SECTION 7D
FOUNDATION INSPECTION AND PROPERTY EVALUATION FOR THE RESIDENTIAL BUYER

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7D.1 INTRODUCTION

If you are house shopping in a geographical area with a known propensity for differential foundation movement, it is always wise to engage the assistance of a qualified foundation inspection service. This could involve an experienced foundation repair contractor or an equally qualified professional engineer (P.E.). The word *qualified* cannot be overemphasized. It is necessary to evaluate the existence of foundation-related problems, determine the cause of the problems, and, when such are found to exist, offer a repair procedure. The cause is particularly important. *Repairs will be futile, if the original cause of the distress is not recognized and eliminated.* The principal problem herein lies with the separation of settlement from upheaval (see Sections 7B.1, 7B.2, and 7B.4) . The checklist in Table 7D.1 presents several of the more obvious manifestations of distress relative to differential foundation movement. With only limited experience, one can learn to detect these signs. The problems of detection become more difficult when cosmetic attempts have been used to conceal the evidence. These activities commonly involve painting, patching, tuck-pointing, addition of trim, installation of wall cover, etc. The important issue in all cases is to decide whether the degree of distress is sufficient to demand foundation repair (see also Section 7B.8). This decision requires extensive experience and some degree of compromise. Several factors influence the judgement.

It is difficult, if not impossible, to properly evaluate the material set out in Table 7D-1 without extensive first-hand experience with actual foundation repairs. To quote Terzaghi, the founder of soil mechanics: "In our field [engineering and geology] theoretical reasoning alone does not suffice to solve the problems which we are called upon to tackle. As a matter of fact, it [engineering and geology] can even be misleading unless every drop of it is diluted by a pint of intelligently digested experience."[48] One good example of the importance of on-the-job experience is the proper determination of upheaval as opposed to settlement. If upheaval were evaluated as settlement, the existence of water beneath the foundation would likely be overlooked. In that case, future, more serious, conse-

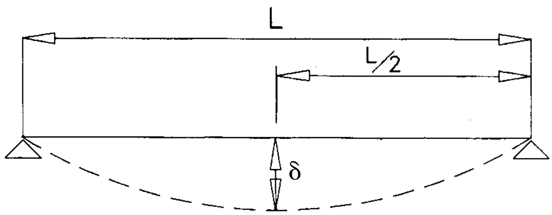
TABLE 7D.1 Inspection Checklist

1. *The extent of vertical and lateral deflection.* Does any structural threat exist or appear imminent? [Most authorities seem to accept a maximum differential movement of 0.3% (over 10 ft = 0.36 in; over 20 ft = 0.72 in) as tolerable for normal residential (frame) construction. The table below gives typical values for various angular distortions (δ) utilizing the "three point method."[7,73] In the real world of remedial concern, two point (δ') is normally the "test" procedure utilized. This is due, in large part, to partition walls and other obstructions that prevent or hinder the three point method. The cited 0.3% equates to 1/333 or 1″/27.75 ft. The wall height has a direct bearing on crack width resulting from δ.[7]

   At the identical δ (or δ') the crack width in a 16 ft wall will be twice that observed in an 8 ft wall, all other factors being equal.]
2. *Is the stress ongoing or arrested?*
3. *The age of the property.*
4. *The likelihood that the initiation of adequate maintenance would arrest continued movement.* [For example, 1) in cases of upheaval, elimination of the source for water will often arrest movement, and 2) where minor settlement is involved, proper watering may reverse or eliminate the problem.]
5. *Value of the property as compared to repair costs.* [Most foundation repair procedures require some degree of compromise. In order to arrive at a reasonable or practical cost, the usual primary concern is to render the foundation "stable" and the appearance "tolerable." In all cases, the primary goal should be a "cost-effective" solution. In virtually all repair, the cost to truly "level" a foundation, if it were possible, would be prohibitive. This is further complicated by the fact that "foundations are not generally built level."[15–17]
6. *Type and condition of the existing foundation.* [If the foundation is pier-and-beam, is adequate crawl space existent? If it is a slab, was it poured with proper thickness, beams and reinforcing steel?]
7. The possibility that, if the movement appears arrested, cosmetic approaches would produce an acceptable appearance.

A simple way to monitor future movement is to place a pencil mark on various doors, sheetrock cracks, and mortar separations, as illustrated by Figure 7D.1. Use a straight edge and sharp pencil. On cracks, place the marks such that horizontal as well as vertical displacements are monitored. Initial, date, and, where applicable, record the width of the crack. Repeat this process at random locations throughout the property. Future inspections will provide the answers to the on-going movement question. If any movement occurs, the lines will no longer line up. The measured crack widths previously recorded will also show movement. This method not only shows movement but provides a guide as to in which direction the movement occurs.

Angular Distortion, δ/L



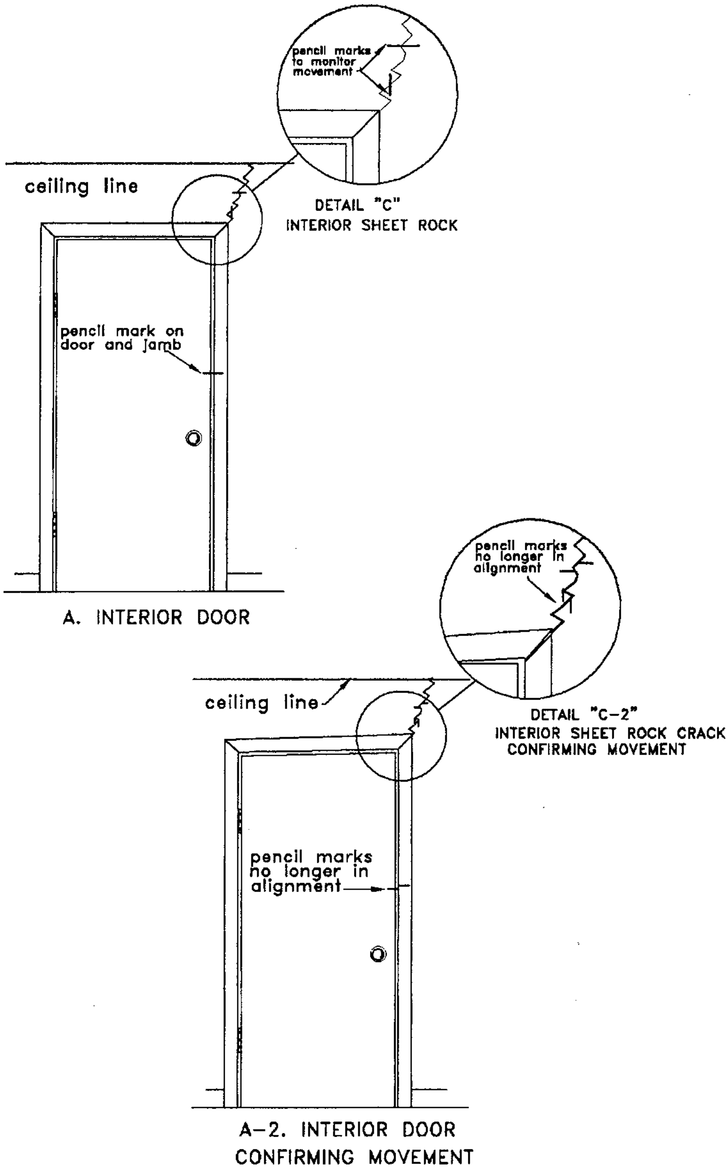
Two Point: $= \delta' = \delta/L/2 = 2\delta/L$

