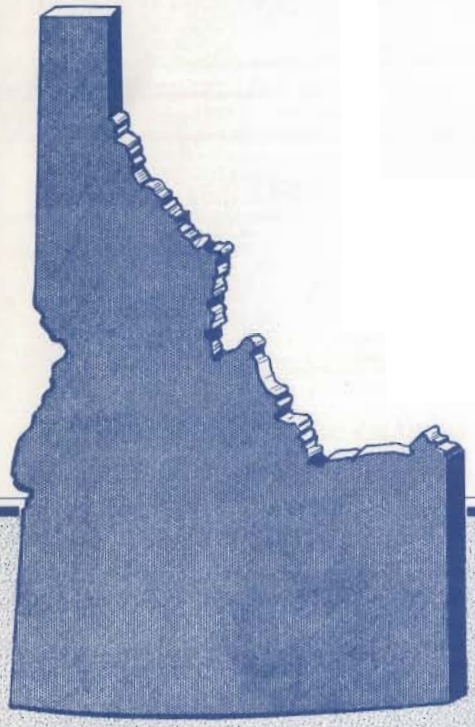
SETTLEMENT STUDY CONDUCTED ON 50-FOOT HIGH GRANULAR APPROACH EMBANKMENT



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RESEARCH PROJECT NO. 52

STATE OF IDAHO DEPARTMENT OF HIGHWAYS

SETTLEMENT STUDY CONDUCTED ON 50-FOOT HIGH GRANULAR APPROACH EMBANKMENT

F-FG-3022(16)
East Connector to Boise

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INTRODUCTION

Settlement of approach embankments, adjacent to structures, has plagued highway engineers for many years. In 1969, the Idaho Department of Highways instituted a settlement study of a 50-foot high gravel approach embankment constructed over a silt and gravel foundation. The embankment was located at the northern end of a combined railroad and canal crossing structure on the east connector to Boise from I-80N. This facility was opened to traffic about five months after the embankment reached final grade.

In this report, the term "consolidation" will not be used because neither embankment nor foundation soils were in a saturated condition.

CONCLUSIONS

Field measured settlements agree quite well with calculated settlements based on laboratory compression tests. Early portions of time-settlement plots are too irregular for interpreting and making conclusions concerning immediate compression within the embankment gravels. The settlement curves generally parallel each other with increasing time indicating that all points are settling equally. This would be the result of foundation compression rather than compression of the embankment gravels. Convergence of the plots would indicate compression within the embankment.

Other conclusions reached from this study are:

1. The monitoring units were not sensitive enough and the reading schedule not often enough to detect compression within the gravel embankment
2. Most of the settlement occurred within one month, and was essentially complete within four months after the embankment reached grade.

3. Settlement appeared to be entirely within the foundation materials and primarily in the silt layer.
4. Subexcavation of the silt layer beneath the structure abutment was effective in substantially decreasing settlement.
5. Traffic did not cause detectable settlement of monitors 3 at Station 23+72 or 25+00.
6. Laboratory compression tests of unsaturated silts adequately defined soil compression characteristics.

EMBANKMENT FOUNDATION

The 50-foot high embankment was constructed on irrigated pasture land. Foundation materials at Station 25+00 are shown in Figure 1. They consist of approximately five feet of silt at dry densities ranging from 80 to 110 pcf and moisture contents of 10 to 15 percent. The angle of internal friction is 31-35 degrees. Compressions of about 1%/ksf at field moisture and 2%/ksf in saturated condition were found from laboratory compression tests. This indicates that with a load of 1.0 ksf, the silt layer would compress 1% if the foundation soils remain at present field moisture, or 2% if foundation soils should become saturated. The compression would be nearly proportional to the applied embankment load. The silt layer increased in thickness toward the structure and was about eight feet thick at Station 23+72.

An extensive, well-graded sand and gravel zone exists beneath the silt layer to considerable depths. Compression of this layer was expected to be negligible.

