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INTERIM REPORT
ON
LIME STABILIZATION OF BRIDGE CONES

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Item 3

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LIME STABILIZATION OF BRIDGE CONES

ABSTRACT

This is an interim report of a study on the use of lime stabilization to reduce embankment settlement at bridge approaches. The study was undertaken with the thought that the addition of lime to lime-reactive fill material might give sufficient strength to the embankment to uniformly distribute the weight of the embankment to the underlying subsoils. The construction and instrumentation of the first trial installation are discussed, the numerous difficulties that were encountered are described, and data recorded during the construction period are presented. The limited amount of data presently available would appear to indicate that little or no difference in settlement or rate of settlement occurred as a result of the lime treatment. At this early stage, however, no definite conclusions may be drawn regarding the effectiveness of the lime treatment in reducing the embankment settlement.

S U M M A R Y

This study concerns the problem of pavement settlement which frequently is observed adjacent to highway bridges. In most cases, the subsidence of the pavements can be attributed to the settlement of the earth embankments underlying the pavements. Additionally, with proper compaction of the fill material during construction, most of the settlement is believed to occur within the existing soils underlying the embankments.

The addition of lime to the fill material throughout the embankment was proposed as a partial solution to this problem of differential settlement. It is conceivable that the interaction of the lime with the clay fill material might provide sufficient strength to the embankment to more uniformly distribute the weight of the fill to the underlying subsoil, and reduce the overall settlement.

The construction of the first lime stabilized embankment has been completed at a site in the Chicago area. This construction and the associated research that took place during construction are described in this report. During this initial installation, changes were made in certain construction procedures which allowed the work to progress more efficiently. These changes are covered in detail in this report.

At the present time the only data available is related to the settlement of the subsoils beneath the embankments during the construction period. Of more critical interest in this study is the settlement that may occur within and below the embankments after the approach slabs are in place.

Repeated breakage of several of the reference pipes during the construction period made accumulation of reliable settlement data somewhat difficult. With the limited amount of data currently available, no definite conclusions can be drawn regarding the effectiveness of the lime treatment.

At the site of the first installation the approach slabs are now in place. Settlement data pertaining to the settlement of the embankment proper, and the approach slabs, as well as continued data on the subsoil settlement, are being compiled and will be included in the next report on this study.

LIME STABILIZATION OF BRIDGE CONES

Introduction

This is the first report on a study of the use of lime stabilization for reducing embankment settlement at bridge approaches. The bump resulting from this differential settlement has often created an unpleasant riding surface which has drawn wide criticism from the traveling public. It is also a problem which requires extensive corrective maintenance when the situation becomes hazardous.

In recognition of the poor riding surface that has developed at many bridge approaches and as an outgrowth of interest in the use of lime in highway construction, the stabilization of bridge embankments with lime was conceived as a possible means of alleviating the settlement problem. This study was undertaken to evaluate the use of lime for stabilizing bridge cones and to determine whether this treatment could serve as a partial solution to the problem of differential settlement.

Because bridge foundations are essentially designed and constructed as unyielding supports, the bump that occurs can be directly related to the settlement of the earth embankments immediately adjacent to the bridge structure. The degree of roughness and its influence on the riding quality of a roadway surface depend on the magnitude of the embankment settlement as it occurs within the bridge approach area. Although some settlement can be expected within the embankment, it is generally believed that, with proper consolidation of the fill material during construction, most of the settlement occurs within the natural soils underlying the newly constructed fill. A further belief held by some, and the one that led directly to the present study, is that poorer embankment soils create nonuniform loading conditions on the underlying soils to provide uneven and locally excessive settlements.

It has been theorized that the addition of lime to lime-reactive embankment soils might give sufficient strength to the embankment to more uniformly distribute the weight of the embankment to the underlying foundation soils. In consideration of this theory, a limited field investigation is being conducted and two trial installations within the Chicago area have been selected for incorporating the research feature.

In conjunction with the research on stabilized embankments, the study also includes an exploratory investigation on the effectiveness of using longer approach spans in reducing the effect of settlement. The purpose of this secondary study is to determine the feasibility of improving the riding quality of bridge approaches by increasing the settlement transitioning length.

The location of dual bridges referred to in this report as the First Avenue project, was the first site selected for using lime in the construction of bridge cone embankments. The project under construction is identified as U-383(31), FA 133, Section 0102-683HBK, Cook County. When completed, the twin structures will carry the northbound and southbound lanes of the First Avenue Expressway over 47th Street.

Construction of the first stabilized cone began on June 19, 1968, and was completed three weeks later on July 12. For reasons discussed later, a decision to discontinue the experimental use of lime from this project was made after completing this one embankment. This decision to delete the lime stabilization from the remainder of the project, however, had little effect on the investigation, and the research work proceeded as originally planned. The observations made and the preliminary data collected during the construction of this first installation are used as a basis for preparing this report. Because completion of the approach slabs is recent, very little data is available on their performance. Aside from briefly mentioning the inclusion of this phase as part of the study, detailed discussion of using longer approach slabs is limited in this interim report.

The second installation is incorporated into the construction contract for the work on Project I-90-3(76)72, Interstate 90, Section 0404-31HBK, Cook County. The contract for this project was awarded on June 18, 1969, and construction of the embankments is scheduled early in the spring of 1970.

At this time, there is insufficient evidence to derive any conclusions as to the benefits in using lime with bridge cone construction. This interim report, however, describes a few of the major experiences encountered during construction of the first installation and presents some of the preliminary settlement data obtained during its construction.

