ARIZONA DEPARTMENT OF TRANSPORTATION

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HILFIKER RETAINING WALLS WITH FULL HEIGHT CAST-IN-PLACE PANELS

Construction Report

Prepared by:
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February 1988

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Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007
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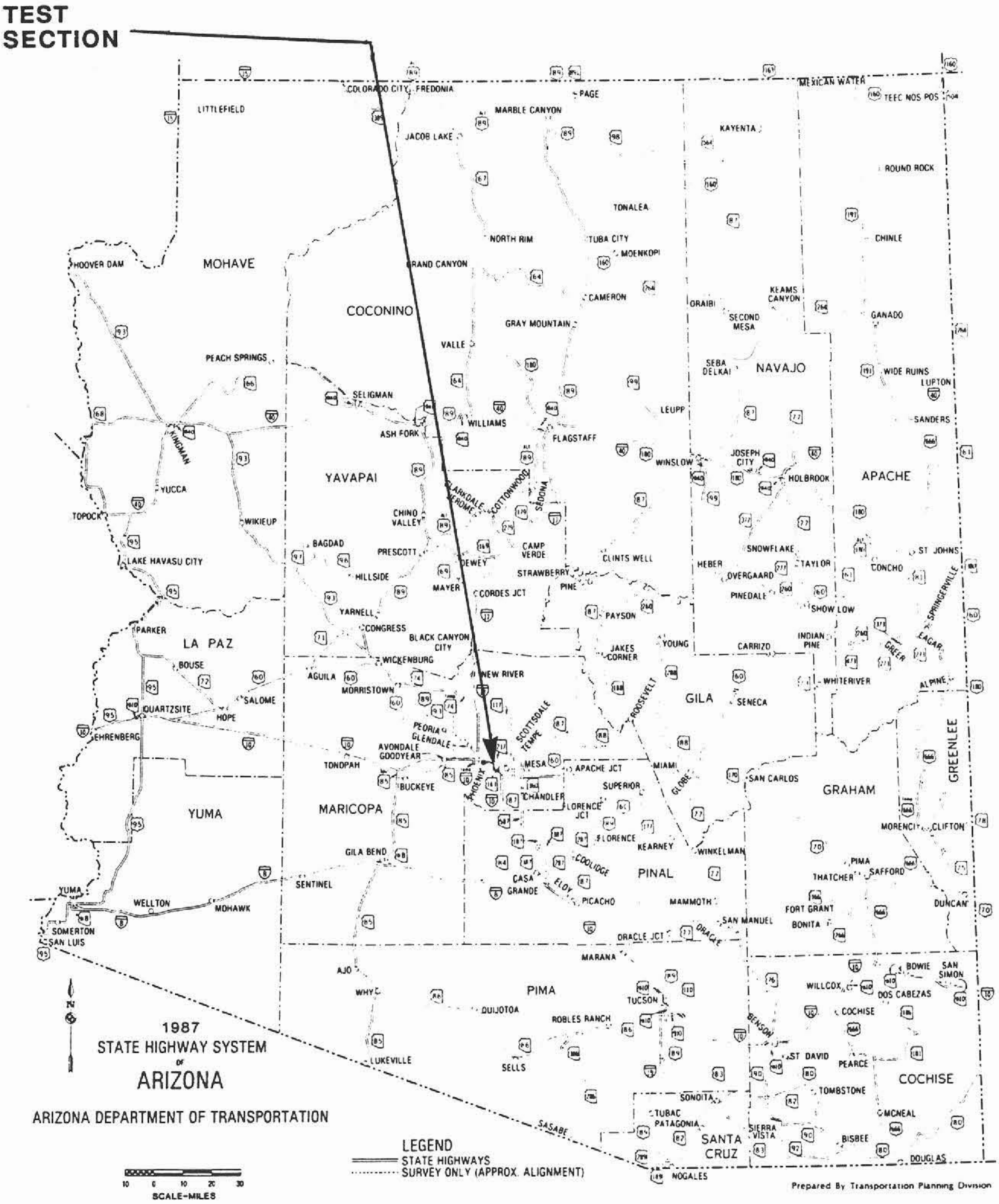
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16. ABSTRACT

Construction of retaining walls utilizing full height panels introduces a degree of indeterminacy to the structure. The ability to effectively analyze the internal behavior of such systems, and limited field performance, qualifies them as appropriate to the experimental category.

Arizona recently utilized this technique for building three permanent earth retaining structures at the interchange of I-10 and 24th Street in Phoenix, Arizona. The construction technique chosen was the Hilfiker Reinforced Soil Embankement with cast-in-place concrete facing.

The construction of the N.E. Wall started in September 1986 and finished in January 1987, while the construction of the S.W. Wall started in October 1986 and finished in November 1987. The construction of the S.E. Wall started in August, 1987, and finished in December 1987.

Settlement and movement of the walls are monitored by surveying bench marks embedded in the walls caps. Settlement up to 0.65" was measured in the N.E. Wall with a maximum lateral movement of 1.1" after three months of construction.

Hairline cracks and air pockets are visible in the finished sections of the concreted panels for these walls.

17. KEY WORDS
Mechanically Stabilized Embankment, Retaining Wall, Reinforcing mats, Subgrade, Backfill Material, Sieve Size, Compaction, Cracks, Honeycombing, Settlement, Full Height Panels, Cast-in-Place

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I. Introduction

A. Background and Problem Statement

Mechanically Stabilized Embankment is a construction material composed of soil fill, which, for certain gradation and compaction conditions is strong in compression and shear, and of reinforcements such as rods, bars, fibers and geotextiles which are strong in tension. These inclusions (reinforcements) interact with soil by means of frictional resistance.

The basic idea of increasing the strength of soil by inclusions is not new. This has been done through centuries in several ways. Straw is usually added to adobe brick to increase its tensile strength. In the past, tree trunks and branches were used with soil for construction of dykes.

As mentioned above, the increase in strength of mechanically stabilized embankments is due to shear bond developed between the reinforcing strips and the soil grains. However, the shear bond is dependent on the effective vertical stress at any given depth. In cohesive soils e.g. clays and silts, due to lack of rapid drainage, the effective normal stress will vary depending on the degree of saturation and the pore water pressure. This makes the design somewhat unpredictable.

For that reason granular soils are usually used for construction of mechanically stabilized structures. Granular soils, e.g. sand and gravel, are free draining and hence, any increase of pore water pressure can be dissipated quickly.

The overall stability of a mechanically stabilized structure should include considerations for sliding, overturning, foundation bearing capacity and excessive settlement. Essential considerations for internal stability are that the reinforcements be safe against both pullout and rupture, and against reduction in effective area of reinforcement due to any means of deterioration such as corrosion.

In the last ten years the proliferation of proprietary mechanically stabilized retaining systems has left State and Federal Engineers with a complex problem of weighing the potential for significant initial cost savings against a frequently unknown product performance record.

Considerable experience has been gained in assessing the performance of these systems which typically utilize small modular precast facing panels approximately 25 sq.ft. in area. These panels, individually attached to the ground reinforcing elements, allow structures to incur considerable settlement without any significant distress.

In recent times, however, aesthetic considerations have compelled designers to require full height panels in lieu of the smaller modular panels.

The utilization of full height panels require the connection of multiple reinforcing elements to a single panel, introducing a degree of indeterminacy to the structure. The inability to effectively analyze the internal behavior of the systems and the paucity of satisfactory performance data, qualifies these systems as appropriate to the experimental category. Considerable concern exists as to the ability of these newer systems to sustain settlements.

B. Objective

The Federal Highway Administration had requested that three permanent earth retaining structures designed for project I-10-3(204) at the interchange of I-10 and 24th street in Phoenix, Arizona be classified as experimental projects.

This request was made because the full height face panels utilized in the retaining wall designs are considered experimental due to limited knowledge and experience with these systems. The three different wall systems listed below were approved by the Arizona Department of Transportation and it was up to the contractor (The Tanner Companies) to decide on which system to choose:

1. Reinforced Earth System with precast concrete face panels and cast-in-place coping
2. Retained Earth System with precast concrete face panels and cast-in-place coping
3. Hilfiker Reinforced Soil Embankment with cast-in-place concrete facing.

The contractor chose the Hilfiker system.

It is the objective of the Arizona Transportation Research Center to document the construction and evaluate the performance of the full height panel retaining systems for a period of at least three years (copy of the workplan is in Appendix A).

This construction report describes the method of construction, progress and difficulties encountered for the N.E. Wall (Ramp 24 A), the S.W.Wall, and the S.E. Wall (Ramp 24 B).

II. Project Location and Description

Project I-IR-10-3(204) begins at 16th street (I-17 milepost 195.09) and extends easterly to 28th street (milepost 150.39) for a distance of approximately 1.73 miles. Among the work included for this project is the construction of a new traffic interchange with Interstate Route 17 which includes grading, draining and placing portland cement concrete pavement.

The work consisted of constructing three permanent retaining walls at the intersection of I-10 and 24th street. These walls will be referred to in this report as: N.E.Wall which corresponds to "Hilfiker RSE Wall Ramp 24-A" as referred to in the plans; S.E.Wall which corresponds to "Hilfiker RSE Wall Ramp 24-B" as referred to in the plans; and the S.W. Wall which corresponds to "EB I-17 Hilfiker Reinforced Soil Wall" as referred to in the plans. See location map in Appendix B.

The three walls were constructed according to the Hilfiker Reinforced Soil Embankment System. Appendix C shows a copy of the cast-in-place (C.I.P.) construction guide provided by Hilfiker.

III. Plan and Profile

Copies of the plans and profiles for the three walls are provided in Appendix D.

IV. Soil Conditions

Four test pits and two drilled borings were performed along the alignment of the S.W.Wall (landfill area) as part of the geotechnical investigation during the design phase. Appendix E contains the boring data.

The excavation log of test pit number 1 showed gravelly sand and fill for the upper 2 ft, and sand, gravel, cobbles and some boulders between 2 ft and 11 ft. The excavation stopped at 11 ft. due to severe caving of material below 3 ft..

The excavation log for test pit number 2 showed gravelly sand and fill to 2 ft., followed by sand, gravel, cobbles, massive concrete blocks (5-6 ft. wide and 6-10 inches thick), asphalt, wood and metal scrap down to 18ft. The excavation was stopped at 18 feet due to severe caving. The concrete rubble may be indicative of a prior contractor's landfill.

Test pit number 3 showed gravelly sand and fill to 2 ft., concrete blocks with asphalt, wood, metal, sand, gravel, cobbles and boulders to 14 ft. and sand, gravel, cobbles, boulders to 19 ft..

Test pit number 4 showed gravelly sand and fill to 2 ft; concrete blocks with asphalt, wood, metal scrap, sand, gravel, cobbles and boulders to 8 ft. and sand, gravel, cobbles, boulders to 13 ft..

In boring number 84-135 silty sand with clay was found at the top 1 ft. while gravel and cobbles existed to 3 ft.. Refusal was at 3 ft. using the CME 55 auger.

In boring number 84-136 gravelly sand and fill was encountered to 2 ft.; landfill consisted of debris mixed with sand, gravel, cobbles and boulders existed to 8 ft., and sand, gravel, cobbles and some boulders existed to 13 ft..

In general the soil profile along the S.W.Wall alignment could be classified as poorly graded sandy material in the upper 2 to 3 feet and poorly graded gravelly material at lower depths with some organic material and concrete rubble present between the two layers. Boring data for the N.E.Wall and for the S.E.Wall was not available.

V. Embankment Construction

Preparation of the subgrade was performed by excavating to the design level. The soil was then tested for resistivity. If the material passed the resistivity test the construction continued; otherwise, the excavation continued for one more foot. In an isolated area additional excavation was performed in order to stabilize the excavation. An approved aggregate base course (ABC) was then spread over the over-excavated areas to the design level.

A reinforced concrete leveling course of fifteen inches in width and six inches in depth was constructed as a base for the cast-in-place concrete face of the Hilfiker wall (Figure No. 1). The final grade of the subgrade was sloping 1% to 2% away from the face of the Wall.

Figure No. 1 Preparation of the Subgrade and Levelling Course

The ABC material was placed and compacted using Caterpillar's 980C front loader and 140G blade. Water was sprayed from a 3.8 thousand gallon water truck after the ABC material was spread.

The first layer of reinforcing mats was placed on the subgrade and pinned in place with form pins (Figure No.2). Mats were made of galvanized welded steel wire mesh (W7xW7). The reinforcing (horizontal) mats were 7.5'x20'(variable), while the backing mats were 8'x2'. Figure Nos. 3 and 4 show typical dimensions of the reinforcing mats and the backing mats respectively.

The first lift of mat erection required a form "spacer cage" chair to hold the backing mat away from the vertical bars of the reinforcing mat (figures 8 and 9 of the C.I.P. Construction Guide -Pages C6 and C7).

Figure No. 2 Placement of the First Layer of Reinforcements

Behind the construction mats a woven geotextile fabric screen was placed in order to retain the compacted backfill behind the wire mesh (Figure No.5). The fabric was initially rolled under the mats but that left a 1/2" to 3/4" crevice which caused concern that the concrete might not fill the crevice. The fabric was then cut at 1/2 ft. intervals and placed in the vertical face of the mats.

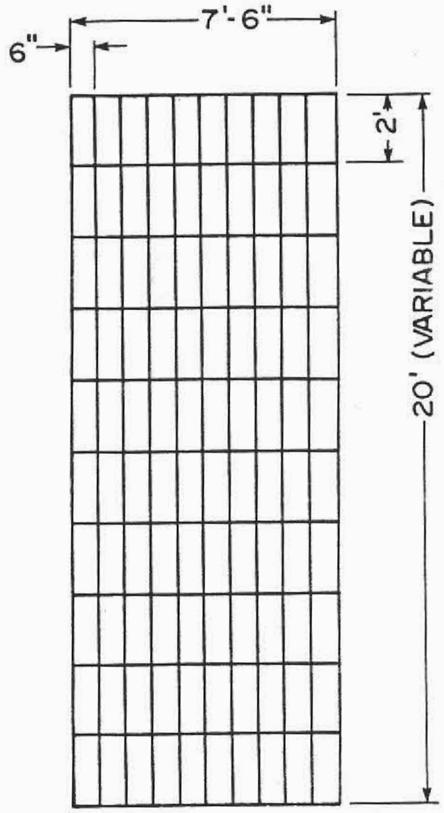
Every 2' lift a #4 non-galvanized rebar was placed, as per the plans, to control any expansion or contraction resulting from temperature changes (Page D3-Appendix D).

The backfill material was then end dumped on top of the reinforcements using a ten wheel dump truck. A grader (Caterpillar's 140G) leveled the backfill. Dumping and leveling continued until a 1' level of backfilling was reached, after which compaction was carried out.

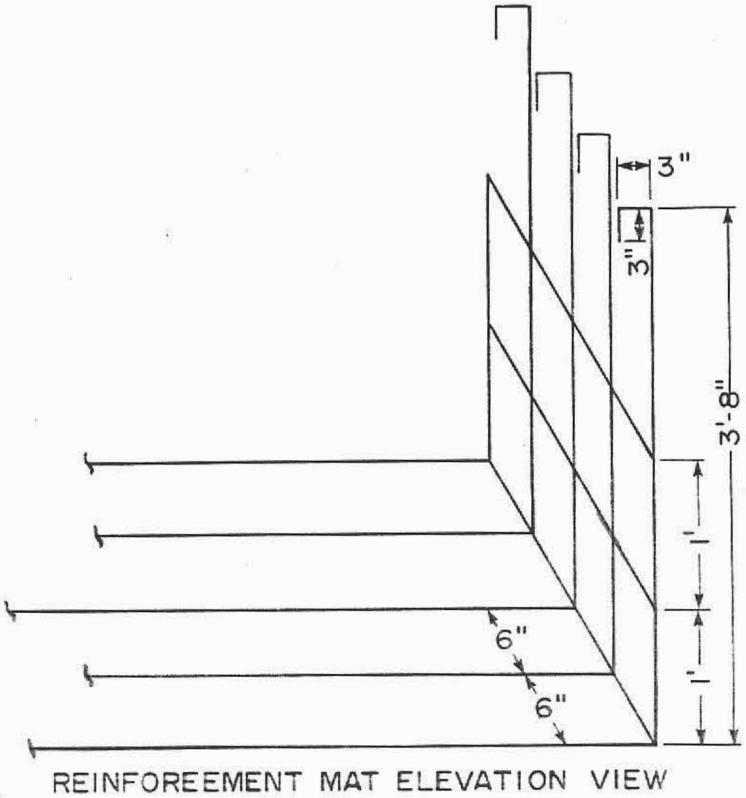
Compaction was performed by random passes of a rock-bucket loader, a grader, a small excavator-compactor backhoe loader, water trucks and the trucks which carried the backfill material to the site.