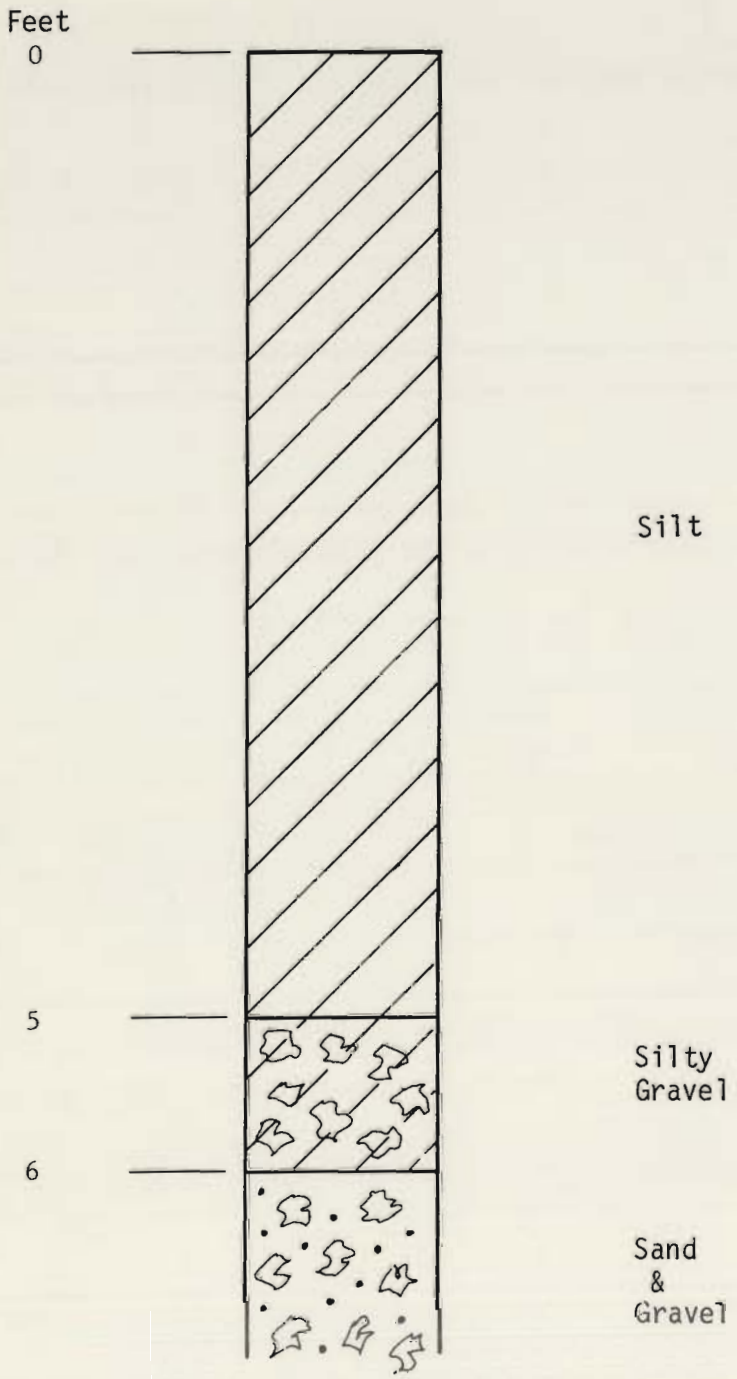

Figure 1 - Soil Profile at Sta. 25+00

CALCULATED SETTLEMENTS

The five-foot thick silt layer was calculated to settle 0.25-foot under the proposed embankment load. Should additional moisture penetrate the layer and cause saturation, another 0.25-foot of settlement was anticipated. About 0.8-foot of settlement was expected in the silt layer beneath the abutment if saturation from the nearby canal should occur. Selective removal of this silt layer beneath the abutment support area was initiated to protect the structure from differential settlement.

Stability of the embankment against shear deformations was considered good.