Research Objective

The specific objective of this investigation is to make an evaluation on the effectiveness of lime stabilization for reducing the settlement of bridge approach pavements and determine whether further studies are warranted for this type of treatment. Recommendations for continuing the study on lime stabilization will be made if the initial results of the trial installations appear to be favorable.

The secondary objectives of this project are to study in detail the settlement relationship between an embankment and the existing subsurface soils underlying the embankment, and to observe the structural performance and behavior of longer approach slabs.

In general, the engineering knowledge obtained from this research will be used for developing a more comprehensive program involving methods and special treatments for alleviating the settlement problem at bridge approaches.

Research Procedure and Instrumentation

To achieve the research objectives for this study, compatible control sections were established at the bridge site so that a direct comparison could be made between the experimental feature and a normal section conforming to present day practice. The two south bridge cones of the dual structures were originally proposed for the experimental sections incorporating the lime treatment. The two north cones were to remain untreated so that comparative evaluation could be made on the effectiveness of the lime treatment. Because of an unforeseen problem encountered during construction of the First Avenue Project, the southeast was the only cone stabilized while the remaining three were left untreated (Figure 1).

During the first day of construction of the lime-stabilized embankment, it became apparent that the amount of water needed to complete the project had been grossly underestimated. Nearly 3500 gallons of water were required for stabilizing the first six-inch lift. It became obvious that at this rate the original estimate of 9000 gallons would be exceeded by several times the estimate. In this situation, the unit price of $0.20 that had been bid by the contractor for what was thought would be a small quantity of water was considered to be unrealistically high, and a decision was made to discontinue the construction of the second proposed cone. Construction and instrumentation of the first cone, however, were completed, and the research work was continued for that portion of the lime stabilization constructed.

The two embankments of the northbound lanes consisting of one stabilized and one untreated cone, were instrumented with settlement platforms and reference rods. These areas were selected for instrumentation on the basis of having equivalent fill heights after construction. Unsuitable soils within both areas were removed to approximately the same depth and the subsoils near the surface appeared somewhat more uniform.

Prior to constructing the embankments, eight platforms were installed for detecting the settlement which occurs within the subsoils underlying the embankments (Figure 2). On the existing ground surface of each embankment, and on a longitudinal line parallel to the roadway, three platforms were placed at locations 20, 40, and 60 feet from the back of the abutment and approximately 3 feet from the edge of the roadway pavement within the east shoulder of the northbound lanes. At a distance of approximately 30 feet from the back of the abutment and along the same alignment, one additional platform for each of the two embankments was buried five feet below the existing ground

