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ENGINEERING OPINION
INVESTIGATION OF FOUNDATION PERFORMANCE
RESIDENCE AT 1521 CR 2291, CLEVELAND, TEXAS, 77327
Date of Inspection: December 17, 2021
Date of Report: December 30, 2021

SUMMARY

The foundation is performing well.

BACKGROUND

A request was made for an inspection and report on the performance of the foundation of the subject house. I was assisted by John Jackson, Engineer. A visual inspection was performed, elevations were measured, and relevant conditions documented with photographs (not included).

Some of the report is boilerplate, advice and information pre-written due to its common nature and used in this report because of its applicability. Boilerplate and outside references will be italicized in this report.

Convention regarding directions: Front faces the street, left and right are as seen from the street facing the house. Back-right indicates back side, right end. Right-back indicates right side, back end.

INSPECTION

The foundation is concrete slab-on-ground with steel reinforcement, with conventional wood framing above, clad in brick veneer.

Damages and conditions at the exterior are shown on the attached Elevation survey sheet. Brick mortar lines were straight and expansion joints unmoved, these are desirable conditions. No damage indicative of foundation movement was observed.

Inspection of the exterior found trees within possible influence of the foundation.

Inspection of the exterior found deficient drainage and landscape conditions at the perimeter of the foundation, as shown on the attached Elevation survey sheet.

Damages and conditions at the interior are shown on the attached Elevation survey sheet. A few ceiling cracks were observed.

An elevation survey throughout the house was performed using a Technidea Zipllevel. The reference zero was the middle interior area. The elevations have a range of 1.6 inches, highest at the left exterior wall, lowest at the front right corner of the house. The foundation generally is flat and level in the left third, and drops to the exterior in the right two-thirds.

The foundation will be judged by the three following objective criteria.

The elevation deflections measured as bending of a straight line calculate to .84/360 (.7 inches in 25 feet, green line, worst case) which does not exceed the generally accepted criteria for foundation performance and repair of 1.00/360 (1 inch bend in 30 feet).

The elevations measured as tilting of a level line across the foundation do not approach the generally accepted criteria for foundation performance (not repair) of 1.00% (2.4 inch difference across 20 feet).

The elevations measured as slope of floors calculate to 1.17% (.7 inches in 5 feet, red line, worst case), which does not exceed 2.00% (1.2 inch difference across 5 feet).

See attached elevation survey.

ANALYSIS

CONCERN: The foundation is dropping to the exterior walls.

FYI: PERIMETER DROP DUE TO AGEING

Perimeter drop of the foundation due to aging is caused by time and expansive soils, accelerated by shallow exterior grade beams, excessive foundation exposure, excessively sloping soil surfaces, lack of watering during dry summers, and poor drainage. This is a very slow process. Since the entire exterior is dropping, there are usually only minor brick veneer damages at the exterior, and few interior damages near the exterior walls, usually at walls orthogonal to the nearby exterior wall. The drop is not recoverable by watering. This condition is very common in older houses, and is the most frequently found condition related to foundation movement in older houses.

DISPOSITION: Ageing is causing the perimeter drop observed and is the main effect on the foundation.

CONCERN: Are the trees affecting the foundation?

FYI: TREE EFFECT, FOUNDATION NOT REPAIRED

Trees desiccate soils and shrink those soils with a clay component. Clayey soils are common in the Greater Houston area. Where the foundation is supported by these shrinking soils, the foundation drops in the area affected by the tree roots, and drops towards the tree. The effect is stronger during dry seasons. During a wet season, the foundation may rise somewhat. Damages normally occur during the dry summer. This cause-and-effect relationship forms the basis for my analysis.

DISPOSITION: The dahoon hollies at the right yard are the concern. The elevations are the lowest in the house at this exterior wall, so there is likely some limited effect.

CONCERN: The foundation is judged as doing well.

DISPOSITION: The curvature and floor slope values would normally bring this foundation into the adequate category, but with no exterior damages and brick lines straight, the foundation is found to be doing well.