INSTALLATION

Six settlement-indicating devices were constructed following the California design as shown in Figure 2. They were installed on centerline at the following locations:

Station		Elevation
23+72	#1	natural ground
	#2	25 feet above natural ground
	#3	50 feet above natural ground
25+00	#1	natural ground
	#2	25 feet above natural ground
	#3	50 feet above natural ground

Installation details furnished to the contractor are shown in Figure 3.

Station 23+72 is the location of abutment 2 and Station 25+00 is 128 feet beyond the abutment. Problems were encountered with monitor units installed beneath the abutment. Unit 1 became inoperative soon after installation. Unit 2, located 25 feet above natural ground, provided good information. Unit 3 was not installed for several months after the embankment was brought to finish elevation because of its possible interference with abutment construction. After it

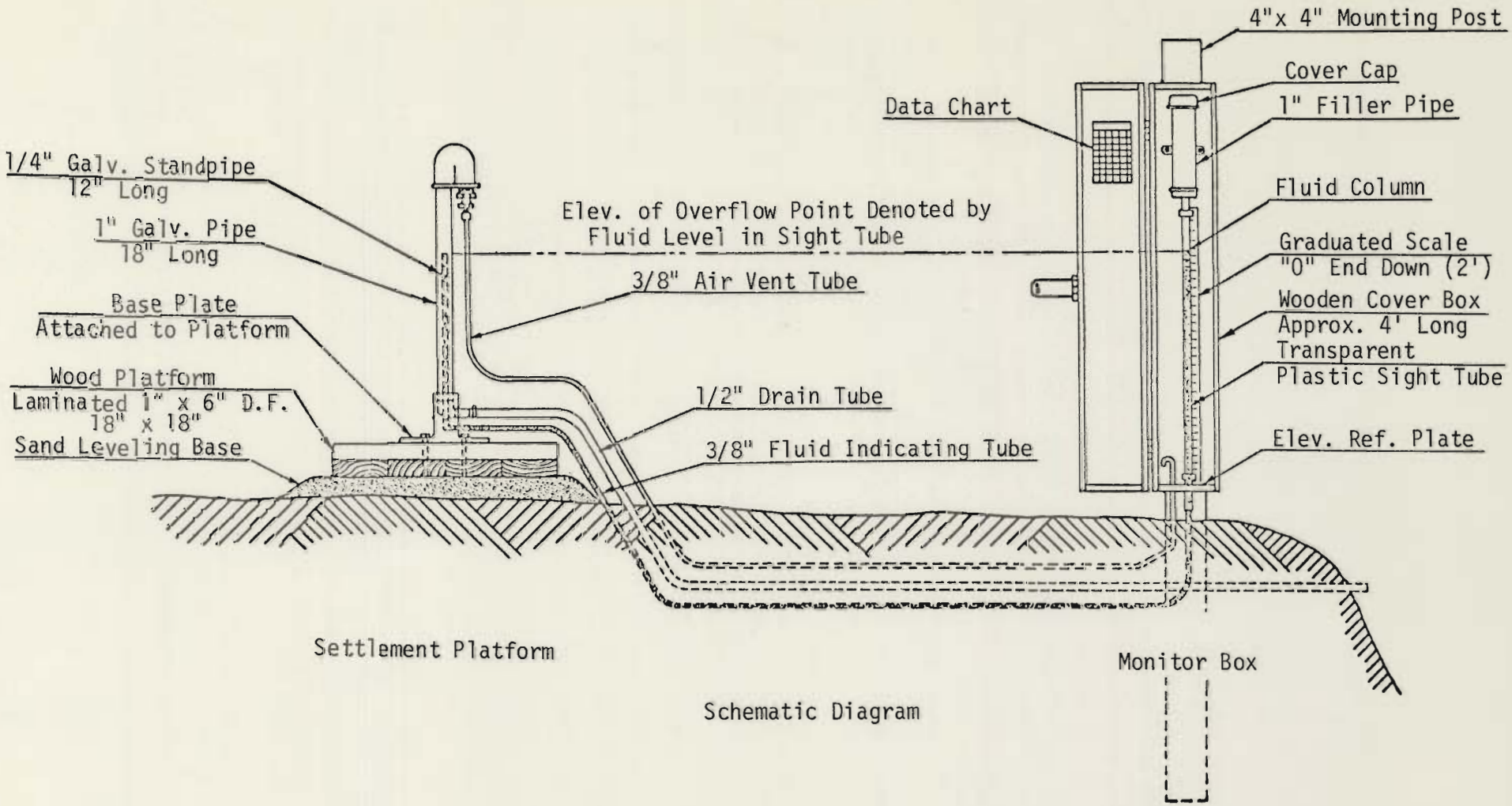

Figure 2 - Settlement Indicating Device - Sealed Fluid Level Type

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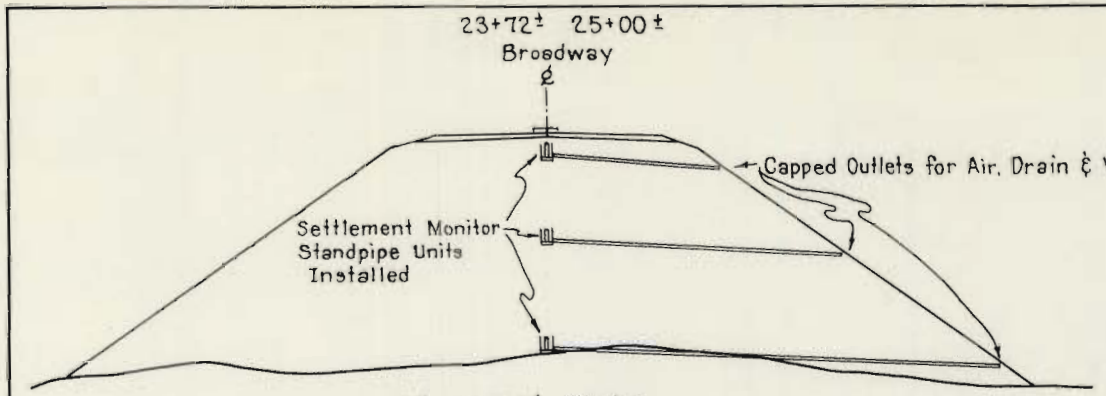
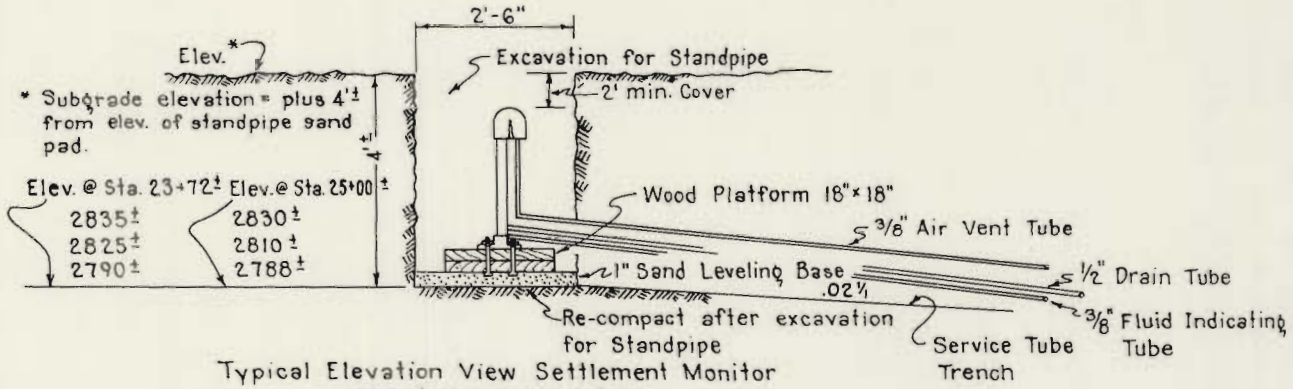
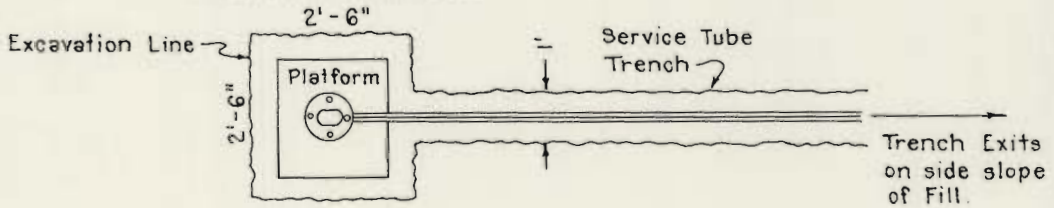


