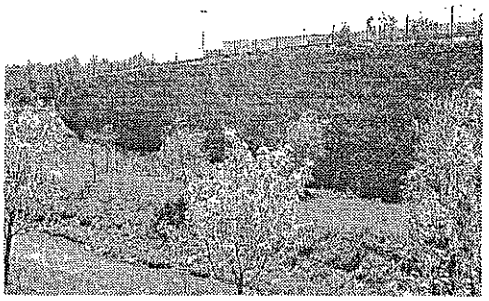
KTC-98-6

KENTUCKY TRANSPORTATION CENTER

College of Engineering

SURVEY AND VISUAL INSPECTION OF KEYSTONE BLOCK WALL AND EMBANKMENT SLIDE AT MIST LAKE PLAZA IN LEXINGTON, KENTUCKY



UNIVERSITY OF KENTUCKY

Research Report KTC-98-6

SURVEY AND VISUAL INSPECTION OF KEYSTONE BLOCK WALL AND EMBANKMENT SLIDE AT MIST LAKE PLAZA IN LEXINGTON, KENTUCKY

by

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Kentucky Transportation Center
College of Engineering
University of Kentucky

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INTRODUCTION

The Kentucky Transportation Center was requested by Bhate Engineering Corporation and A.B. Shopping Center Properties, Inc. to evaluate and monitor apparent movement in the Keystone Block retaining structure and the earth embankment located next to the Walmart Department Store at Mist Lake Plaza in Lexington, Kentucky. In June 1997, a report (KTC-97-11) was submitted which summarized work that had been conducted prior to June of 1997. The initial report included results of the inspection of the surface drainage, inspection of subsurface storm water drainage, inspection of the embankment, and inspection and photo-logging of visible wall distress. In June 1997, several monitoring points were established on the face of the wall and the parking area behind the wall. This report discusses the results of this monitoring.

SURVEY AND ESTABLISHMENT OF MONITORING POINTS

Wall Face

In June 1997, during the installation of monitoring points, it was brought to the attention of both Bhate and KTC that Black Engineering in Lexington had monitored the wall for Keystone Block Company during construction. Black Engineering was retained by KTC to resurvey the already existing monitoring points set for Keystone, and in addition, to establish additional points where needed. These monitoring points were last surveyed in September 1997. Survey information by Black Engineering is contained in Appendix A.

Vertical lines of monitoring points had been installed in five locations. The approximate locations are shown in Figures 1 and 2.

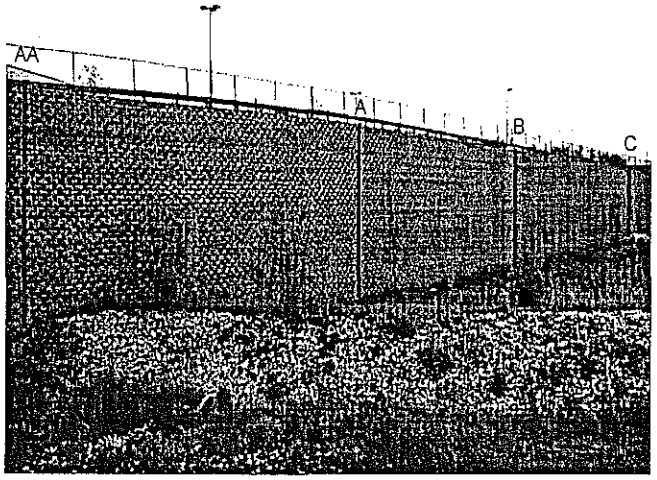


Figure 1

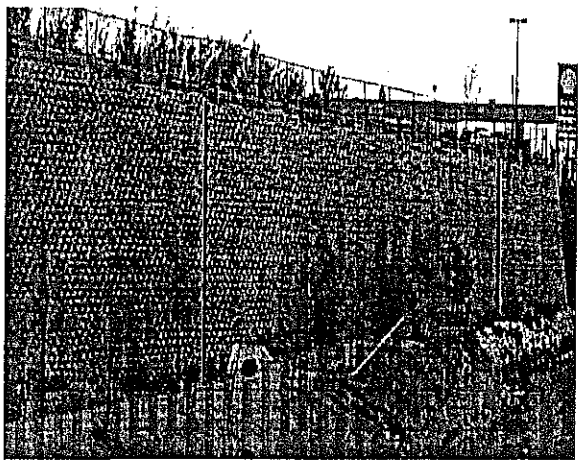


Figure 2

Readings taken by Black Engineering (Appendix A) indicate that the lower portion of the wall at Station A and Station B has moved forward 8 to 9 inches. It is apparent that a considerable amount of this movement had occurred during and shortly after construction. Approximately 1 to 2 inches of additional forward movement occurred between August 1994 and September 1997. To evaluate the rate of movement, data were analyzed back to May 22, 1993 when the wall was completed. The difference between readings has been plotted in Figures 3 through Figure 7. The Figures indicate that the rate of movement appears to have decreased significantly.