CONCERN: Is foundation repair underpinning an option?

DISPOSITION: The condition of the foundation is not as constructed, but as it is presently found to be doing well, it is not a candidate for foundation leveling.

CONCERN: Drainage is deficient.

DISPOSITION: Deficient drainage and landscape conditions do not normally have a noticeable effect on the foundation, though they can have long-term effects. In this case the drainage and landscape conditions are not a factor in the present condition of the foundation.

The foundation performance falls within the objective performance criteria.

CONCLUSION

Considering the range of elevations, damages, curvature, tilt, stability, age, and identifiable causes of movement, I find the foundation is performing well.

If recommendations are followed, the foundation should perform well in the foreseeable future.

No foundation repair is required or recommended.

The foundation appears to be structurally sound.

RECOMMENDATION

GENERAL RECOMMENDATION

I recommend the following measures to keep your foundation performing as well as possible: Regarding the soils around the foundation: If needed, place soil around the perimeter of the foundation, you only need four inches of foundation exposure, make sure the soil is sloped so it drains away from the foundation, and keep grass or plants growing for a few feet around the foundation. Regarding watering: You only need water enough to keep the plants or grass healthy, normally only required during the dry Summer months. Do not water at flatwork next to the foundation, such as patios and driveways. There is no need to water where there has been foundation repair. Never allow free water within 2 feet from the foundation, nor water the separation that sometimes appears between the soil and the foundation. Do not plant trees closer than 12 feet from the foundation.

CAVEAT

My approach to the mitigation of foundation problems is to eliminate the source of the problem rather than ignore them and install piers or pilings. The installation of piers or pilings can provide immediate results, but ignoring the causes of the foundation performance problems can result in further foundation problems in future years. Eliminating the cause of the problems can involve years before the foundation has recovered and is stable again, and the foundation may not recover to a level acceptable to the owner or professionals.

I will give you the best advice based on my experience, the experiences provided by other professionals and clients, generally accepted information, and scientific principles. I may predict future performance based on generally accepted principles and experience, but factors beyond my control or beyond my ability to observe can affect in unpredictable ways.

This report of observations and opinions was prepared for the exclusive use of the client, and is not intended for any other purpose. Gerard J. Duhon assumes no responsibility whatsoever for the use of this report by any third party. Any third party with an interest in this property should obtain a professional opinion to satisfy their own objectives. This report is based upon information provided at the time of this report. The conditions described are limited to structural and finish issues discovered during a visual, nondestructive survey of the stated scope of the investigation. The investigation is limited to the stated scope, and limited by financial and time constraints.



