

Report on Measurement of Lean Angle for Perimeter Fencing of Woods of Wimbledon  
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Executive Summary: Perimeter fencing of the Woods of Wimbledon residential development in Houston, Texas was measured for lean angle. There are two fences, one along Strack Road and one along Middlestedt Road. There are a total of 44 support posts on each of the two fences for a total of 88. A total of 78 posts were measured for lean angle. Ten posts were covered with vines or otherwise obstructed and were not measured. Out of the 78 posts which were measured, 61 had some lean angle outward with 3 having some angle inward. There were 37 posts with greater than 1 degree of lean angle, 13 posts with more than 2 degrees of lean angle, 4 posts with more than 3 degrees of lean angle, and 1 with more than 4 degrees. This last post measured about 4.8 degrees of outward lean and is in the worst shape of all posts examined.

Along Strack Road there are several areas which have been eroded on the Strack Road side of the fence and may have been caused by drainage pipes installed through the fence just above the footing. At one point the footing was exposed and was found to be 2 inches inside the edge of the post.

Post lean angle was examined for instability based on 3 different types of subsurface support by the footing. Instability is defined for this report as the angle where the weight of the posts tends to increase the lean angle. In the worst case examined an angle of 5.2 degrees would become unstable. The impact of this would be that the posts would likely continue to fail even if the initial cause of the post lean was removed.

It is recommended that the fences be examined on a yearly basis so that the rate of deterioration can be determined. It is likely that the rate will increase with larger lean angles. Methods of repair should be examined for the fence as the cost of repair is likely to increase in the future as the fence leans at a greater angle. Consideration should be given to a line item in the annual budget to replenish the Capital Fund as fence repairs are completed.

History: The Woods of Wimbledon residential development in Houston, Texas is bordered on two sides by a road way, Strack Road on the northwest and Middlestedt Road on the southeast. When driving or walking along these routes it is visually obvious that the fence along these streets is leaning, primarily in an outward direction. A substantial number of support posts of the fencing were measured for lean angle to determine the amount of deviation from vertical for posts that had the largest amount of inclination and to provide a base line value for comparison to future measurements.

Measurement Method: Tools used for measurement included a tape measure and a level which was 18 inches long. The top of the level was placed near the center of one of the rows of bricks used to construct the post. The level was then held such that the level was vertical. The distance from the bottom of the level to the row of bricks immediately horizontal to the bottom of the level was measured and recorded. This procedure was used along the Middlestedt fence. Nomenclature used is to list the post number as counted from the Steubner Airline end of the fence. Thus the reading for MSA 3 would be the third post along Middlestedt with the number 1 post being closest to Steubner Airline. Similarly, SSA 3 would be the third post along Strack with the number 1 post being closest to Steubner Airline.

The procedure was modified along the Strack Road fence to improve accuracy. The top of the level was placed near the center of one of the rows of bricks used to construct the post. The level was held along and against the post and the initial offset at the bottom of the level to the post brick in a horizontal direction was measured and recorded. The level was then held such that the level was vertical. The distance from the bottom of the level to the row of bricks immediately horizontal to the bottom of the level was measured and recorded. This second procedure should be used in future measurements for improved accuracy.

The results of the measurements are given in Table 1 at the back of this report. The row of bricks used for the top of the level are recorded and are counted from the top cap of the post downward. If brick row 2 was used for the top of the level then that would be the second row of bricks below the top cap. In addition, there was a notation whether the center brick in the post was used or the right or left side brick was used. The location along the post for measurement was selected for convenience and to allow better repeatability in future measurements.

The differential between the initial measurement and the measurement made when the level was vertical is shown in Table 1 as well. The table for fence posts along Middlestedt only shows the differential measurement as there was no initial measurement made. Fig 1 illustrates the technique used with the tape measure and the level. The angle was calculated from the differential distance and the length of the level and is listed in Table 1.

The width of the fence post was measured and recorded along with the height and is given in Table 1. It is believed that all the fence posts were built to be the same approximate height and that any difference in height of posts is due to the ground level being above the base of the post.