L	δ/L*	δ'/10 ft, in†	δ'/20 ft, in
12.5 ft (150 in)	1.5%	1.8 in	3.6 in
20.8 ft (250 in)	0.4%	0.48 in	0.96 in
25 ft (300 in)	0.33%	0.4 in	0.8 in
	0.31%	0.375 (3/8″)	0.6875 (11/16″)
33 ft (400 in)	0.25%	0.3 in	0.6 in
42 ft (500 in)	0.2%	0.24 in	0.48 in
50 ft (600 in)	0.167%	0.2 in	0.4 in

*δ is constant at 1 in and L varies as shown.
†Distance indicated (120 in or 240 in) times $2\delta/L$.
Source: After U.S. Dept. of the Navy, 1988, and Whitman and Lambe, 1979.
Example conversion: Assume: 1 in deflection (δ) over 25 ft (150 in).

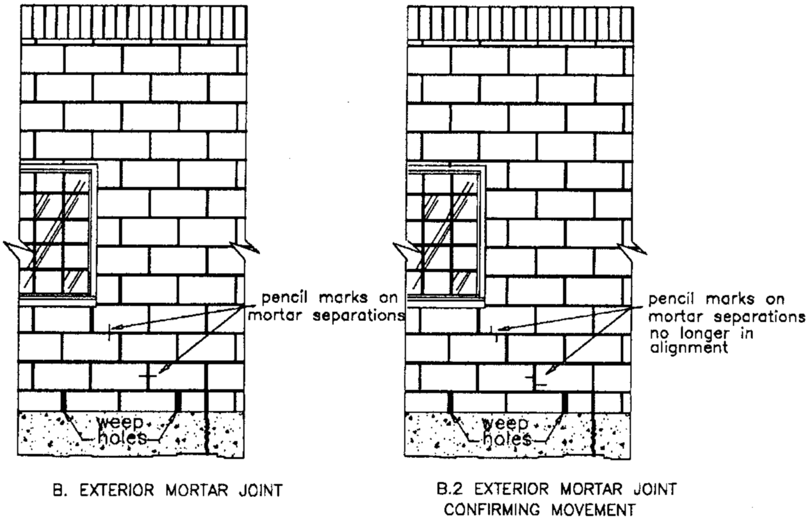
1″/25 = 0.33%, comparing to two point analysis:

$\delta'/10' = 0.33$ or $\delta' = (120\text{ in})(0.0033) = 0.4$ in.



(a)

FIGURE 7D.1 Monitoring ongoing movement.



(b)

FIGURE 7D.1 (*continued*). Monitoring ongoing movement.

quences would be nearly certain. Thankfully, there are usually no similar consequences in making the error of labeling settlement as upheaval. Essentially, this is true because first, all of foundation repair techniques are designed to raise a lowermost area to some higher evaluation, and second, there is no undisclosed cause for continual problems. In cases of settlement, one merely raises the distressed area to "as built." In instances of upheaval, it becomes necessary to raise the "as built" to approach the elevation of the distorted area. The latter is obviously far more difficult.

The existence of foundation problems need not be particularly distressing so long as the buyer is aware of potential problems before the purchase. As a rule, the costs for foundation repair are not relatively excessive, the results are most often satisfactory, and the net results are a stronger, more nearly stable foundation.3 It is the surprise that a buyer cannot afford.

7D.2 FOUNDATION INSPECTIONS/SELECTING AN INSPECTOR

The cost for a residential foundation inspection service is quite nominal, varying from about \$150.00 to \$500.00 (1998 dollars), depending on the time involved and the locale. A word of caution: be selective in choosing your inspector. Since the late 1980s many institutions such as lenders, insurers, and sophisticated buyers have begun the practice of requiring a structural inspection performed by a registered professional engineer (P.E.). The engineer should be registered as a structural or civil engineer. In some states (Texas, for example) an engineer registered in any discipline (mechanical, electrical, petroleum, aeronautical, industrial, etc.) can represent himself as qualified to make the inspection. More often than not, these people are not qualified by either experience or education. The engineer of choice should be independent, unbiased, and not associated (directly or indirectly) with any self-serving entity—foundation repair company, builder, insurer, etc. If possible, the engineer should have extensive hands-on experience in foundation repair. If not, he should request specific repair proposals from qualified repair companies. If the engineer accepts (or rejects) any bids proposed by qualified contractors, he should do so based on a comprehensive, conclusive mathematical analysis. This avoids both overkill and ensures a competent repair.

Experience has shown that often engineers not properly qualified or schooled in foundation problems tend to present defective or slanted reports. As an example, on separate occasions, the same "engineers" have specified *either:* 1) 12 in (30 cm) diameter piers, 6 ft (1.8 m) on centers and drilled to 10–12 ft (3 to 3.6 m) with caged 4 #5s and sometimes even belled to 24 in (60 cm), *or* 2) an 8″ diameter (20 cm) straight shaft with 3 #3s, 6 ft (1.8 m) on centers and drilled to 10–12 ft (3–3.6 m). The 12″ diameter option contains specifications that (compared to the 8″ diameter option) are either a gross overkill, or apparently intended to remove the 12″ (30 cm) diameter pier from price contention. (The ridiculous specifications increase the comparative cost for a 12″ diameter (0.3 m) pier by about $75.00.) A 12″ (0.3 m) pier to 10 ft depth, on 8 ft (2.4 m) centers reinforced with 3 #3s would represent a superior choice. By the way, in this specific example, none of the engineers were registered as either structural or civil. One was registered as a mining engineer and two others as mechanical engineers. This is offered as an observation, not a condemnation. This does not suggest that errors are not made by well-meaning civil or structural engineers. This happens frequently, usually as the result of lack of experience. Errors in judgment, intentional or otherwise, tend to produce a gross overcharge and/or ineffective repairs.