Placement Sketch



Typical Elevation View Settlement Monitor Standpipe Installation



Typical Plan View Settlement Monitor Standpipe Installation

NOTES

Excavation for installation of the six settlement monitor standpipes and trenching for the service tubes shall be accomplished by excavating in the compacted subgrade to the elevations shown in the Elevation View. The standpipes shall be placed in two vertical stacks of three units at the stationing and elevations shown on centerline.

The standpipe platform shall be installed horizontally leveled on a compacted sandbase as shown.

EST. QUANTITIES (6 Strs.)

Excavation	95 C.Y.
Fine Granular	95 C.Y.

Settlement Monitor Standpipe Installation

Figure 3 - Installation Details

Figure 4 - Rate of Embankment Construction

was installed, no settlement was monitored.

The rate of building the embankment is shown in Figure 4.

MEASURED SETTLEMENTS

Elevation determinations of each settlement platform and monitor box were made periodically and plotted to show the relationship of settlement, embankment height and time. This was done by checking the elevations of the monitor boxes with a permanent bench mark located some distance away from the embankment then, by measuring the relative movement of the settlement platform with respect to the monitor box, actual elevations at each point of interest was obtained.

Station 25+00

Settlement of platforms 1, 2, and 3, and monitor boxes 1A, 2A, and 3A are shown in Figure 5. These curves are the average of scattered points from individual readings. Variation from reading to reading was experienced and is attributed primarily to temperature effects on the solution. No corrections were made to the readings to account for this.

Settlement monitor platform 1, placed at natural groundline on centerline indicates that about 0.35-feet downward movement has occurred. About 1/3 of this happened during embankment construction and 2/3's subsequent to completion of the embankment.

Settlement platform 2, located about 25 feet above natural ground, in the embankment recorded downward movement of 0.20-foot. Approximately 1/2 of this occurred during construction of the upper 25 feet of embankment. Settlement platform 3, near finished gradeline, recorded downward movement of about 0.10-foot.