Discussion: Once the data had been collected stability calculations were made. Three types of support were considered as shown in Fig 2. The first condition examined footing support over the entire cross section of the fence post and that the post was leaning but the footing remained in its original position. The second condition examined footing support over the post that was 2 inches inside over the entire post cross section perimeter as was measured when the lean angle data was collected. The post was leaning in this second condition but the footing remained in its original position. The third condition examined this reduced footing support but pivoting with the post at a footing depth of 30 inches. If the weight of the footing was considered in case 3 it would lower the center of mass distance. The center of mass was not changed for calculating instability angle for condition 3 as the actual construction of the footing is not known nor is the material used for the footing known. For the footing to be moving with the post it is likely the footing may have failed and these failure cracks or breaks in the footing may be numerous which would result in a smaller footing size moving with the post.

The fence posts were considered to be of uniform construction which allows the center of mass to be used to determine the lean angle where the post becomes unstable. In calculating the center of mass the top cap on the fence post was neglected. If the cap were factored it would actually raise the center of mass slightly which would reduce the angle where instability was reached by a small amount. The angle where instability is reached is when the center of mass passes over the outer support for the post. At this point the weight of the post tends to force the post to lean instead of tending to restore the post to its original position. The angle where the post becomes unstable is given on each of the figures for the 3 conditions.

Plots were made of the fence lean angle which are not to scale but are intended to represent the general top view of the fence as it exists. These plots are shown in Fig 3.

Observations: Outside the fence on Strack is a borrow ditch. There is a possibility that the existence of this borrow ditch is contributing to the movement of the fence since the soil pressure inside the fence line is likely to be greater than outside. Along Middlestedt there is a borrow ditch for a portion of the fence which is not as deep as along Strack. The rest of the fence along Middlestedt has no borrow ditch but the ground slopes away from the fence outward. This could have a long term effect of slow movement taking place over a lengthy period of time. The fence is likely to have been put in place some 35 years ago.

Several portions of the fence have vines growing on the fence surface which could contribute to brick and mortar deterioration. In a few places weeds are growing through the center portion of the fence which could also contribute to problems with the fence. Erosion from drain pipes placed through the fence along Strack Road is likely to continue if the drains are still active.

Conclusions: Options to repair the fence should be examined as it is likely the fence will continue to lean further likely causing more expensive repair work in the future or even fence replacement in some sections if the fence were to fall.

Regular measurements of the fence, yearly perhaps, should be made to determine the rate of lean increase.

Erosion on the outside of the fence along Strack Road should be addressed either with placement of proper materials to prevent additional erosion or by redirecting drainage pathways away from the fence and toward the central portion of the neighborhood.

Consideration should be given to regular maintenance to keep the fence free of vines and other growth.

The budget should have a yearly line item to replenish money taken from the Capital Fund so that a large financial assessment sometime in the future could be avoided.

Table 1 Measurement Results and Calculation of Lean Angle - (Msmt = Measurement)