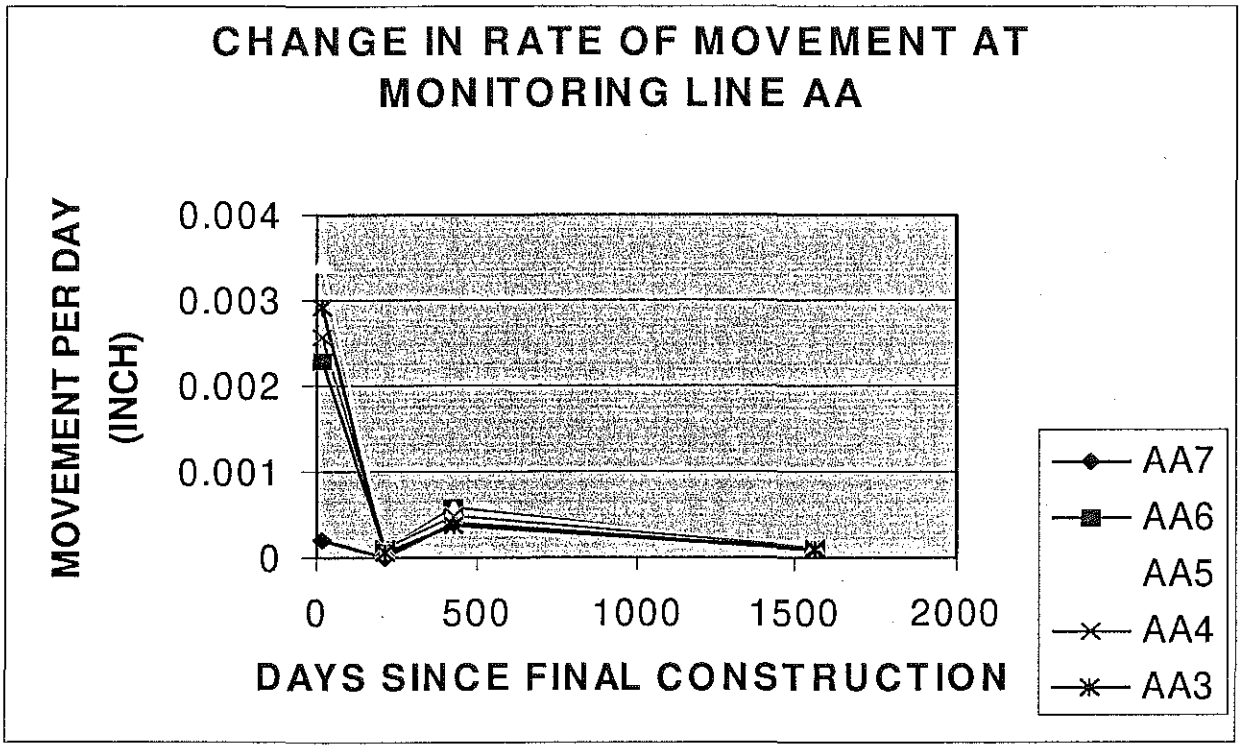


Figure 3. Monitoring Line AA

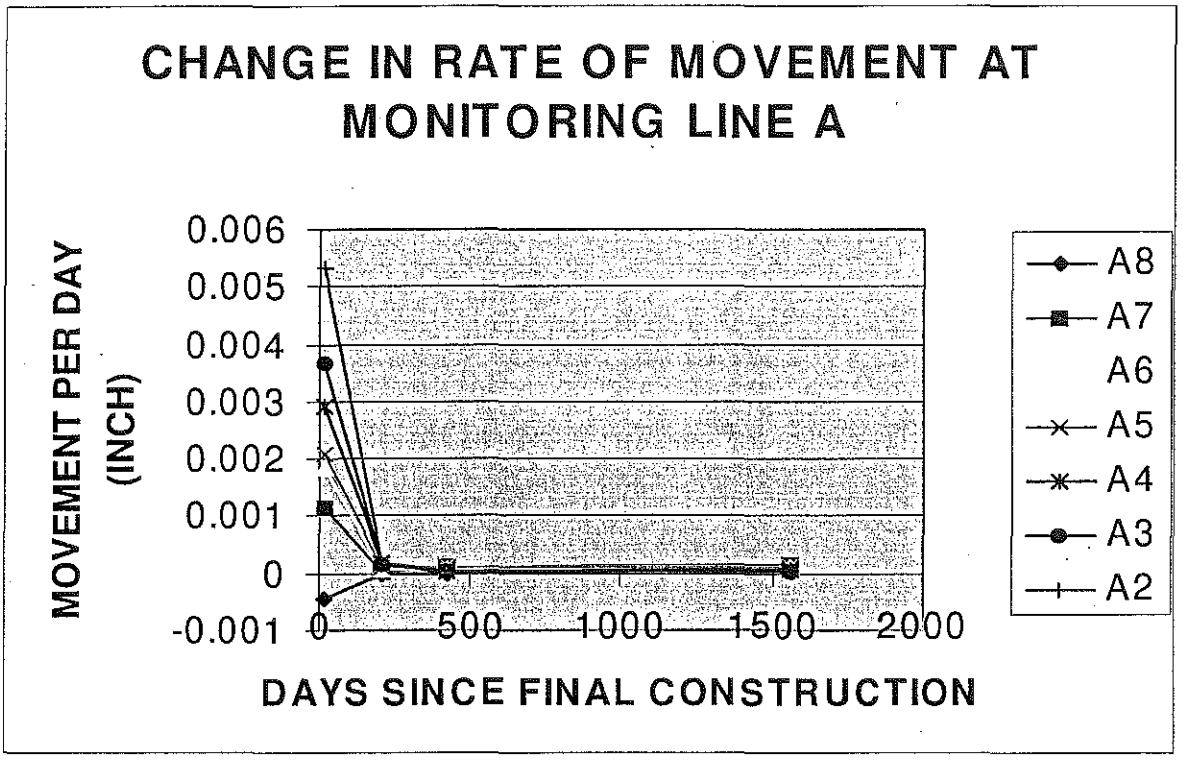


Figure 4. Monitoring Line A

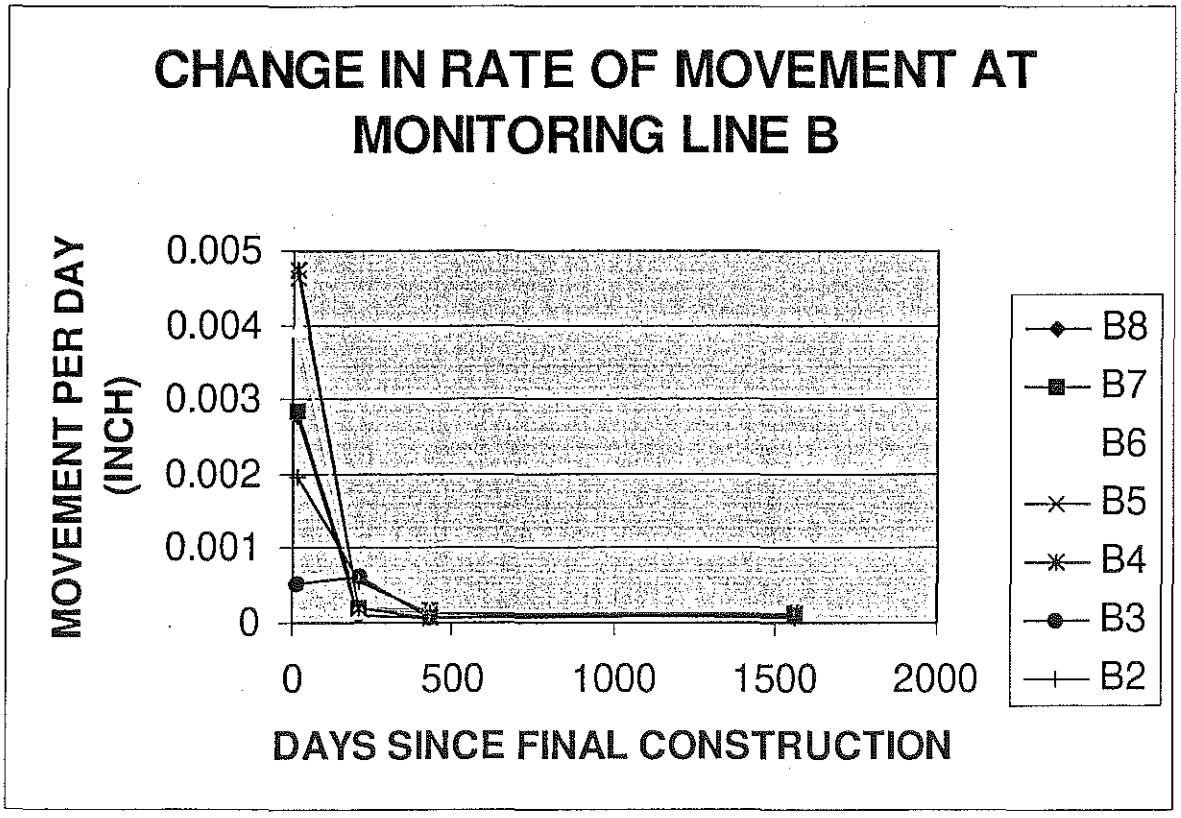


Figure 5. Monitoring Line B

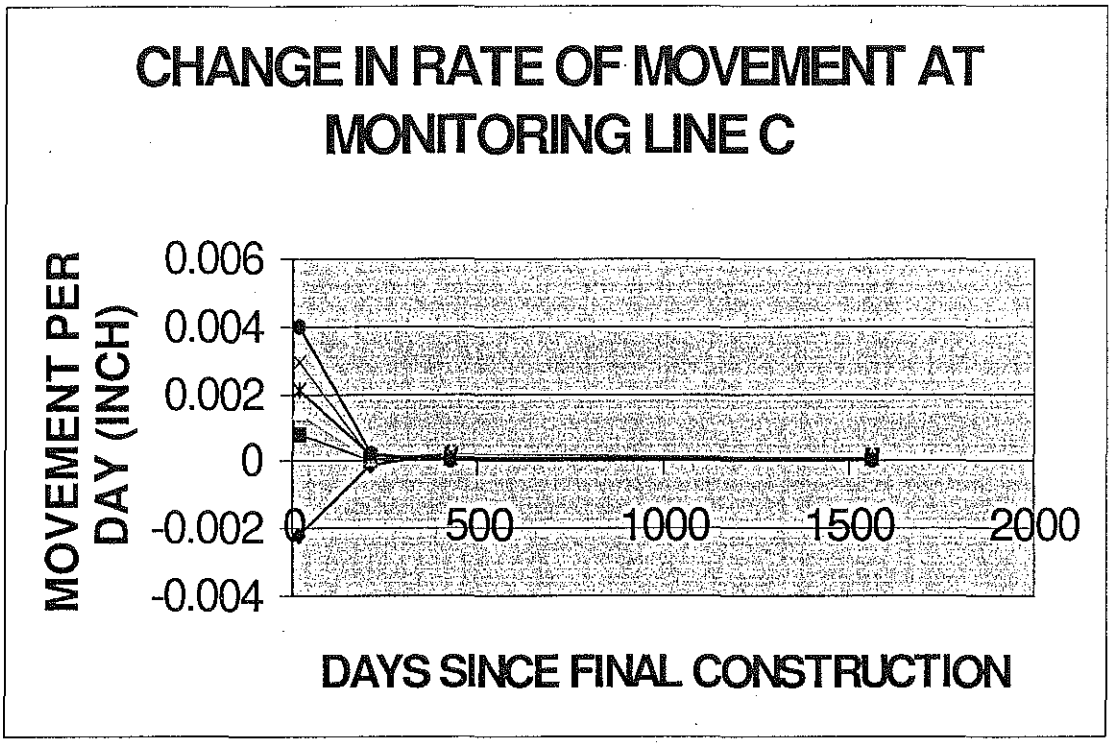


Figure 6. Monitoring Line C

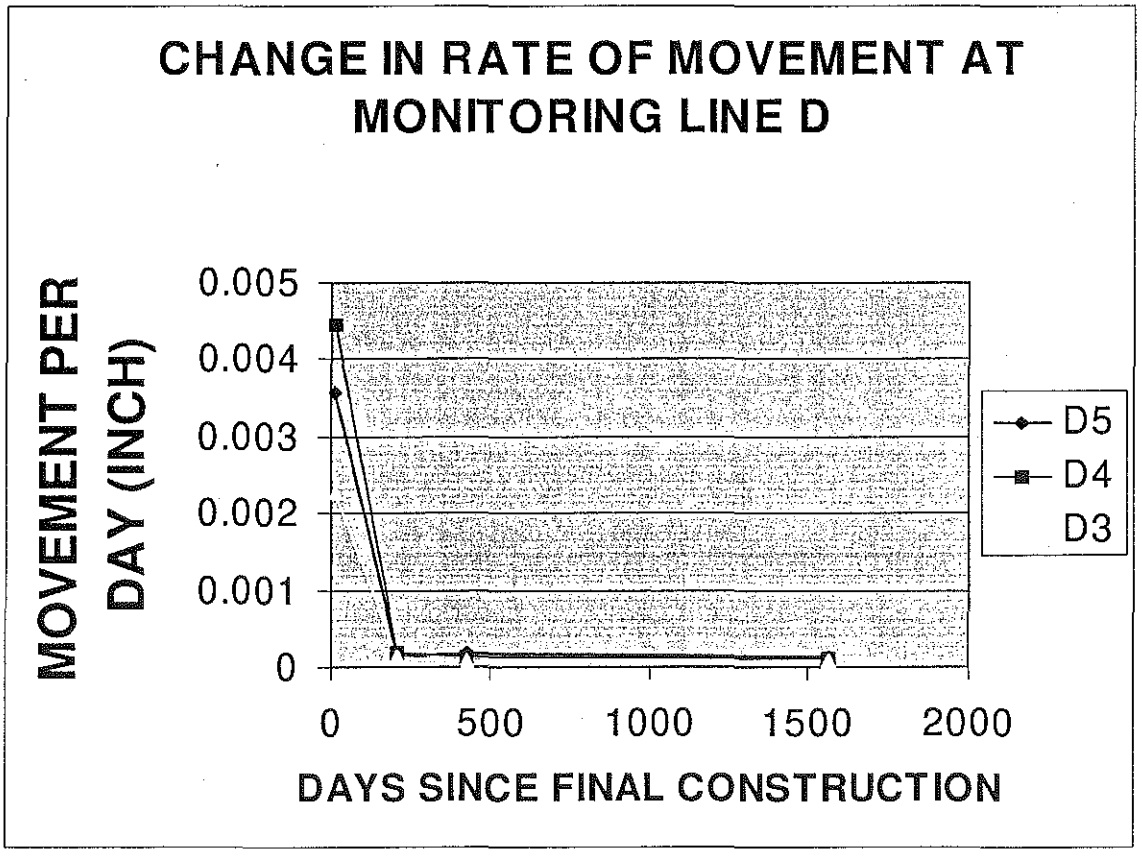


Figure 7. Monitoring Line D

From visual observations, it is apparent that forward displacement has occurred just north of monitoring line C, directly behind vertical catch basin No. SD4 (Storm Drain No. 4) (see location in Appendix B). Figures 8 and 9 show the displacement in the Keystone Wall around SD4. It is apparent that settlement in the fill around the catch basin has caused some forward displacement in