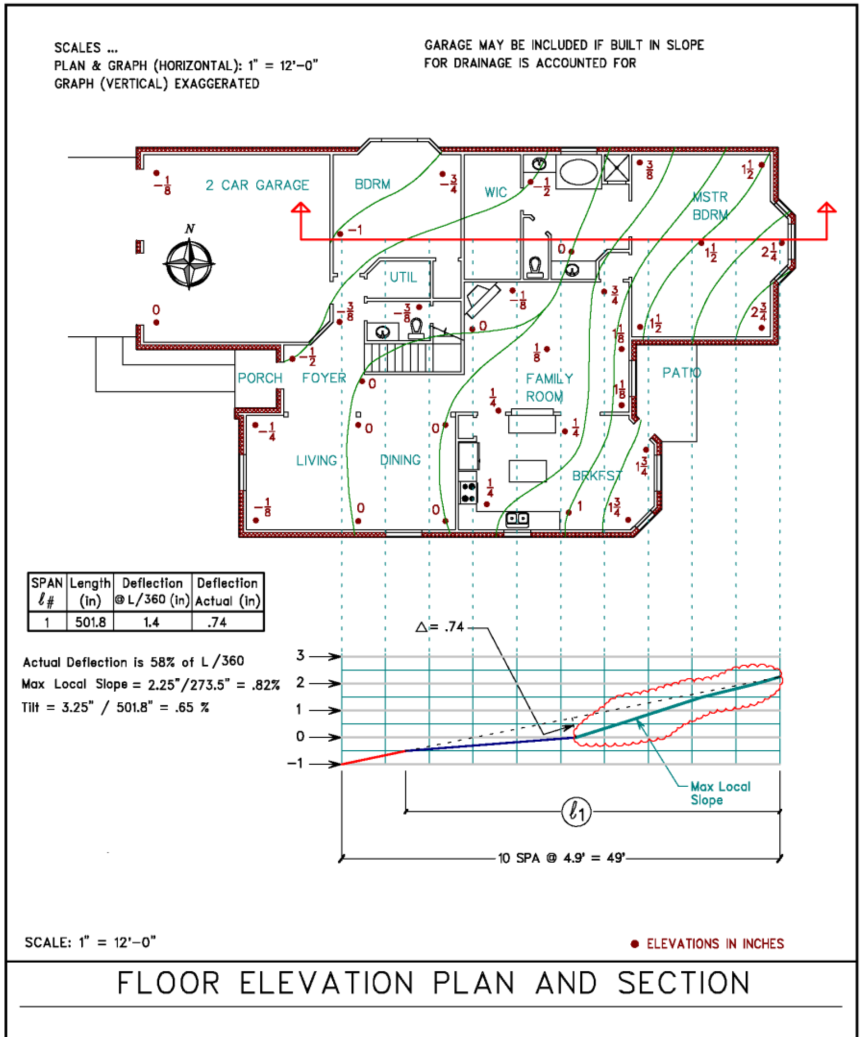
- Contours are lines of equal elevations over the plane of the foundation and are drawn from the level distortion plan either manually or with the aid of computer software. When drawing contours manually, points of equal elevation should be connected to form smooth lines or curves and labeled as such. Elevation documentation should be made available. For example, all points 1.5" above the datum should be connected and labeled as +1.5".

- It is important to consider the number of elevation points and the accuracy limitations of the machine used to make elevation measurements. To account for this it is typical to draw contours in 0.5" increments when documenting a survey showing time-change elevations between an as-built survey and a reasonably current survey. When one of the elevation surveys used to make a time-change elevation survey is not an as-built survey, smaller increments may be used if there are an adequate number of points recorded. At best, the increments should correspond to the accuracy of the surveying instrument.

- Unless a benchmark is used, contours alone do not indicate whether heave or subsidence has occurred if a non-stationary reference datum is used. A contour of -0.5" indicates that the area is one-half inch lower than the datum, not that the area has settled 0.5". However, when no benchmark is used, the examination of the contour plan or the adjusted elevation plan, in conjunction with the phenomena plan discussed above and other information such as sewer leaks correlated with geotechnical information or other anomalies may allow an Engineer to opine whether heave or subsidence has occurred.