Compaction within 2 ft. nearest to the backing mats (2 foot zone) was performed by water jetting the 1 ft. closest to the backing mat, while the second foot was mechanically compacted by a hand vibrating tamper (jumping jack). Initially hand rammers were used but were found to be slow and inefficient. (Figure No. 6 shows the trucks used for dumping backfill material and the tampers used to compact the AB material in the 2 foot zone).

No special requirements were specified for the backfill material in the 2 ft. zone. However, attempts were made by the contractor to use backfill material that passed a 4" sieve size during the

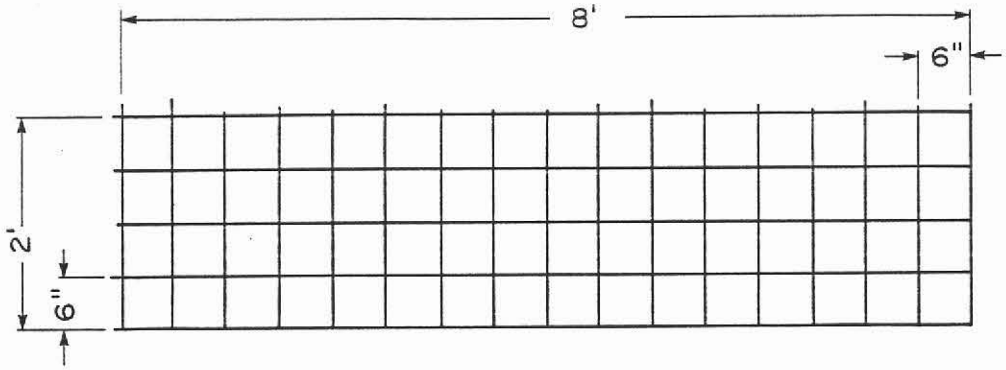


REINFORCEMENT MAT PLAN VIEW

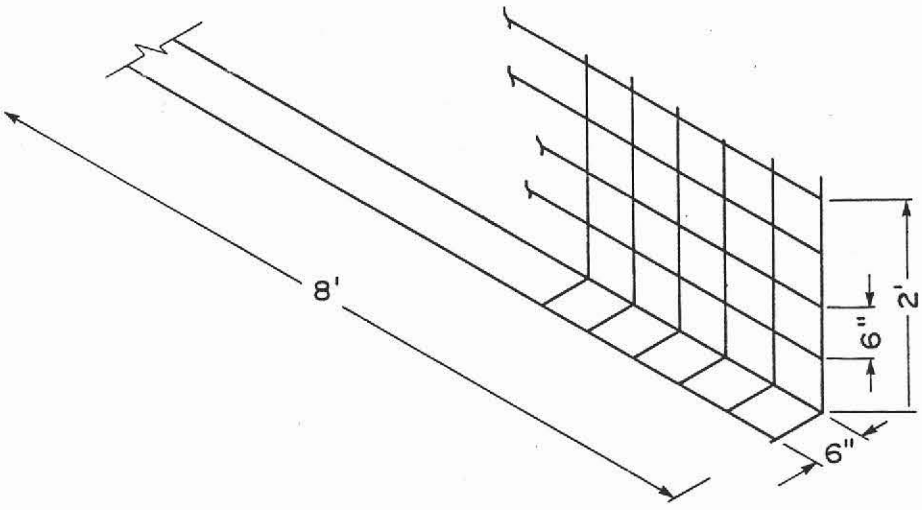


REINFOREEMENT MAT ELEVATION VIEW

Figure No. 3 Typical Dimensions of the Reinforcement Mats



BACKING MAT PLAN VIEW



BACKING MAT ELEVATION VIEW

Figure No. 4 Typical Dimensions of the Backing Mats construction of the N.E. and the S.W. walls. Such attempts, as witnessed by the author, did not always prove to be successful as can be seen in Figure No. 7.

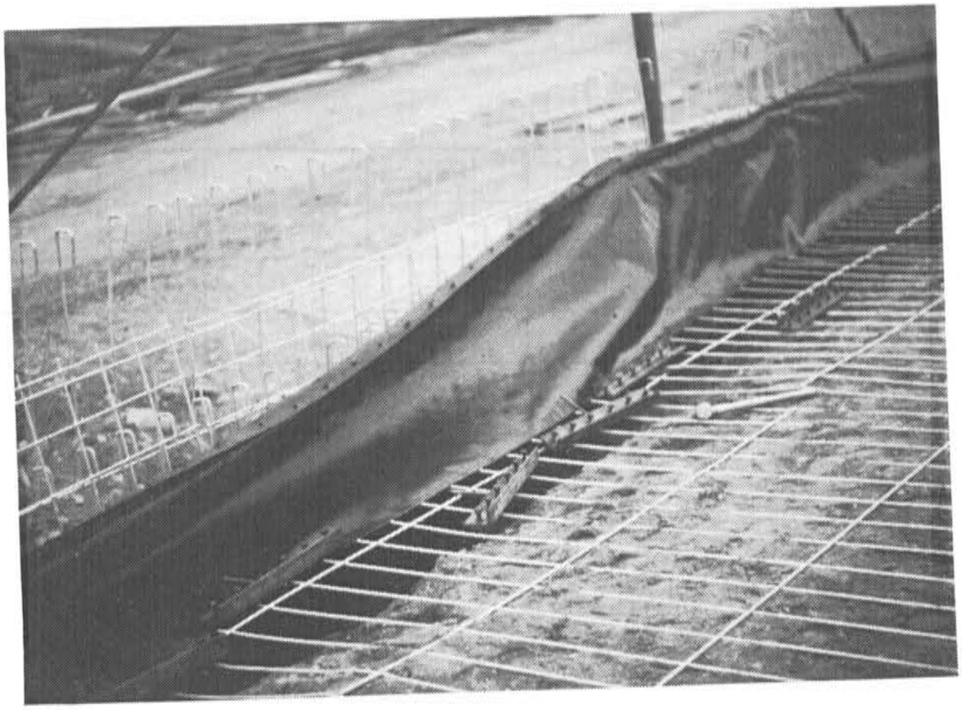


Figure No. 5 Tying of the Woven Geotextile Fabric Screen to the Reinforcements

Figure No. 6 Trucks Dumping the Backfill Material and Workers are Compacting the 2 Foot Zone Area

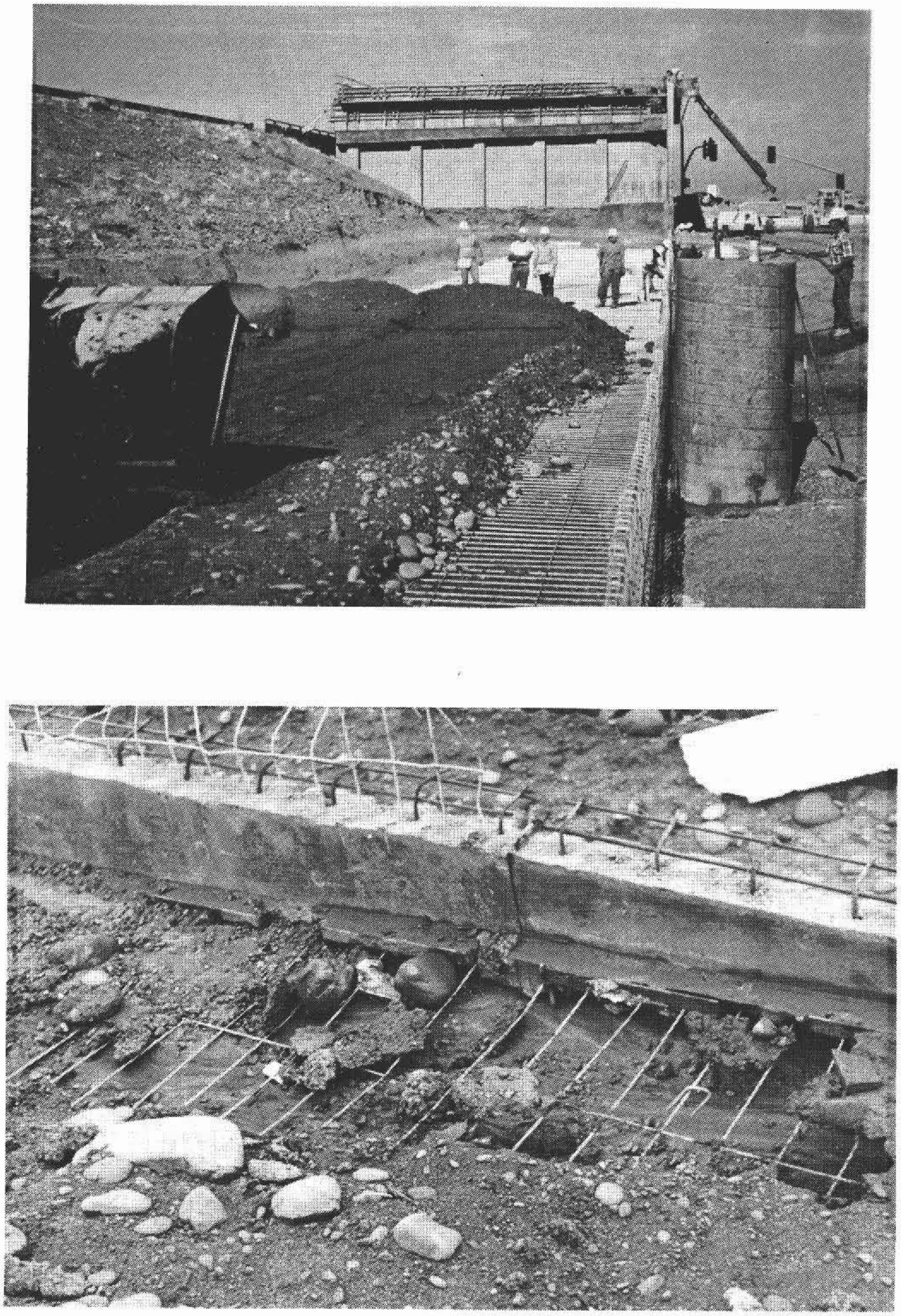


Figure No. 7 Backfill Material Used With Unsuccessful Attempts to Dispose of Rocks Larger Than 6" Sieve Size (Different Locations).

The backfill material for the N.E.Wall and most of the S.W.Wall consisted of a river run material obtained from the old embankments that existed on the site. This material had many rocks larger than 6". Attempts were made using a rock bucket and sometimes manual labor, to remove rocks that were larger than 6" sieve size. However, such attempts, as witnessed by the author, were not successful as 5% to 15% rocks larger than 6" sieve size were visible. Water was sometimes sprayed on the backfill material to enhance compaction (Figure No. 7).

Originally the backfill material obtained from the site was processed on a grizzly, and then mixed together in order to obtain the specified gradation. However, this material did not pass the minimum resistivity requirement of 3000 ohm-cm. Resistivity test results revealed failing resistivities. Results ranged from 536 ohm-cm to 2412 ohm-cm.

The backfill material for the S.E.Wall and a small section of the S.W.Wall consisted of a cohesionless material passing a 3" sieve size. This material was produced by Calmat of Arizona and had passed the specified resistivity test. Another backfill material produced by Union Rock company was also approved in case the backfill material produced by Calmat of Arizona was not sufficient.

Chloride, sulfate and pH tests were also performed on the backfill material to check its suitability against facilitating corrosion when in contact with the galvanized steel reinforcing mats.

Resistivity test results ranged from 3183 to 10300 ohms-cm, while the pH test results ranged from 7.9 to 9.3. Results from chloride and sulfate tests showed an absence of both. Appendix F contains a copy of ADOT's specifications for acceptance of backfill material, and Appendix G shows copies of typical results of resistivity, pH, chloride and sulfate tests for backfill material obtained from the river run on-site material and from Calmat of Arizona.

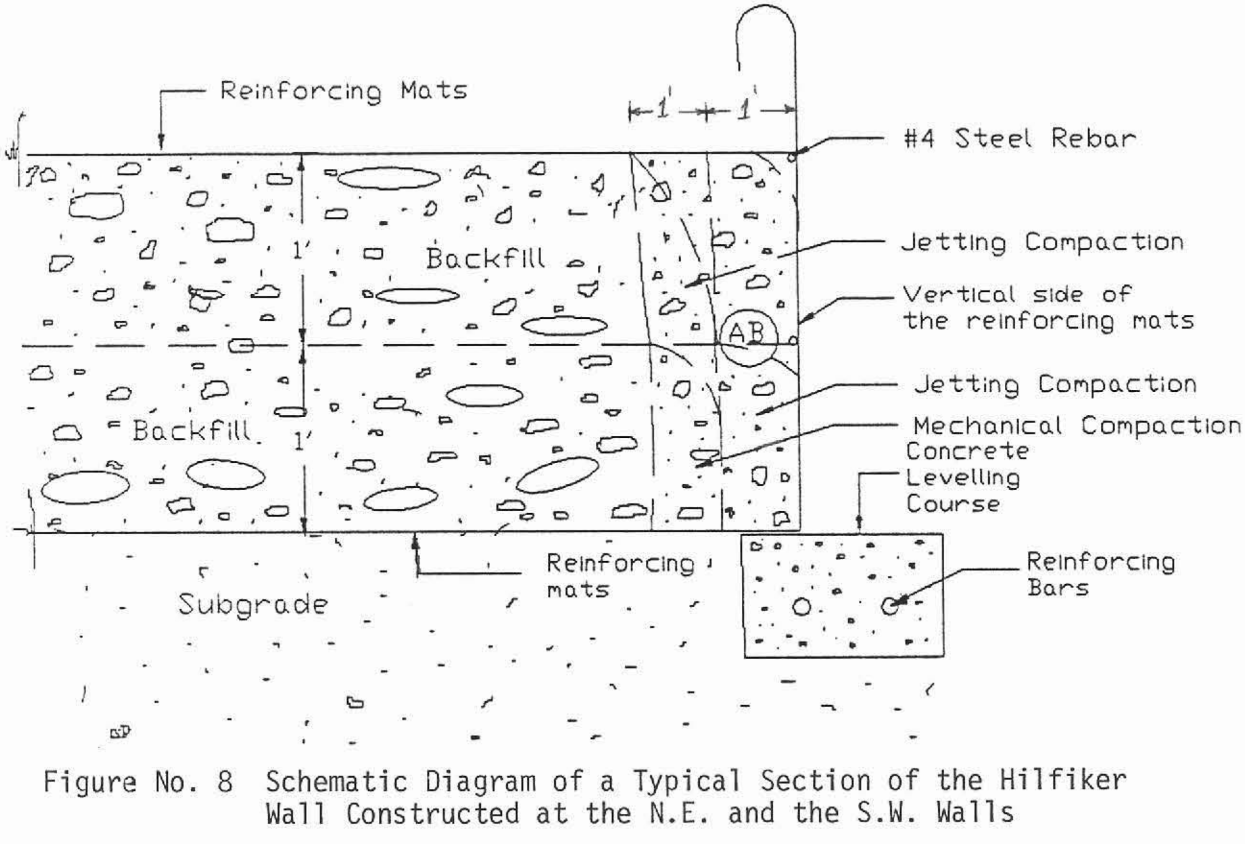


Figure No. 8 Schematic Diagram of a Typical Section of the Hilfiker Wall Constructed at the N.E. and the S.W. Walls

Random field density tests (AASHTO T-180), conducted by ADOT, showed that the specified 90% of the maximum dry density after compaction was achieved; field density test results ranged from 90% to 101%. Appendix H contains copies of typical results for field density tests.

The process of dumping, leveling and compacting the backfill material was repeated for the next 1' level after which a layer of reinforcement was placed. (Figure No.8 shows a schematic diagram of a typical section of the Hilfiker wall).

The contractor checked the outside vertical and horizontal alignments of the reinforcements by using a four foot carpenter's level and string line. With the addition of vertical layers of reinforcing mats the new mats lock into the proceeding ones. This locking effect ensured the verticality as the height of the wall increased (Figure No.9).