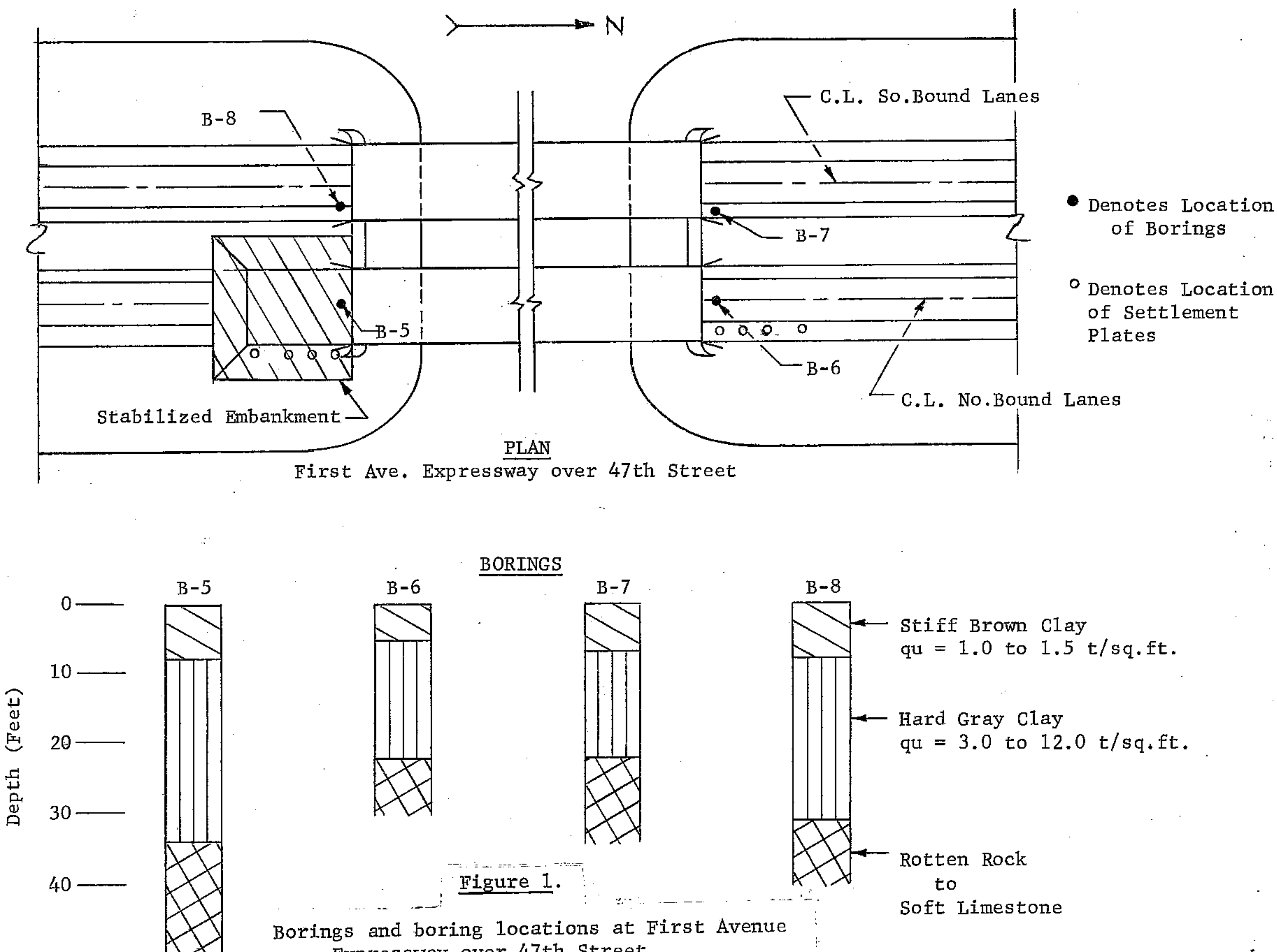
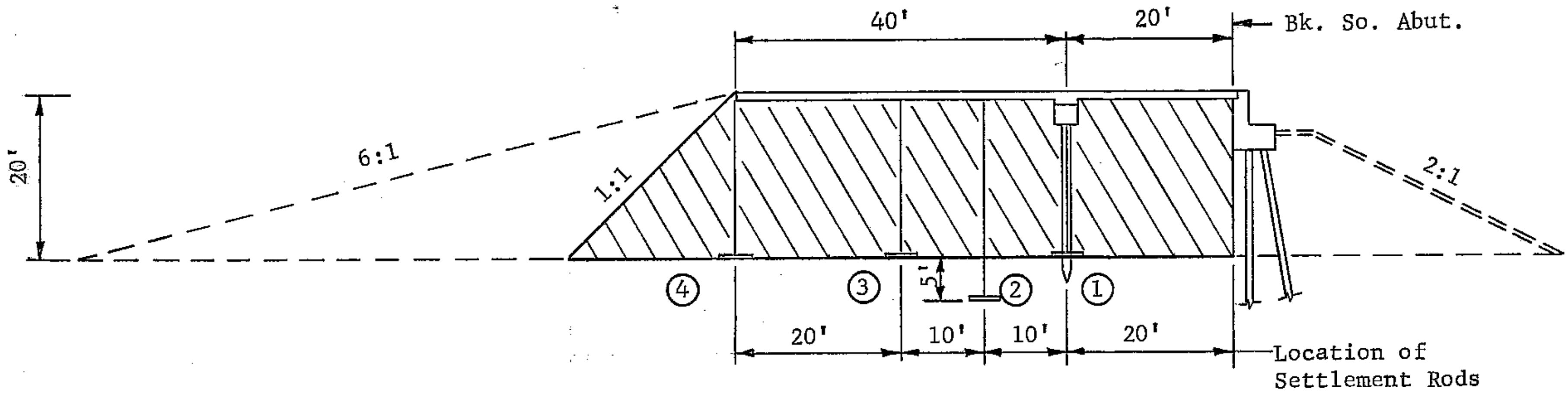
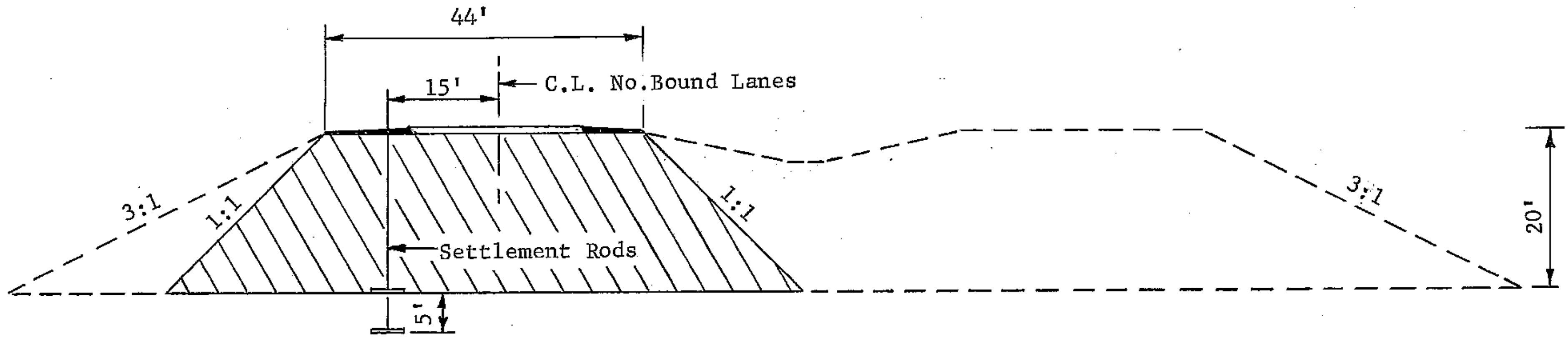


Figure 1.

Borings and boring locations at First Avenue Expressway over 47th Street



PROFILE OF STABILIZED EMBANKMENT
Not to scale
(Stabilized portion shown hatched)



CROSS SECTION OF ROADWAY LOOKING SOUTH
Not to scale
(Stabilized portion shown hatched)

Figure 2.

Location of settlement rods within stabilized embankment.
Settlement rods within unstabilized embankment in similar location.

line. The excavation for the buried platforms was made by hand with minimum disturbance to the surrounding soils and was later backfilled with porous granular materials after installing the platforms and reference rods.

The settlement platforms below the embankments consist of 3- by 3-ft by 1/4-in. steel plates and the reference rods are made of sections of 3/4-in. black pipe coupled with standard fittings capable of providing a tight connection. The reference rods were extended in 5-ft increments as the embankments were constructed. After completion of the shoulder work, each reference rod was encased with a capped section of 2-in. diameter pipe, 2 ft in length.