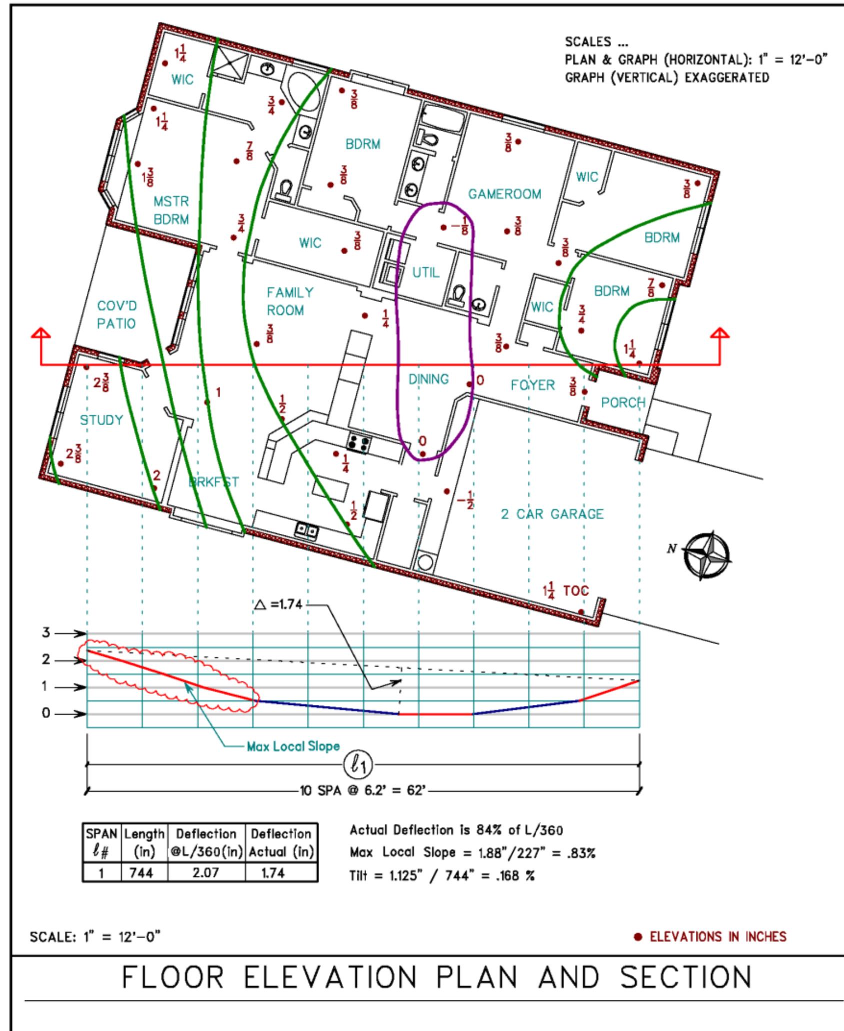
THE FOLLOWING EXAMPLES SHOW ONE METHOD OF PRESENTING THE DATA

- This section contains examples which show how a cross section is cut using adjusted elevation readings and contours to create a profile to check the tilt, localized slope, and curvature in any direction for a section across a foundation.



SPAN $\ell_\#$	Length (in)	Deflection @L/360 (in)	Deflection Actual (in)
1	501.8	1.4	.74

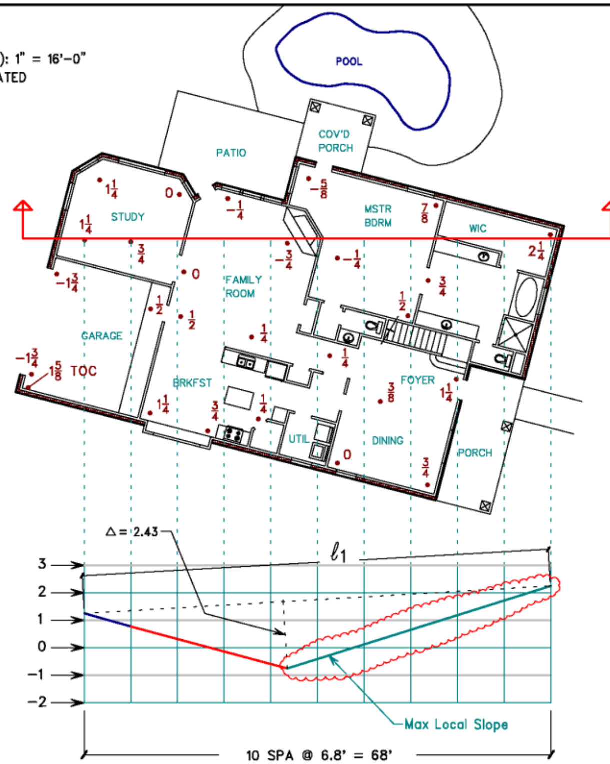
Figure 6.4.1



SPAN $\ell_\#$	Length (in)	Deflection @L/360 (in)	Deflection Actual (in)
1	744	2.07	1.74