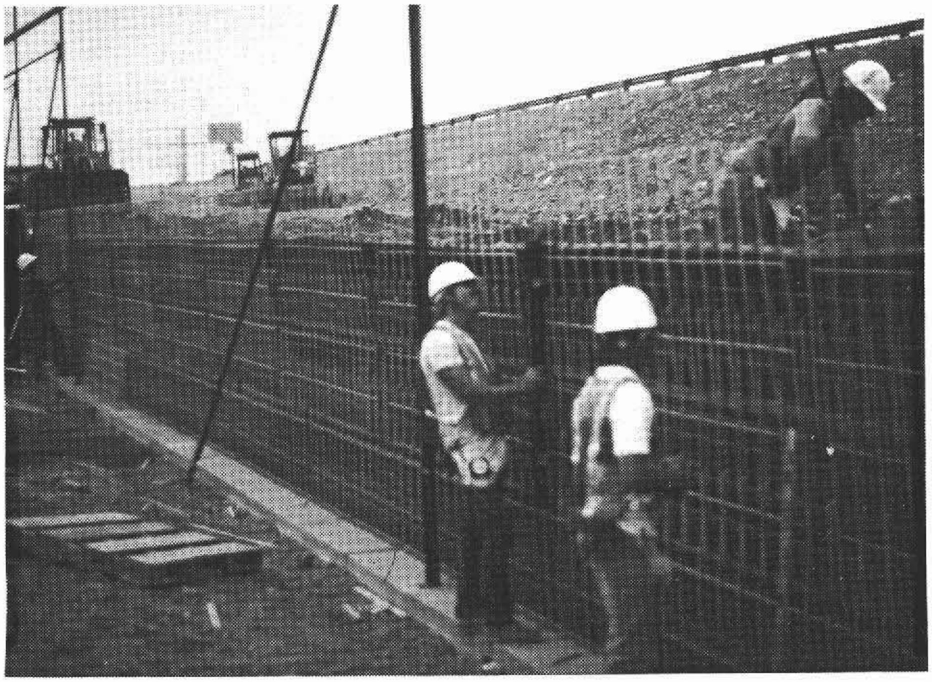


Figure No. 9 Workers Checking the Vertical and the Horizontal Alignment of the Hilfiker Wall

The area closest to the bridge abutment required that the structural backfill and the wall backfill should meet the required specifications of both backfills in the overlap areas. Page F4 shows a copy of the gradation for class 2 aggregate base that was used as a structural backfill, and pages F5 and F6 show a copy of the specifications for the structural backfill.

VI. Panel Construction

After the embankment was constructed to its full height (Figure No. 10), the construction of the cast-in-place concrete wall began . Rubber inner forms and wood outer forms were used to achieve the specified rustication (Appendix I contains a copy of literature about the used forms).

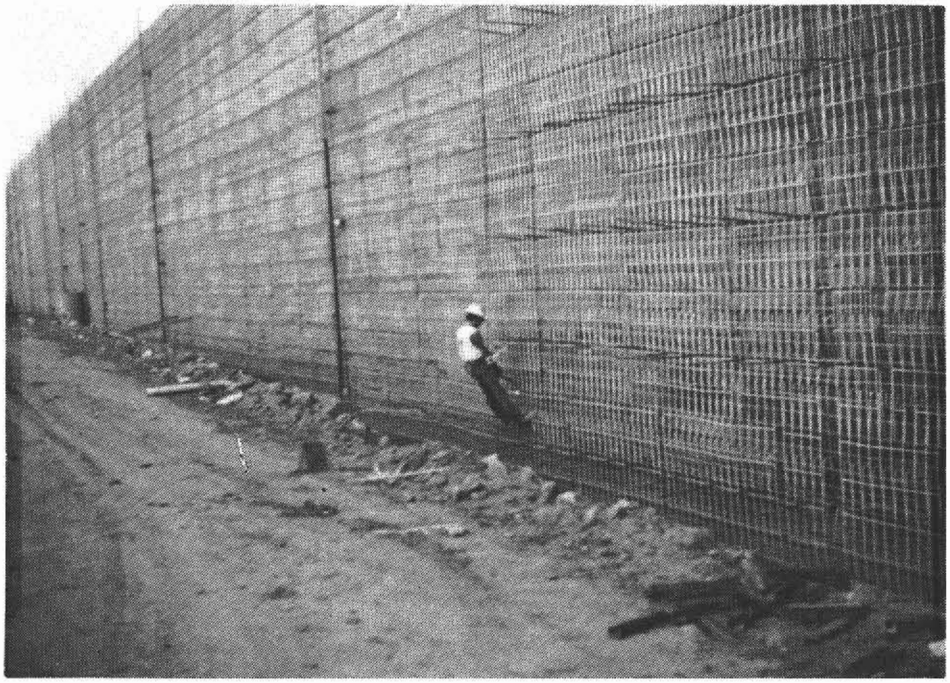


Figure No. 10 Side View of the N.E.Wall Before the Construction of the Cast-in-Place Full Height Panels

Saw cutting of the concrete, to provide for horizontal rustication, was done for some areas where the rubber/wood forms were used where the contractor did not provide for the rustication. Figure No.11 shows the rubber/wood forms used.

The concrete was ready mixed and was delivered to the site in transit mixers. It was poured from great heights (the full height of the panels) in free fall motion. Long internal vibrators were initially used (Figure No. 12), but the resulting concrete showed extensive honeycombing and air voids. External vibrators were then added to the internal ones (Figure No.13) and the quality of the finished concrete improved a little, however, the honyecombing and the air voids were still visible.

Figure No. 11 Rubber/Wood Forms Used to Achieve the Specified Rustication

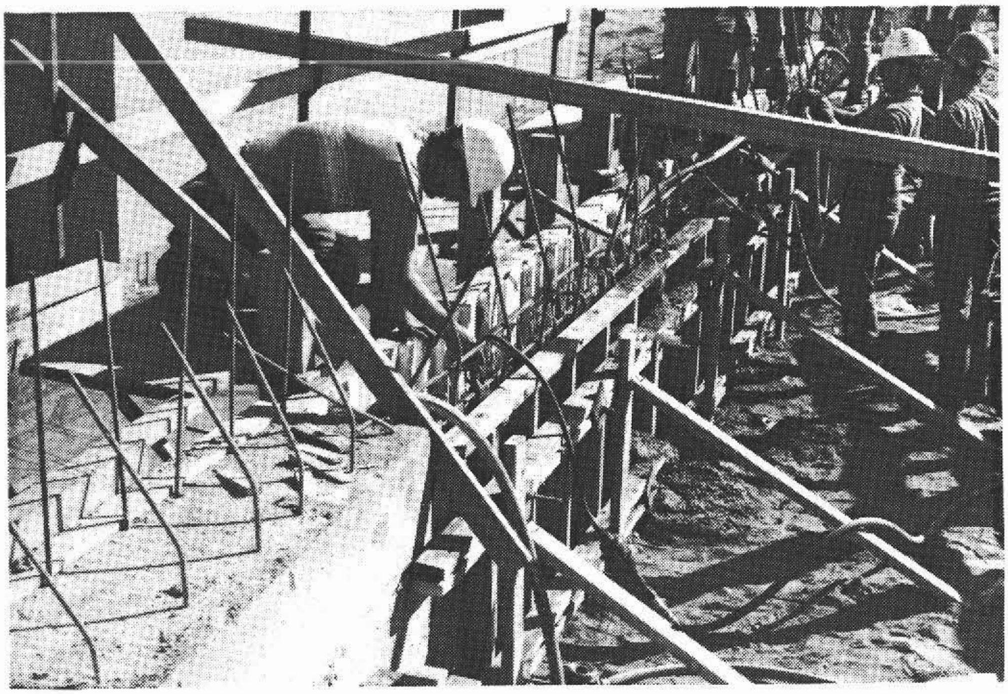


Figure No. 12 Long Internal Vibrators were Initially Used for Vibrating the Concrete Panels

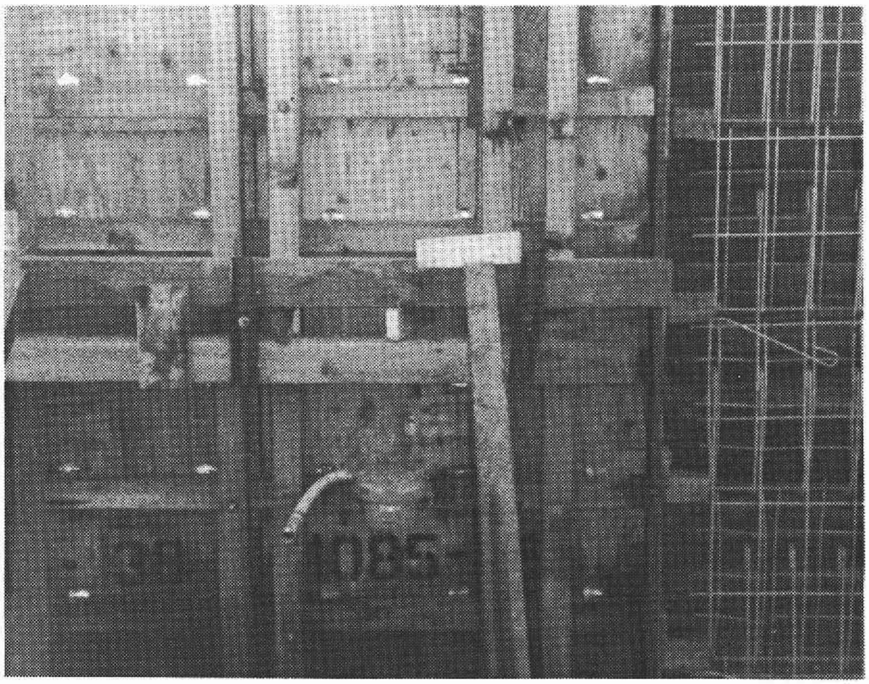


Figure No. 13 External Vibrators Were Later Added at the Lower Part of the Wall

The external vibrators did not improve the quality of the concrete finish (Figure No.14) because vibrations would not penetrate well thru the rubber/wood forms. After repairs (Figure No.15) and painting the honeycombing was barely visible, but the air pockets and the cracks were clearly visible.

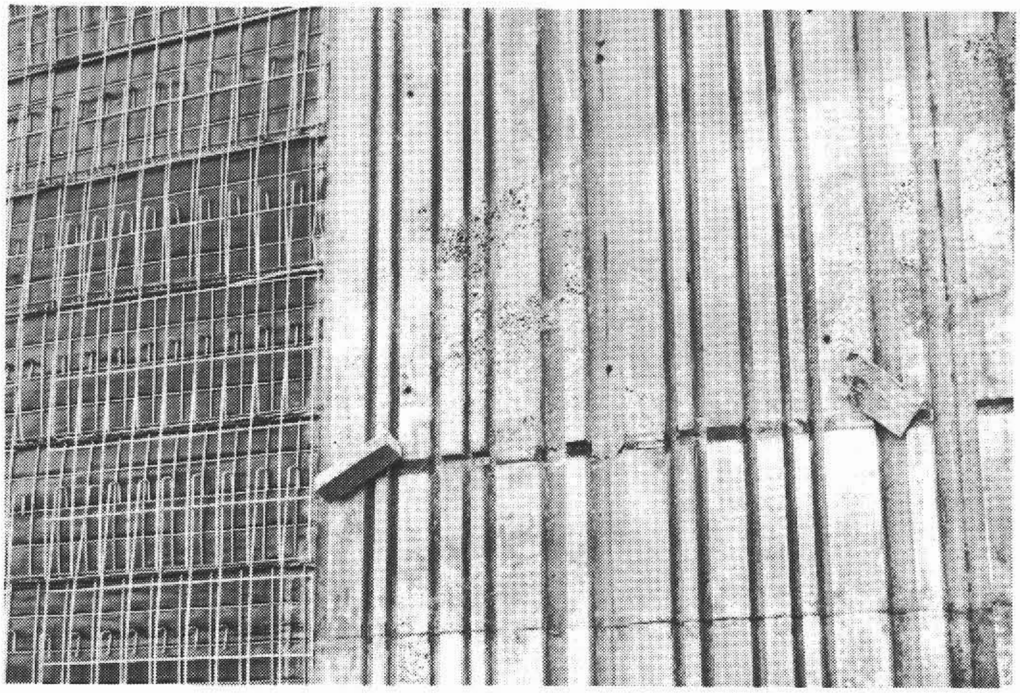


Figure No. 14 Honeycombing and Air Pockets

Figure No.15 Some Honeycombing Was Still Visible Even After Patching Attempts

The contractor could neither use tremie concrete nor larger diameter internal vibrators because of insufficient clearance. The thickness of the concrete facing panel including the reinforcements was 6" with only 1 1/2" clearance for the internal vibrators.

Three different mix designs were tried by the contractor in order to provide an acceptable finished quality. Twenty eight day compression test results ranged from 4360 psi to 5900 psi. Appendix J contains copies of the various mix designs tried by the contractor, and copies of typical compression test results.

The construction of the S.E.Wall and a small section of the S.W.Wall started after about one year of the starting date for the construction of the N.E.Wall and the S.W.Wall.

VII. Evaluation of the N.E.Wall

Preparation of the subgrade for the construction of the embankment started in the first week of September 1986. The construction (without painting) finished in January 1987.

The subgrade was excavated to 1 ft. below the design level, because the soil did not meet the resistivity requirements, and then backfilled with approved material.

The specifications required that the backfill material should pass a 6" sieve size, however, this requirement was not met at all times.

Twenty field density tests were performed on the 15,273 cubic yards of backfill material.

Discontinuous transverse cracks (Figure No. 16) whose width ranged from 0.007" to 0.03" developed at the horizontal rustications in the lower part of the wall along the concrete panels. Few vertical (longitudinal) cracks were visible (Figure No.17). Also few cracks were apparent in areas between the horizontal rustications.

These cracks could be the result of a combination of shrinkage and settlement of the concrete. Shrinkage is the result of moisture reduction, while the settlement of the concrete could have been aggravated by the use of a high slump (6" +or- 1). At one time the contractor tried an 8" +or- 1 slump to see if the cracks would disappear, such trials were not successful.

The observed honeycombing and air voids may largely be attributed to the placement and vibration procedures. Not enough vibrators and unsystematic insertions could have contributed to the problem. Other factors that may have contributed to the concrete honyecombing and air entrapment were an insufficient clearance among the reinforcing steel and the forms where the internal vibrators were inserted, and the properties of the concrete mix.

No drainage outlets, as per the plans, were provided in the wall/embankment system.

Nine aluminum capped bench marks were inserted in the wall's concrete cap at various locations in order to monitor the movement of the wall in the future. Appendix K shows a survey map for the established bench marks. The survey was performed in March 1987.

The first survey of the aluminum bench marks was performed on June 29, 1987 (109 days after the original survey). During this period the wall settled 0.16" at cap # 2 (14.46' height) and 0.65" at cap # 6 (24.77' height) with an average settlement of 0.36" among all 9 caps. Lateral movement varied from 0.32" at cap # 8 (29.46' height) and 1.08" at cap # 1 (11.22' height) with an average lateral movement of 0.56" among all 9 caps. Copy of Survey #1 is in Appendix K.

The height of the wall ranged from 8' to 32', while the length was approximately 1000 ft.

VIII. Design and Construction Changes for the N.E.Wall

Two change orders and three force accounts were issued during the construction of the N.E.Wall.

Change order no. 15 was requested by the contractor in order to alter the construction requirements, at station 0+69.58 to 10+93.34, to eliminate the 1:48 batter and to construct a vertical wall instead. The contractor requested this change for ease of construction and to provide a better finished product. The Engineer approved this change and there was no change in costs involved.

Change order no. 25 was requested by the contractor to allow dropping of the concrete, in the wall facing panels, more than eight feet without the use of approved pipes or tubes. The contractor felt that there was no space allowed for a tremie, and used a flowable mix design. The concrete was dropped into the formed wall from the top. The Engineer approved this change, with no change in costs involved.

Force account no.18 was initiated by ADOT to compensate the contractor for additional work involved in over-excavating (one foot) the unsuitable material (material did not meet the resistivity requirements) from beneath the Hilfiker wall and replace it with suitable material. The cost for this force account was $16,000.00.

