ENGINEERED FOUNDATION SOLUTIONS

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# ENGINEERING OPINION

INVESTIGATION OF FOUNDATION PERFORMANCE
RESIDENCE AT 4216 ELI STREET, HOUSTON, TEXAS, 77007
Date of Inspection: March 12, 2021
Date of Report: March 15, 2021

## SUMMARY

The foundation is performing very 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 Gregory Hein, Engineer. A visual inspection was performed, elevations were measured, and conditions documented.

The following information was provided: The townhouse was built in 2004.

*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

Damages and conditions at the exterior are shown on the attached Elevation survey sheet. No damage indicative of foundation movement was observed. The exterior front façade is clad with stucco; the remaining exterior is Hardie plank. These materials do not show damage from foundation movement readily.

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

Inspection of the exterior found adequate drainage and landscape conditions at the perimeter of the foundation.

Damages and conditions at the interior are shown on the attached Elevation survey sheet. Two doors at the 3rd story show diagonal wall cracks. The door to the master bath binds at the top.

An elevation survey throughout the house was performed using a Technidea Ziplevel. The reference zero was the foyer. The elevations have a range of 0.7 inches, highest at the 1st floor bedroom, lowest at the entrance. The foundation generally is flat and level with a slight slope downward towards the front and left.

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

The elevation deflections measured as bending of a straight line do not approach 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 do not approach 2.00% (1.2 inch difference across 5 feet).

See attached elevation survey.

## ANALYSIS

CONCERN: Trees are within influence of 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.*

### FYI: TREE REMAINS IN PLACE WHEN INSTALLING FOUNDATION

*Trees desiccate soils and shrink those soils with a clay component. Clayey soils are common in the Greater Houston area. If a foundation is placed over soil influenced by large mature trees, the foundation within influence can be expected to be subject to some low level of instability, as the tree requirement for water and the weather provision of water varies. If the effect of the tree is lost, the foundation will rise within the area of influence. These old-growth trees should be removed only upon the advice of an engineer familiar with the condition. Old growth trees are characterized by*

*historical evidence of trees prior to development, the trees being native to the area, and if from a heavily wooded area, the form of the tree being tall and narrow crowning high relative to planted trees.*

DISPOSITION: The tree that is 2' from the corner of the townhouse is an old growth tree and should not have any deleterious effects upon the foundation. The front oak tree is of the size and proximity that it may cause effect upon the foundation in the years to come. If damages occur in the future at the front of the townhouse, call for another inspection, a root barrier may be advised, at a cost of about $1500.
********

CONCERN: The 3rd story cracks at the doors and the door binding at the master bath.

**FYI: UPPER LEVEL FRAMING DEFLECTIONS**

FLOORS: Upper level floors will sag, or deflect, where the support is over floor joists, which is totally normal and expected. Directly over walls there will be no sag. Over large rooms the deflection will be greater. Depending on the stiffness and direction of the joists, the sag can be noticeable or bothersome.
DOORS: Doors with the hinge side over a wall and the latch side over joists will sometimes bind due to normal deflections. This normally happens years after construction, in the following scenario: Before the problems the drywall is keeping the structure straight and supporting the loads above, then something happens to exceed the drywall's ability, then sometimes the drywall cracks and doors do not fit or function properly. The drywall yielding pushes the support function to the framing, which is the proper role, but this role change is accompanied by some unevenness due to the framing deflections. In some flooring and door cases the sag, or deflection, is excessive and should be considered for structural repair.

DISPOSITION: The cracks and binding of the 3rd story doors are presently not due to any foundation movement. They are attributable to minor framing deflections of floor spanning the open floor living area below where these damages have occurred.
********

The foundation levels fall within the objective performance criteria.

*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.*

## CONCLUSION

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

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

No foundation repair is required or recommended.

The foundation appears to be structurally sound.

## RECOMMENDATION

As provided above for any possible future effect of the tree.