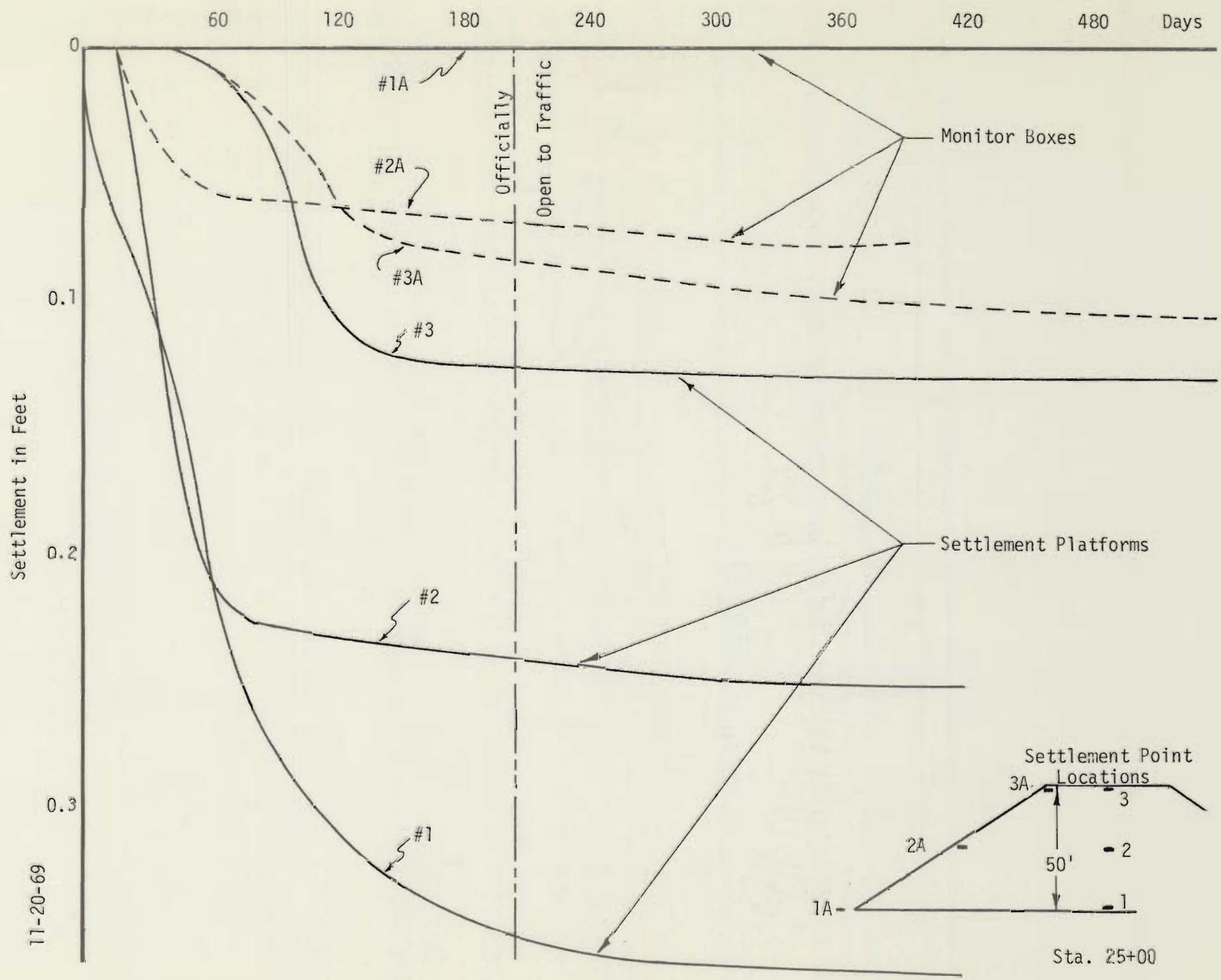


Figure 5 - Settlement Curves for Monitors at Sta. 25+00

The monitor boxes, placed in the embankment slope, show settlement at their locations. Number 2A and 3A show .07 and 0.10 feet of settlement, respectively, whereas 1A showed no movement.

A plot of the amount of downward movement of each settlement platform and monitor box since installation is shown in Figure 6.

Station 23+72

Settlement of monitors 1 and 3 is not included because of malfunction and late installation. Unit 2, as shown in Figure 7, had recorded downward movement of 0.11-foot at the settlement platform in the fill and 0.15-foot at the monitor box on the fill slope. This trend of greater settlement beneath the fill slope than beneath the embankment centerline, as shown in Figure 8, is opposite to the trend at Station 25+00. This was expected because the silt layer was subexcavated from beneath the centermost part of the embankment at the structure abutment location. Otherwise, approximately 0.5-foot of settlement could have been anticipated, resulting in considerable differential settlement between the approach, the abutment, and the other structure supports.