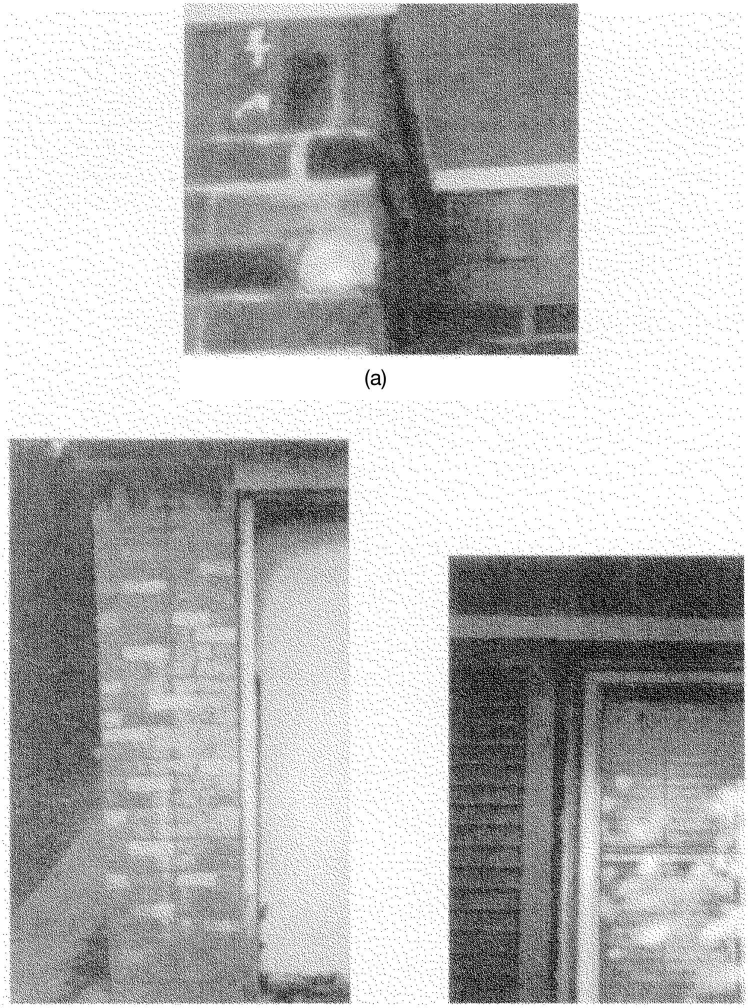
The engineer of choice should be unbiased and independent as well as competent. It is sometimes difficult for engineers (or anyone else for that matter) to be objective when a decision is contrary to the interest of the party paying their bill. This is particularly evident in the number of engineers who accept or recommend practices, procedures, or causes with obvious technical flaws.[15–17] Many of these people are either on the payroll of foundation repair companies who "push" a particular process, or retained by insurance companies with self-serving agendas.

Evaluate any disclaimers included in the engineer's report. If the engineer specifies the method of repair, he likely assumes legal responsibility for the outcome of the repair and future stability of the structure. This is probably true, despite any disclaimer included in his report. These disclaimers, often used as some attempt to shield the engineer from inexperience, probably would not survive an appropriate court of law. The repair contractor would likely be named as a third party defendant in any litigation resulting from repair; however, the ultimate responsibility would likely fall on the engineer who designed and specified the repairs. In this event, the consumer would be lucky if the defendant engineer carried insurance. Otherwise, the consumer is apt to be without recovery unless his state requires bond coverage for practicing engineers. This situation can be avoided (somewhat at least) by the engineer (or owner) soliciting proposals from qualified foundation repair companies who specify and, in turn, provide warranty for all work. The question now become "how can one determine the presence of a potential foundation problem."

7D.3 INDICATIONS OF STRUCTURAL DISTRESS

Following is a simple checklist for evaluating the stability of a foundation. If you have questions or uncertainty regarding any of the items, consult a qualified authority. One might also refer back to Section 7B.8.4 in order to evaluate the "severity" of any observation. Figure 7D.2 presents photographs showing several of the following concerns:

1. Check the exterior foundation and masonry surfaces for cracks, evidence of patching, irregularities in siding lines or brick mortar joints, separation of brick veneer from window and door frames, trim added along door jam or window frames, separation or gaps in cornice trim, spliced (extended) trim, separation of brick from frieze or fascia trim (look for original paint lines on brick), separation of chimney from outside wall, masonry fireplace distress on interior surfaces, etc.
2. Sight ridge rafter, roof line, and eaves for irregularities.

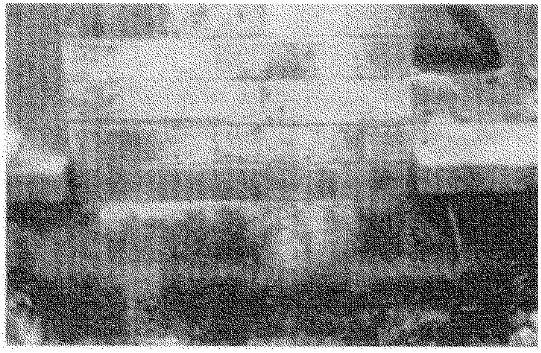


(a)

(a) (b)

FIGURE 7D.2 Evidence of differential foundation movement. (a) Brick veneer tilted inward; often an indication of interior slab settlement. (b) Separation of brick veneer from garage door jamb. (c) Brick veneer separated from window frame.

3. Check interior doors for fit and operation. Check for evidence of prior repairs and adjustment such as shims behind hinges, latches or keepers relocated, tops of doors shaved.
4. Check the plumb and square of door and window frames. Are the doors square in the frames? Check to see if the strike plates have been adjusted to accommodate the strikers. A relocation might indicate movement. Measure the length of the door at the door knob side and the hinge side. A discrepancy suggests that the door may have been shaved. Also feel the top of the door



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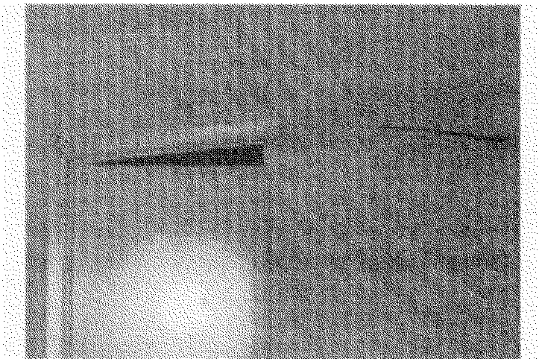