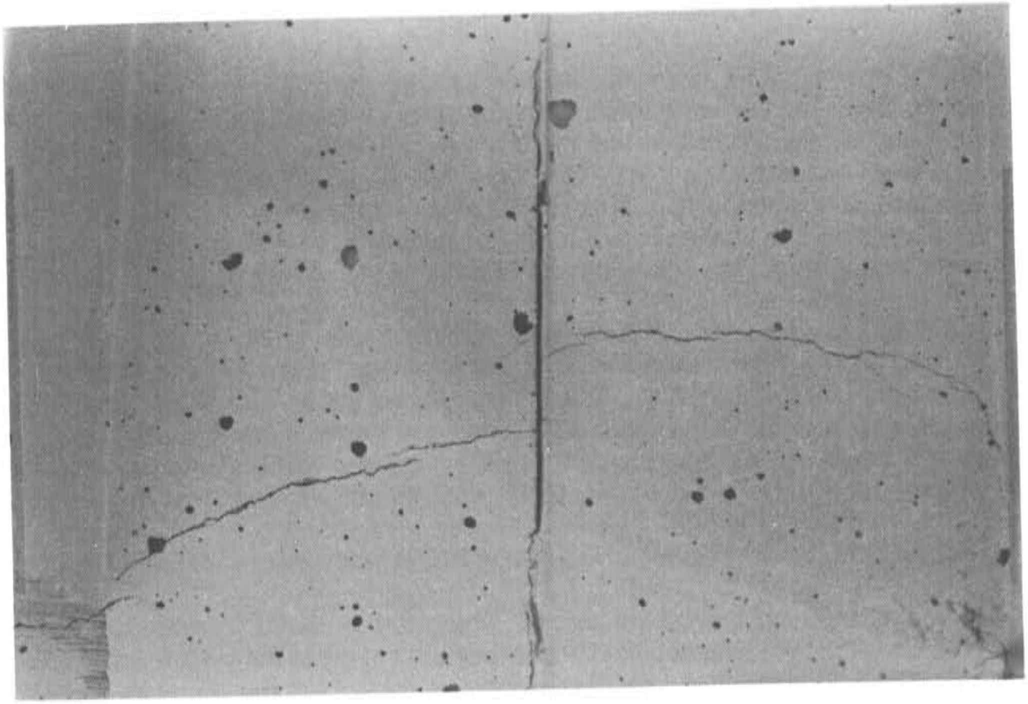


Figure No. 17 Shrinkage/Concrete Settlement Hairline Cracks and Air Voids

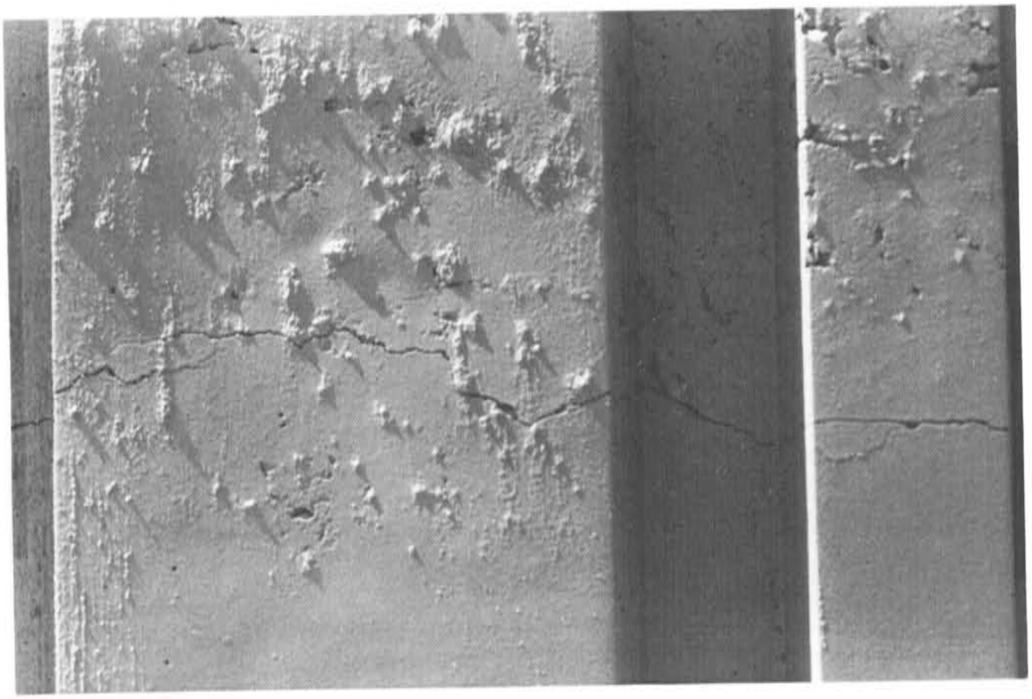


Figure No. 16 Shrinkage/Concrete Settlement Cracks and Air Voids

Force account work order no. 27 was initiated by ADOT in order to compensate the contractor for the additional work involved in adjusting the reinforcing mats. This was a design error as the project plans indicated that the top mat of the wall be 6" minimum below subgrade, while the pavement section is 15". The top mats were removed and the backfill material underneath was excavated and leveled to the proper superelevation (Figure No. 18 shows a schematic diagram of the conflict between the top mats and the PCCP). The top mats were then placed at the proper level. The cost of this force account was $4950.00.

Another change occurred (as part of force account # 27) in the construction of the approach slab near the bridge abutment. The standard detail plans (Page L1 shows a copy of the anchor slab details, M-9) required 5' and 3.5' deep lugs for the section of the pavement closest to the approach slab near the bridge abutment. However, because the top mats were 1' below the subgrade and could not be cut or shortened, the lugs had to be shortened to 1' depth. The reinforcements could not be cut or shortened because the pullout resistance is critical.

Appendix M contains a copy of the design stability calculations for the Hilfiker Wall.

Force account work order number 37 was given by ADOT in order to compensate the contractor for sealing the construction joint between the coping of the Hilfiker wall systems and the new PCCP. The 1/2" premolded joint filler, shown on sheet 57 of the plans, would allow possible infiltration of water into the retaining wall system. The contractor removed the filler and replaced it with a bituminous joint sealant. The cost of this force account was $5000.00. For the S.W.Wall and the S.E.Wall the contractor was compensated for the difference in cost between installing the joint filler and the sealant only.

Three lanes were opened for traffic on July 27, 1987.

IX. Evaluation of the S.W.Wall

The construction technique of the S.W.Wall was the same as that of the N.E.Wall. The construction started in October 1986, stopped in March 1987, and continued on September 1987, and then finished in November 1987. The contractor stopped working on this wall between March and September in order to concentrate on finishing the west bound section of the project (Figure No.19).

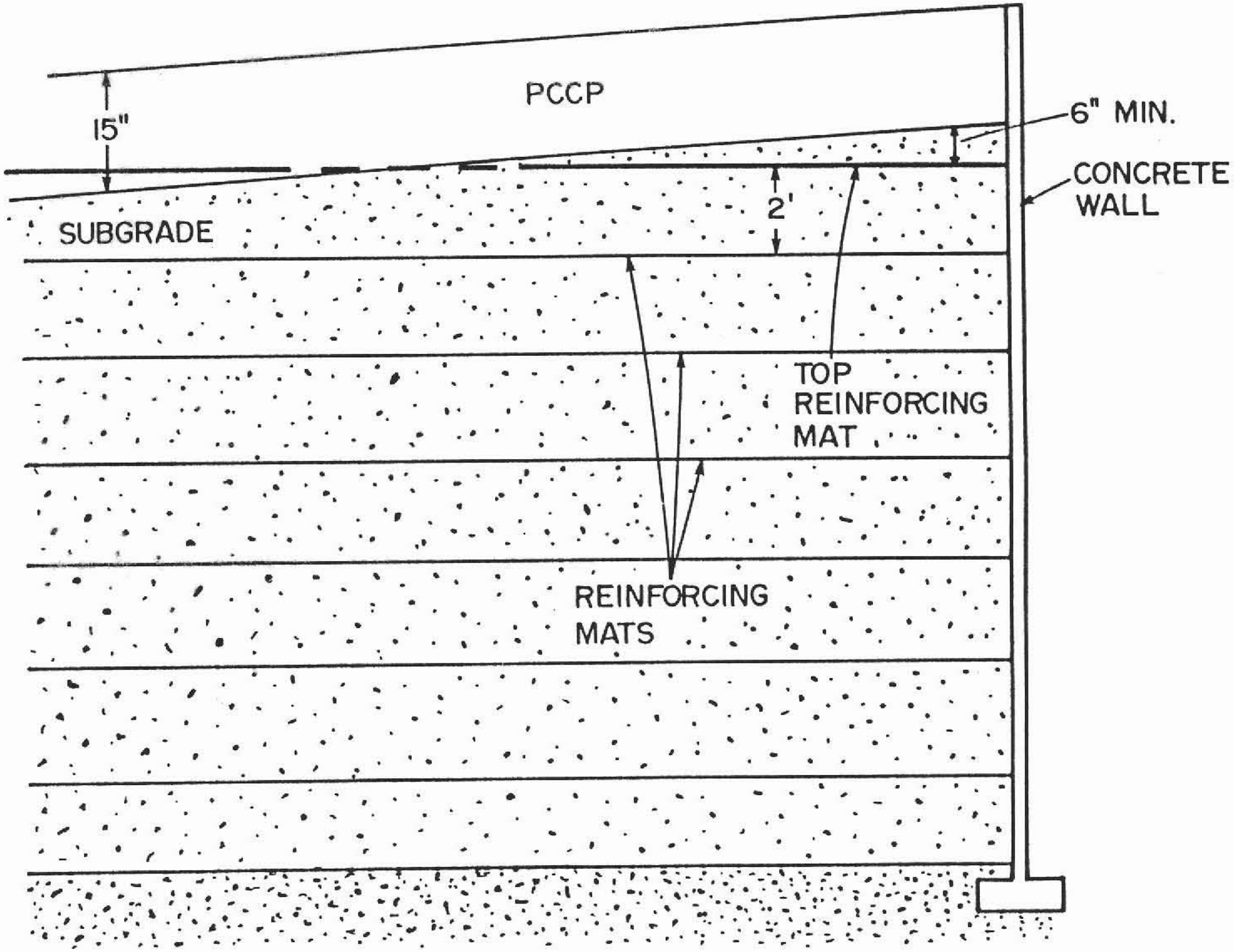


Figure No. 18 Schematic Diagram Showing the Conflict Between the Top Mat and the Portland Cement Concrete Pavement (PCCP)

Figure No. 19 Site of the Top of the Wall/Embankment System Looking East During the Idle Period

The subgrade was over-excavated 8 1/2 ft. to remove concrete rubble. During this excavation the soil was caving and gunnite had to be used to stabilize the sides of the excavation .

Subgrade preparation (Figure No.20), backfill material, compaction method, testing and the equipment used for the construction were the same as those for the N.E.Wall.

Figure No. 20 Preparation of the Subgrade and the Levelling Course

The backfill material used for the most part during the construction of the embankment did not meet the gradation requirements with 5% to 15% particles larger than 6" sieve size (Figure No.21). During the construction period between September and November 1987 the backfill material used passed a 3" sieve.

Figure No. 21 Backfill Material With Rocks Larger Than 6" Sieve Size

Compaction technique for the S.W.Wall was similar to that of the N.E.Wall.

Twenty two field density tests were performed by ADOT during the construction period.

Cracks, honeycombing and air voids were visible in the finished section of the concreted panels (Figure No.22).

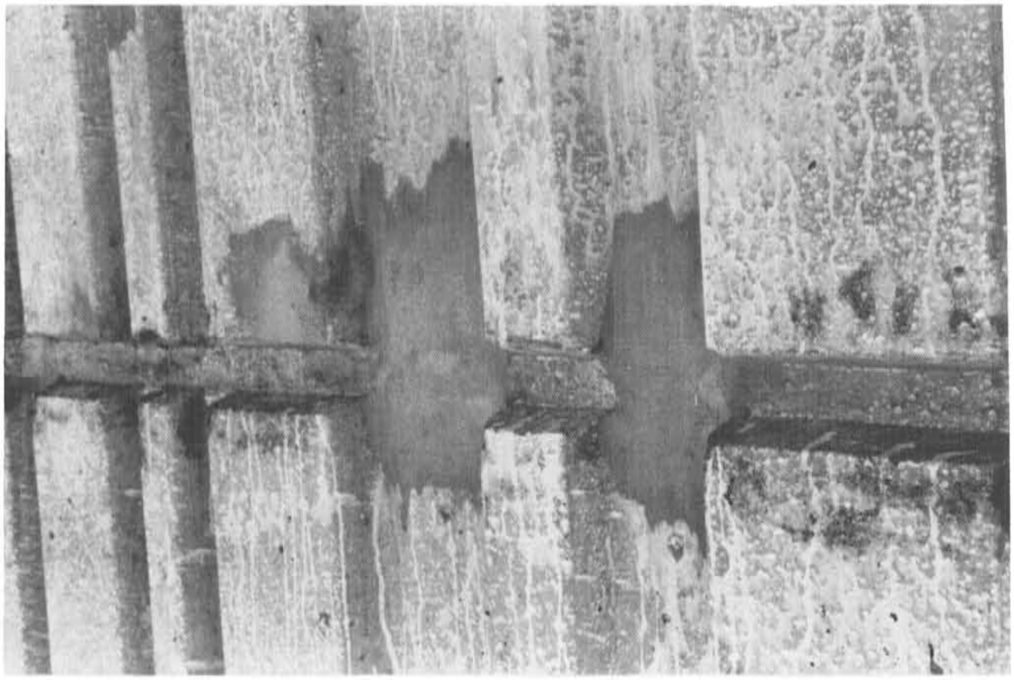


Figure No. 22 Patching Some of the Honeycombed Areas

A spot check at the middle of the S.W.Wall, utilizing a ladder, showed similar cracking pattern along the horizontal rustication as that of the N.E.Wall. It is safe to assume that such cracks exist along all the horizontal rustications in the concrete panels, since one cannot check the upper parts of the wall without the use of a crane (Figure No.23).

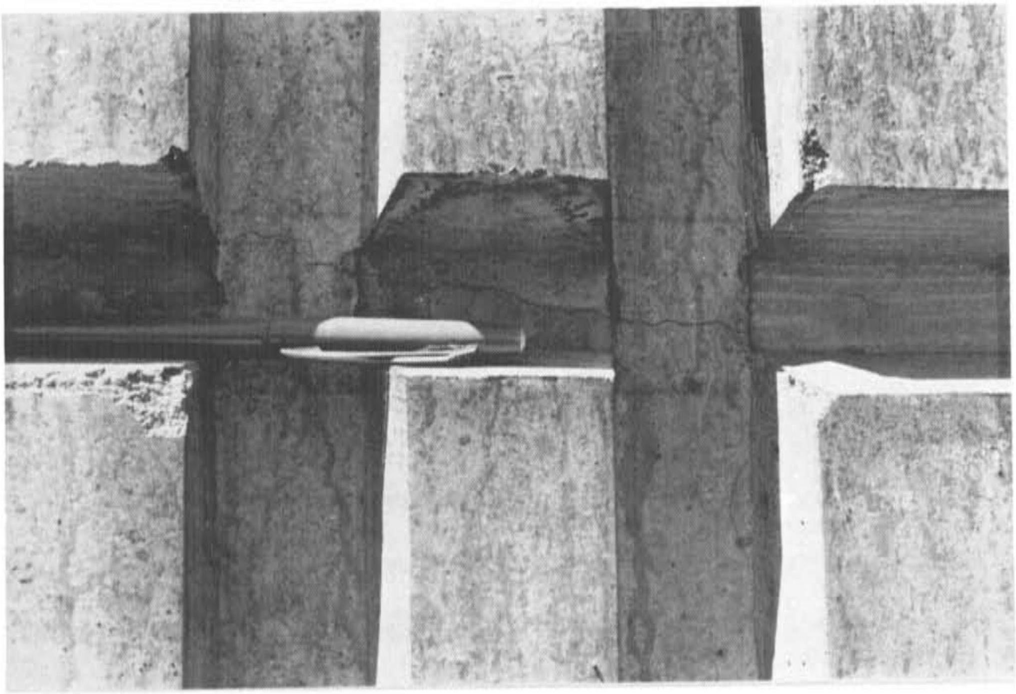


Figure No. 23 Typical Cracks (0.007" - 0.03") Along the Horizontal Rustication of the Concrete Panels

During the construction stage of the embankment a crane was turned over by an inexperienced driver who forgot to put out the crane's outriggers before lifting the forms. The crane tilted to its side falling on a section of the embankment (Figures No.24 & 25).