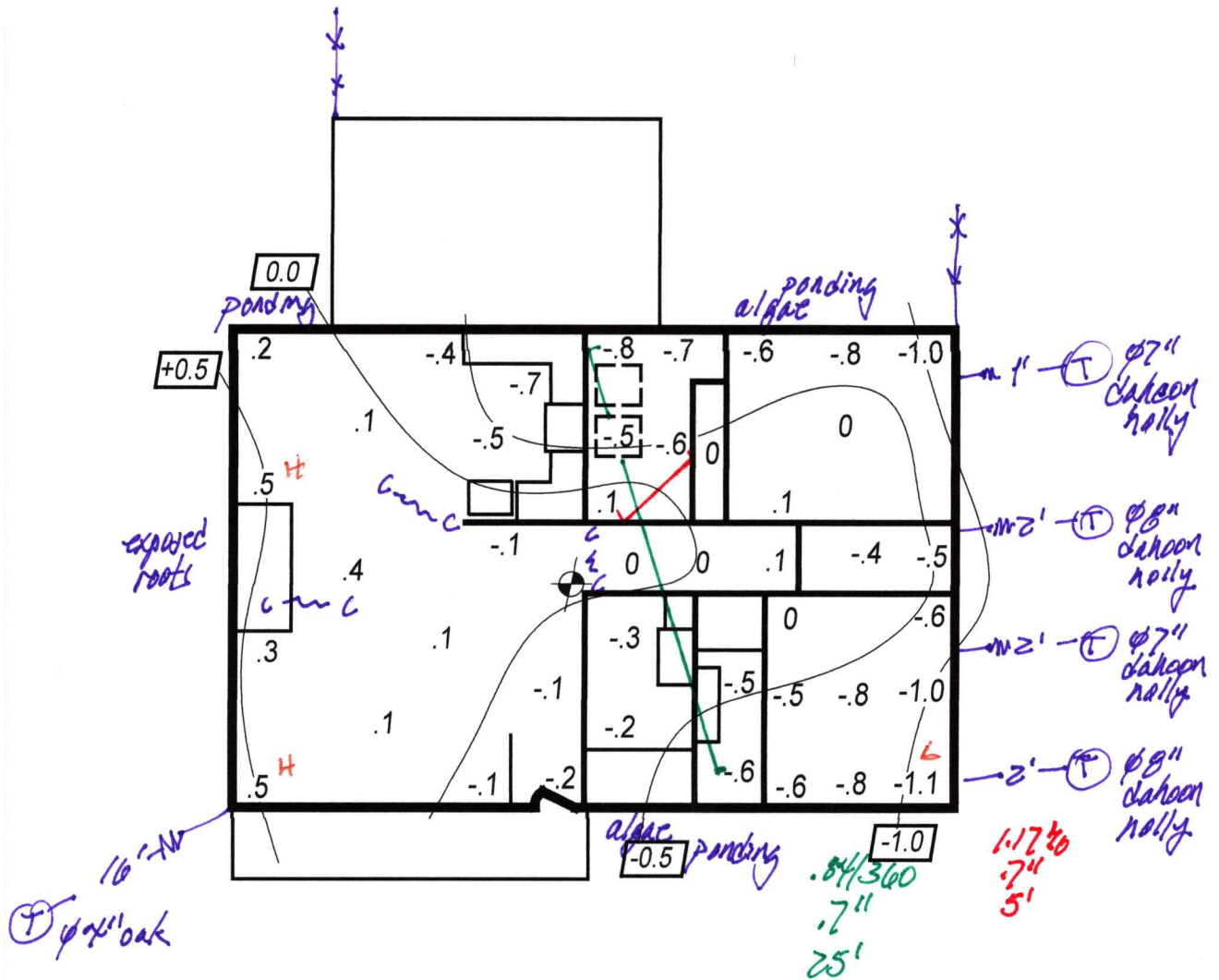
Attachments:

- Elevation survey
- Keys
- Performance criteria

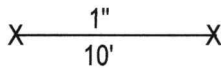
SLAB SURFACE ELEVATIONS AND OBSERVATIONS

1521 CR 2291, Cleveland, Texas, 77327

December 17, 2021



- ELEVATIONS IN INCHES
- CORRECTED FOR FLOORING
- CHARACTERISTIC DAMAGES ANNOTATED
- ISO-ELEVATION (CONTOUR) LINES AT .5 INCH INTERVALS



Donald J. Kuban, P.E.