the face of the wall structure. It was apparent, at the time of the last survey of the wall face, that monitoring line C was not close enough to record any of this movement. An additional monitoring line was installed at this location on September 24, 1997. Additional monitoring will provide better information on current rates of movement in the various wall segments.

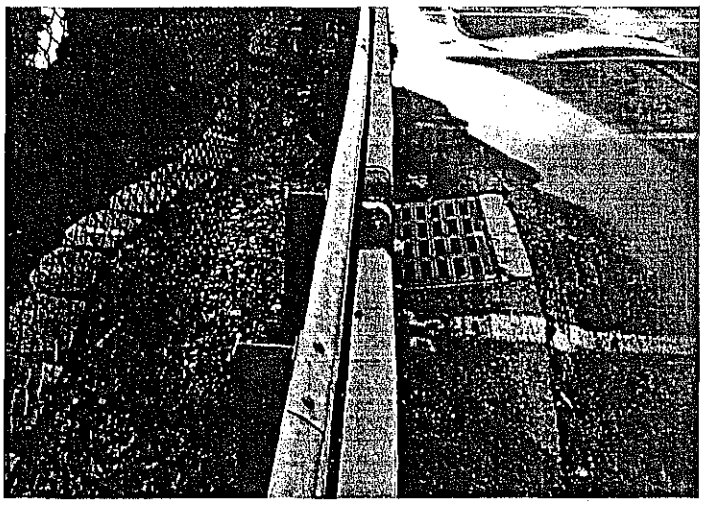


Figure 8. Showing change in wall alignment behind SD4.

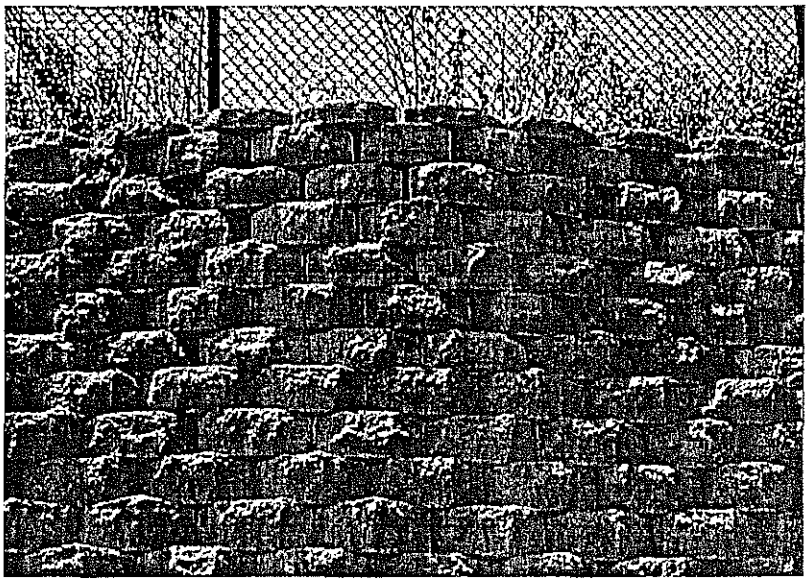


Figure 9. Forward Displacement in Keystone Wall occurring behind SD4.

Vertical Settlement

As mentioned in the initial report, vertical settlement of the asphalt pavement was apparent around the catch basins. A level survey of the parking area behind the retaining structure was conducted in 1997 (Figure 10). Settlement around SD3 (Figure 11) appears to be due to a significant amount of water infiltrating the risers in the drop box. In addition, material is also being lost on the backside of SD3 due to the earth embankment slide.

Water infiltrating into the riser of SD3 was sampled on July 1 and July 10, 1997. The water samples were taken to Kentucky American Water Company (KAWC) for testing. The fluoride levels tested were 0.3 and 0.4. KAWC concluded that the water was not treated water. KAWC indicated the source was likely ground water that has been running through limestone. KAWC indicated that limestone will increase the levels of fluoride by a couple of tenths.