The settlement which occurs within the embankment proper is measured by three additional reference plates set on top of the finished subgrade in each of the two newly constructed embankments. These plates of smaller configuration are 6- by 6-in. metallic sheets, perforated for attaching a reference rod with a screw-type fitting. The perforated sheets were located and anchored onto the subgrade before placing the subbase and shoulder materials. After completing the shoulder work, the plates were relocated by drilling through the shoulder and subbase materials. Reference rods 1/2 in. in diameter and ranging from 10 to 20 inches in length were attached to the settlement plates. Each rod was encased with a 3/4-in. O.D. pipe which was capped with a removable plug.

Instrumentation for the First Avenue project was completed on October 17, 1969, and settlement readings are being taken at regular intervals. The initial profiles at the approach slabs have been established and top-of-slab elevations will be taken periodically for relating the deflection characteristics to the structural performance of the approach slabs.

Stabilized Embankment Materials

The borrow soil incorporated into the lime stabilized embankment is classified A-7-6(15) clay, and standard compaction tests of the natural material indicated a moisture-density relationship of 107 lb per cu ft, dry density, at optimum moisture of 19.6 percent. The soil contained 62 percent clay (minus 0.005 mm) which greatly exceeded the minimum 15 percent specified to insure that a reactive soil would be incorporated into the project. This same soil was also used for standard embankment throughout the project.

Laboratory tests were conducted to determine the unconfined compressive strengths of various soil-lime compositions from which the optimum design proportions could be established. Two specimens for each routine mixture containing 3, 5, and 7 percent lime were prepared in duplicate at optimum water content and tested for unconfined compressive strength. The results of the tests are shown in Figure 3.

The specimens tested were 2 inches in diameter by 4 inches in length, and cured at 120° F in sealed containers for 48 hours. After curing, the specimens were allowed to come to room temperature and were tested in compression at a constant rate of deformation of 0.05 in. per min. From the results, a 5 percent lime content which produced optimum strength was selected as the design mixture. A standard dry density of 104.2 lb per cu ft at 22.6 percent optimum moisture was obtained for this design.

Construction of Stabilized Embankment

Procedures established for constructing and field-testing the stabilized embankment consisted of the following:

(1) Test for moisture content of borrow soil

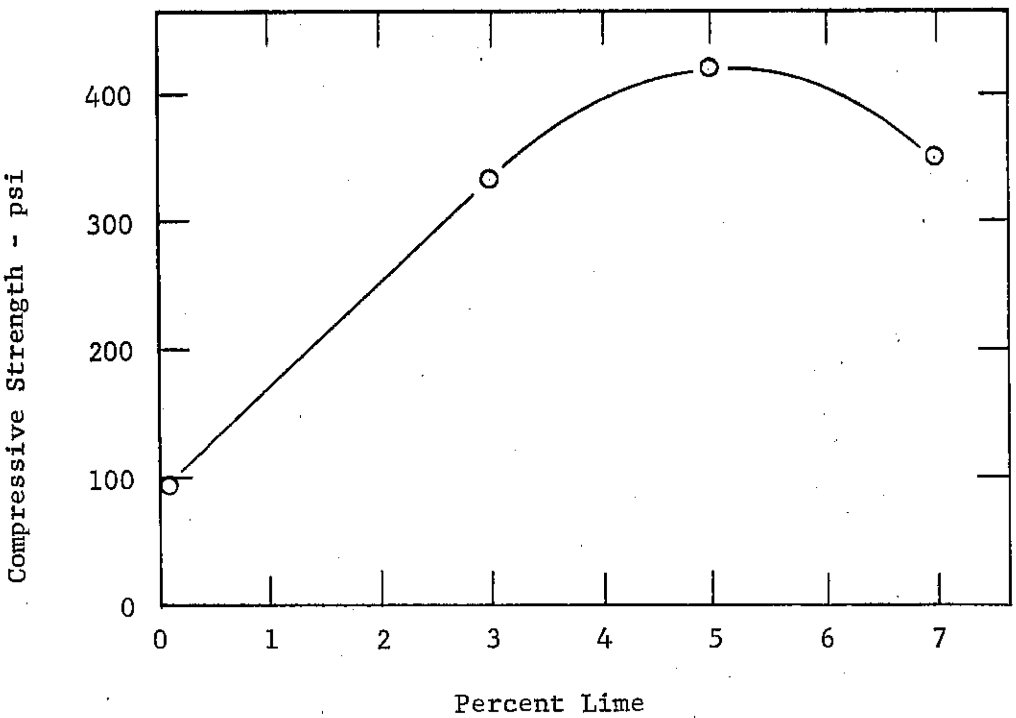


Figure 3. Compressive strength of lime-soil mixtures

(2) Initial pulverization of the borrow soil

(3) Addition of lime and initial mixing of the lime-soil composition

(4) Test for moisture content of lime-soil mixture

(5) Addition of water and final mixing of lime-soil composition

(6) Test for particle size-dry sieving

(7) Compaction of lime-soil composition

(8) Test for compaction

A summary of the contractor's daily operation, and the quantities of materials used for each lift are shown in Table 1. Also shown in the same table are the test results of samples taken from each lift.

The borrow soil was brought in by 5-axle semi-dump trucks, in the amount necessary for constructing each 6-in. lift, and leveled to a fairly uniform thickness with a Caterpillar 977, High Lift. A Rex self-propelled Pulvi-Mixer was used for pulverizing and mixing the soil-lime composition.

The lime was transported in bulk from the mill in cement hopper trucks and transferred by blower into a 35,000 lb bulk dispensing tanker. A self-contained augering system within the tanker was used to release the bulk lime through two discharge outlets located at the rear of the trailer. Although the material tended to deposit in windrows, a fair distribution of the lime during its discharge from the rear of the trailer resulted. Wind conditions during the construction period were always less than moderate and wind losses were very nominal.