SURVEY KEY

EXTERIOR

RULE: ARROWHEAD POINTS IN DIRECTION OF RELATIVE MOVEMENT OF BRICK, NORMALLY A GOOD INDICATOR OF DIRECTION OF DROP

Fn [FOUNDATION] †† [CONSTANT WIDTH SEPARATION OR CRACK] Tr [TRIM] Sd [SIDING] Br [BRICK] St [STUCCO]
 -x-x-x [FENCE] ∅Fn [NOT FOUNDATION RELATED] T_N [NEIGHBOR'S TREE] † [CRACK] FnJ [FOUNDATION JOINT]
 [TRIM DISPLACEMENT] \$ [SEPARATION] ∅P [NO PROBLEM] Cab [CABINET]
 EXTERIOR WALL SHOWN $\Delta_{rp+.1/7}$ [CRACK, OPENED AT TOP, AT WINDOW, REPAIRED, THEN OPENED UP .1" ACROSS 7"] c/o [DRAINAGE CLEANOUT]
 #_{rp} [REPAIRS AT WINDOW] ↗ [RECOVERED MOVEMENT] ⊗ [RECOMMENDED REPAIR PILE OR PIER LOCATION]
 [DAMAGES AT DOOR] T_{rem} [REMOVED] ⊙ [INSTALLED PILE OR PIER LOCATION] [ROOT BARRIER]
 $\Delta_{.4/17}$ [VERT CRACK, OPENED AT TOP, NOT @ WINDOW OR DOOR, OPENED .4" IN 17"] †_{.3} [CONSTANT WIDTH CRACK, .3" WIDE, WINDOW]
 [TRIM DISPLACEMENT, SEVERE] T ∅18" PECAN [TREE, 20' FROM FOUNDATION, IN DIRECTION SHOWN, AN 18" DIAMETER PECAN TREE] ⊠ [COLUMN]
 [AT FRONT ENTRANCE, BRICKS MOVE IN DIRECTION SHOWN] ++x [FOUNDATION EXPOSURE 12"+]
 siding [SIDING START AND FINISH, PRESUMABLY BRICK OTHERWISE] xJ ✓ [EXPANSION JOINT NOT MOVED]
 +x [FOUNDATION EXPOSURE IN EXCESS OF 6"] N/A [NOT ACCESSIBLE] WW [WING WALL] F_{Fn} [CRACK AT Fn EXPOSURE]
 L† [LINTEL CRACK] [PIER OR PILE NOT FOUND] EXTERIOR WALL SHOWN ⊙ [PRESENCE OF PIER/PILE VERIFIED]
 MA [MONTHS AGO] [DOUBLE WALL LINE INDICATES SEPARATE Fn] [HORIZONTAL BRICK MORTAR OR SIDING LINE UP IN MIDDLE OF WALL] RL† [RUSTY LINTEL CRACK]