	Initial Msmt Inches	Level Msmt Inches	Differential Msmt Inches	Width Inches	Height Inches	Lean Angle Degrees
Measured from row 3 to row 8 at center on post	MSA 1	5/8	5/8	16 3/4	95	1.99
Measured from row 3 to row 8 at center on post	MSA 2	3/16	3/16	16 3/4	94 1/2	0.60
Measured from row 3 to row 8 at center on post	MSA 3	0	0	16 3/4	94 1/4	0.00
Measured from row 6 to row 11 at left on post	MSA 4	0	0	16 3/4	95 1/4	0.00
Measured from row 5 to row 7 at center on post	MSA 5	1/8	1/8	16 3/4	94 1/4	0.80
Measured from row 5 to row 7 at center on post	MSA 6	3/16	3/16	17 1/4	91 3/4	1.19
Measured from row 4 to row 8 at right on post	MSA 7	3/16	3/16	16 3/4	91 3/4	0.72
Measured from row 3 to row 8 at center on post	MSA 8	0	0	17 1/2	92 3/4	0.00
Measured from row 6 to row 11 at center on post	MSA 9	7/16	7/16	17 1/2	90 1/4	1.39
Measured from row 3 to row 8 at center on post	MSA 10	0	0	16 3/4	89 3/4	0.00
Measured from row 6 to row 9 at center on post	MSA 11	1/16	1/16	17 1/4	91 3/4	0.30
Measured from row 3 to row 8 at center on post	MSA 12	0	0	16 1/4	89 1/4	0.00
Measured from row 5 to row 10 at left on post	MSA 13	0	0	17 1/2	87 1/8	0.00
Measured from row 7 to row 9 at center on post	MSA 14	0	0	16 1/2	86	0.00
Measured from row 8 to row 10 at center on post	MSA 15	3/16	3/16	16 3/4	81 1/2	1.19
Measured from row 6 to row 7 at center on post	MSA 16	0	0	17 1/4	81 1/2	0.00
Measured from row 5 to row 10 at center on post	MSA 17	3/8	3/8	17 1/4	77	1.19
Measured from row 3 to row 8 at center on post	MSA 18	1/4	1/4	17	80 1/2	0.80
Measured from row 3 to row 8 at center on post	MSA 19	7/16	7/16	16 1/2	81	1.39
Measured from row 5 to row 10 at left on post (Post bulging out and cracked)	MSA 20	5/8	5/8	16 1/2	80 1/2	1.99
Measured from row 3 to row 8 at center on post	MSA 21	1/8	1/8	17	79 1/2	0.40
Measured from row 3 to row 8 at center on post	MSA 22	0	0	17	82 3/4	0.00
Measured from row 6 to row 8 at center on post	MSA 23	0	0	16 3/4	82 3/4	0.00
Measured from row 6 to row 10 at center on post	MSA 24	3/8	3/8	17	82 3/4	1.43
Measured from row 6 to row 9 at center on post	MSA 25	3/16	3/16	16 1/2	81 3/4	0.90
Measured from row 6 to row 11 at right on post	MSA 26	5/16	5/16	16 1/2	80 1/4	0.99
Measured from row 3 to row 8 at left on post	MSA 27	5/16	5/16	16 3/4	79 3/4	0.99
Measured from row 3 to row 8 at left on post	MSA 28	0	0	17	80 1/2	0.00
Measured from row 7 to row 12 at right on post	MSA 29	3/16	3/16	17	80 1/4	0.60
Measured from row 3 to row 6 at center on post	MSA 30	0	0	16 1/4	80 1/4	0.00
Measured from row 3 to row 8 at center on post	MSA 31	1/2	1/2	17	80 1/2	1.59
Measured from row 3 to row 8 at center on post	MSA 32	5/8	5/8	17	80 3/4	1.99
Measured from row 3 to row 8 at center on post	MSA 33	3/8	3/8	17	81 1/2	1.19
Measured from row 3 to row 8 at center on post	MSA 34	1/2	1/2	16 3/4	80 1/4	1.59
Measured from row 6 to row 11 at center on post (Weed growing through fence)	MSA 35	9/16	9/16	16 1/2	81	1.79

Table 1 Measurement Results and Calculation of Lean Angle - (Msmt = Measurement)