At the beginning of construction, the contractor used a vibratory roller, Tampo VP-90, having a gross weight of 11,500 pounds and a maximum centrifugal force of 15,000 pounds for compacting the lime-soil composition. With this equipment alone, some difficulty was experienced in achieving the specified 97 percent compaction. A substantial improvement in the rate of compaction was reported on

TABLE 1.

QUANTITIES AND TEST RESULTS

Date 1968	Lift	Moisture Content of Borrow %	Water Added gals.	Lime Added lbs.	Gradation Passing No. 4 Sieve %	Compaction %
6/19	0	--	3500	26700	--	97.8
6/19	1	--	3500	25900	--	101.0
6/20	2	--	2140	24800	--	103.5
6/20	3	--	2140	26800	--	100.3
6/20	4	17.5	2140	27600	--	100.0
6/21	5	17.5	3000	26400	59.0	100.1
6/21	6	24.0	0	25700	57.0	99.8
6/22	7	22.0	1000	26000	49.3	98.2
6/22	8	21.2	1000	26900	60.0	103.0
6/24	9	17.0	2200	25600	59.5	100.0
6/28	10	20.9	500	24700	59.0	100.3
7/1	11	18.6	1200	28300	58.0	99.7
7/1	12	15.0	3000	27800	58.0	98.0
7/1	13	16.0	2500	25300	54.0	99.0
7/2	14	22.0	0	21700	58.0	98.5
7/2	15	18.9	1000	22600	58.0	106.0
7/3	16	19.6	800	25100	68.0	104.3
7/3	17	19.0	1000	21200	56.0	100.0
7/3	18	19.0	1000	24100	63.0	99.2
7/5	19	19.0	1000	16700	56.0	98.7
7/5	20	20.5	0	22000	56.0	100.9
7/5	21	19.0	1000	18200	57.0	106.5
7/6	22	18.5	1000	17900	58.1	104.0
7/6	23	20.4	500	17400	57.5	106.2
7/6	24	22.9	0	16700	60.4	103.7
7/8	25	22.0	0	18200	63.0	99.7
7/8	26	18.1	1500	18000	56.0	99.3
7/9	27	23.0	0	16800	62.0	106.4
7/9	28	21.8	0	17500	70.5	102.1
7/9	29	25.0	0	15500	59.0	103.0
7/10	30	20.1	500	21200	64.3	100.0
7/10	31	18.3	1500	14600	55.0	105.0
7/10	32	21.4	0	17800	54.0	107.0
7/11	33	15.0	3000	16700	65.0	100.0
7/11	34	21.0	0	15200	65.5	110.3
7/11	35	23.0	0	13400	60.0	101.9
7/12	36	20.4	0	19900	62.5	102.5
7/12	37	20.6	500	14100	73.0	97.4

July 1, 1968, with the later addition of a 50-ton self-propelled compactor. The contractor's rate of production after including this compactor was increased from two to three lifts per day, which represented a substantial decrease in the effort required to accomplish the specified compaction.

A Speedy Moisture Tester with a calcium carbide gas generator was introduced early into the project. The use of this device provided a rapid means for measuring the water content of the borrow soil as the soil material was brought into the construction site and for establishing the optimum moisture of the composite material after mixing.

Some difficulty was experienced in meeting the original gradation specification. This specification required that, prior to compacting each layer, the mixture be pulverized to the extent that 60 percent, by hydrated weight, would pass a No. 4 sieve. Without a waiting period for initial curing, considerable effort was required for complying with this specification. Although an initial curing period of 24 to 48 hours is beneficial before final pulverization, this aging period to permit mellowing of the clay particles is uneconomical for continuous multi-layer construction within the limits of bridge cone embankments. To make this type of construction economically feasible, an average of three lifts per day are needed for a continuous daily operation. To allow the work to proceed at a reasonable rate on this project, the specification for the gradation of the lime-soil composition before compaction was relaxed to 50 percent passing a No. 4 sieve. This revision in the gradation requirement permitted a more reasonable rate in placing of the embankment. While the more rigorous requirement is compatible with base and subbase construction, it was concluded to be overly restrictive when applied to multi-layer embankment construction.

Processing of the lime-soil mixture was found to proceed more efficiently at moisture contents at the lower end of the specified range of optimum moisture content $\pm$ 2.0 percent.

On July 8, 1968, the pulverizing effort was supplemented on a trial basis with a second Rex Pulvi-Mixer. This second mixer was added to the operation in an attempt to improve the rate of pulverization of the soil material. It was apparent, however, that little benefit could be gained in the early stage of pulverization by increasing the pulverizing effort. The average passing gradation achieved with one Pulvi-Mixer was 58.3 percent and after adding the second mixer, the average was only slightly increased to 62.2 percent. Allowing the rained-out days the rate of embankment placement for one Pulvi-Mixer averaged about 2.6 lifts per day. This same average rate was obtained with two mixers.

After completing the embankment, concentrations of the lime material were noted at the lift interfaces as the stabilized material was being excavated for the bridge abutments. At first it was believed that this segregation had occurred throughout each layer; but evidence to the contrary was found during the precoring for the approach piling. Visual inspection of the inside surfaces of the cored holes did not reveal the lime segregation that was previously noted. The lime-soil composition within the limits of precored holes appeared very uniform with the lime evenly distributed throughout. The segregation is believed, therefore, to be confined to the outer edges and not to extend through the central portion of the embankment.

