

SETTLEMENT OF RUBBISH FILL YELLOW FREIGHT SYSTEM FACILITY – BOSTON

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Introduction

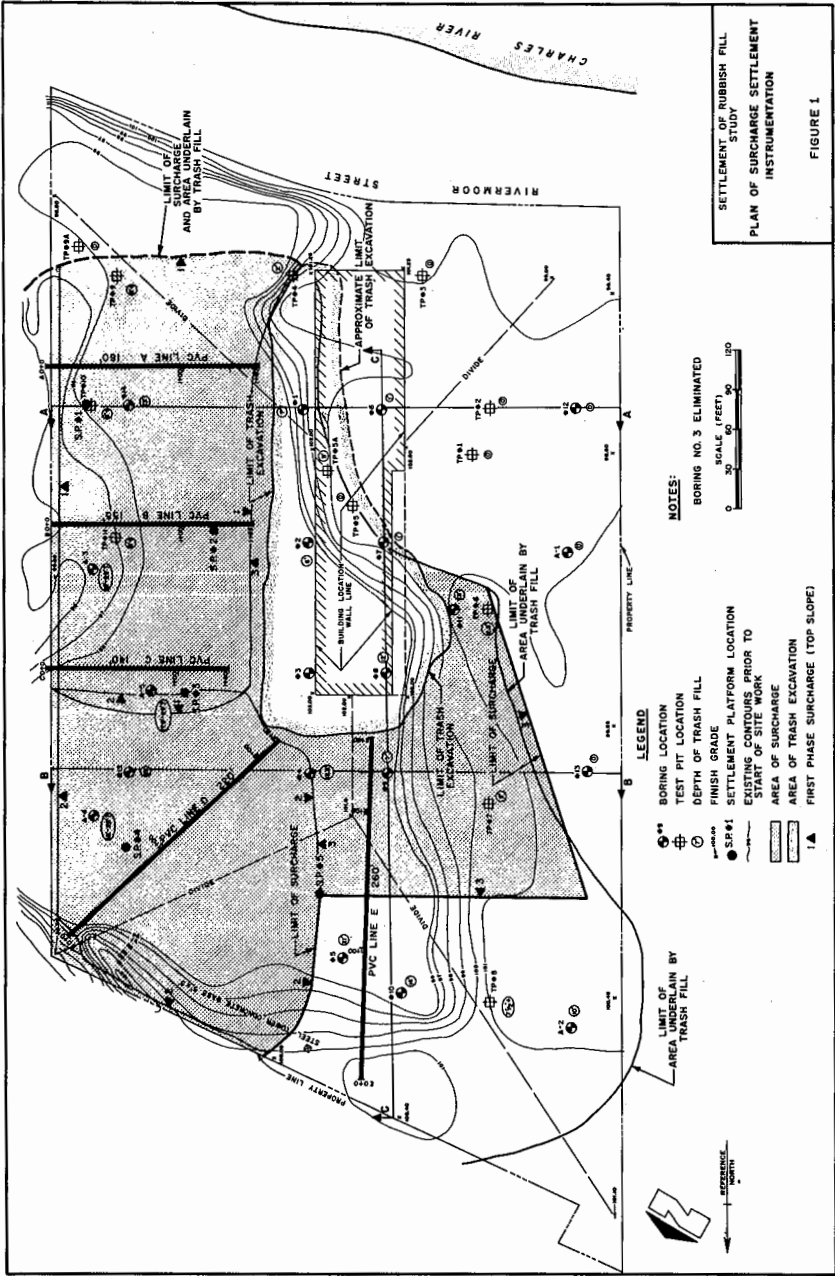
This paper presents the results of settlement measurements obtained at the site of a trucking facility presently under construction in West Roxbury, Massachusetts. The terminal building is located on a suitable portion of the site which allowed use of normal shallow foundations. However, the proposed paved yard area is underlain by a maximum of 25 feet of rubbish fill which had been placed on the site in the mid 1950's. The cost of excavation below water and replacement of the rubbish with granular fill in this area would have been prohibitive. It was therefore decided to leave the rubbish in place and to surcharge the site with an excess of fill above the required raise-in-grade to minimize post construction settlement beneath pavements.