### 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.*

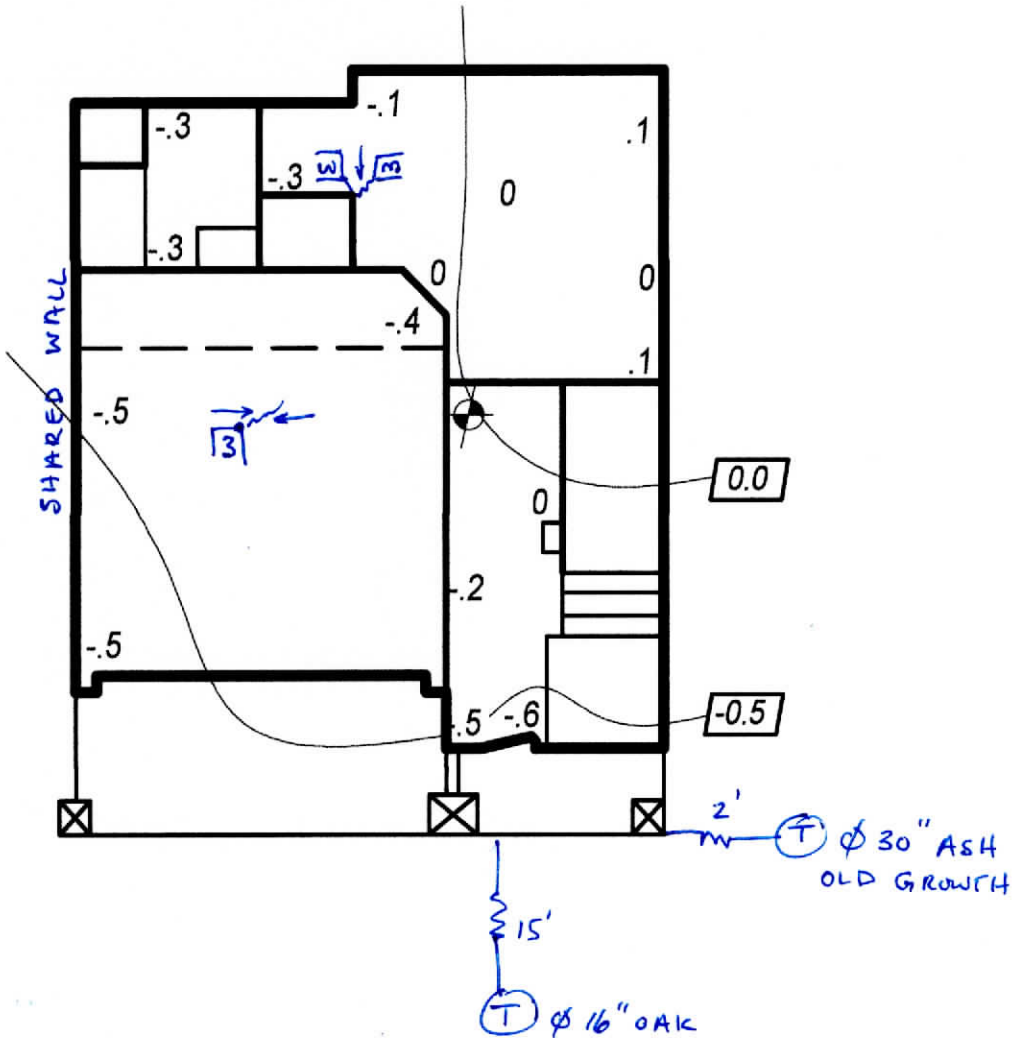
*I am not licensed by the Texas Real Estate Commission (TREC) and do not perform inspections in the manner promulgated by the Commission (We are not looking for problems or inspecting general conditions, we are investigating stated problems). Property purchasers are urged to have properties inspected by a TREC inspector prior to commitment.*


Attachments:
- Elevation survey
- Keys
- Performance criteria

# SLAB SURFACE ELEVATIONS AND OBSERVATIONS

## 4216 Eli Street, Houston, Texas, 77007

March 12, 2021




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

1" = 10'

Gerard J. Kulon, P.E.

- GARAGE ELEVATIONS TAKEN AT CEILING

# 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]

[FENCE] ⌀Fn [NOT FOUNDATION RELATED] (TN) [NEIGHBOR'S TREE] ¢ [CRACK] FnJ [FOUNDATION JOINT]

[TRIM DISPLACEMENT] $ [SEPARATION] ⌀P [NO PROBLEM] Cab [CABINET]

EXTERIOR WALL SHOWN

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] (Trem) [REMOVED] [INSTALLED PILE OR PIER LOCATION] [ROOT BARRIER]

.4/17 [VERT CRACK, OPENED AT TOP, NOT @ WINDOW OR DOOR, OPENED .4" IN 17'] .3 [CONSTANT WIDTH CRACK, .3" WIDE, WINDOW]

20'—(T) ⌀18" PECAN [TREE, 20' FROM FOUNDATION, IN DIRECTION SHOWN, AN 18" DIAMETER PECAN TREE] ⊠ [COLUMN]

[TRIM DISPLACEMENT, SEVERE] pilings [PILINGS, FOUNDATION REPAIR, START AND END] pilings rp [TRIM DISPLACEMENT, REPAIRED]

[AT FRONT ENTRANCE, BRICKS MOVE IN DIRECTION SHOWN] ++x [FOUNDATION EXPOSURE 12"+]

siding [SIDING START AND FINISH, PRESUMABLY BRICK OTHERWISE] siding XJ [EXPANSION JOINT NOT MOVED]

+x [FOUNDATION EXPOSURE IN EXCESS OF 6"] N/A [NOT ACCESSIBLE] WW [WING WALL] Fn [CRACK AT Fn EXPOSURE]