	Initial	Level	Differential			Lean		
	Msmt	Msmt	Msmt	Width	Height	Angle		
	Inches	Inches	Inches	Inches	Inches	Degrees		
Measured from row 6 to row 11 at center on post (Weed growing through fence)	MSA	35	9/16	9/16	16 1/2	81	1.79	
Measured from row 11 to row 16 at right on post (Post near Benfer Rd)	MSA	36	9/16	9/16	24 1/2	120	1.79	
Measured from row 13 to row 18 at center on post (Post near Benfer Rd)	MSA	37	5/8	5/8	32 1/2	130 1/2	1.99	
Measured from row 15 to row 20 at right on post (Post near Benfer Rd)	MSA	38	5/16	5/16	32 3/4	124	0.99	
Measured from row 13 to row 18 at right on post; Height on right side of post (Post near Benfer Rd)	MSA	39	(1/4)	(1/4)	25	122 1/2	(0.80)	
Measured from row 3 to row 8 at left on post	MSA	40	(3/8)	(3/8)	17	81	(0.20)	
Measured from row 3 to row 8 at center on post (Weed growing through fence)	MSA	41	3/8	3/8	17	82	1.19	
Measured from row 3 to row 8 at left on post	MSA	42	9/16	9/16	17 1/2	83 1/2	1.79	
Measured from row 3 to row 8 at center on post	MSA	43	1 1/2	1 1/2	16 3/4	83	4.76	
Measured from row 3 to row 8 at right on post	MSA	44	7/8	7/8	17 1/4	82 1/4	2.78	
Shrubby restricts access	SSA	1						
Measured from row 3 to row 8 at center on post (Weed growing through fence)	SSA	2	1/16	1/4	3/16	17 1/4	83 1/2	0.60
Measured from row 3 to row 8 at left on post	SSA	3	0	0	0	16 3/4	82 1/2	0
Measured from row 5 to row 10 at left on post	SSA	4	1/4	5/16	1/16	17 1/2	84 3/4	0.20
Measured from row 7 to row 13 at right on post	SSA	5	0	3/4	3/4	17 1/2	82 1/2	2.39
Measured from row 5 to row 10 at center on post	SSA	6	0	1	1	17	83	3.18
Measured from row 3 to row 8 at center on post	SSA	7	0	3/8	3/8	17 1/4	85	1.19
Measured from row 3 to row 8 at center on post	SSA	8	1/4	5/16	1/16	17	86	0.20
Measured from row 3 to row 8 at center on post	SSA	9	3/8	7/16	1/16	16 1/4	83	0.20
Measured from row 3 to row 8 at center on post	SSA	10	5/16	3/8	1/16	17 1/2	82	0.20
Measured from row 3 to row 8 at center on post (Footing exposed 2 inches inside edge of post)	SSA	11	0	9/16	9/16	17	84 1/2	1.79
Measured from row 3 to row 8 at center on post (Missing brick on post cap)	SSA	12	3/4	1/2	(1/4)	17	83 1/2	(0.80)
Measured from row 3 to row 8 at center on post (Height measured on right side of post)	SSA	13	1/4	9/16	5/16	17	82 3/4	0.99
Measured from row 3 to row 8 at left on post	SSA	14	0	13/16	13/16	17	84 1/2	2.58
Measured from row 3 to row 8 at left on post	SSA	15	1/8	11/16	9/16	17 1/4	84	1.79
Measured from row 3 to row 8 at left on post	SSA	16	3/16	1	13/16	17 1/2	83 1/2	2.58
Vines growing on post	SSA	17						
Vines growing on post	SSA	18						
Vines growing on post	SSA	19						
Vines growing on post	SSA	20						
Vines growing on post (Post near Rose Cottage Dr)	SSA	21						
Vines growing on post (Post near Rose Cottage Dr)	SSA	22						
Shrubby obstruction (Post near Rose Cottage Dr)	SSA	23						

Table 1 Measurement Results and Calculation of Lean Angle - (Msmt = Measurement)