INTERIOR

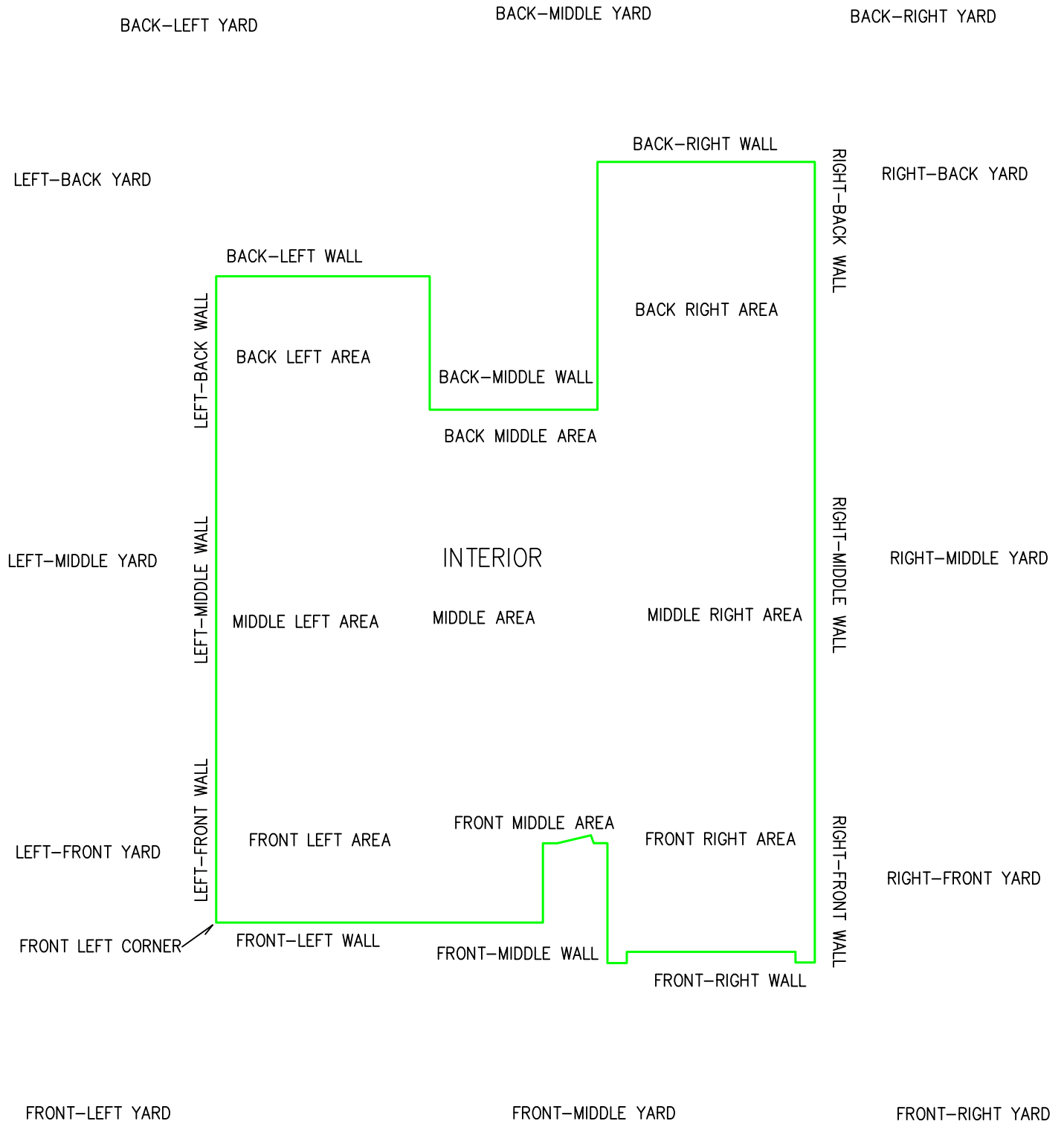
C ~~~ C [CEILING CRACK] +var [POSITIVE SEASONAL VARIATION] var [VARIES]
 2C ~~~ 2C [UPPER LEVEL CEILING CRACK] Wdm [WATER DAMAGE]
 [WALL TO WALL DISTRESS] F ~~~ F [FLOOR CRACK] < > [CRACK SEPARATING] NP [NAIL POP]
 [WALL TO CEILING DISTRESS] [REFERENCE ZERO] H [WATER HEATER] [REFRIGERATOR]
 W\$F [WALL TO FLOOR SEPARATION, GAP] W ~~~ W [WALL CRACK]
 W\$C [WALL TO CEILING SEPARATION, GAP] W ~~~ [WALL CRACK CONTINUES TO CEILING] ↑ [DOOR INTERFERES AT TOP]
 [SEVERE WALL TO WALL DISTRESS] C [CONDITION DOUBLE CHECKED] [SHOWER]
 [ELEVATION TRANSFER POINT]
 RULE: AT INTERIOR, ARROWHEAD POINTS TO INTERPRETED DIRECTION OF DROP
 [AT DOORWAY, INTERPRETATION OF DOWN DIRECTION, DAMAGES AT DOWN SIDE] [WASHER/DRYER]
 [AT DOORWAY, INTERPRETATION OF DOWN DIRECTION, DAMAGES AT DOWN AND UP SIDES]
 [AT WINDOW, INTERPRETATION OF DOWN DIRECTION, DAMAGES AT DOWN SIDE]
 [AT DOOR, INTERPRETATION OF DOWN DIRECTION, DOOR BINDS, DOOR/JAMB MARGIN UNEVEN]
 [MINOR, NON-INTERPRETED DAMAGE AT DOOR, BINDING AT SIDE] [WALL OPENING, NON-INTERPRETED Dm]