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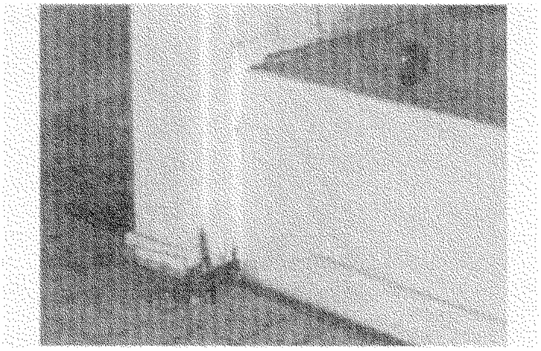
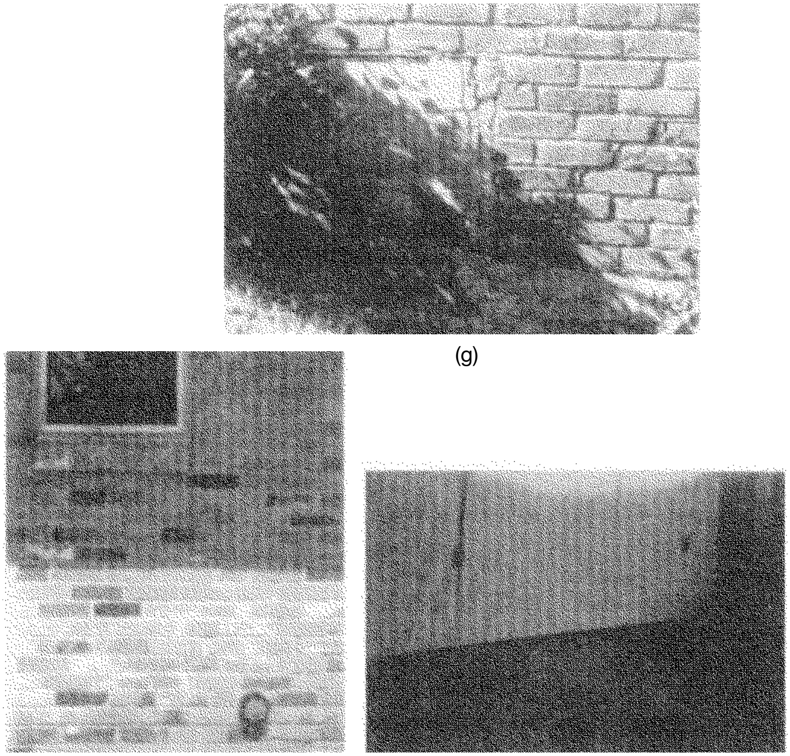


(f)

FIGURE 7D.2 (*continued*). Evidence of differential foundation movement. (d) Horizontal separation in brick mortar. (e) Interior door frame out of plumb, causing sheetrock cracks. This illustrates the effect of upheaval in an interior slab. The high point is to the right side of the door. (f) Interior slab settlement. This shows separation of interior slab from the wall partition. Note also that the bathtub has settled away from the ceramic tile.



(g)

(h)

(i)

FIGURE 7D.2 (*continued*). Evidence of differential foundation movement. (g) Crack in perimeter beam. This illustrates a major crack in the perimeter beam accompanied by secondary cracks in brick veneer and brick mortar. (h) Stair step separation in brick mortar. This shows an obvious crack in the brick mortar, but does it represent a problem concern? First, the crack width is less than ¼ in (0.6 cm). Second, the mortar joints are straight. Third, the cornice trim at the corner is tight. Fourth, no interior damage was noted. Thus, the damage is not one of concern. (i) Slab upheaval. This is a fairly typical representation of slab upheaval. Note the very obvious crown in the slab surface (approximately 4 in or 10 cm) accompanied by vertical separation in wallboard, crack in floor slab, and separation in show mold from slab.

above the door knob. If it is smooth, the door may have been sanded or shaved. If the door rubs slightly at the top, shimming the hinge plate might provide alignment without altering the door.

5. Note grade of floors. A simple method for checking the level of a floor (without carpet), window sill, counter top, etc. is to place a marble or small ball bearing on the surface and observe its behavior. A rolling action indicates a "down hill" grade. (A hard surface such as a board or book placed on the floor will allow the test to be made on carpet.)
6. Inspect wall and ceiling surfaces for cracks or evidence of patching. *Note:* Any cracking should be evaluated on the basis of both extent and cause. Most hard construction surfaces tend to

crack. Often, this can be the result of thermal or moisture changes and not foundation movement. However, if the cracks approach or exceed ¼ in (0.6 cm) in width, the problem is *possibly* structural. On the other hand, if a crack noticed is, for example, ⅛ in (0.3 cm) wide, is it a sign of impending problems? A simple check to determine if a crack is "growing" is to scribe a pencil mark at the apex of the existing crack and, using a straight edge, make two marks along the crack, one horizontal and one vertical. If the crack changes even slightly, one or more of the marks will no longer match in a straight line along the crack and/or the crack will extend past the apex mark. A slight variation of this technique is to mark a straight line across a door and matching door frame. If any movement occurs, the marks will no longer line up. Continued growth of the crack or displacement of the doormarks would be a strong indication of foundation movement.

7. On pier-and-beam foundations, check floors for firmness, inspect the crawl space for evidence of moisture, deficient or deteriorated framing or support, and ascertain adequate ventilation. The crawl space should be dry with adequate access. As a rule of thumb, one ft^2 ($0.9\ m^2$) of vent is suggested for each 150 ft^2 ($13.5\ m^2$) of floor space.
8. Check exterior drainage adjacent to foundation beams. Any surface water should quickly drain away from the foundation and not pond or pool within 8 to 10 ft (2.4 to 3 m). Give attention to planter boxes, flower bed curbing, and downspouts on gutter systems.
9. Look for trees that might be located too close to the foundation. Some authorities feel that the safe planting distance from the foundation is 1 or preferably 1.5 times the anticipated ultimate height of the tree. More correctly, the distance of concern should be perhaps 1 to 1.5 times the canopy width. Consideration should be given to the type of tree. Also, remember that the detrimental influence of roots on foundation behavior is grossly overrated (see Sections 7A, 7B.2, and 9A).
10. Are exposed concrete surfaces cracked? Hairline cracks can be expected in areas with expansive soils. However, larger cracks approaching or exceeding ¼ in (0.6 cm) in width warrant closer consideration.[17,61]

Absence of the foregoing evidence of structural distress suggests one of two conclusions: 1) either there has been no differential movement (hence no need for repairs), or 2) serious cosmetic work has been performed. In the latter case, the evidence will still be present, only much more difficult to detect. Look for 1) tapered or "out of place" trim strips, 2) newly paneled walls or walls covered with a fabric, 3) patches that do not match the rest of the surface in either texture or color, 4) striker or keeper plates adjusted, 5) doors cut or sanded (feel the top edge to see if it has been cut or sanded and measure both sides of the door to determine whether or how much the door has been cut), 6) differences in widths of mortar joints, and also 7) sight mortar joints to assure that joints are all straight and level. Refer also to Section 7D.3. In instances where no distress has occurred, foundation leveling is neither required nor advised and such attempts could create serious damage. Foundations are often constructed out of level. In fact, the tolerance often acceptable for residential and light commercial construction often exceeds 1″ (2.5 cm) over 20 linear ft (6 m). The home owner is not normally aware of this "out-of-level" because the framing carpenters compensate by adjusting the floor plates. Hence, the finished product boasts plumb and level door frames with generally square corners and level cabinets. Grade elevations subsequently taken on this foundation might still show "diselevations" up to 5 in (12.5 cm) over 100 ft (30 m). However, without differential movement (Figure 7D.3), no leveling would be practical or possible.