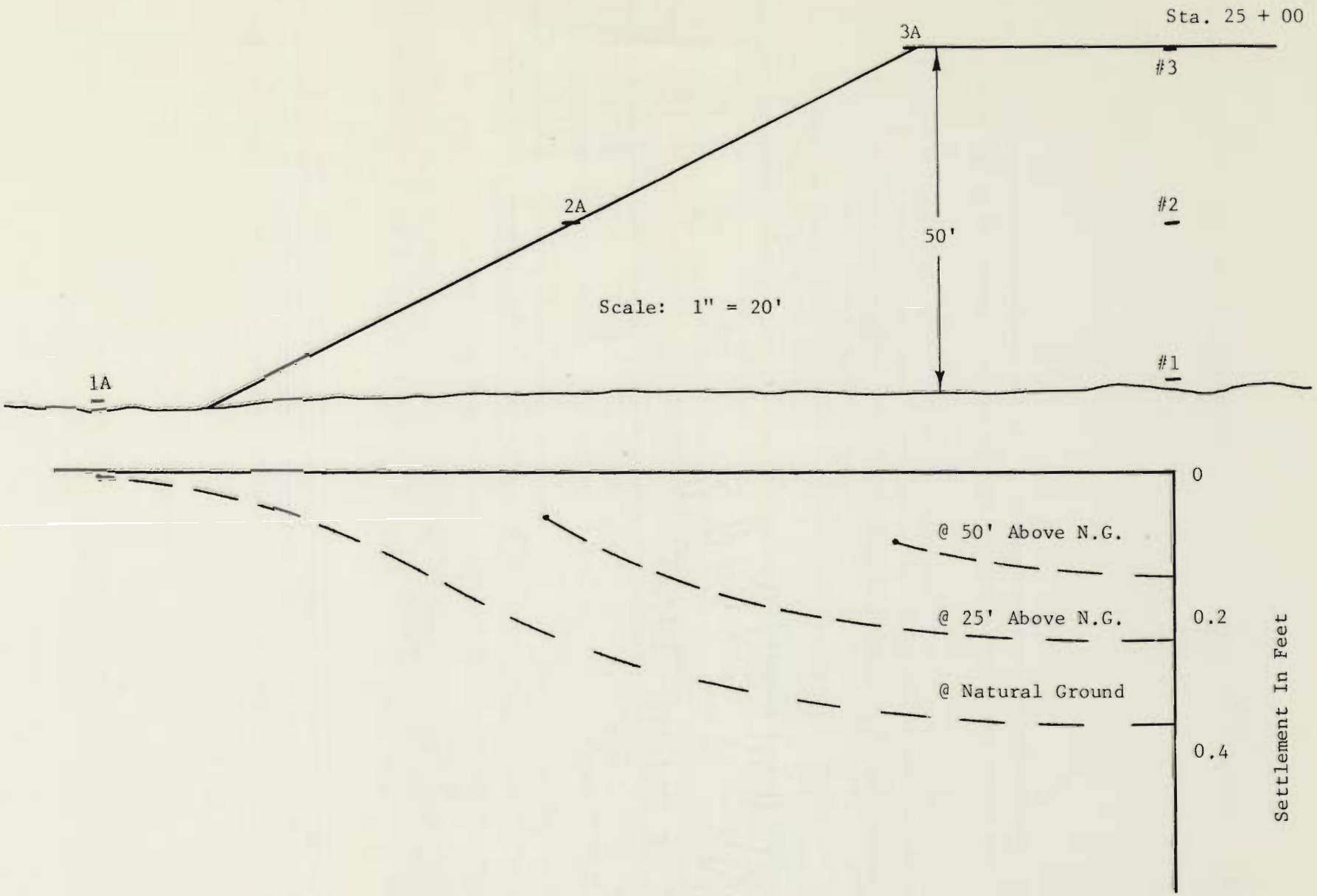


Figure 6 - Curves Showing Settlement of Monitor Units at Various Locations in Embankment X-Section