A program of field instrumentation was undertaken to monitor the settlement performance and to identify areas that might undergo severe post construction differential settlement. Provision was made in the construction specifications to provide additional surcharge in these areas using observed settlements as a guide. However, only minor revisions to the planned surcharge program resulted. A description of the site and the pertinent results of the settlement measurements are presented.

1.00 Site Description

The site is located on Rivermoor Street in West Roxbury, Massachusetts, as shown on Figure 1. It is bounded by Rivermoor Street on the south, by property of the Rexall Drug Company and United Liquor Company on the west and east respectively, and by a Boston Edison Company transmission line on the north. In 1969, the site was characterized by a low wet area over most of the eastern portion, and by relatively flat, slightly higher flanking terrain on the western portion. The absence of vegetation was indicative of a filled situation and possibly a cut situation in the western portion.

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According to local residents, the site previously had been used as a sand and gravel pit and later abandoned. At a later date the site was used as a dump by the City of Boston. Both observations are consistent with subsurface data obtained from borings and test pits.

2.00 Test Borings and Test Pits

A total of 14 test borings and 13 test pits were made at the site in late April and early May 1969. These explorations are located as shown on Figure 1.

The borings ranged in depth from 25 feet to a maximum of 60 feet. Samples were taken using the conventional 1-3/8-inch I.D. split-spoon sampler, and the standard penetration resistance of the sample in blows per foot was obtained. Test pits were excavated with a ¼-cubic yard backhoe in order to examine the materials in place.

3.00 Subsurface Conditions

Subsurface profiles showing representative conditions are given on Figure 2. These conditions may be further generalized as follows:

3.1 Conditions in South and West Portions of Site

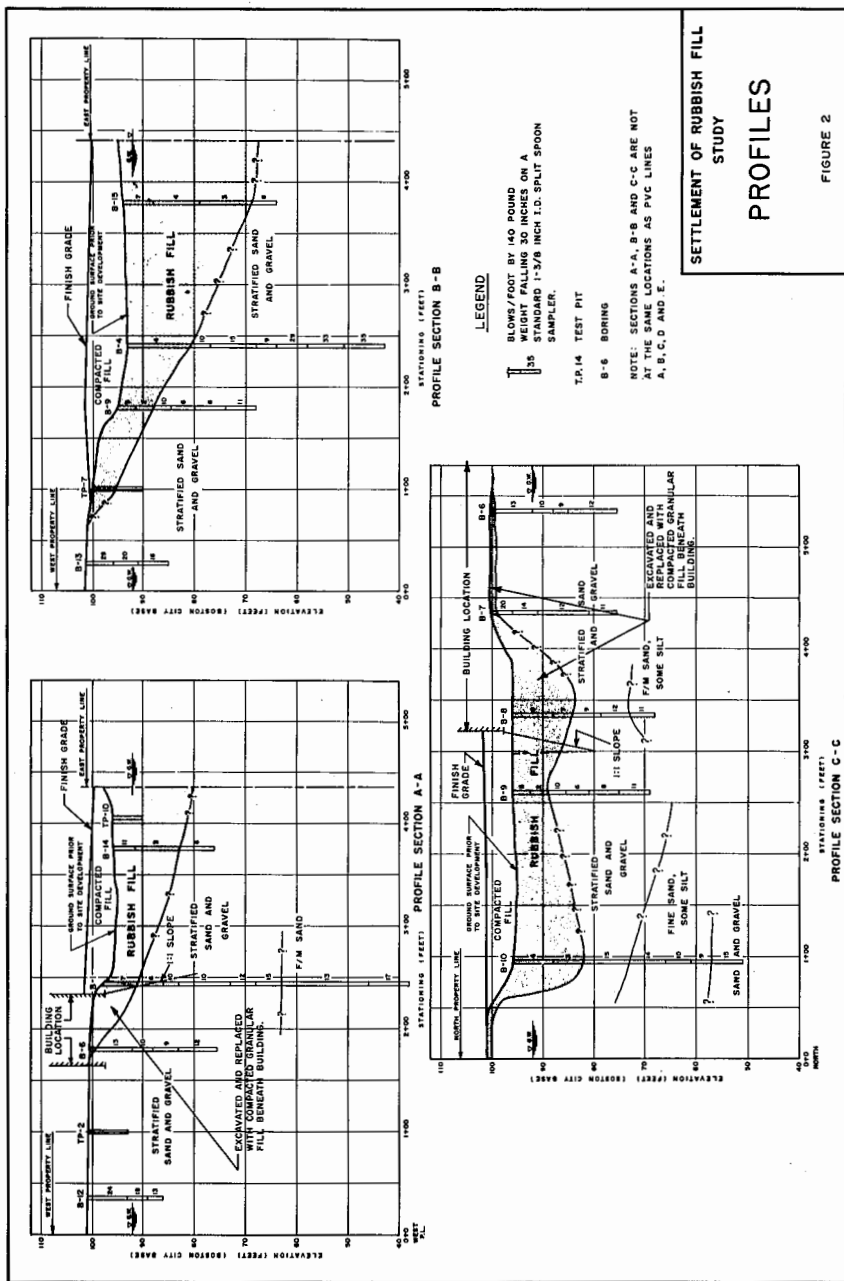
Prior to recent construction the subsurface conditions in this portion of the site were characterized by loose to medium dense granular deposits. These are natural soils containing fine to coarse sands and fine gravel in the upper 10 to 25 feet, and containing fine to medium sands with some silt and little or no gravel below depths of 19 to 25 feet and extending to depths of at least 60 feet below present ground surface.