	Post	No.	Initial Msmt Inches	Level Msmt Inches	Differential Msmt Inches	Width Inches	Height Inches	Lean Angle Degrees
Shrubbery obstruction (Post near Rose Cottage Dr)	SSA	24						
Measured from row 3 to row 8 at center on post	SSA	25	0	1/4	1/4	17 1/4	83 3/4	0.80
Measured from row 3 to row 8 at right on post	SSA	26	3/16	9/16	3/8	17 1/4	81 3/4	1.19
Vines growing on post	SSA	27						
Measured from row 3 to row 8 at right on post	SSA	28	9/32	1/2	7/32	18	82	0.70
Measured from row 3 to row 8 at center on post	SSA	29	1/8	5/8	1/2	17	84 3/4	1.59
Measured from row 7 to row 12 at center on post	SSA	30	0	7/8	7/8	17	84 1/2	2.78
Measured from row 3 to row 8 at center on post	SSA	31	9/16	15/16	3/8	17	84	1.19
Measured from row 3 to row 8 at center on post	SSA	32	1/2	11/16	3/16	16 1/4	85	0.60
Measured from row 3 to row 8 at center on post	SSA	33	1/4	3/8	1/8	17 1/4	84 1/2	0.40
Measured from row 5 to row 10 at center on post	SSA	34	0	1 3/16	1 3/16	16 3/4	83	3.77
Measured from row 3 to row 8 at center on post	SSA	35	1/8	9/16	7/16	16 1/2	81 1/2	1.39
Measured from row 3 to row 8 at center on post	SSA	36	0	1/2	1/2	17 1/2	82 1/2	0.70
Measured from row 5 to row 10 at center on post	SSA	37	0	0	0	17 1/4	83 1/2	0.00
Measured from row 4 to row 9 at left on post (Vine on post)	SSA	38	1/8	3/16	1/16	17 1/4	81 1/2	0.20
Measured from row 5 to row 10 at center on post	SSA	39	1/8	7/8	3/4	17 3/4	79 3/4	2.39
Measured from row 3 to row 8 at center on post	SSA	40	3/16	1 1/8	15/16	18	81	2.98
Measured from row 3 to row 8 at center on post	SSA	41	7/16	1 9/16	1 1/8	17 1/4	82 1/2	3.58
Measured from row 3 to row 8 at right on post (Vine on post)	SSA	42	3/8	1 3/16	13/16	16 3/4	84 1/2	2.58
Measured from row 7 to row 12 at center on post	SSA	43	3/16	1 1/8	15/16	17 1/4	82 1/2	2.98
Measured from row 3 to row 8 at left on post	SSA	44	1/16	3/8	5/16	16 1/2	84 1/2	0.99

Total number of posts measured	78
Total number of posts with some lean angle outward	61
Total number of posts with some lean angle inward	3
Total number of posts with some lean angle outward greater than 1 degree	37
Total number of posts with some lean angle outward greater than 2 degrees	13
Total number of posts with some lean angle outward greater than 3 degrees	4
Total number of posts with some lean angle outward greater than 4 degrees	1
Maximum lean angle measured (degrees)	4.76