The differences between grade elevation, deflection, and differential movement are, for some reason, very confusing to many people. For repair purposes, the primary issue of concern is differential movement. Perhaps the following analogy will help bring clarity to the confusion.

In Figure 7D.3, Door A won't latch and clearly does not properly fit frame, an example of differential movement. Note also the sheetrock cracks. This represents a potential for foundation "leveling." Door B fits and latches properly although floor is obviously not level. This door was framed square on an unlevel floor. This situation does not represent a potential for foundation repair.

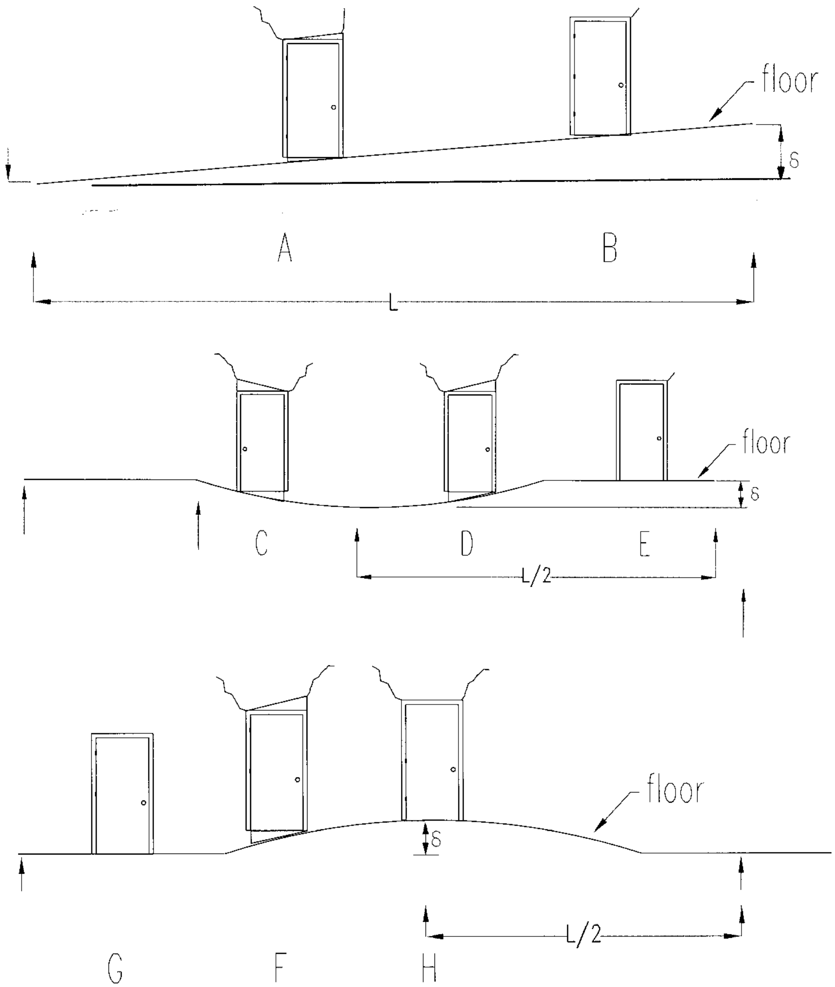


FIGURE 7D3. Evaluating door misalignment.

Doors C and D won't latch and are low on the hinge side. The sheetrock is badly cracked. The center slab has settled and is a strong candidate for foundation repair. In the case of a concrete slab foundation, the likely repair would involve mudjacking. If the foundation is concrete pier-and-beam with concrete interior pier caps, the logical repair procedure would be shim the interior floors or existing pier caps. Refer to Sections 8B.1 and 7B.2

Door E shows no evidence of differential movement, since it is located outside the area of differential movement.

Door F won't latch, clearly does not fit the frame, and is high on the inside (door knob). The sheetrock is severely cracked. This distress needs repair.

Door G shows no distress, since it also is not the subject of differential movement.

Door H shows minor distress, which on its own probably would not suggest repair. However, this door is situated along the peak of the heave. Doors perpendicular to and on a plane with F may show similar movement. However, all doors parallel with the slope of heave will appear similar to door F. This foundation is in need of serious foundation repairs. The procedure would require underpinning the perimeter with the hopes of raising the (more or less stable) lower areas to meet or minimize the heave (δ) Refer to Section 7B.4. As one might expect from the described repair procedure, upheavel is the most difficult of all foundation problems to correct.[13,18]

In fact, repairs are frequently a matter of compromise, " level to extent practical from a cost-results balance and stabilize." Refer also to Section 7A.3. The interior would then be supported and/or leveled as outlined for settlement in the prior example. The foregoing analysis should be used to evaluate or interpret any grade elevation developed from the property inspection performed by either the engineer, house inspector or foundation contractor, as the case my be. Refer also to Section 7B.7.2.

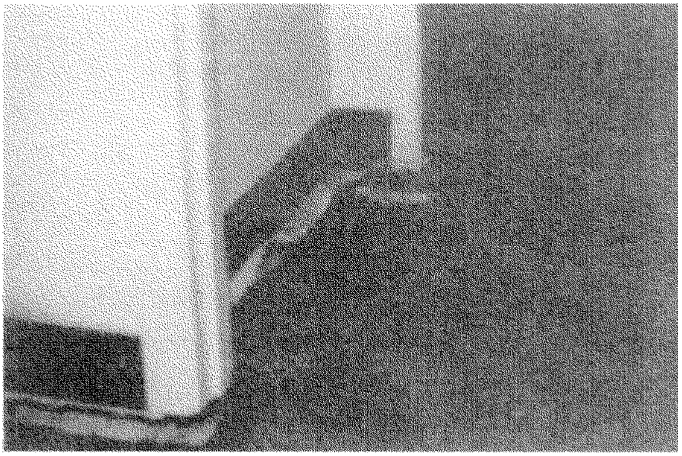
7D.4 IMPACT OF FOUNDATION REPAIR ON PROPERTY EVALUATION

Do foundation repairs impact resale values? This is a question often heard, particularly from appraisers and attorneys. Generally speaking competent foundation repairs should produce an end product at least equivalent to and, more often, superior to the original. Figure 7D.4 shows before and after photos of actual foundation repair. In all instances, the damage was completely reversed. (This is generally, but not always, the case.) The repaired foundation will have no increased susceptibility to future problems. In fact, the properly repaired foundation might be considerably more resistant to future problems. These facts are due, at least in part, to such factors as:

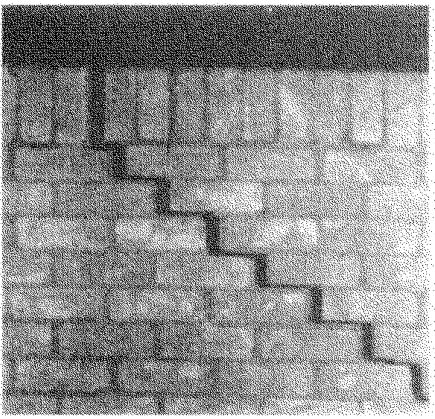
1. Underpinning and mudjacking provide support to the foundation that either did not preexist or had been rendered ineffective.
2. The cause of the foundation failure was hopefully identified and corrected prior to the repair. [With the new (unrepaired) foundations, some problem might exist but not be detected until a visible foundation problem actually develops.]
3. Certain repair procedures (such as mudjacking or chemical stabilization) actually help stabilize the soil moisture, inhibit moisture transfer within the soil, and increase soil resistant to shear. (The grout placed by mudjacking tends to serve somewhat as horizontal and vertical capillary barriers.)
4. A foundation properly repaired by a reputable contractor will be covered by a warranty of some duration. The legitimate warranties generally vary in length from 1 year to 10 years, with restrictions or limitations in coverage after the first year or so. Read any so-called "lifetime" or extended-term warranty carefully. If it sounds too good to be true, you can be sure *it is.*

A foundation is no different than any other inanimate object—it refuses to move unless forced to do otherwise. Eliminate or prevent this force and no movement occurs. In the case of foundations built on expansive soils, the primary force is provided by variations in soil moisture. Add water and the soil swells. Remove water and the soil shrinks. Do neither and no movement occurs. It makes no difference whether the foundation is new, old, or previously repaired.

Proper maintenance and alert observation to the early warning signs of impending distress will prevent or minimize all foundation movement. Drainage and proper water content can be easily controlled by common sense. The "unknown" in the formula involves the accumulation of water beneath slab foundations due to some form of utility leak. The most serious source is some form of sewer leak. As a rule, the latter is usually detected after the fact from the various signs of differential foundation movement as manifested by sheetrock cracks, ill-fitted doors, windows, cabi-



(a)

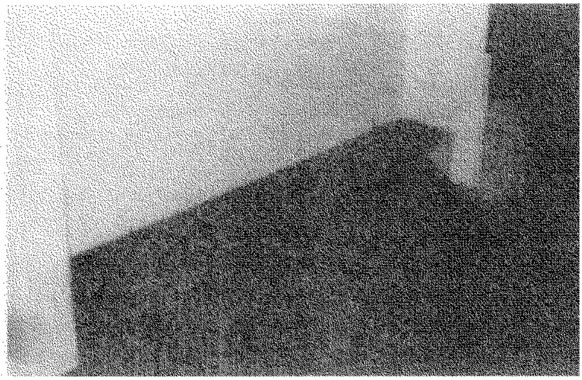


(b)

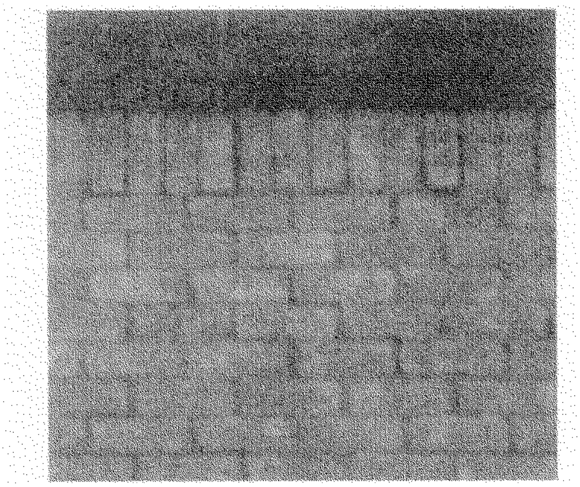
FIGURE 7D.4 Foundation leveling. (a) The floor is separated from the wall partition by about 4 in (10 cm). (b) The separation in brick mortar is an excess of 2 in (5 cm).

nets, etc., or deviated floors. Figure 7B.8.3A shows a simplistic slab behavior as it is being heaved. Figure 7B.8.3b shows what happens to the rebar after the slab is heaved. Catch the problem sufficiently early, eliminate the cause and, in some cases, avoid the need for foundation repair. Notice that no differentiation is given as to age or history of the subject foundation. It makes little difference.

The principal foundation concern in purchasing a property should be whether the foundation was properly designed for the site conditions, competently constructed, and properly maintained. The occurrence of foundation repair would have no negative impact, providing the repairs were properly executed.



(c)



(d)

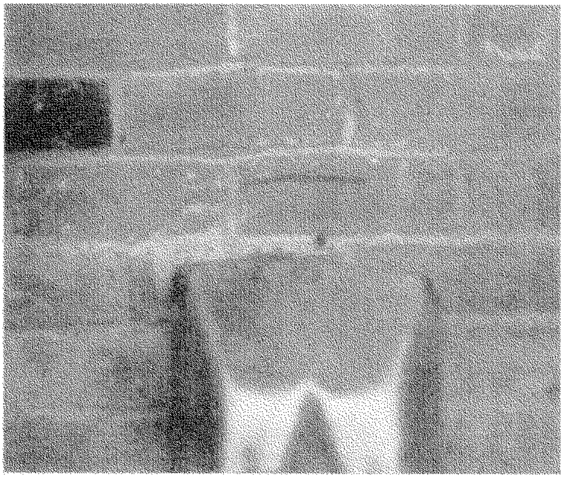
FIGURE 7D.4 (*continued*). (c) and (d) Results from foundation levelings of (a) and (b), respectively. The separations are closed. The end results of foundation levelings are not always so impressive.

7D.5 WARRANTIES AND SELECTING A REPAIR CONTRACTOR

Once the method of repair has been resolved, the selection of a contractor has been narrowed considerably. A next point to consider might be the contractor's warranty.