The rate of pile precoring through the stabilized materials was observed to be substantially slower in relation to the untreated embankment. The rate of coring in the lime-soil composition with a rock auger was approximately 8 ft per hr as compared to the rate of 28 ft per hr achieved in coring through the untreated embankment with a normal earth auger of the same diameter. The degree of effort required for precoring through the stabilized material was approximately 3 1/2 times the normal rate for untreated compacted soils. Equal difficulty also was experienced when making other excavations within the stabilized embankment.

Laboratory Analysis

In order to correlate the field settlement measurements with theoretical values derived from standard laboratory procedures a consolidation test was performed on a soil sample obtained from the level of the five- to six-foot clay layer which would support the embankments. The time required for a field clay layer to reach a given degree of consolidation can be predicted from this test, if the manner in which the sample and the field layer drains is known. This is based on the Terzaghi theory of one-dimensional consolidation.

In the laboratory, the soil sample was encased in a plastic cylinder and supported on a porous stone. Loads were applied to the sample in increasing increments through a steel piston which fit tightly within the plastic cylinder. Most of the moisture drainage, therefore, would be expected to occur at the bottom surface of the sample. Leakage was observed around the piston, however, which could cause the true drainage condition to be somewhat intermediate between free drainage at one surface only and free drainage at both surfaces.

As the settlement rates measured in the field were studied, it became apparent that they corresponded closely to the theoretical values for free drainage of the sample at two surfaces. Possibly more leakage had occurred around the perimeter of the piston during the lab test than had been considered. Consequently, double drainage of the sample was used in plotting the theoretical limits for the settlement of the field layer.

The exact manner in which the field layer drains is difficult to determine from preliminary field work alone. The available borings indicate a thick bed of impervious material below the five-to six-foot clay layer directly beneath the embankments. The assumption that a similar soil profile exists throughout the general area of the embankments would indicate that drainage of the field layer should mostly occur at the upper surface.

The available information, however, was not sufficient to conclude that single surface drainage of the field layer is the correct assumption. In order to achieve objective theoretical limits for the settlement of the field layer, two theoretical time-settlement curves were plotted, with one curve corresponding to single surface drainage and the other to double surface drainage of the field layer.

Data from the consolidation test were used in plotting void ratio-pressure curves and time-consolidation curves. Using the compression index as found from the void ratio-pressure curves, the theoretical ultimate settlement of the six-foot clay layer was predicted to be 1.79 inches. Since the location of the settlement plates provides a means for measuring the relative settlement of the upper five feet of clay beneath the embankments, the ultimate settlement of this layer was predicted to be 1.56 inches. These values are the ultimate settlement which should occur in the layers due to the pressure of the entire embankment which is about 2000 lbs per sq ft.

From the time-consolidation curve, the coefficient of consolidation of the clay was determined. Using this coefficient and predicted settlement values corresponding to the rate of construction of the embankments, the theoretical time-settlement curves were plotted for the five-foot clay layers (Figures 4 and 5). As noted above, two theoretical curves were plotted for each embankment to conform to the two limits of drainage of the field layer.