3.2 Conditions in East and North Portions of Site

The subsurface conditions in the eastern and northern portions of the site are characterized by the presence of rubbish fill within the approximate limits indicated on Figure 1. The maximum depth of fill was encountered at Boring No. 15 where it was found to be in excess of 25 feet. Information from boring logs and penetration resistance indicated that the rubbish fill was very loose. Test pits excavated into this material verified the loose and compressible nature of the deposit. The fill is underlain by loose to medium dense natural granular deposits consisting of fine to coarse sand and fine gravel.

4.00 Construction at Site

After investigation of the site in early 1969, excavation and filling of the site was started in September 1969. The limits of the various items of work are shown on Figure 1. The work consisted of:



1. Within the building limits: Removal of rubbish fill and replacement with compacted granular fill.
2. Areas to be paved: Surcharge of rubbish fill with approximately six feet of temporary earth surcharge for periods not less than 30 days.
3. Other areas: Direct filling over zones underlain by rubbish.
4. Construction of the building on normal shallow foundations, starting in September 1970. Construction was completed in August 1971.

5.00 Settlement Measurements

5.10 Settlement Devices

Measurements of settlement during filling and surcharging were undertaken along five horizontal lines (PVC Lines A to E) and at five settlement platforms located as shown on Figure 1. The settlement measurements were made using a hose settlement device capable of obtaining a continuous profile of settlement along the buried PVC lines. Detailed descriptions of the apparatus and the measurement technique are appended hereto.