7D.5.1 Warranty

A foundation will not move unless forced to do so. The force causing foundation movement (in expansive soils) is generally water—too much or too little. The contractor has no control over the availability of water to the foundation. Therefore, most contractor's warranties limit liability for up-



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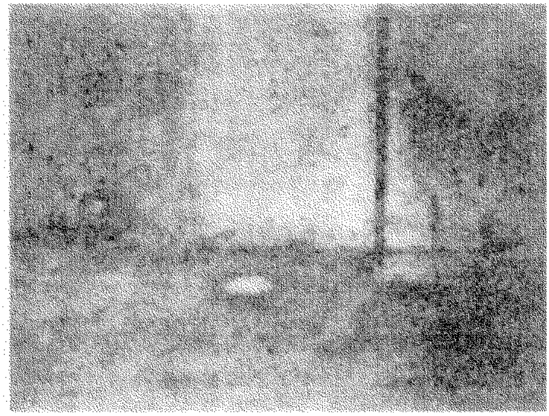

(f)

FIGURE 7D.4 (*continued*). Foundation leveling. (e) Mudjacking in progress. The shovel and scribed marks monitor the raise of slab. At this point, the raise has been more than the width of a brick. (3½ in or 9 cm). This is shown by the distance between the shovel point and the original scribed mark (the shovel handle is on a stationary surface.) (f) In this example, the shovel point is on the stationary surface. The floor slab is down about 4 in (10 cm). (g) The floor is restored to it original grade.

heaval, whether caused by deficient drainage (ponding), excessive watering, or domestic sources. Excluding these events, the foundation is not likely to experience significant movement anyway. The quality contractor's standard limited warranty (usually 1 to 2 years) will frequently: 1) waive the upheaval restriction on a limited basis, 2) provide transfer to new owners, and 3) cover differential movement in excess of ¼″ to ³/₈″ (0.6 to 0.9 cm). (Lower ranges of movement are allowed since virtually all foundations on expansive soils will move. In fact, slab foundations were originally designed to accommodate soil movement (often 0.3%). Hence, the term "floating slab" (refer to the Introduction and Section 7B.8.4). Many contractors will also offer a limited *extended* warranty to cover the repaired foundation for an extended period of time, usually 3 to 10 years. Use of the "extended coverage" would cost the consumer a reduced amount, often about one-half the normal charges. The "extended coverage" is frequently free of extra cost to the consumer unless, of course, work is actually performed.

Be wary of "lifetime" warranties or other ridiculous warranty claims. The verbiage of the lifetime warranty often includes several or all of the following caveats:

1. Covers *initial owner only* or reduces to 10 year warranty if property changes hands within 10 years.
2. Does *not cover* foundation movement due to *heave.* (Over 70% of all slab foundation repairs are precipitated by upheaval.)
3. Specifically excludes settlement (or movement) of interior floors.
4. Covers materials only.
5. Limits coverage to replace or rework *material* installed by contractor. Additional material or "new" installations subject to normal charge.
6. Limits coverage to *vertical settlement.*
7. Requires differential deflection of 0.4% (1 in over 240 in), as opposed to the "normal" 0.3% (1 in over 360 in), to define failure. Refer to Section 7B.8.4.
8. Exempt all "consequential" damage such as landscaping, floor covering, sheet rock, brick, masonry or concrete, utilities, etc. (This is basic to most, if not all, warranties.)

The terms *lifetime* and *warranty* are somewhat deceptive, to say the least. Aside from the foregoing, for a lifetime warranty to be taken seriously it would need to be backed by a *substantial,* irrevocable, escrow account. The balance for such a fund should start at perhaps $500,000.00 (U.S.) and be increased annually as the company increases exposure. A half million dollars would assure full dollar coverage on a mere 30 to 100 jobs, dependant, of course, on the size of the composite projects and assuming that neither punitive nor treble damages become involved. (A major foundation repair company might perform upwards of 40 jobs per month.) Many warranties, particularly the so-called lifetime warranties, are equivalent of insuring swimming pools against theft. The rates are quite cheap and the coverage can be lifetime; however, the protection is meaningless.

When all is said and done, the best and most consumer-protective warranty is probably represented by the "normal" 2 Year Standard Limited Warranty. In effect, these warranties state "Contractor warrants work performed by the contractor against *settlement* in excess of ¼ in for a period of 24 months after completion of initial work." Note particularly the reference to settlement. Most warranties (and contractors) exclude upheaval because this problem is caused by water accumulation and is beyond the control of the contractor.

Most recurrent problems, which are generally the responsibility of the contractor, occur within the first year. Even then, the problems are likely to be quite minor. The principal exception to this represent those circumstances where: 1) a slab foundation is underpinned without the prerequisite mudjacking, or 2) defective methods are used to underpin the perimeter and proper mudjacking is not performed. Sometimes, more than two years are required for these problems to become apparent to the consumer. However, the Extended Limited Warranty (5 to 10 years) will adequately cover any of these contingencies.

Upheaval represents the largest cause for recurrent foundation failure of slab foundations on expansive soils. This problem is exempted from most, if not all, warranties. However, some companies will accept this as a covered item *strictly* as a public relations concession. Where the concession is made, the coverage is provided by the Standard Limited Warranty.

The foregoing analysis is understood when one remembers the principal of physics—"Nothing moves unless *forced* to do so." With slab foundations or expansive soils, this force is generally water and, most often, excess water. This occurrence is beyond the control of even the most conscientious contractor.

In other cases, recurrent problems can result that are not related to expansive soil behavior. Generally, these are also exempted by the contractor and might include such instances as sliding or embankment failure, erosion, consolidation of fill due to decay of organic content or collapse of soil structure, thaw of permafrost, etc. (see Section 7A).

If you have a warranty concern, consult your attorney for an opinion. Be more concerned about what the warranty covers and less about the duration.

7D.5.2 Selecting a Contractor

Next in the process to find the preferred contractor is to consider individual credentials. To help ensure the selection of a competent contractor, consider the following criteria:

1. The contractor has at *least* five years experience (preferably ten) in your locale dealing with problems similar to your own. Request proof of experience. Contact the *Yellow Pages* to determine the contractors' continuous years therein. There are companies in the *Yellow Pages* who advertise "X" years experience. In reality, a number of different employees may each have a few years experience, which totals "X."
2. The contractor should be fully insured and licensed, where applicable.
3. The contractor should be financially stable. A bankrupt contractor offers little or no protection or recourse for complaints.
4. Check with the Better Business Bureau, Attorney General, and County and District Courts to evaluate litigation and/or unresolved disputes. Any contractor in business for an extended period of time is subject to complaints. The concern is how the disputes were resolved.
5. Does the contractor have adequate technical competency? Repairs are neither repetitious nor sometimes even similar. The contractor must have the ability to adapt.
6. Ascertain that the contractor owns all the proper equipment with which to do your job. Use of unfamiliar equipment has been known to result in serious property damage. The contractor should do his own work with company personnel. In some cases, *limited* subcontracting has proven acceptable.
7. Hire a contractor who pays his sales force a salary. Many contractors compensate sales on a per pier sold basis (often \$10 to \$15). This gives rise to an overabundance of piers with corresponding neglect to other areas.

With careful reliance on the foregoing paragraphs, an honest, capable, and economical foundation repair should be the reward. As stated in Part 8, the principal goal is to identify and eliminate the cause of the problem. This done (and assuming competent repairs), recurrent movement is unlikely unless a new cause develops.