Settlement Measurements During Construction Period

Boring exploration of the subsoils within the general areas of the bridge cones

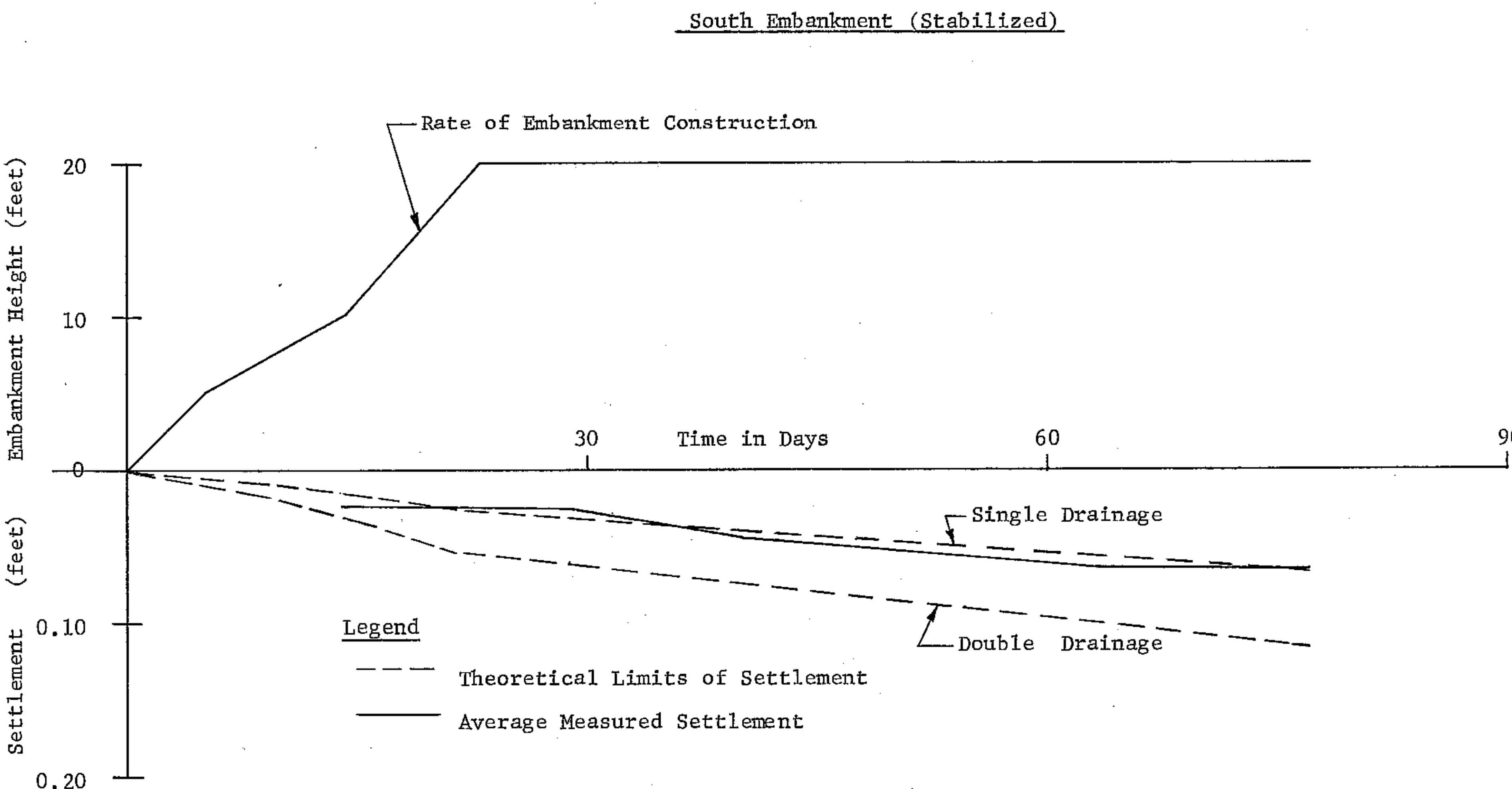


Figure 4.

Theoretical and measured settlement of stabilized embankment correlated to rate of embankment construction

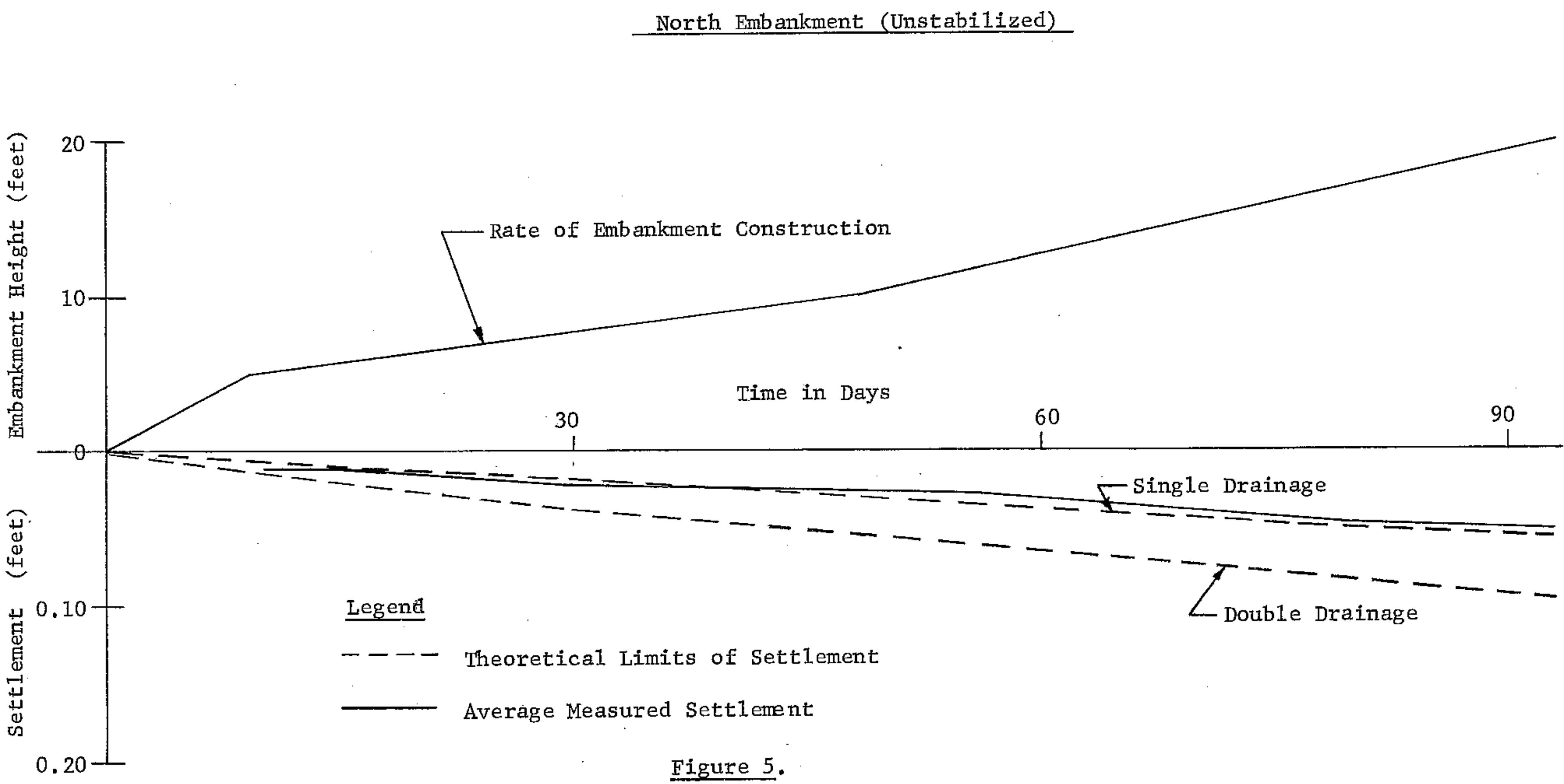


Figure 5.

Theoretical and measured settlements of unstabilized embankment correlated to rate of embankment construction.

at the First Avenue site indicated a 6- to 8-ft surface layer of stiff brown clay having an unconfined compressive strength of about 1 to 1 1/2 tons per sq ft. Underlying this layer is 20 to 25 ft of hard to very stiff gray clay ranging in strength from about 3 to 12 tons per sq ft. This intermediate layer extends down to stratified layers of rotten rock or boulders resting on soft limestone. Borings from the general area of the embankments are shown in Figure 1.