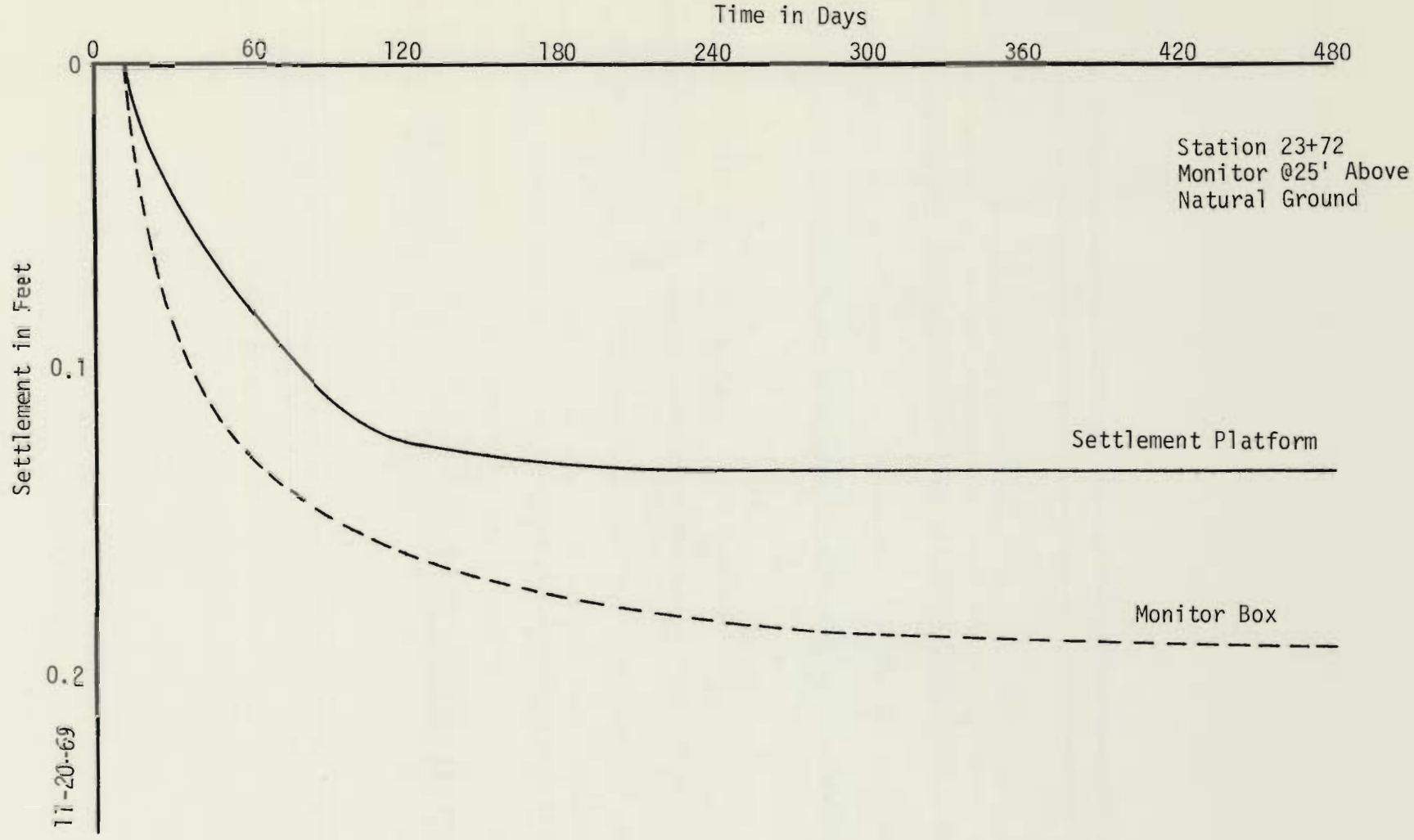


Figure 7 - Settlement Curves for Monitor @25' Above Natural Ground at Station 23+72