5.20 Results of Measurements

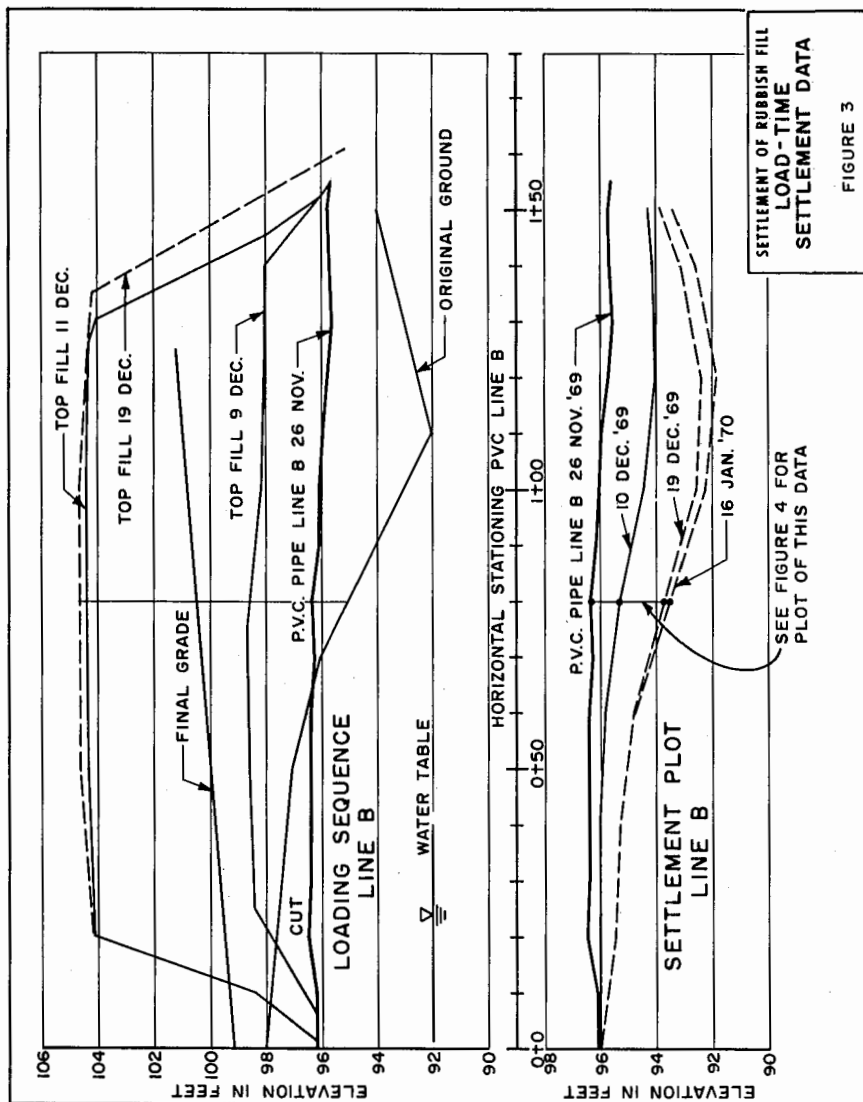
Observations of settlements were made at several points along the five buried PVC pipes at periodic intervals during filling and surcharging. Typical data obtained along PVC Line B are shown on the bottom portion of Figure 3 and on Figure 4. It may be noted that maximum differential settlements of the order of four feet were experienced along this line. The filling and loading sequence along this line is shown in the upper portion of Figure 3.