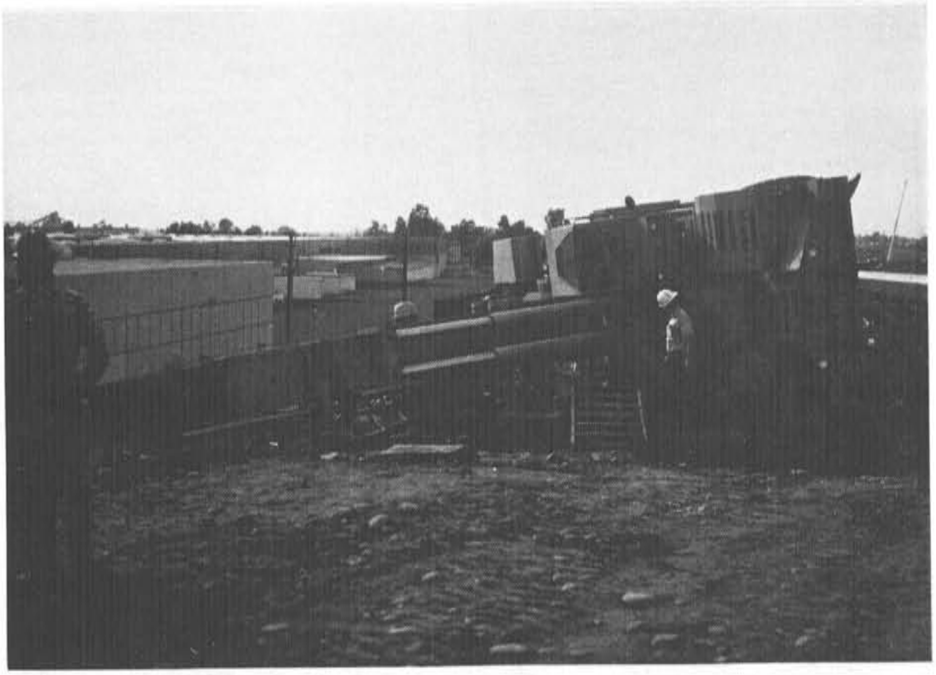


Figure No. 24 The Crane After Turning Over

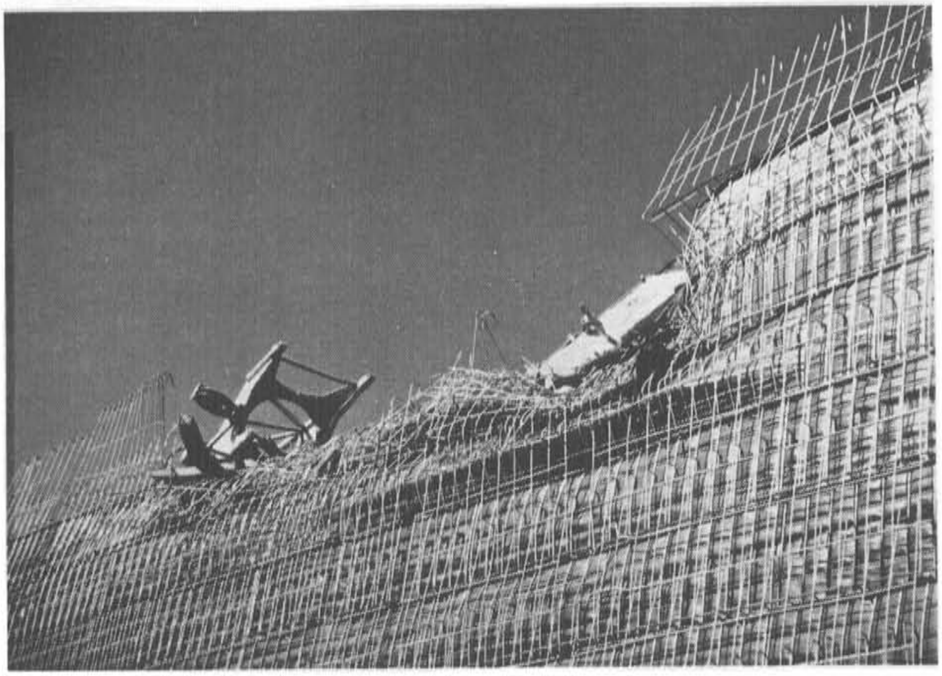


Figure No. 25 The Damage Done By The Crane

There was no human injury, but the reinforcements were bent and the damage was repaired by straightening out the reinforcements and adding some more rebars (Figure No.26). The damaged reinforcements were retreated for galvanization

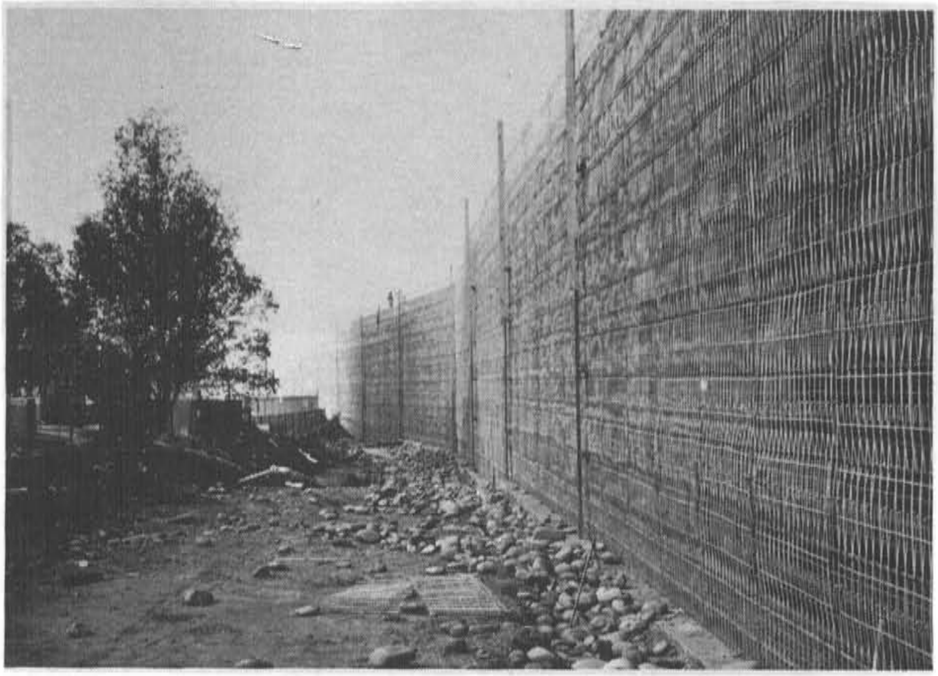


Figure No. 26 Site of the Damaged Section of the Wall After Repairs

Figure No. 27 Steel is Exposed to Atmosphere Due to Severe Honeycombing and Insufficient Concrete Cover

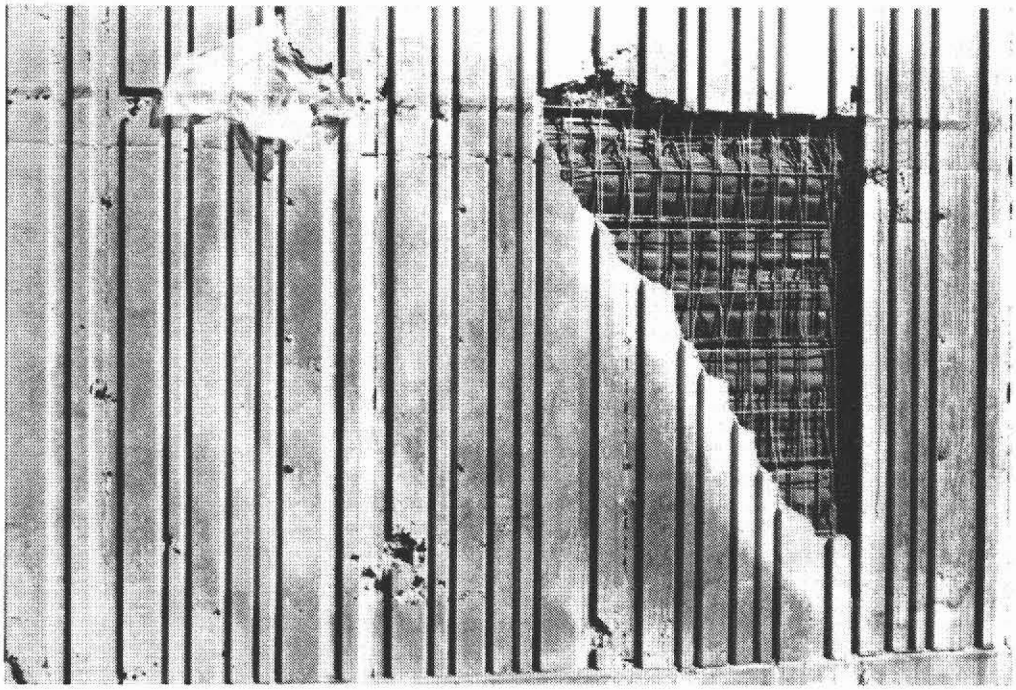


Figure No. 28 Two Panels Had to be Broken Due to Bad Concrete Finish

During the later construction period of this wall, the quality of the finished concrete showed severe honeycombing and air voids as can be seen in Figures numbered 27 and 28. At one location (Figure No.28) the contractor had to break the face of two panels at two different spots (one spot is covered with a nylon sheet), and replace them with a better quality concrete finish. Figure No.29 shows patching attempts to remedy some of the severe honeycombing at other locations.

Figure No.29 Patching Attempts To Remedy The Severe Honeycombing

Another problem occurred when the bottom of the bridge abutment (wing wall) adjacent to the last panel was left partially unconcreted (Figure No.30). This caused the soil structural backfill to flow thru the crevices after a rain (Figure No.31). There was a difference in design elevations of the wing wall and the bottom of the wall.

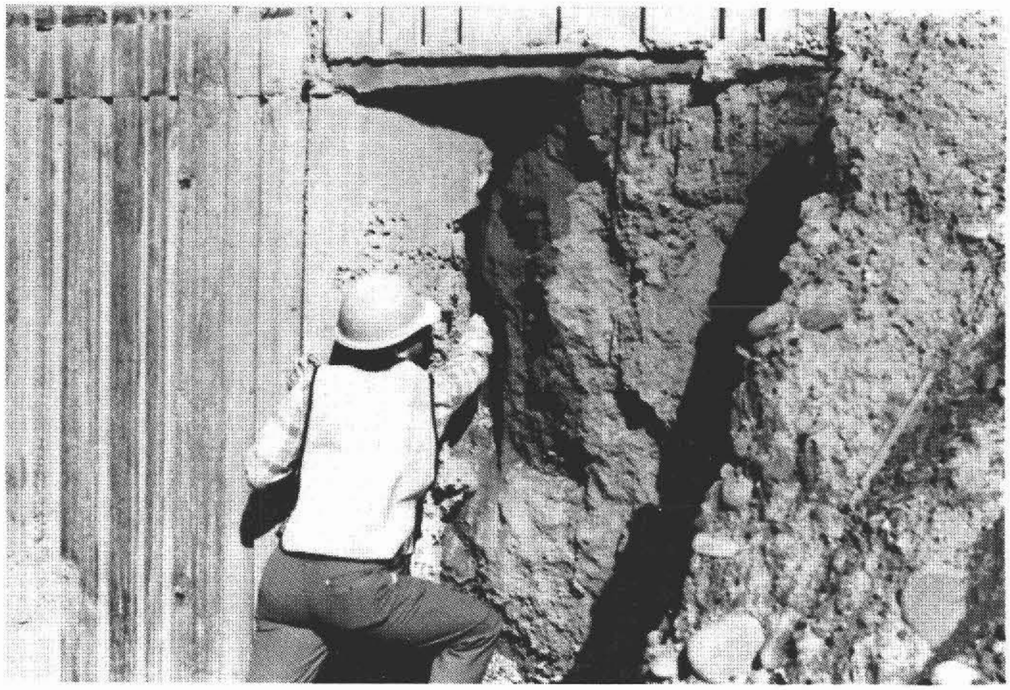


Figure No. 30 Location of the Crevices Where the Backfill Material Seeped Thru After a Rainy Evening

This movement of the structural backfill caused a sizable depression on top of the wall as can be seen in Figure No.32. The contractor provided support at the bottom of the bridge abutment (Figure No.33), and refilled the depression formed at the top of the embankment with a structural backfill material. This material was compacted using jetting techniques.

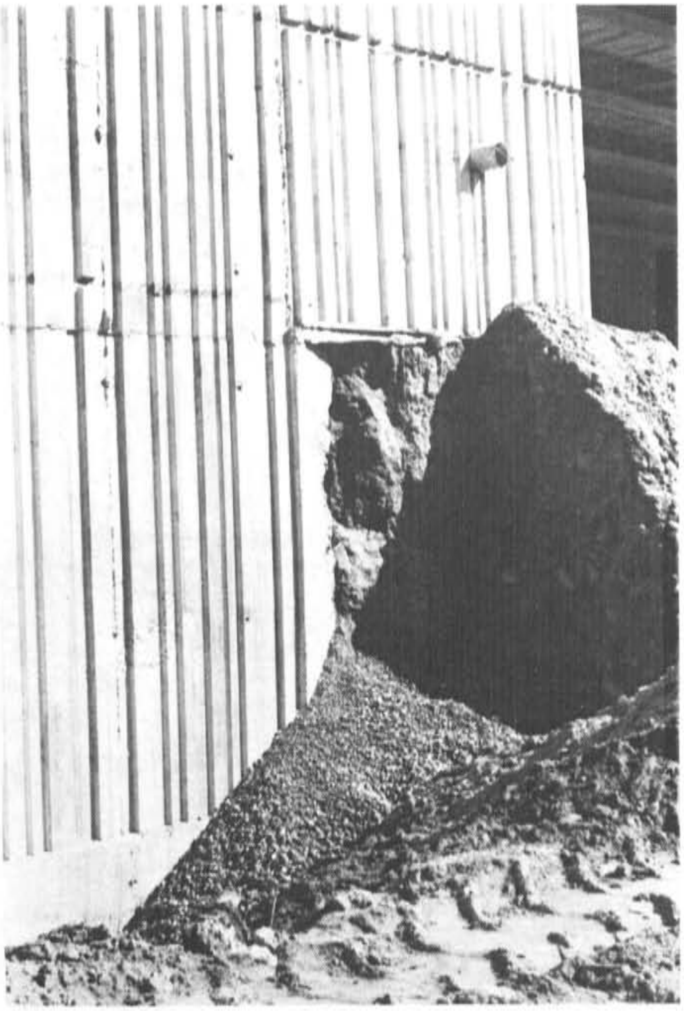


Figure No. 31 The Backfill Material After Seeping Thru the Crevices

Figure No. 32 The Depression Formed at the Top of the Wall Due to the Seeping of the Backfill Thru the Wall's Bottom

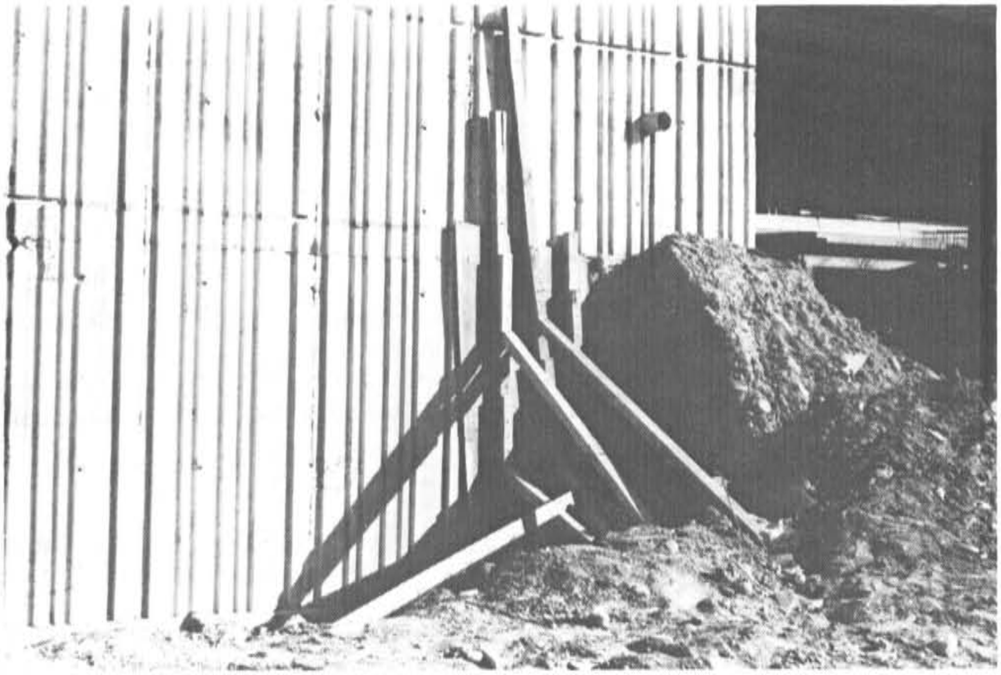


Figure No. 33 Corrective Measure Taken for the Crevices at the Bridge Abutment

An area between the wall and the PCCP is to be left exposed to the atmosphere according to the plans. Such area may cause erosion to the backfill material at the west end of this wall after rainfall. Erosion of the backfill material is already occurring and one can see the exposed reinforcing elements at the west end of the wall. ADOT asked Howard, Needles, Tammen & Bergendoff, the project's construction manager, to examine this problem and to incorporate any necessary corrective action into the landscape contract. No corrective action has been taken as of to date. Appendix N shows a copy of ADOT's letter.

No drainage outlets, as per the plans, were provided in the wall/embankment system.

Aluminum bench marks were inserted at various locations in the concreted section of the wall cap for future survey. The survey will monitor any horizontal/vertical movement of the top of the wall. Appendix O shows the survey's layout and data obtained on December 15, 1987.

After construction, the height of the wall ranged from 4' to 30' and its length was 1220'.

Three lanes were opened for traffic on January 17, 1988.

X. Design and Construction Changes for the S.W.Wall

Two change orders (# 25 & # 54) and one force account were executed. Change order # 25 was requested by the contractor in order to make the necessary adjustments to meet the requirements of section 9140118 of the special provisions for catch basins # 738 and # 739.

Due to the location of the catch basin in relation to the Hilfiker wall, there was a conflict with the placement of the reinforcements which would reduce the overall strength requirements of these reinforcements in the area of the catch basins. Hilfiker requirements include longitudinal wire continuity which can only be maintained through the use of the catch basin blockouts.