Figure 6.4.2

SCALES ...
PLAN & GRAPH (HORIZONTAL): 1" = 16'–0"
GRAPH (VERTICAL) EXAGGERATED



Max Local Slope = 3" / 461" = .65%
Tilt = 1" / 516" = .19%
Actual Deflection is 107% of L/360
(Check for corresponding Functional Structural Phenomena)

SPAN $\ell_{\#}$	Length (in)	Deflection @L/360 (in)	Deflection Actual (in)
1	816	2.27	2.43

SCALE:
1" = 16'–0"

● ELEVATIONS IN INCHES

FLOOR ELEVATION PLAN AND SECTION

Figure 6.4.3

COMMENTS ON FOUNDATION MOVEMENT

- Aspects of foundation movement that should be considered in the method presented herein include, but are not limited to:
- Movement of the foundation during construction and prior to occupancy.
- The initial movement or "settling in" period of the foundation and superstructure after occupancy. Most go through a 12 to 24 month adjustment period as yards, landscaping, and watering programs are established.
- Seasonal movements, which are due to changes in the climate that affect soil moisture content.
- Foundation movement due to unanticipated issues such as removal of established trees and other vegetation, plumbing leaks, inadequate site drainage, improper roof gutter systems, faulty pool or pool deck installation, etc. These issues need to be addressed by the contractor and by the building owner through construction and maintenance procedures (see references for further information).
- Engineering judgment should be used .

REFERENCES

- American Concrete Institute (ACI) *117R-90, Commentary on Standard Specifications for Tolerances for Concrete Construction and Materials*, Re-approved 2002
- American Concrete Institute (ACI) *302.1R-04, Guide for Concrete Floor and Slab Construction*
- American Concrete Institute (ACI) 332.1R-06, *Guide to Residential Concrete Construction*
- American Society of Civil Engineers (ASCE), Texas Section, *Guidelines for the Evaluation and Repair of Residential Foundations,* Version 1, January 1, 2003
- American Society of Civil Engineers (ASCE), Texas Section, *Guidelines for the Evaluation and Repair of Residential Foundations,* Version 2, May 1, 2009
- American Society of Civil Engineers (ASCE), Texas Section, *Recommended Practice for the Design of Residential Foundations*, Version 1, January 1, 2003
- Foundation Performance Association (FPA) Document No. FPA-SC-03-1, *Distress Phenomena Often Mistakenly Attributed To Foundation Movement*, May 1, 2004
- Foundation Performance Association (FPA) Document No. FPA-SC-07-0, *Foundation Maintenance and Inspection Guide for Residential and Other Low-Rise Buildings*, March 23, 2003
- Foundation Performance Association (FPA) Document No. FPA-SC-12-0, *Guidelines for Evaluating Foundation Performance by Monitoring*, January 9, 2006
- Foundation Performance Association (FPA) Document No. FPA-SC-13-0, *Guidelines for the Evaluation of Foundation Movement for Residential and Other Low-Rise Buildings*, July 15, 2007
- Foundation Performance Association (FPA), Document No. FPA 201-2001, Supplement #1, *Criteria for the Inspection of and the Assessment of Residential Slab-on-Ground Foundations*, Presentation Paper by Don Lenert, June 19, 2002
- Foundation Performance Committee (FPC, since renamed to Foundation Performance Association, i.e., FPA), Document No. FPC 201-97, *Criteria for the Inspection of and the Assessment of Residential Slab-on-Ground Foundations*, 1997
- Texas Board of Professional Engineers (TBPE), *Policy Advisory 09-98-A - Guidelines Regarding Design, Evaluation and Repair of Residential Foundations*, 1998
- Texas Residential Construction Commission (TRCC), *Limited Statutory Warranty and Building and Performance Standards*, 2005
- PTI Technical Notes, *Performance Evaluation of Residential Concrete Foundations, by Kenneth B. Bondy, 2000*
- *Estimation of Floor Slab Distortion from Elevation Differential Data on Groups of Residential Structures, by Kenneth D. Walsh, M. ASCE, and Colin T. Milberg, M. ASCE*
- *PTI, Construction and Maintenance Manual for Post-Tensioned Slab-On-Ground Foundations, by the Post Tensioning Institute, Third Edition, May, 2006.*