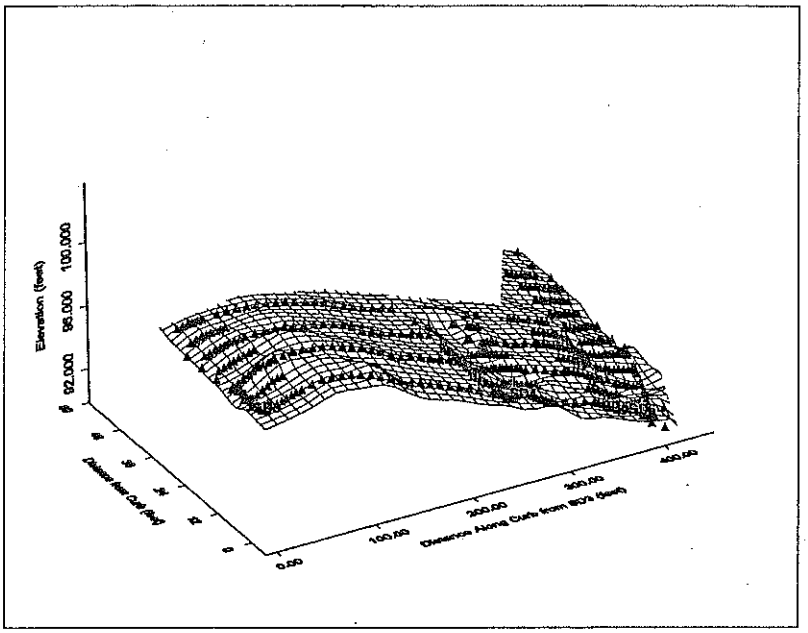


Figure 10. 3D Surface Plot of Parking Area Behind Keystone Block Wall.

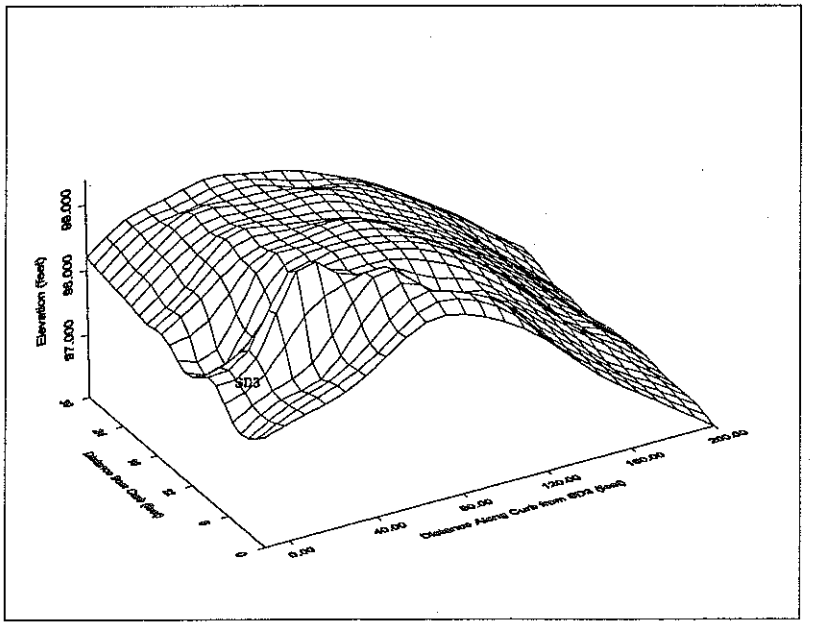


Figure 11. Settlement Observed Near SD3.

The most significant settlement is occurring around SD4. As shown in Figure 12, significant amounts of settlement have occurred directly in front of the catch basin. A large sunken area also extends back approximately 30 feet just left of the basin. This sunken area does not appear to follow any of the storm drains discharging into the basin. A portion of the material appears to be coming through the face of the wall.

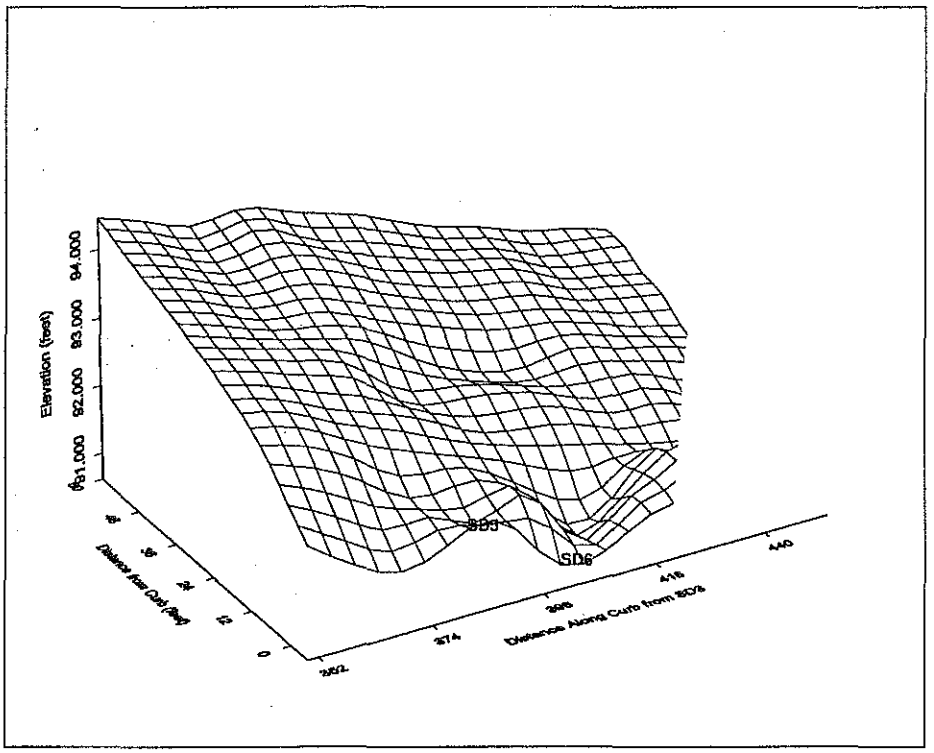


Figure 12. Settlement Observed Around SD5 and SD6.

A significant amount of settlement also appears to be occurring on the north end of the wall at SD5 and SD6. This is shown in Figure 13 and Figure 14.

Figure 13. Settlement Observed Around SD6.