Moreover, the 24" pipe between CB #738 and CB # 739 was designated to be placed within the wire mats at the Hilfiker wall. Since the continuity of the mats must be maintained, the slope of the pipe had to be flattened so that the pipe did not pass through a mat. Hence the pipe was aligned at an angle towards the median. The cost of this change order was $955.00.

Change order # 54 was requested by the contractor in order to install the foundation for the barrier transition and guardrail in the area from I-17 station 234+88 to station 235+60 as per sheet number 103 of the plans (page D9).

The barrier transition (with drilled shafts) and guardrail both have underground features which would conflict with the reinforcing mats in the Hilfiker wall. As the mats could not be cut it was necessary to extend the special 1/2 barrier to station 234+88 where the mats were clear off the roadway prism, and the barrier transition and guardrail could be installed without conflict.

The cost for this change order was $3960.00.

Force account # 41 was initiated by ADOT in order to compensate the contractor for the additional work involved in installing the light pole foundation at station 235+00.

This work was necessary as the foundation could not be installed utilizing the standard practices, because of conflict with the reinforcing mats as the mats can not be cut without affecting the integrity of the wall. A blockout was formed around the foundation and it cost $1500.00.

Figures numbered 34 and 35 show some finished sections of the S.W.Wall.

XI. Evaluation of the S.E.Wall

The construction technique for the S.E.Wall was similar to that of the other walls (Figures numbered 36 and 37). The construction started in late August 1987 and finished in late December 1987 (Figure No.38).

The subgrade was prepared in the same manner as that of the N.E.Wall. The backfill material used was obtained from Calmat of Arizona, as mentioned earlier, and it passed a 3" sieve size. The decision to switch from a material passing 6" sieve size to a 3" sieve size was made by the contractor because, according to the contractor, it was easier to work with.

Compacting technique, testing and the equipment used for the construction were the same as that of the other walls.

Twelve field density tests were done by ADOT's personnel during the construction of this wall.

Few concrete shrinkage cracks were visible in this relatively short wall and the concrete finish was of a better quality than the other two walls.

No drainage outlets, as per the plans, were provided in the wall/embankment system.

Aluminum caps were embedded in the wall cap at various locations in order to monitor the top movement of the wall. Appendix P shows a layout and data of the survey done on January 13, 1988.

The length of the wall was about 680 feet, while the height ranged from 3 to 12 feet.

Figure No. 34 The Finished Product of the S.W.Wall Looking East

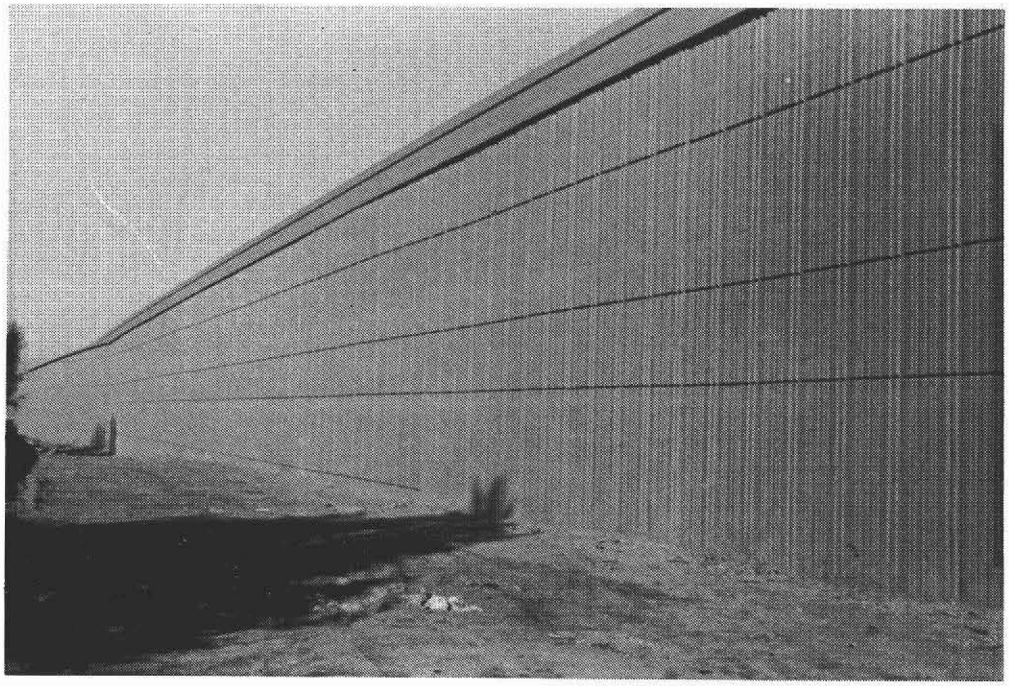


Figure No. 35 The S.W.Wall Looking West

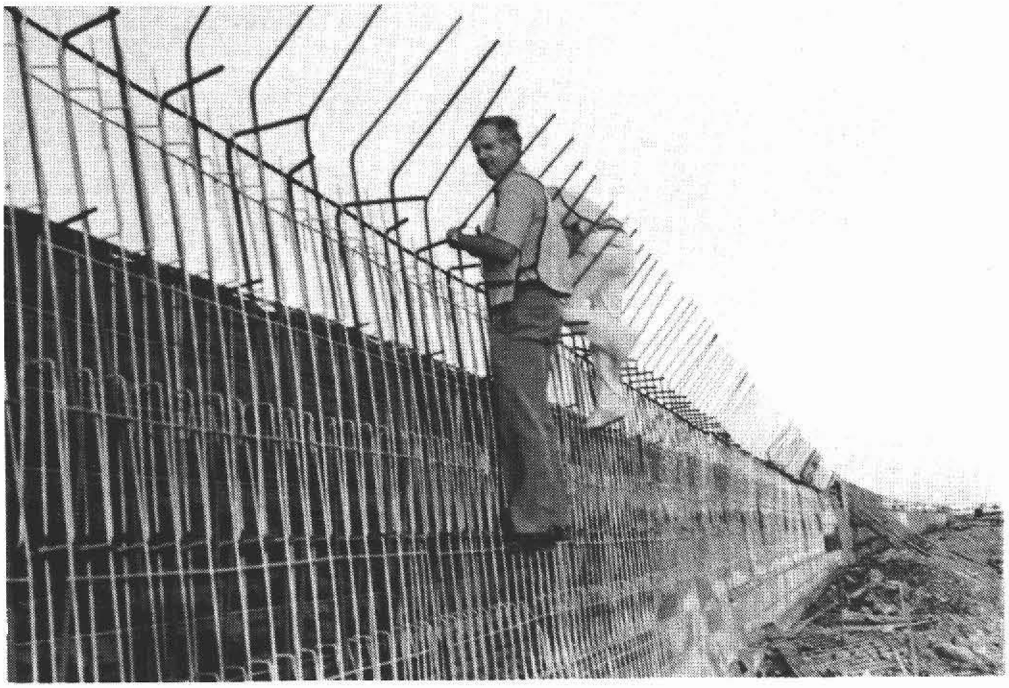


Figure No. 36 The S.E.Wall After Erection of the Reinforcements

Figure No. 37 Construction Techniques were Similar to Those of the Other Two Walls

XII. Design and Construction Changes for the S.E.Wall

Towards the end of the construction of this wall, the contractor did not have enough reinforcing mats to be placed at the proper elevation as per the plans. The contractor, however, increased the fill above the top mats up to 3 ft. instead of 2.5 ft. as was required on page 57 of the plans (page D3). This increase in fill height above the top mats was approved by the Hilfiker company.

No change orders nor force accounts were issued during the construction of this wall.

Three lanes were opened to traffic on January 17, 1988.

Figure No. 38 Site of the S.E.Wall After Construction

XIII. Conclusions and Recommendations

Due to the ease of construction and better compaction (as witnessed in the S.E. Wall and part of the S.W. Wall), it is recommended that material passing a 3" sieve size be used as a select backfill material for similar future projects.

Compaction requirements over the embankment's backfill material should be increased from 90% (as was specified for this project) to 95% of the maximum dry density. Such requirement will alleviate any differential settlement which may occur, in the roadway pavement, between the area of the embankment under the hilfiker mats (90% compaction), and the rest of the embankment (95% compaction). This recommendation should also result in better construction control and is consistent with ADOT's specification section 205-3.04 (page F7).

Upon observing the finished concrete product of similar construction technique, in the Phoenix area, it was noticed that such walls showed similar finish to that of the N.E. and the S.W. walls. Better concrete finish may be obtained if the thickness of the wall is increased to more than 6", and if the external vibrators were placed on a movable rail which is fixed to metal-type forms. This technique should allow better concrete pouring, placement and vibration.

Since no drainage outlets were provided, water can permeate thru the 1/2" pre-molded joint filler that exists between the portland cement concrete pavement and the gutter into the wall and possibly seep out thru the cracks developed in the facing panels eroding with it the fines from the backfill material. A force account work order was initiated, during the construction, to replace the joint filler with a waterproof sealant.

Although the # 4 rebar is embedded in concrete, water seeping into the wall might cause corrosion due to the fact that some sections of the wall facings are honeycombed and have air pockets which, with time, could allow water and air to penetrate and reach the rebar. For future similar construction technique, galvanization of the # 4 rebar and better concrete finish are recommended in order to attenuate corrosion.

If the Hilfiker system is used for future projects, it is recommended to incorporate the design of the Hilfiker Wall around the roadway design features. This should eliminate any contradiction between design features, e.g. catch basins, pipes, anchor lugs, cross slope superelevation, guard rail and light pole foundations, etc...Such coordination should save time and money.

The lump sum cost for the construction of the three retaining walls as listed in the plans is $1,150,000.00. The contractor indicated that this amount was not sufficient to cover construction costs, and did not comment on the actual cost figures. However, upon dividing $1,150,000.00 by the constructed area in ft2 (68,862.00 ft2) a $16.70/ft2 would be the price that ADOT paid the contractor. This price seems to be very competitive with market prices of other systems.

A visual reconnaissance of the wall facing will be performed annually and for a period of three years, or if the need arises. Should distress become evident, physical surveys utilizing the embedded bench marks will be conducted to establish the magnitude and extent of difference from the original survey. The crack occurrence and width will be monitored to document changes with time.

Full scale instrumentation of a mechanically stabilized embankment with full height panels, should be implemented in order to better assess the design and construction of such a proprietary.

APPENDIX A

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

ARIZONA TRANSPORTATION RESEARCH CENTER
January 22, 1986

Mr. Ed Wueste
Division Administrator
Federal Highway Administration
3500 North Central Avenue
Suite 201
Phoenix, Arizona 85012

SUBJECT: EXPERIMENTAL PROJECT AZ8601
Proposed Workplan For Reinforced Earth
Embankment Utilizing Full Height Panels
Project I-10-3(204) C
16th St. to 28th St.

Dear Mr. Wueste:

The FHWA has requested that the three permanent earth retaining systems designed for Project I-10-3(204) be classified as experimental projects. This request was made because the full height panels utilized in the retaining wall designs are currently considered experimental (see FHWA Geotechnical Advisory 5.0.3) due to limited knowledge and experience on these systems.

Enclosed is the workplan for the above referenced project for your review and approval. It is intended that this workplan be accepted as a general workplan applicable to all full height panel construction utilized in retaining wall designs. Additional projects requiring experimental designation will incorporate this same "approved workplan" and will be submitted under separate cover. It is further requested that this specific project be eligible for an evaluation under Experimental Project No. 1, "Ground Modifications Systems".

In the event you have questions regarding this project or workplan, please contact Mr. Larry Scofield of my staff.

Respectfully,

F.R. McCullagh

Frank R. McCullagh, P.E.
Assistant State Engineer
Transportation Research Center

LAS:rm

Enclosure

cc: John Lawson
Al Zuckerman

"FULL HEIGHT PANELS UTILIZED IN RETAINING WALL DESIGNS"

FHWA EXPERIMENTAL PROJECT NO. AZ8601

ADOT PROJECT NO. I-10-3(204)C

16TH STREET TO 28TH STREET

PROBLEM STATEMENT

The proliferation of proprietary earth retaining systems has left highway engineers with a complex, and sometimes ambiguous problem of weighing the potential for initial cost savings against a frequently unknown product performance record.

In the last ten years considerable experience has been gained in assessing the performance of these systems which typically utilized small modular precast facing panels approximately 25 sq. ft. in area. These panels, individually attached to the ground reinforcing strips, allowed structures to incur considerable settlement without any significant distress. In recent times, however, aesthetic considerations have compelled designers to require full height panels in lieu of the smaller modular panels.

The utilization of full height panels requires the connection of multiple reinforcing strips to a single panel, introducing a degree of indeterminacy to the structure. The inability to effectively analyze the internal behavior of the systems and the paucity of satisfactory performance, qualifies these as appropriate to the experimental category. Considerable concern exists as to the ability of these newer systems to sustain settlements.

OBJECTIVE

The objective of this project is to document the construction and evaluate the performance of the full height panel retaining systems for a period of at least three years. The progress, methods of construction, difficulties encountered and required design changes will be reviewed.

Should performance problems develop, the causes and necessary remedial measures will be monitored and reported.

WORKPLAN

The proposed workplan is in accordance with the requirements outlined in FHWA Geotechnical Advisory 5.0.3 for Experimental Project No. 2 "Ground Modifications Systems". At minimum, the following information will be collected and reported:

I. SITE INFORMATION

A) Project Location and Description

B) Plan and Profile

C) Subsurface Profile

   1) Laboratory Test Results
   2) Field Test Results

D) Site Problems

II. DESIGN DETAILS

A) Alternates Considered

B) Design Procedures (Example Computations)

C) Monitoring Program

D) Specification Types

E) Method of Construction Acceptance

III. CONSTRUCTION DATA

A) Unit Prices

B) Change Orders

C) Placement and Erection Procedures

D) Construction Problems

E) Time-Rate of Construction Estimates

Note: The monitoring program will consist of physical survey information collected as necessary to detect manifestations of distress. No instrumentation is anticipated at this time.

IV. PERFORMANCE EVALUATION

A) Assessment of Design and Construction Practices

B) Performance Appraisal with Time

C) Documentation of Required Maintenance and Effectiveness

V. REPORTING

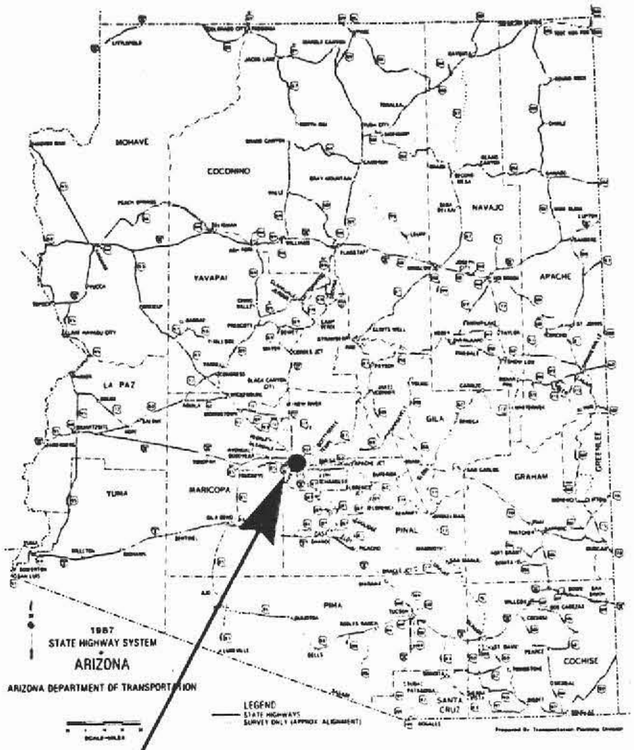
A) A post construction report will be prepared which describes the cost, installation procedures, evaluation techniques and erection equipment utilized to construct and analyze the wall system. This report should be prepared within 120 days after completion of construction.