L¢ [LINTEL CRACK] [PIER OR PILE NOT FOUND] EXTERIOR WALL SHOWN (V) [PRESENCE OF PIER/PILE VERIFIED]

MA [MONTHS AGO] RL¢ [RUSTY LINTEL CRACK]

[DOUBLE WALL LINE INDICATES SEPARATE Fn] [HORIZONTAL BRICK MORTAR OR SIDING LINE UP IN MIDDLE OF WALL]

## 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 C [WALL CRACK CONTINUES TO CEILING] [DOOR INTERFERES AT TOP]

[SEVERE WALL TO WALL DISTRESS] √ [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]

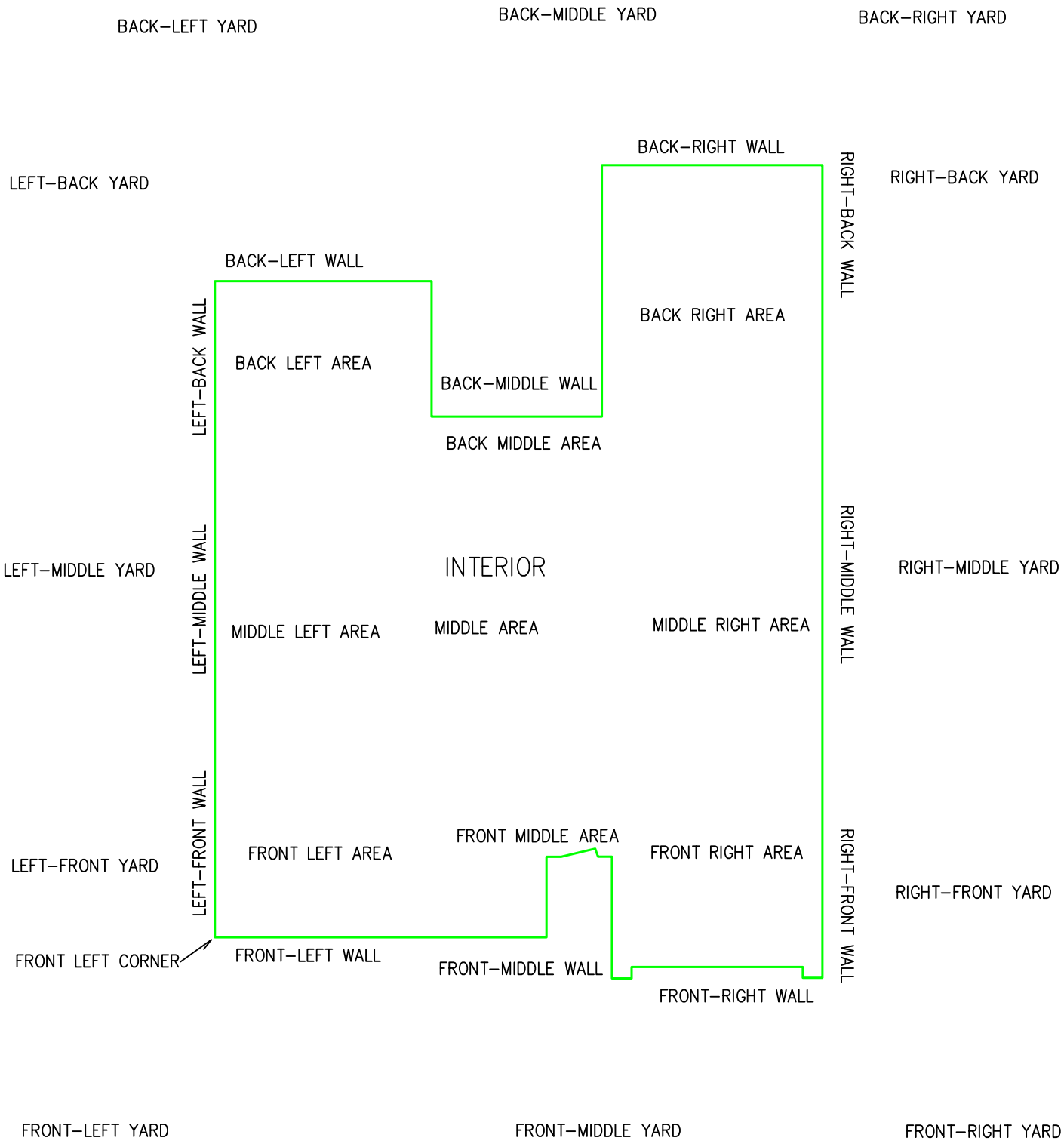
⊕ [YARD DRAIN INLET] hole [WATER APPEARS TO DRAIN UNDERNEATH Fn] cond [AC CONDENSATE DRIPS NEXT TO Fn]

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 pluming 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.

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# 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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