7D.6 BUILDING CODES

New construction is governed, to a large extent, by municipal or national codes.[29,36,90,93] Most major cities have written codes allegedly based on the Council of American Building Officials (CABO) publication for one and two family dwellings, 1989 Edition. This information does not provide any real assistance, as far as foundation repair is concerned. In fact, the author is not aware of any significant industrial, municipal, national or governmental code covering foundation repair, although some maybe in the offing.

Many municipalities in the United States have established city policies intended to control at least certain aspects of foundation repair. Generally, this is through the requirement of building permits. At the end of the day, about the only benefit from this policy is to the city coffers, at the expense of the citizens. The municipality offers no guidelines as to proper repair procedures. The code merely requires the seal of a P.E. In Texas, the P. E. might be schooled in such areas as aeronautical, sanitary, industrial, electrical, mechanical, agricultural, petroleum, mining, or, if the citizen is extremely lucky, civil or structural engineering. In many cases, this "engineer" has neither leveled a foundation in his entire career nor does he provide any mathematical analysis that would verify his design or support his credibility. Refer also to Section 9A.

7D.7 LEVELS OF EVALUATION (PROPOSAL)

Due to the high number of complaints (and resulting litigation) against engineers performing design or evaluation of residential foundations, the industry has been under intense pressure to provide a commentary or policy that would minimize that legal exposure.

One such entity, the Texas Board of Professional Engineers, made some attempt in this direction. The Residential Foundation Committee (RFC) produced the Policy Advisor (PA), 09-98-A, in late 1998.* The purpose of this PA was stated as two-fold:

A. Provide recommendations to various non-engineering entities on how to minimize the probability that residential foundation problems, currently encountered by home owners, will occur.
B. Provide practicing licensed professional engineers with guidance in the preparation of design and evaluations of residential foundations to minimize the probability that problems, currently encountered by home owners, will occur.

(Readers interested in design should obtain a copy of both the PA and the RFC documents from the Texas Board of Professional Engineers, P.O. Drawer 18329, Austin, Texas 78760-8329.)

Inspection/evaluation/repair was approached from a cursory review. The essential points that *might* be of benefit to these practitioners could be summarized as follows:

If a the development of a repair plan or forensic report is the purpose for the evaluation, the engineer must establish the minimum level of evaluation required to adequately accomplish that purpose. Inherrent in this rule is the notion that an engineer is to provide an optimized, cost-effective design (repair).

The board recommends the use of the following three levels of evaluation design.

1. *Level A*. This level of evaluation will be clearly identified as a report of first impression conclusions and/or recommendations and will not imply that any higher level of evaluation has been performed. Level A evaluations will typically:

a. Define the scope, expectations, exclusions, and other available options
b. Interview the home owner and/or client if possible
c. Document visual observations personally made by the engineer during a physical walk-through
d. Describe the analysis process used to arrive at any performance conclusion
e. Provide a report containing one or more of the following: observations, opinions, performance conclusions, and recommendations based on the engineer's first impressions of the condition of the foundation

2. *Level B*. This level builds upon the elements found in a Level A evaluation. In addition to the items included in Level A, a Level B evaluation will typically:

a. Request and review available documents such as geotechnical reports, construction drawings, field reports, prior additions to the foundation and frame structure, etc.

*This policy was removed from the Texas State Board web page and at least temporarily shelved in early 2000. It is awaiting more review.

b. Determine relative foundation elevations to assess levelness at the time of evaluation and to establish a datum

c. If appropriate, perform noninvasive plumbing tests, recognizing that additional invasive testing is also available

d. Document the analysis process, data, and observations

e. Provide conclusions and/or recommendations

f. Document the process with references to pertinent data, research, literature, and the engineer's relevant experience

3. *Level C.* This level builds upon the elements found in the Level B evaluation. In addition to the items included in Levels A and B, a Level C evaluation will typically:

a. Conduct noninvasive and invasive plumbing tests as required by the engineer;
b. Conduct site-specific geotechnical investigations as required by the engineer
c. Conduct materials tests as required by the engineer to reach a conclusion
d. Obtain other data and perform analyses as required by the engineer
e. Document the analysis processes, data and observations
f. Provide conclusions and/or recommendations

The stated levels of evaluation will likely provide some shield against litigation to those engineers responsible for foundation evaluation reports. At least this wording might both limit the engineer's exposure and better communicate to the consumer the extent of the evaluation.

However, PA seems to lack provisions that would either improve the quality of the foundation evaluation or the competency of the engineer to thus afford the consumer a degree of confidence in the engineering community. Refer also to Section 9A.

Another aspect, obvious by its absence, is any attempt to standardize or monitor repair procedures. Refer to Section 7B.4. Any efforts along these lines would be a tremendous benefit to the consumer. Before any substantial movements can be made in this direction, some group or individual must devote the time (and weather the criticism) necessary to produce the meaningful data. Courage is required to stand up and tell a contractor or engineer that his repair method is inappropriate, too expensive, or both.

If competent foundation evaluation followed by competent repair could be established, both the consumer and the engineering community would truly benefit.

On the brighter side, anything done to improve and standardize foundation design will favorably impact foundation repair/evaluation procedures.

7D.8 CONCLUSIONS

Regardless of the foundation repair contractor's skills or methods, he can generally locate an engineer who is willing to sign off on any proposal and/or drawing(s). This secures a building permit. Next, the city requires inspections with the intent of ascertaining that the work performed is according to the engineers' approved design, not with any regard as to the *merit* of the repairs. Generally, this provides little service to the consumer, unless he has hired a less than honest contractor. The city inspectors can, in fact, threaten the success of a job, principally by delaying the pouring of concrete. Drilled pier shafts should be poured as quickly after drilling as possible. An overnight delay can be detrimental to the function of the drilled pier/haunch.

A reasonable and effective code covering foundation repair would be a substantial asset to the owners and repair contractors alike. However, *serious* thought must be given to establish a valid, workable, reasonable code (see Sections 7B.1 through 7B.6). So much "hocus pocus" is written about foundation failure and repair that it has become increasingly imperative that fiction needs to be separated from fact. Writers have attempted to base a *trend* on one or two questionable case histories. In other cases, repair procedures have not been subjected to a *thorough* mathematical analysis to evaluate such characteristics as component resistance to: 1) shear, tensile, lateral, or compressive stress, 2) moments that induce misalignment or cause failure, 3) potential heave, 4) chemical attack or deterioration, and 5) load attributed to the weight of the structure.

The specific design of the foundation, the site conditions and the bearing soil characteristics are examples of other factors to be considered when adopting repair procedures.

Proper forethought and the input of knowledgeable, experienced, unbiased contractors in concert with equally capable engineers, geotechnicians, and/or perhaps architects could well develop a usable foundation repair code. Actually, the need would require a series of codes applying to variable conditions. Refer also to Section 9A.