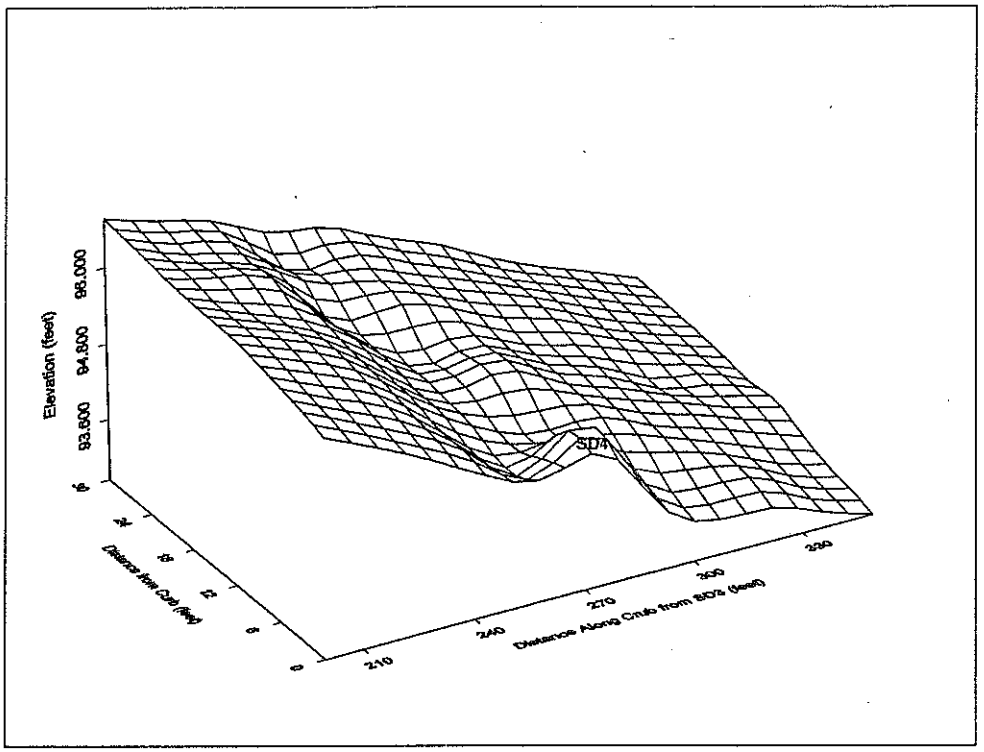


Figure 14. Observed Around SD4.

Visual Observations

Since the initial report, additional settlement has occurred around all the storm drains (catch basins). Separation of the concrete curb and the asphalt has increased near the earth embankment. Additional sliding of the embankment has occurred around the SD3 (Figure 15). The slide is starting to undermine the edge of the pavement (Figure 16).

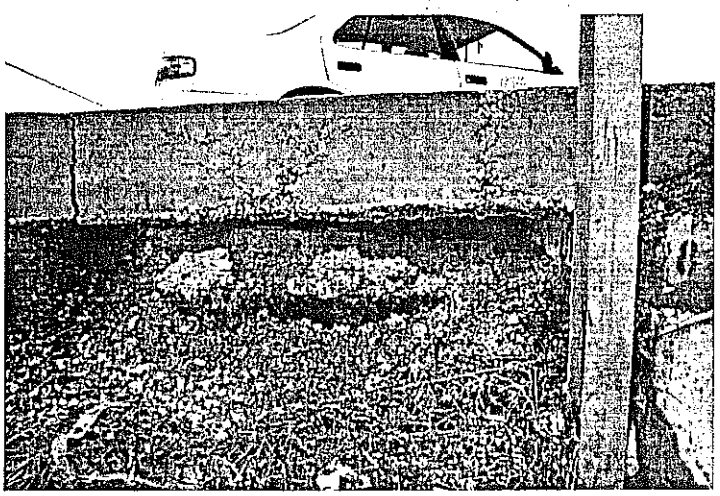


Figure 15. Edge of Pavement Undermined

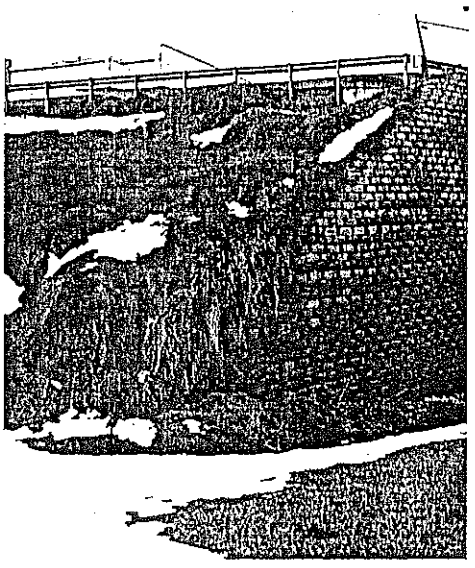


Figure 16. Embankment Slide

Staining on the base of the wall and erosion on top of the brim of the basin wall indicate that the water has flowed over the basin wall.

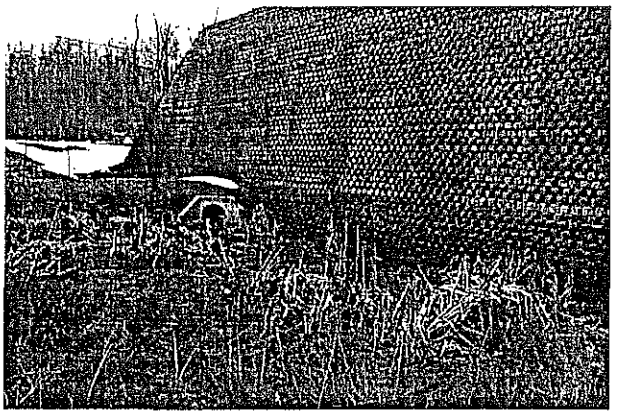


Figure 17. Retention Basis and Staining on the Keystone Wall, indicating High Water Levels.

CONCLUSIONS

It is apparent from the visual observations and the control surveys that since May of 1997 additional settlement has occurred in the parking area directly behind the wall. Most of the settlement is confined to the areas around the storm drains. Information from the control survey indicates that in several areas the base of the wall has moved eight to nine inches since construction. The rate of movement appears to have decreased significantly since final completion of the wall in 1993. At this time, without an additional survey, the current rate of movement cannot be determined. Additional monitoring points were established in areas that were not moving at the time the initial monitoring points were installed. Water samples collected and analyzed from SD3 indicated that the infiltrating water is ground water and not city water. Until the parking area is repaired and the water is channeled back to the storm drains, it is likely that movement in the wall and settlement in the parking area will continue.