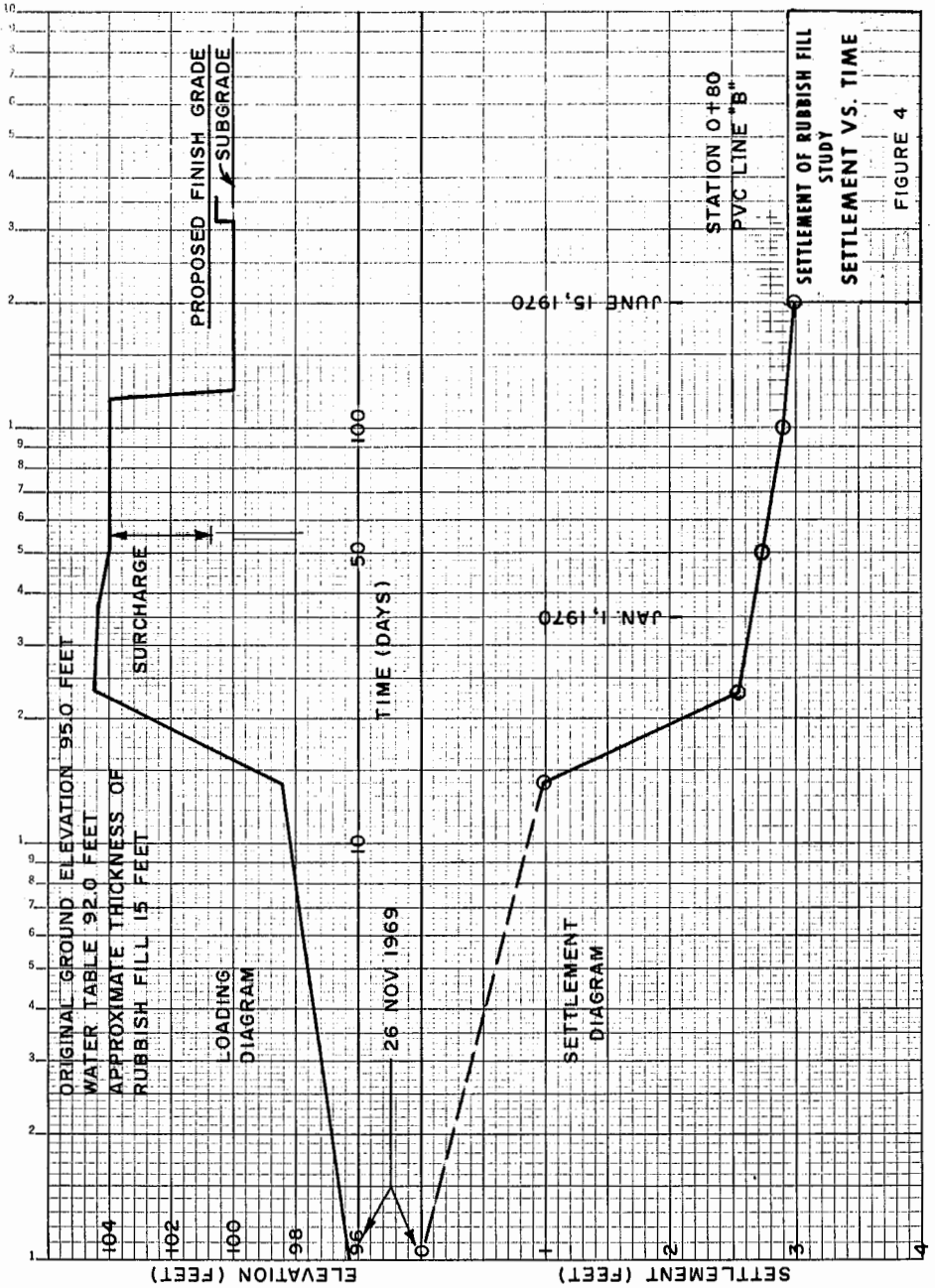
The unit compression defined by the total settlement divided by initial thickness of rubbish fill was calculated for each of the observation points. These data were plotted against applied surface load as shown in Figure 5 for a typical point. Although the scatter was wide, most of the points fell within the maximum and minimum lines shown on Figure 5.