DRAINAGE

RULE: ARROWHEAD POINTS IN DIRECTION OF MOVEMENT OF WATER d/s>impound [GUTTER DOWNSPOUT DRAINS TO IMPOUND]
 . . . [ROOF DRIP LINE] < [ROOF VALLEY RUNOFF] -dn [SURFACE DRAINAGE TOWARDS Fn]
 d/s+6 [d/s DISCHARGES 6" FROM Fn] Dn? [TRUE DRAINAGE OBSCURED] d/s+ [DISCHARGING TO POSITIVE DRAINAGE]
 impound [WATER CAPTURED NEXT TO FOUNDATION] pond [WATER RESTS NEXT TO FOUNDATION] → [DIRECTION OF Dn]
 † [YARD DRAIN INLET] hole [WATER APPEARS TO DRAIN UNDERNEATH Fn] cond [AC CONDENSATE DRIPS NEXT TO Fn]
 OTD [OBSTRUCTION TO DRAINAGE]
 pits [GROUND DEPRESSIONS]

ALL DAMAGES NOTED ON SURVEY PRESUMED TO BE FROM FOUNDATION MOVEMENT.
 MOST COMMON NOTATIONS SHOWN, LESS COMMON NOTATIONS DERIVED OR WRITTEN OUT.
 WALLS SHOWN GREEN. BRACKETED ITALICS ARE EXPLANATION FOR SYMBOLS
 INTERPRETATION IS THE DETERMINATION OF DOWN SIDE MADE BY THE ENGINEER/TECHNICIAN BASED ON DAMAGES, MEASUREMENTS, AND CONDITIONS.

LOCATION KEY



TERMINOLOGY

FOUNDATION

GRADE: The level of the surface of the ground.

LANDSCAPE, GRADES (noun): The surface of the ground.

LANDSCAPE (verb): To change the surface geometry of the ground.

PIERS: A general term for all concrete foundation support products, or a specific term for the bell-bottom poured-in-place product.

PILES: A specific term to the pre-cast cylinder foundation support products, which have most of the market in residential repair.

FOUNDATION REPAIR: Not repair of the foundation itself, but leveling of the foundation. Term not precise but in general usage. Proper term would be foundation leveling. For foundation repair, piles or piers are placed at intervals, normally at 7-8' for one story and 5-6' for 2 stories. Underpinning is the general term for the piers or piles in place.

EXPANSIVE SOIL: Soil with clay constituents, common in the Greater Houston area and other areas, which will swell when moisturized and shrink when dried.

FOUNDATION EXPOSURE: The portion of the foundation visible from the yard. Code requires 4 inches of exposure below bricks. Too much exposure normally means not enough of the grade beam is below grade, resulting in accelerated aging of the foundation. The foundation normally extends inches to feet below grade at the perimeter.

LINTEL: The steel angle iron at the top of masonry (brick) openings, such as over windows, doors, overhead garage doors.

GRADE BEAM: The very thick edge of the foundation. It is usually 12" wide, and 12"-18" thick in good older construction, and 22"-36" thick in good newer construction. Some of the grade beam is above ground (exposure), and some of it is below grade.

EXPANSION JOINT: Vertical gap/joint in the brick veneer walls, about ½"-1" wide, normally filled (not required), in long straight walls. Expansion joints will close and open due to the flexure of the wall, and thereby resist cracking of the brick veneer nearby.

FRIEZE TRIM: The trim found below the soffit covering (trimming) the top of the brick veneer wall.

DRAINAGE

PIT: Larger depression in the grade near the foundation. Can be caused by collapse of backfill soils after foundation or plumbing repair.

POND, PONDING: Water puddling in an area, presumably standing and not being absorbed into the soil easily.

IMPOUNDING, IMPOUNDED: The action of resisting proper drainage and retaining water due to a border around the area.

OBSTRUCTION TO DRAINAGE: Normally an area of high grade which obstructs proper drainage.

POSITIVE DRAINAGE: Drainage away from the foundation. NEGATIVE DRAINAGE: Drainage towards the foundation.