RECOMMENDATIONS

It is recommend that an additional set of readings on both the face and the parking lot be should be obtained this Spring to determine the rate of subsidence in the parking area and forward movement in the retaining structure. A detailed survey of the face of the wall should also be conducted for future reference.

As recommend in the previous report:

The parking lot along the wall and the access road behind the store should also be repaved. Breaks in the concrete curb should be repaired. In addition, it is recommended that a french drain be installed to collect the water being discharged along the back of the store from the roof gutters. The embankment should be repaired as soon as possible to eliminate any further damage to the retaining structure and the parking lot. Some form of slope reinforcement is recommended for the slide rather than simply regrading and sodding. The surface water infiltrating the drop box inlets and the slide should be isolated. If this water is found to be flowing from the cut and fill, it is recommended that a cutoff trench be installed to intercept the water before it reaches the embankment and the retaining structure. Any cracks or separations in the pavement and curb should be sealed prior to placement of the overlay.

APPENDIX A
SURVEY BY BLACK ENGINEERING

PRECISION SURVEY
KEYSTONE RETAINING WALL
MIST LAKE PLAZA
LEXINGTON, KENTUCKY

(Revised 09-24-1997)

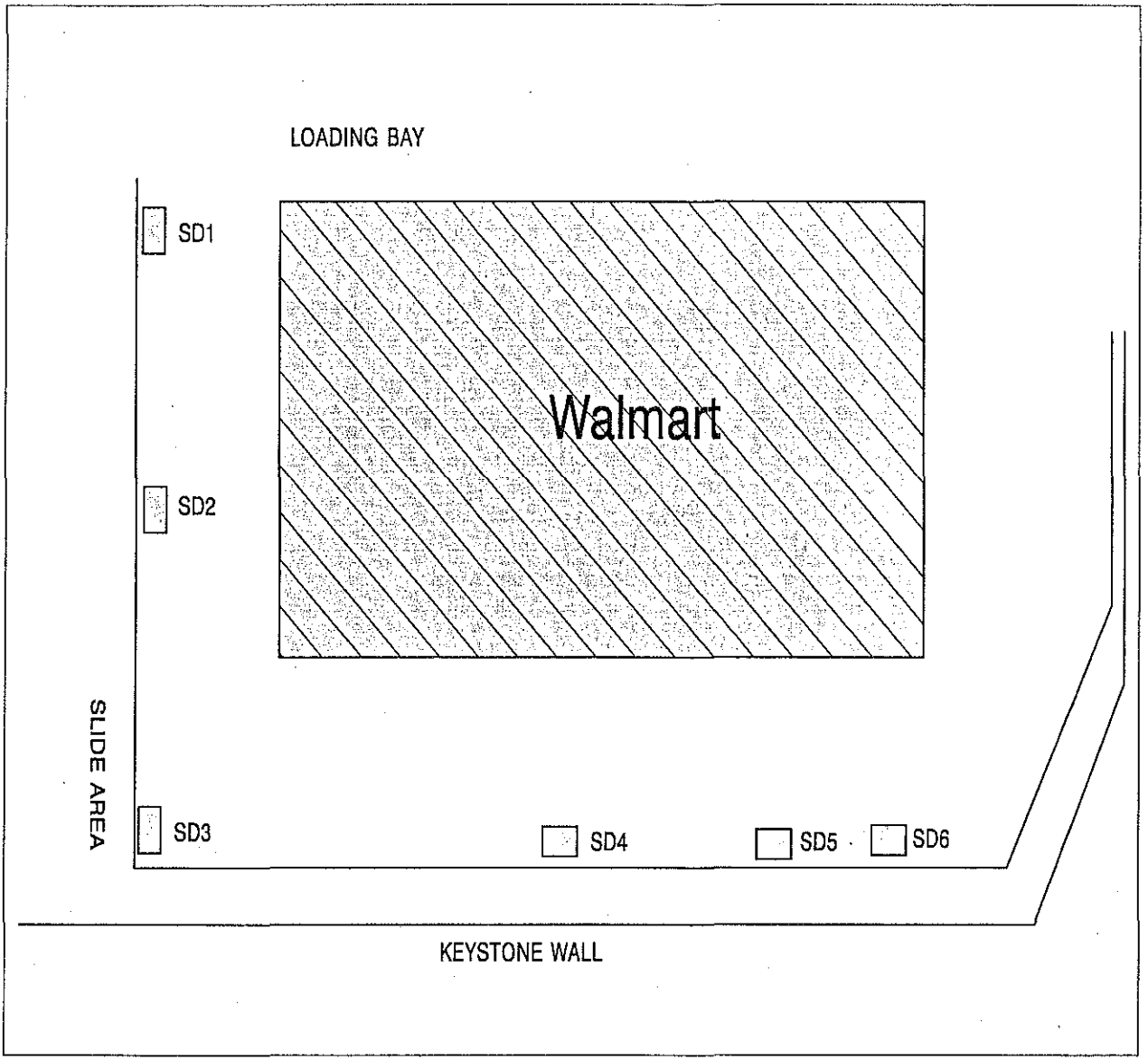
Vertical Line in Wall Face	Horiz. Dist. from Baseline, ft.	Horiz. Dist. from Baseline, ft.	Horiz. Movement from Initial Reading, in.	Horiz. Dist. from Baseline, ft.	Horiz. Movement from Initial Reading, in.	Horiz. Dist. from Baseline, ft.	Horiz. Movement from Initial Reading, in.	Horiz. Dist. from Baseline, ft.	Horiz. Movement from Initial Reading, in.	Horiz. Dist. from Baseline, ft.	Horiz. Movement from Initial Reading, in.	Horiz. Dist. from Baseline, ft.	Horiz. Movement from Initial Reading, in.	Horiz. Dist. from Baseline, ft.	Horiz. Movement from Initial Reading, in.	Horiz. Movement 5/22/93 to 09-24-97 in.
	05-02-93	**05-06-93**		**05-09-93**		**05-22-93**		**06-08-93**		**12-23-93**		**08-01-94**		**09-24-97**		Post-Construction
AA TOP	(elev)			107.91		110.98										
AA7						234.3989		234.3955	*0.0408*	234.3941	*0.0576*	234.3060	*1.1148*	234.2020	*2.3628*	*2.3628*
AA6						233.7145		233.6779	*0.4392*	233.6634	*0.6132*	233.5400	*2.0940*	233.4270	*3.4500*	*3.4500*
AA5						233.0486		232.9936	*0.6600*	232.9766	*0.8640*	232.8570	*2.2992*	232.7310	*3.8112*	*3.8112*
AA4				232.5835		232.3825	*2.4120*	232.3412	*2.9076*	232.3182	*3.1836*	232.2107	*4.4736*	232.0920	*5.8980*	*3.4860*
AA3				231.9682		231.7780	*2.2824*	231.7312	*2.8440*	231.7179	*3.0036*	231.6389	*3.9516*	231.5320	*5.2344*	*2.9520*
AA2				231.3163		231.1389	*2.1288*							230.9050	*4.9356*	*2.8068*
AA1				230.9828		230.8047	*2.1372*									
AA BOT	(elev)			83.22												
A TOP	96.10	103.40		110.70		116.85										
A9						235.4068								235.3350	*0.8616*	*0.8616*
A8						234.6386		234.6458	*-0.0864*	234.6500	*-0.1368*	234.6493	*-0.1284*	234.4890	*1.7952*	*1.7952*
A7						233.8921		233.8742	*0.2148*	233.8659	*0.3144*	233.8452	*0.5628*	233.6930	*2.3892*	*2.3892*