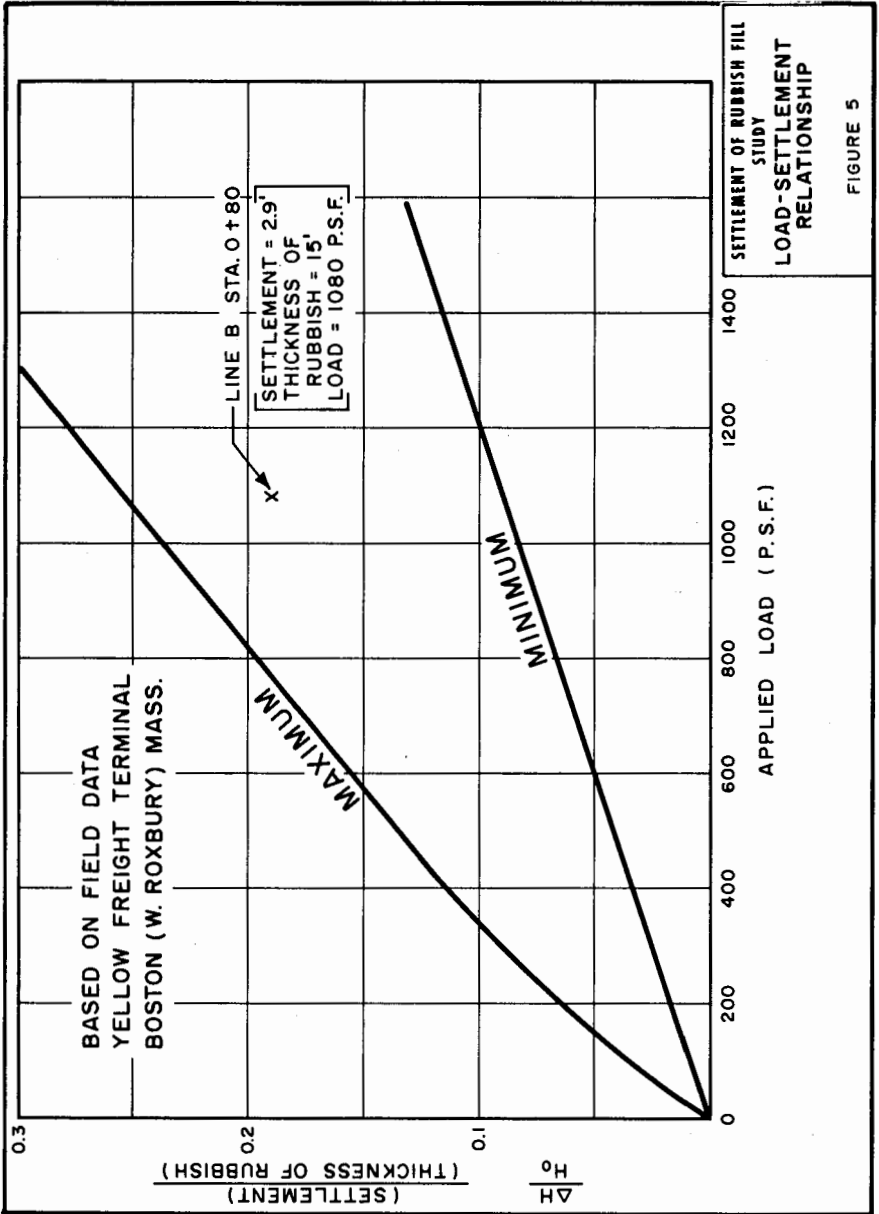
5.30 Settlement Parameters

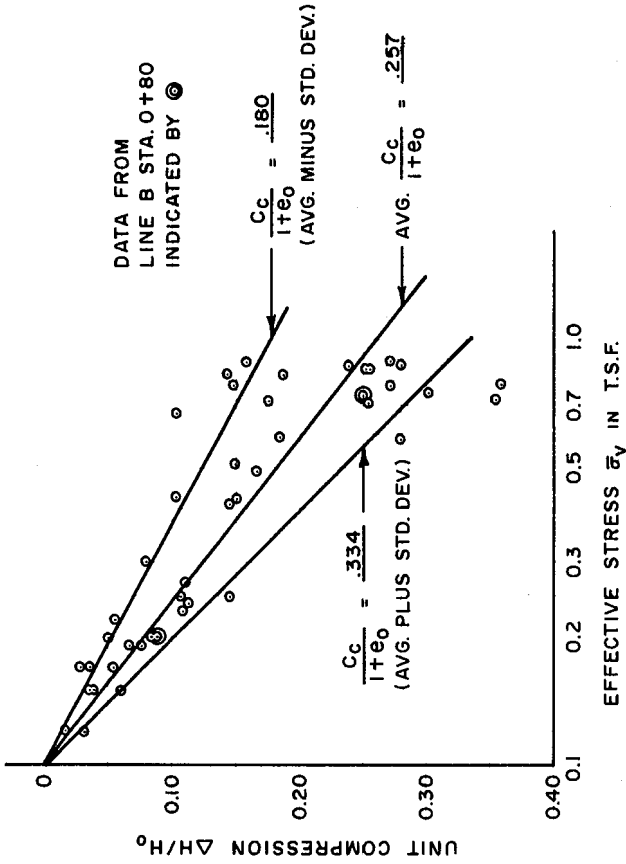
An attempt was made to analyze the data in terms of the conventional parameters that are used with one-dimensional consolidation theory. These parameters are $C_c/(1+e_0)$; c_v and C_∞ . The "e log p" plot for all data points is given in Figure 6. In this plot the assumption is made that the unit compression versus pressure relationship is linear on a semi-log plot.

The results shown on Figure 6 and the other parameters were compared with field results from other projects and from published data. This information is given on Table 1. It should be noted that the time-settlement mechanism of rubbish fill may not bear any theoretical resemblance to Terzaghi consolidation theory. For example, the coefficient of secondary compression in rubbish fill is









PLOT OF SETTLEMENT DATA
(normalized to common $\bar{\sigma}_{v0}$ of 0.1 T.S.F.)