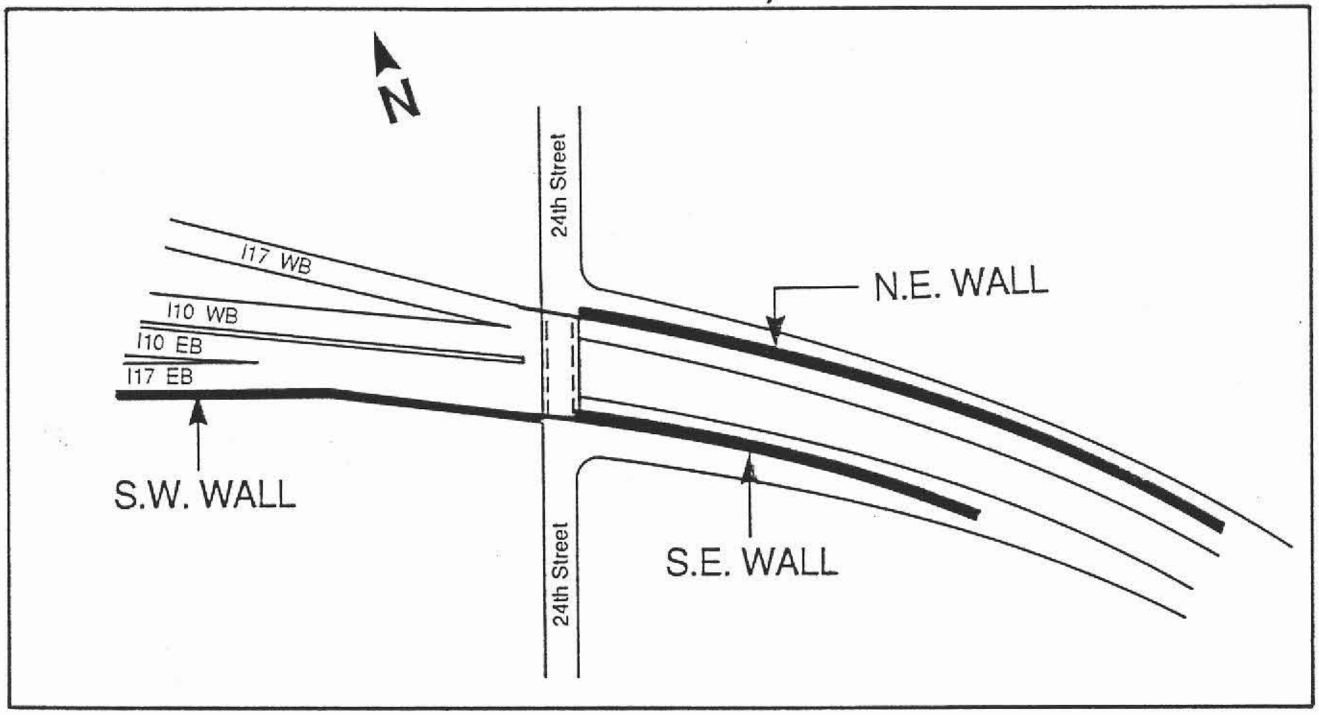
B) Performance evaluations will be conducted on a periodic basis at least annually for the first 3 years. Should distress become evident, physical surveys will be conducted to establish the magnitude and extent of the problem.

C) A final report will be prepared at the end of the evaluation period which describes and analyzes the data collected and summarizes the findings.

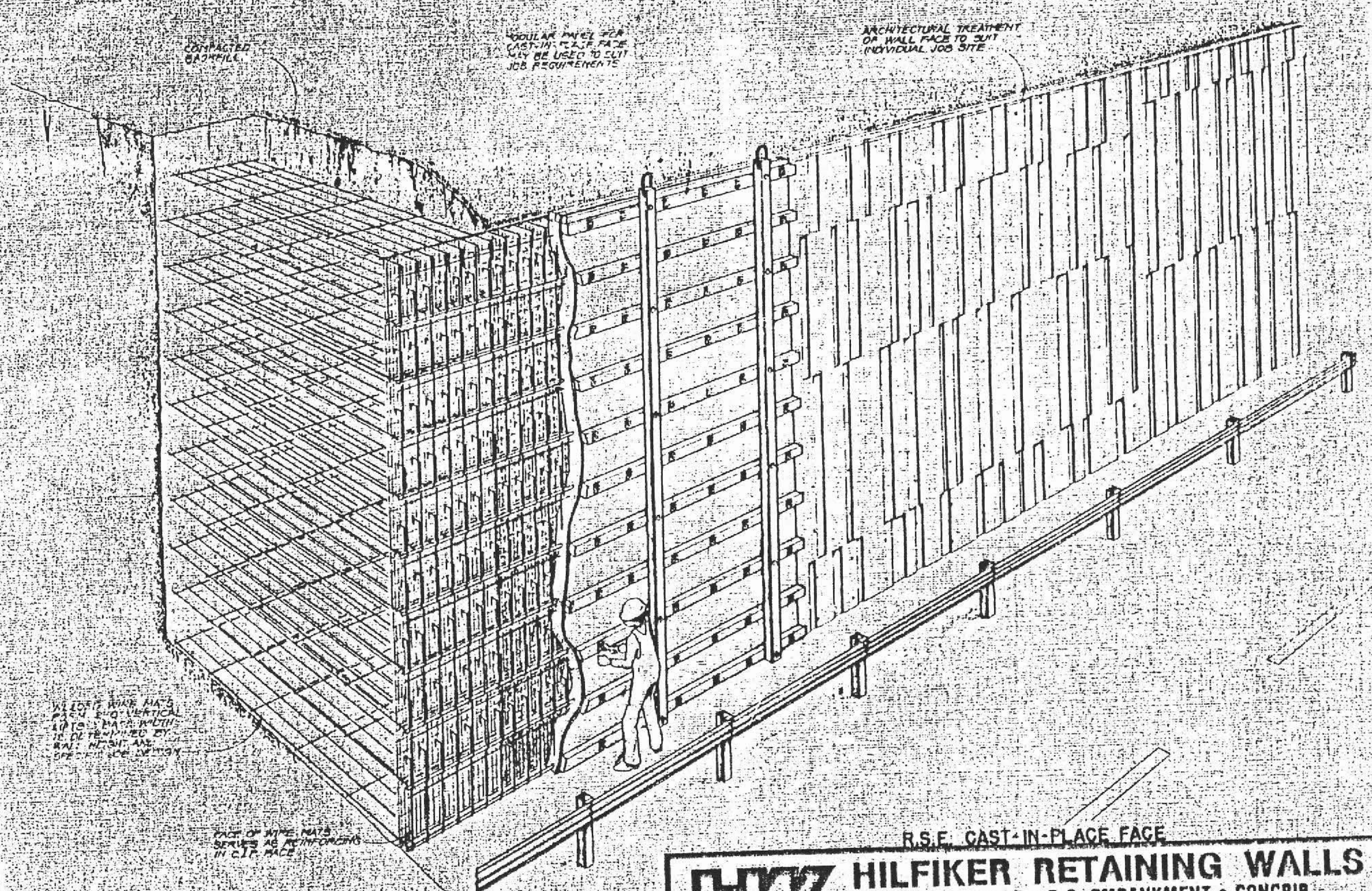
APPENDIX B

LOCATION MAP





C.I.P. CONSTRUCTION GUIDE

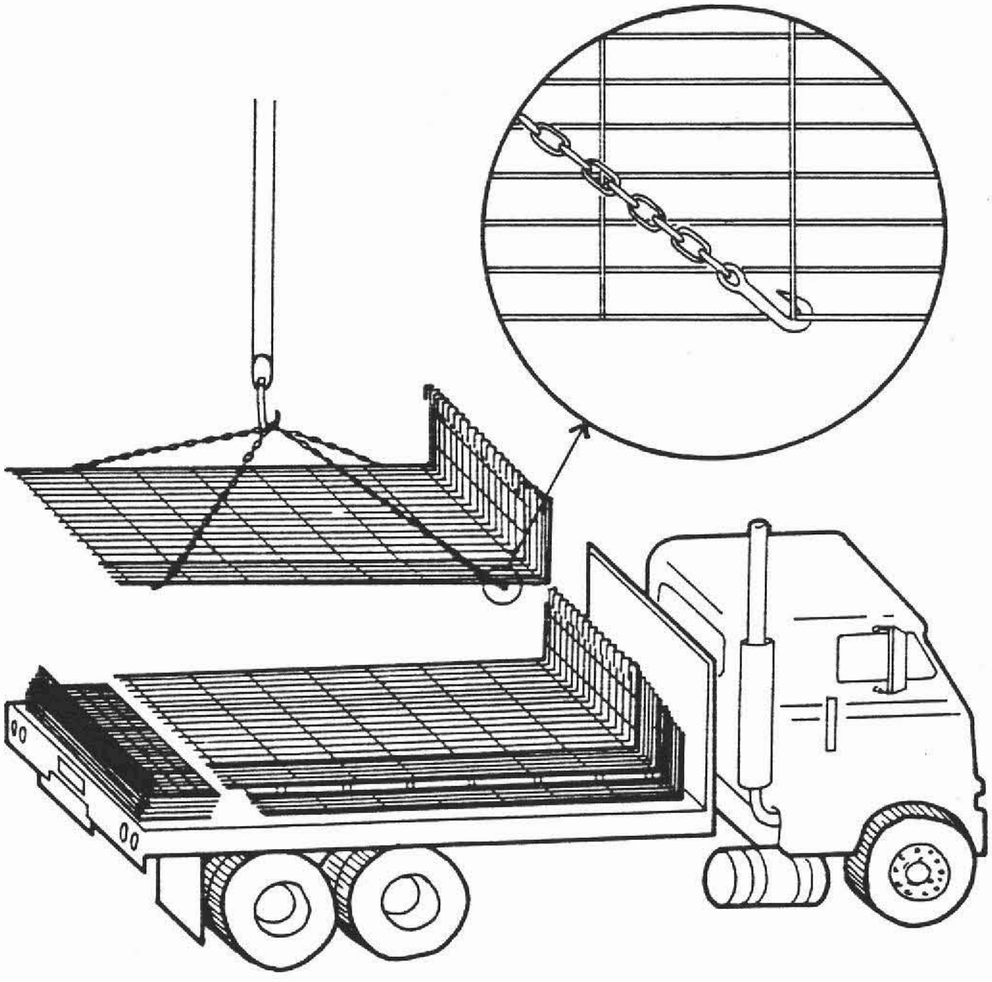


R.S.E. CAST-IN-PLACE FACE

HILFIKER RETAINING WALLS
WELDED WIRE • R.S. EMBANKMENT • CONCRIB
(707) 443-5091 • P.O. Drawer L • Eureka, CA 95501

11-81

TO UNLOAD

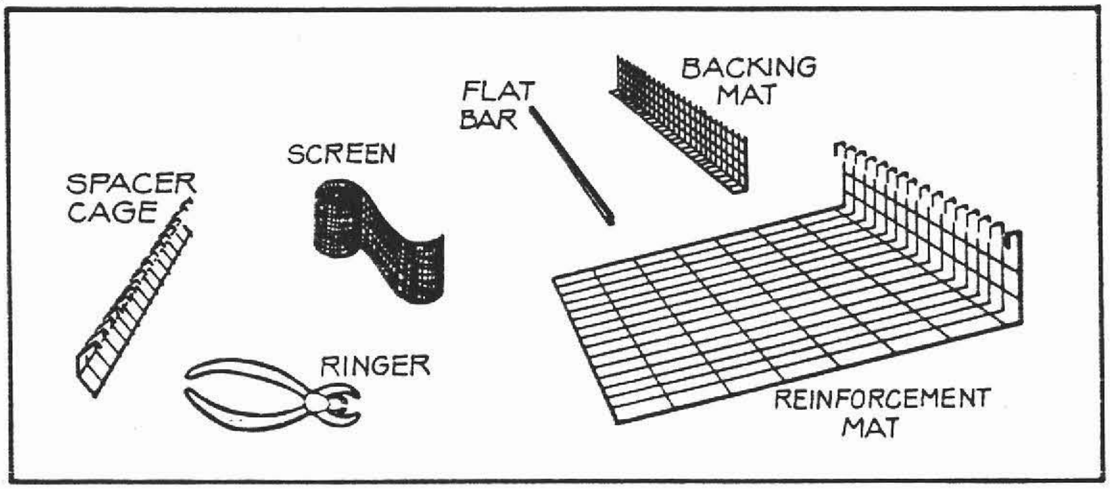


TO UNLOAD: HOOK CHAINS AS SHOWN, BEING SURE TO HOOK THE BOTTOM-MOST WIRE ON EACH BUNDLE.

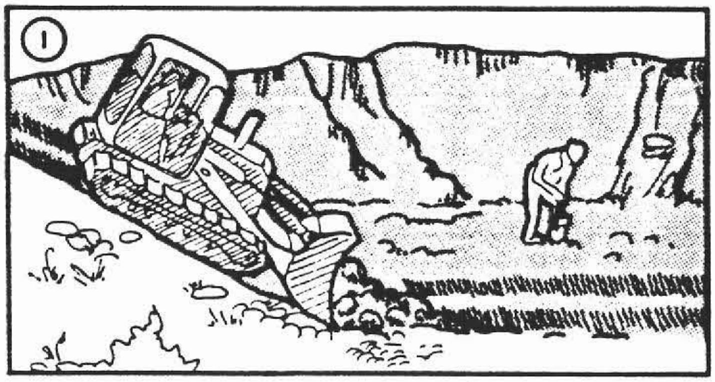
NOTE :

THIS BOOKLET IS INTENDED TO BE A GENERAL GUIDE FOR THE INSTALLATION OF THE HILFIKER R.S.E. WITH C.I.P. FACE WALL. IF ANY PART OF YOUR CONSTRUCTION PLANS ARE AT VARIANCE WITH INFORMATION IN THIS GUIDE, FOLLOW YOUR CONSTRUCTION PLANS.

WALL PARTS

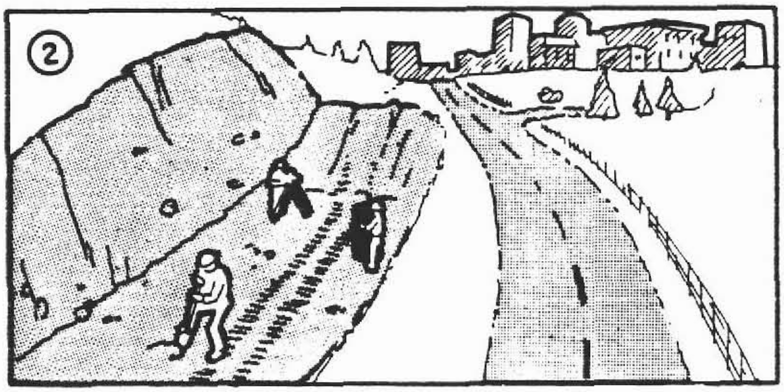


EXCAVATION



EXCAVATE ACCORDING TO THE PLANS AND SPECIFICATIONS OF YOUR JOB

YOU MUST EXCAVATE TO A SOLID FOUNDATION THAT WILL SUPPORT THE WEIGHT OF THE WALL.



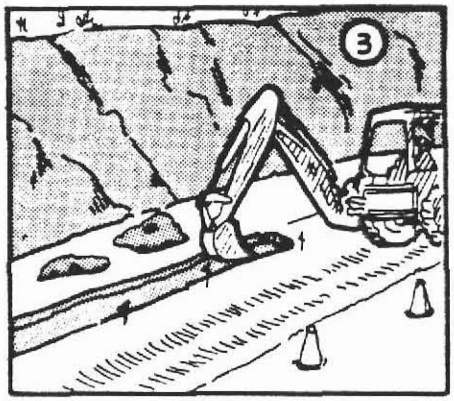
MAKE SURE WALL FOUNDATION IS TO LINE AND GRADE.

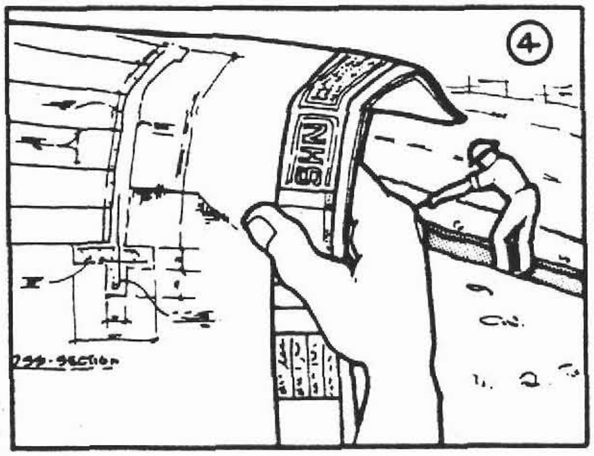
A LITTLE TIME SPENT NOW MAY SAVE A LOT OF TIME LATER

PREPARE THE TRENCH FOR THE CAST-IN-PLACE LEVELING COURSE. BE SURE YOU HAVE THE REQUIRED BERM IN FRONT.

FOLLOW THE PLANS AND SPECIFICATIONS OF YOUR JOB FOR SIZE AND REINFORCING OF LEVELING COURSE.

POUR THE CONCRETE AND LEVEL THE TOP OF IT TO YOUR EXCAVATED GRADE.