HOLE: A deep narrow void in the ground near the foundation, may be an entry for water under the foundation.

GAP: A narrow space between the foundation and the soil, usually found when the soil is dry, may be a place for water to drain at the foundation with negative results.

CLAYEY SOIL: Soil which has a significant clay content. Clayey soil will shed water and form the drainage surface. Clayey soil will stick together when soil is moist and compressed in your hand grasp. Clayey soils are native to most areas of Greater Houston, more so towards the coast.

SWALE: A landscape feature which will drain water. The swale is normally started as a ditch which has the proper drop for drainage. Once the ditch is proven successful, the sides are broadened and integrated into the existing soil surface, creating a natural looking landscape feature effective at drainage.

ROCK TRENCH: A drainage method consisting of digging out a trench at the perimeter of the foundation, and filling with rocks. This results in water being in contact with the foundation exposure, which can be detrimental to the foundation and cause water damage to flooring. In the best case, the water drains quickly from the trench and no detriment occurs. In the worst case water stands in the trench and its presence is not observed.

ALGAE, MOSS: Living organic matter indicating chronic high moisture. If found on the foundation it usually means water is being absorbed into the concrete, which can result in water damages to flooring.

ANALYTICAL DESCRIPTIVE TERMS

INDICATIVE, INDICATES: Strong direct cause-and-effect evidence.

SUPPORTIVE: Weak or indirect cause-and-effect evidence.

IN AGREEMENT: May be due to the stated condition.

ENGINEERING OPINION CRITERIA FOR JUDGING FOUNDATION PERFORMANCE

The main generally accepted objective criteria for foundation performance is L/360, one inch of curvature/deflection/bending in 30 feet, accompanied by some damages in the area. A thorough discussion of the subject of foundation performance can be found in the Foundation Performance Association FPA-SC-13, Guidelines for the Evaluation of Foundation Movement for Residential and Other Low-Rise Buildings.

My criteria deviate somewhat from the FPA, but the findings regarding the adequacy of foundation performance are about the same.

The following are my main objective criteria for judgment of foundation performance.

- Deflection in excess of L/360 across 20+ feet of distance, in middle third of span.
- Tilt, across the entire foundation, in excess of 1.0%.
- Slope, across at least 5 feet, in excess of 2%.
- Doors and windows non-functional.

The deflection, tilt, slope, and functional criteria above are objective and useful for judging the performance of the foundation. Other criteria, both objective and subjective, are also considered in making a determination of foundation performance. These other criteria include:

- Structural damages, including foundation, consider amount and type.
- Finish damages, consider amount and type.
- Proper fit of doors and windows, consider amount and type.
- Area and directions of floors in excess of deflection criteria.
- Area of floor exceeding 1% slope. Slopes in excess of 1% are considered noticeably unlevel.
- Age of building.
- Stability of foundation.
- Identifiable causes of foundation distress.
- Residence or attached garage, consider type of area affected.
- Range of elevations.

For purposes of communicating the performance of the foundation, it is normally described as doing very well, well, adequate, and inadequate. There is some engineering judgement involved in choosing the classification.

As a rule, a foundation which is judged inadequate will have foundation repair recommended, and vice versa. In cases where the rule is not applied, the engineer should have valid reasoning and be well-explained.

Tilt is a criteria which may not cause damages and is difficult to correct, and is more difficult to use to judge a foundation. Tilt between 1% and 1.5%, exceeding the 1% tilt criteria, with low level of deflection and damages, may be considered adequate with no recommendation for foundation leveling. Tilt in excess of 1.5% will be considered inadequate and usually requiring leveling. Whether the tilt was created at construction or the foundation moved later, and whether the tilt is considered stable, are two important factors to consider in judging tilt.

The term sub-standard regarding foundation performance indicates adequate performance with no foundation repair recommended, but the conditions of the foundation and due to the foundation may diminish the market value of the house.



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