A6						233.2050		233.1755	*0.3540*	233.1607	*0.5316*	233.1451	*0.7188*	233.0030	*2.4240*	*2.4240*
A5						232.6702		232.6369	*0.3996*	232.6145	*0.6684*	232.5879	*0.9876*	232.4760	*2.3304*	*2.3304*
A4		232.5614		232.3650	*2.3568*	232.0832	*5.7384*	232.0366	*6.2976*	232.0032	*6.6984*	231.9930	*6.8208*	231.9220	*7.6728*	*1.9344*
A3	232.0590	231.9943	*0.7764*	231.8446	*2.5728*	231.5254	*6.4032*	231.4670	*7.1040*	231.4373	*7.4604*	231.4317	*7.5276*	231.3810	*8.1360*	*1.7328*
A2	231.4164	231.3975	*0.2268*	231.2514	*1.9800*	230.9851	*5.1756*	230.8997	*6.2004*	230.8617	*6.6564*	230.8628	*6.6432*	230.7790	*7.6488*	*2.4732*
A1	231.0298	231.0221	*0.0924*	230.9821	*0.5724*	230.8394	*2.2848*	230.7562	*3.2832*							
A BOT	83.41															
B TOP	96.12	103.50		110.27		115.39										
B8						234.8186		234.7742	*0.5328*	234.7559	*0.7524*	234.7400	*0.9432*	234.5870	*2.7792*	*2.7792*
B7						234.0749		234.0296	*0.5436*	233.9924	*0.9900*	233.9600	*1.3788*	233.8020	*3.2748*	*3.2748*
B6						233.2487		233.1856	*0.7572*	233.1533	*1.1448*	233.1178	*1.5708*	232.9650	*3.4044*	*3.4044*
B5						232.4237		232.3492	*0.8940*	232.3134	*1.3236*	232.2849	*1.6656*	232.1520	*3.2604*	*3.2604*
B4						231.7657		231.6901	*0.9072*	231.6544	*1.3356*	231.6384	*1.5276*	231.5220	*2.9244*	*2.9244*
B3	231.8779	231.7980	*0.9588*	231.6429	*2.8200*	231.3396	*6.4596*	231.3311	*6.5616*	231.2084	*8.0340*	231.1935	*8.2128*	231.0980	*9.3588*	*2.8992*
B2	231.3571	231.3176	*0.4740*	231.1717	*2.2248*	230.8874	*5.6364*	230.8559	*6.0144*	230.7468	*7.3236*	230.7204	*7.6404*	230.6370	*8.6412*	*3.0048*
B1	230.9842	230.9704	*0.1656*	230.9129	*0.8556*	230.7666	*2.6112*									
B BOT	84.08															
C TOP	89.54	89.54		97.77		109.78										
C7						234.3534		234.3880	*-0.4152*	234.4059	*-0.6300*	234.3487	*0.0564*	234.1690	*2.2128*	*2.2128*
C6						233.5922		233.5800	*0.1464*	233.5756	*0.1992*	233.5199	*0.8676*	233.3360	*3.0744*	*3.0744*
C5						232.7025		232.6789	*0.2832*	232.6608	*0.5004*	232.6160	*1.0380*	232.4350	*3.2100*	*3.2100*
C4		232.4893		232.4805	*0.1056*	232.2750	*2.5716*	232.2279	*3.1368*	232.2030	*3.4356*	232.1588	*3.9660*	232.0170	*5.6676*	*3.0960*
C3	231.9437	231.9333	*0.1248*	231.9208	*0.2748*	231.7015	*2.6316*	231.6680	*3.3084*	231.6407	*3.6360*	231.6223	*3.8568*	231.5190	*5.0964*	*2.1900*

C2	231.4166	231.3967	*0.2388*	231.4009	*0.1884*	231.2466	*1.8516*	231.1831	*2.8020*	231.1426	*3.2880*	231.1351	*3.3780*	231.0840	*3.9912*	*1.9512*
C1																
C BOT	84.21															
D TOP				93.09		103.61										
D5						233.1866		233.1295	*0.6852*	233.1029	*1.0044*	233.0648	*1.4616*	232.9210	*3.1872*	*3.1872*
D4						232.6406		232.5693	*0.8556*	232.5319	*1.3044*	232.5041	*1.6380*	232.3780	*3.1512*	*3.1512*
D3				232.0378		231.9643	*0.8820*	231.9281	*1.3164*	231.9031	*1.6164*	231.8853	*1.8300*	231.7840	*3.0456*	*2.1636*
D2				231.1525		231.0830	*0.8340*	231.0449	*1.2912*							
D1				230.5444												
D BOT				86.17												

← Construction complete

Blocks installed but no readings taken due to inaccessibility to top of wall during construction.

APPENDIX B
LOCATION OF STORM DRAIN INLETS


LOADING BAY
SD1
SD2
SD3
Walmart
SLIDE AREA
SD4
SD5
SD6
KEYSTONE WALL