Beneath the top surface layer of 6 to 8 feet of stiff brown clay, the foundation is reasonably firm and impervious with little settlement anticipated below the surface layer. The free drainage path would pass through the top of the surface layer with some small amount of lateral drainage possible near the edges of the embankments. The top 2 or 3 feet of surface soil was considered unsuitable and was removed by the contractor before construction of the embankments. This leaves a layer of about 4 to 6 ft from which settlement is expected. The predicted settlement for a layer of this thickness is relatively small as indicated by the computed settlements shown in the previous section.

As the embankments were constructed, reference pipes were extended from the settlement plates in five-foot increments. From elevations taken at the top of the pipes as the work progressed, settlement-time curves were plotted using the initial elevations of the settlement plates as a base. These curves indicated that the plates settled, then rose, settled again and finally started to rise. It is not believed that the plates actually behaved in such a manner. Since all of the plates followed the same general pattern and the variation for the plates at each embankment was similar in magnitude, it is believed that the temporary benchmark used for reference during the construction phase was disturbed. Consequently, the data in this form were not accepted as reliable.

Since plate number 2 was located five feet below the other three plates at each embankment, it is possible to study the relative settlement of the five-foot layer. It was assumed that the settlement of plate number 2 is negligible since it is seated near the top of the impervious stiff clay layer. Based on this assumption the settlement of the five-foot layer was considered to closely approach the actual total settlement of the subsoil beneath the embankments.

Most of the settlement readings during the first few days of construction showed settlements considerably larger than were predicted. It is believed that this is due to the initial seating of the settlement plates. Despite the precautions taken to not disturb the subsoil on which the plates were placed, it is thought that some initial pressure was required before a uniform distribution of the load to the subsoil was accomplished.

To account for this factor, the first reading plotted was the one which was made from five to ten days after construction of the embankments had commenced. Also it was assumed that the magnitude of the first measured settlement was an amount represented by the theoretical limits. In doing this the rate of the measured settlement could then be compared with the theoretical rate from that time forward.

Another source of error during the construction period was the repeated breakage of several of the settlement pipes. This breakage was often caused by large lumps of soil rolling against the rods as the borrow material was being dumped from the trucks. Pipe number 4 (Figure 2) at the north embankment broke so frequently that settlement measurements taken from this pipe during this time period are considered unreliable and were not used in the analysis. In the next trial installation a stronger structural steel pipe section will be used which may alleviate this problem.

Allowing for such sources of error as initial seating of the settlement plates, and breakage of the pipes during construction, the average time versus settlement curves for pipes number 1 and 3 at the north (unstabilized) embankment and pipes number 1, 3, and 4 at the south (stabilized) embankment were plotted (Figures 4 and 5). The curves for both the stabilized and unstabilized embankments appear to fall close to the theoretical limits and near the limit indicating single surface drainage of the field layer. This appears to justify the initial assumption made for the field drainage. Both curves lie close enough to the theoretical limits to consider the theoretical assumptions as being reliable indicators of the rate of measured settlement.

Summary Comments

From the data compiled during the construction period, no definite conclusions can be drawn regarding the effectiveness of the lime treatment. The limited amount of information presently available would appear to indicate that little or no difference in settlement or rate of settlement of the subsoils occurred during construction as a result of the lime treatment. Of more critical interest in this study, however, is the settlement within and below the embankment after the approach slabs are in place. This would be the cause of the differential settlement affecting the approaches, and consequently the primary reason that this study was initiated. At the First Avenue site the approach slabs are now in place. Settlement data pertaining to the settlement of the embankment proper, and the approach slabs, as well as continued data on the subsoil settlement are being compiled and will be included in the next report on this study.

While constructing the first trial lime-stabilized embankment, several changes were made to allow the work to progress more efficiently. These changes are as follows:

(1) Difficulty was experienced in meeting the pulverization requirement with the lime-treated soil. The specification requirement of 60 percent by

hydrated weight passing a No. 4 sieve was relaxed to 50 percent. This permitted a reasonable construction rate. The more stringent requirement, while appropriate for base and subbase construction, was concluded not to be warranted for embankment construction.

(2) In the small work area of the bridge cone, the lime-soil mixture could not be allowed sufficient time to cure to a state where pulverization could be done with maximum effectiveness, while at the same time making efficient use of men and equipment. Pulverization undertaken early in the curing period so that a continuous operation could be preserved sometimes proceeded more slowly than desirable. The addition of a second pulverizing mixer to the operation did not produce much benefit.

(3) Some difficulty was experienced in achieving the specified 97 percent compaction with the vibratory roller initially used. The later addition of a 50-ton self-propelled compactor substantially improved the rate of compaction.

After the embankment was completed, excavation work for the abutment revealed segregation of the lime in each six-inch lift with high concentrations of lime appearing near the surface of the lifts. Further investigation indicated that this segregation was apparently limited to areas near the perimeter of the embankment while the interior of the embankment was not affected.

During the course of this study it is planned to acquire information about the settlement of the embankment proper, the subsoils beneath the embankment, and the approach slabs. At the present time the only data available are related to the settlement of the subsoils beneath the embankment during the construction period. The accumulation of reliable settlement data during this period was somewhat handicapped by the repeated breakage of several of the reference rods. With the embankments now completed, the approach slabs in place, and all settlement plates and reference rods permanently installed, data which are more comprehensive and accurate will be compiled. This additional data should be more meaningful for evaluating the effectiveness of the lime treatment at this site.