Fig 1 Method of Measurement of Fence Post Angle

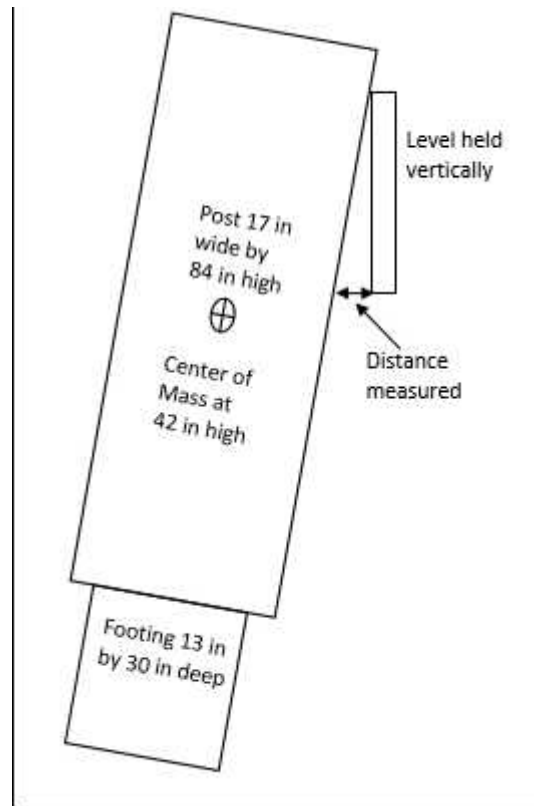
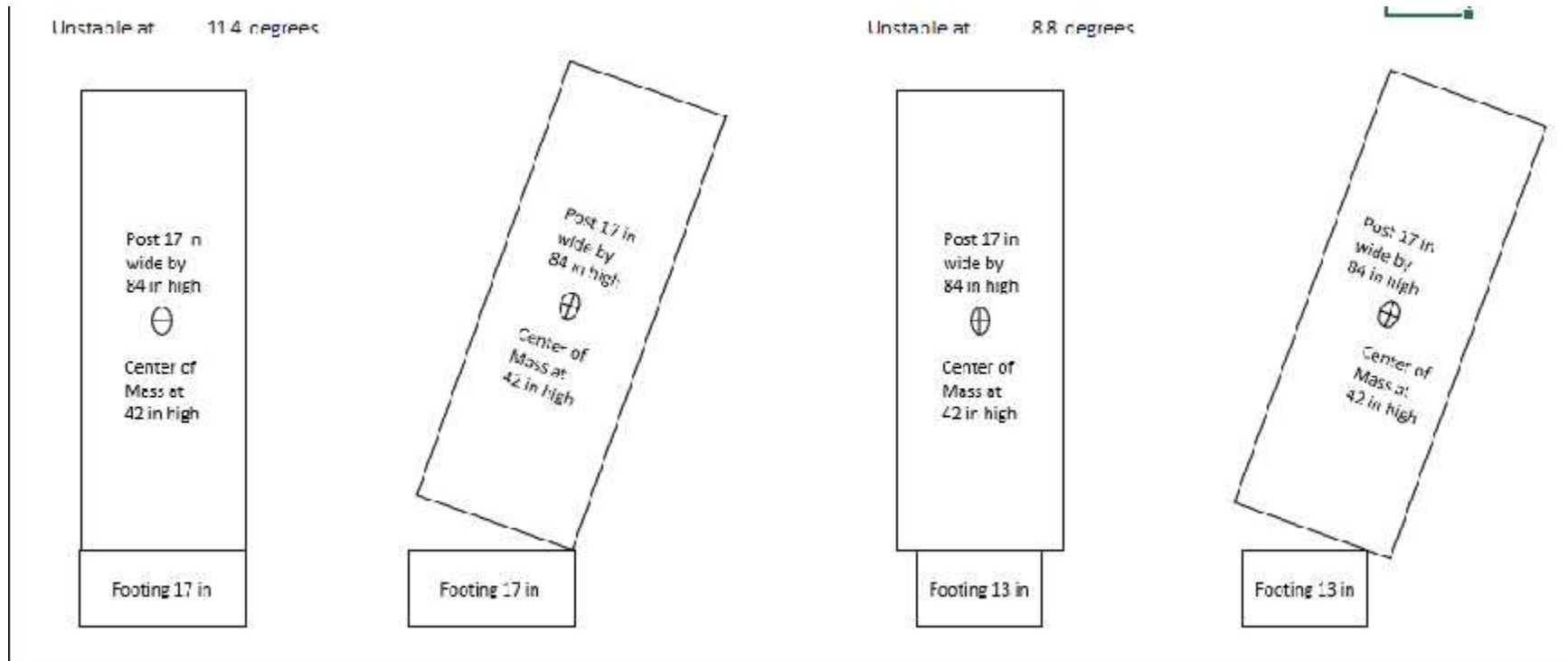




Fig 2 Illustration of 3 Types of Footing Support and the Angle Calculated for Instability



Unstable at 5.2 degrees

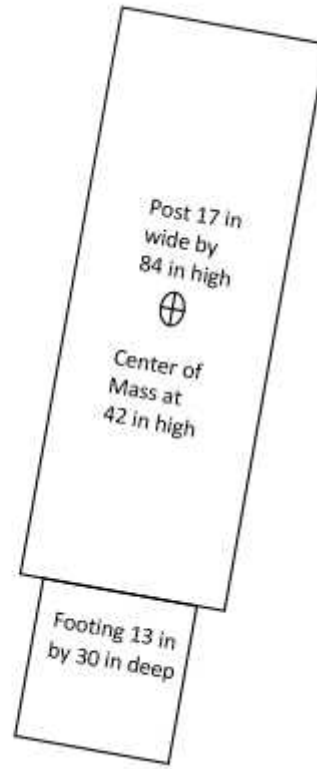
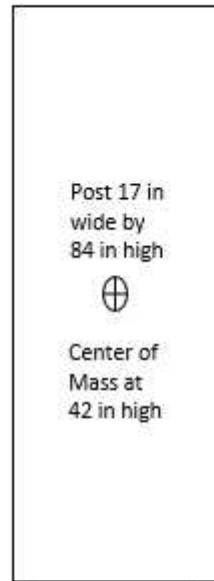


Fig 3 Plots of Fence Lean as Measured along Strack Road and Middlestedt Road