SETTLEMENT OF RUBBISH FILL STUDY
COMPRESSION VS. LOG PRESSURE
FIGURE 6

Table 1. Summary of Compression Characteristics of Rubbish Fill

SITE	C_c $1+e_0$	C_v Ft^2/Day	C_α
Yellow Freight Terminal West Roxbury, Massachusetts (Reference 1)	.257±.077	3.35±2.71	.024±.020
Columbia Point Housing Project Boston, Massachusetts (Reference 2)	—	—	.021±.003
Sanitary Landfill Site — Georgia (G.F. Sowers — Reference 5)	.3 (est)	—	.007 to .015
Large Diameter Cell Tests California (References 3 and 4)	.192	2.12	.020
Typical Peat Values (Reference 2)	.25 to .45	0.1 to 0.8	.015 to .035

partly related to chemical decomposition. Nevertheless for this project the selected parameters were a convenient way of presenting the results and for comparison of results with other projects. It may also be seen in Table 1 that the results were of the same order of magnitude as might be anticipated in highly organic soils such as peat.

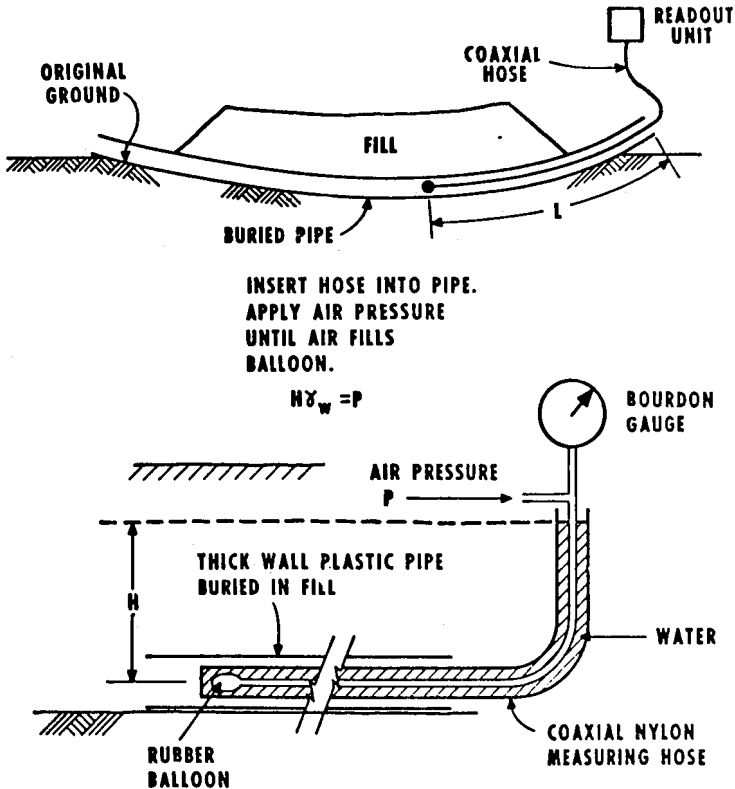
Acknowledgement

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Principle of Operation of Full-Profile Settlement Gauge

The principle of operation is based on the method proposed by Broms and Bergdahl (Reference 6).

A 1½-inch I.D. thick wall PVC pipe is laid in a shallow trench on the original ground surface or at any elevation within the fill, and subsequently covered by fill material. To measure the elevation of *any* point of the pipe, a probe, connected to plastic tubing, is pulled along the pipe. By achieving an air/water pressure balance across a thin rubber balloon housed in the probe, the elevation of the probe can be determined, as shown below.



The major advantages of the gauge, as compared with conventional settlement platforms, are:

1. It does not interfere with earthmoving operations.
2. It provides a full profile of readings along the buried pipe (which is of particular significance if thickness or compressibility of comparable material varies in a horizontal direction).

3. The same instrument can be used on many successive jobs, the only item expended on each job is the buried pipe.
4. Accuracy of measurement is adequate for settlement measurements above rubbish fill and peat.

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