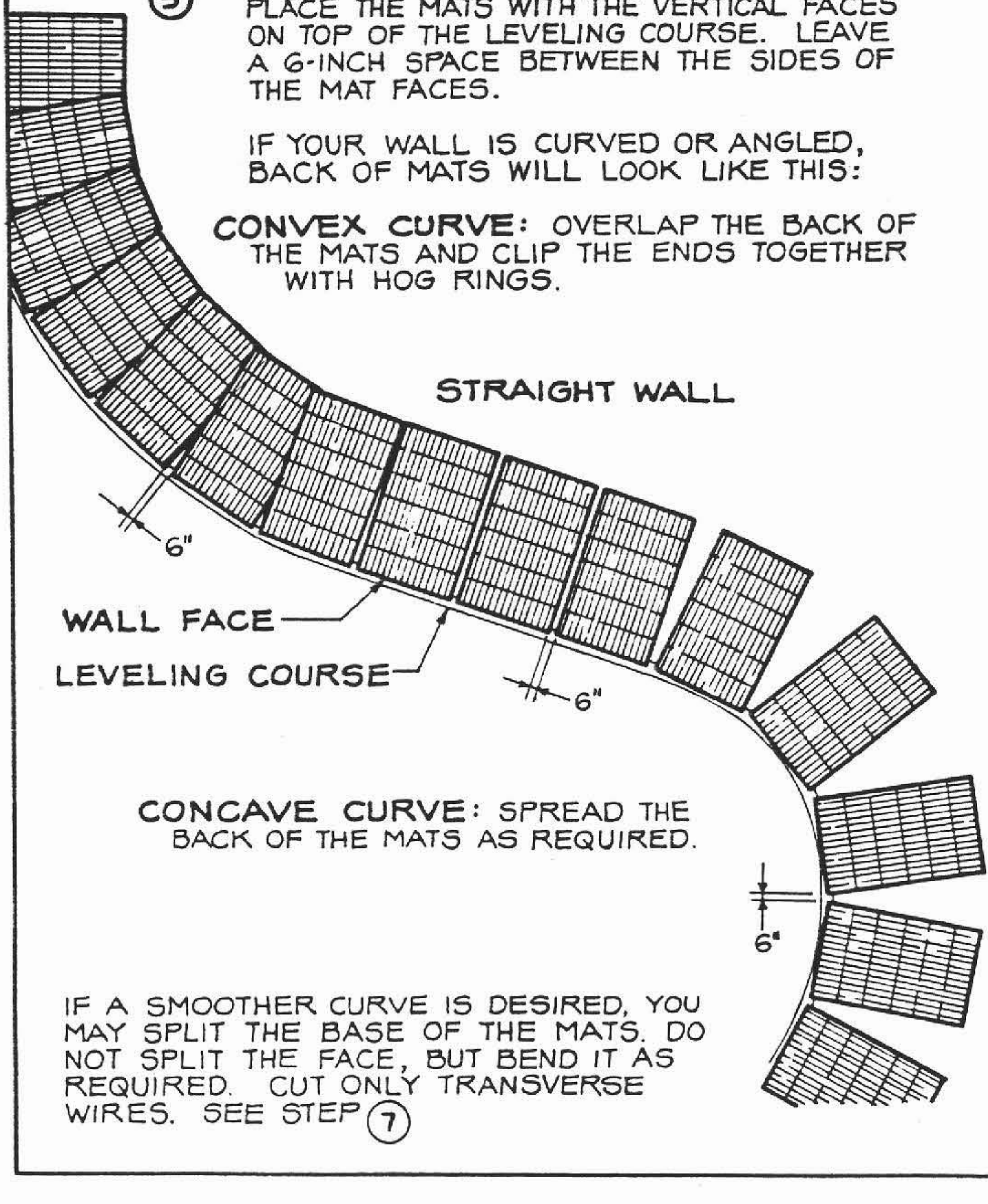
IF YOUR CONSTRUCTION PLANS CALL FOR A VARIABLE BASE WALL WITH A CAST-IN-PLACE FOOTING, CUT AND PREPARE SOIL AND REINFORCING ACCORDING TO PLANS.

POUR THE FOOTING WITH A KEY FOR LATER KEYING INTO THE CAST-IN-PLACE FACE

⑤ PLACE THE MATS WITH THE VERTICAL FACES ON TOP OF THE LEVELING COURSE. LEAVE A 6-INCH SPACE BETWEEN THE SIDES OF THE MAT FACES.

IF YOUR WALL IS CURVED OR ANGLED, BACK OF MATS WILL LOOK LIKE THIS:

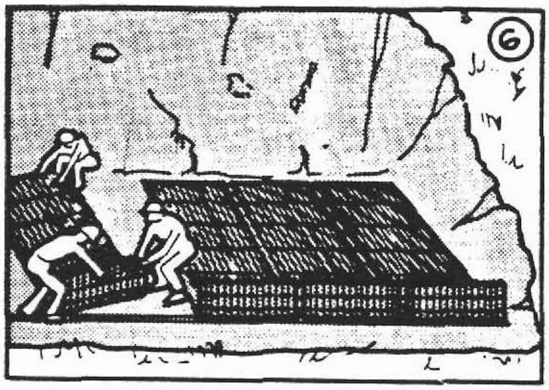
CONVEX CURVE: OVERLAP THE BACK OF THE MATS AND CLIP THE ENDS TOGETHER WITH HOG RINGS.



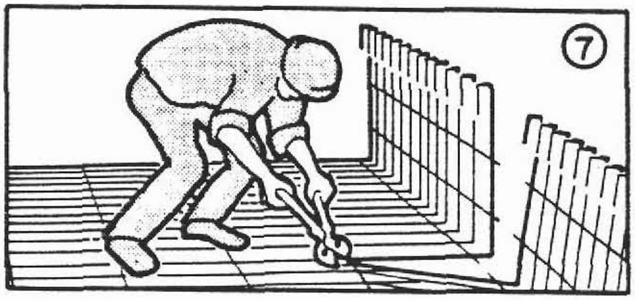
CONCAVE CURVE: SPREAD THE BACK OF THE MATS AS REQUIRED.

IF A SMOOTHER CURVE IS DESIRED, YOU MAY SPLIT THE BASE OF THE MATS. DO NOT SPLIT THE FACE, BUT BEND IT AS REQUIRED. CUT ONLY TRANSVERSE WIRES. SEE STEP ⑦

CONSTRUCTION OF FOUNDATION LAYER

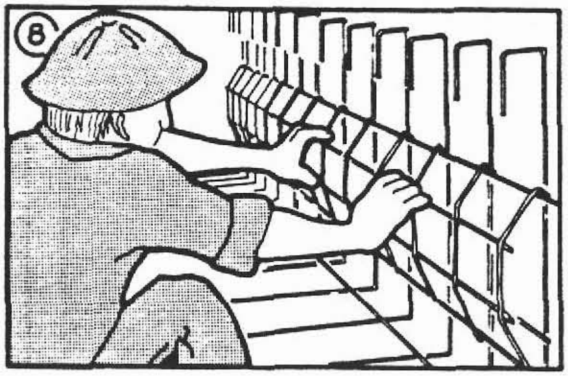


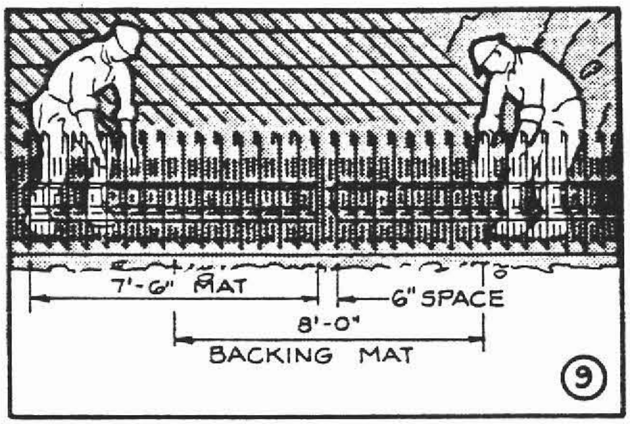
PLACE THE MATS FOR THE FIRST LIFT. BE SURE THE MAT FACES ARE PROPERLY LOCATED ON THE LEVELING COURSE OR FOOTING.
SOIL AROUND THE CAST-IN-PLACE CONCRETE MUST BE LEVEL AND SOLID.
USE A STRINGLINE WHERE WALL IS STRAIGHT TO ALIGN THE MAT FACES. STAKE TO HOLD IN PLACE.



MATS MAY BE CUT TO FIT EXCAVATION IF NEEDED.
CUT ONLY TRANSVERSE WIRES. **DO NOT** SHORTEN THE BASE DEPTH OF THE MATS.

INSTALL THE WIRE SPACER CAGES. PLACE THE HOOKED WIRES OVER THE TOP HORIZONTAL WIRE ON THE MAT FACE. THE BOTTOM WIRE ON THE SPACER CAGE RESTS AGAINST THE MAT FACE.
SPACER CAGES ARE INSTALLED ONLY IN THE FIRST LIFT.



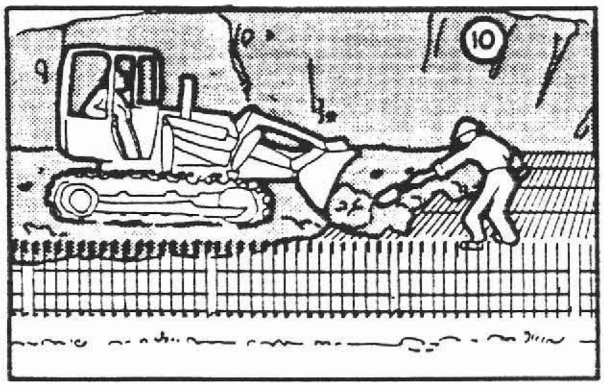


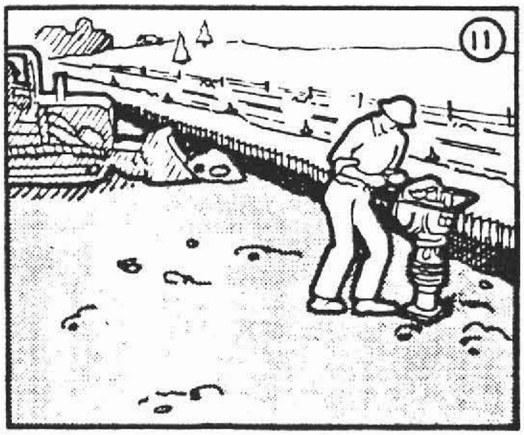
PLACE THE BACKING MATS AGAINST THE SPACER CAGE WITH THE 6-INCH FOOT TOWARD THE INSIDE OF THE WALL. BACKING MATS SPAN FROM CENTER TO CENTER OF THE 7'-6" MATS. USE HALF BACKING MATS AT THE ENDS OF THE LIFT.
UNROLL THE SCREEN AGAINST THE BACK OF THE BACKING MATS AND CLIP WITH HOG RINGS

BEGIN LOADING BACKFILL OVER THE BASE OF THE MATS.

DO NOT OPERATE HEAVY EQUIPMENT ON EXPOSED WIRE.

WHEN THE BACK OF THE MATS ARE WEIGHTED WITH FILL, THE STAKES CAN BE REMOVED.

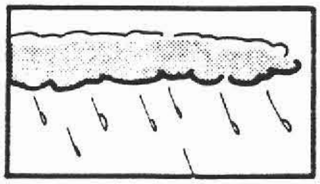


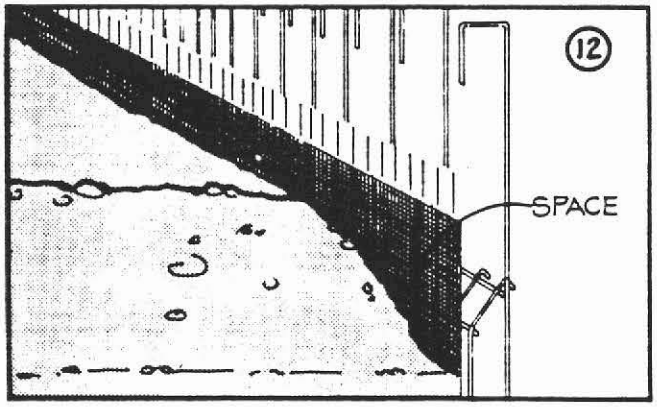


PLACE AND COMPACT A LAYER OF BACKFILL ABOUT 12 INCHES DEEP. USE CARE WHEN COMPACTING THE SOIL AGAINST THE BACKING MAT SO YOU DON'T BEND IT OUT. THE 3-INCH SPACE BETWEEN THE BACKING MAT AND THE WIRE FACE **MUST BE** MAINTAINED.

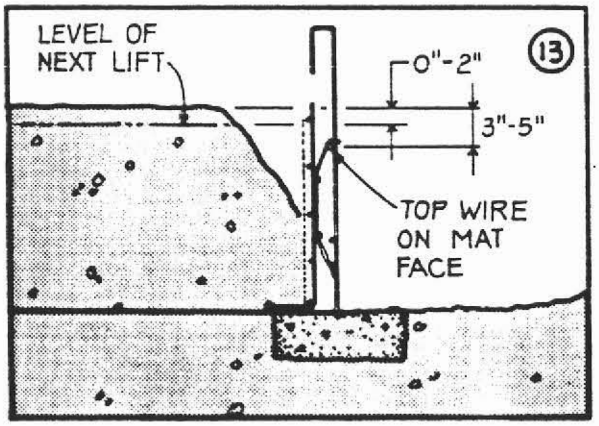
DO NOT HIT OR DAMAGE THE WIRE WITH COMPACTING EQUIPMENT.

IT IS IMPORTANT TO KEEP THE BACKFILL DRY. IF RAIN IS EXPECTED, PROTECT THE BACKFILL WITH A PLASTIC COVERING. IF BACKFILL DOES GET WET, REMOVE THE WET MATERIAL BEFORE CONTINUING CONSTRUCTION.





PLACE AND COMPACT THE REMAINING BACKFILL FOR THIS LIFT. STOP THIS LAYER OF BACKFILL JUST BEFORE IT REACHES THE BACKING MATS TO PREVENT BENDING THE MATS OUTWARD WHEN YOU COMPACT. YOU WILL FILL THE SPACE WHEN YOU PLACE THE BACKFILL IN THE NEXT LIFT.



THE TOP OF THE COMPACTED BACKFILL MUST BE 0~2 INCHES ABOVE THE LEVEL OF THE NEXT LIFT (3~5 INCHES ABOVE THE TOP WIRE ON THE MAT FACE)

THIS IS TO INSURE AGAINST UNDERFILLING, WHICH WOULD CAUSE BULGING OF THE BACKING MATS LATER.

NOTE: THIS WALL IS A REINFORCED SOIL STRUCTURE.

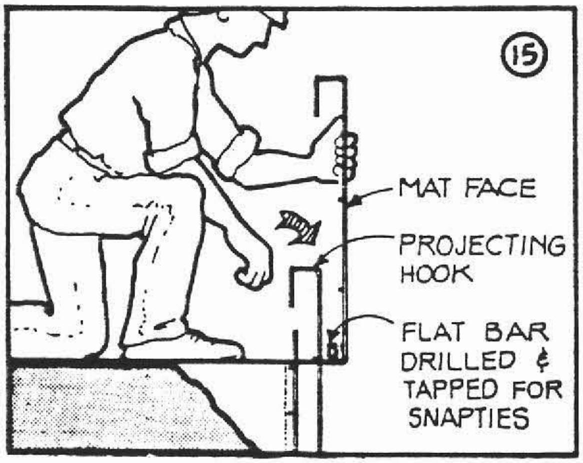
IT IS IMPORTANT THAT THE BACKFILL MATERIAL BE CAREFULLY COMPACTED TO PREVENT LATER SETTLEMENT.

WORKING YOUR WAY UP

⑭
PLACE THE REINFORCEMENT MATS FOR THE NEXT LIFT.

LOWER THE MATS CAREFULLY OVER THE PROJECTING HOOKS OF THE LIFT BELOW. DO NOT BEND THE HOOKS OUT OF LINE.

THE TOP OF THE VERTICAL WIRES OF THE BACKING MAT BELOW WILL PROJECT ABOUT 2 INCHES THRU THE BASE OF THIS LIFT. KEEP THEM **BEHIND** THE FIRST TRANSVERSE WIRE IN THE BASE OF THESE MATS.



LEAVE SOME CLEARANCE BETWEEN THE MAT FACE AND THE PROJECTING HOOK TO DROP THE FLAT BAR DOWN BETWEEN THEM. TAPPED HOLES IN THE BARS FACE THE FRONT OF THE WALL.

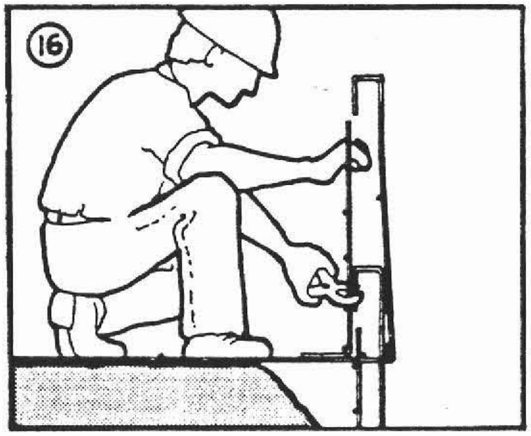
(FLAT BARS ARE PLACED FOR THE FULL LENGTH OF EVERY LIFT)

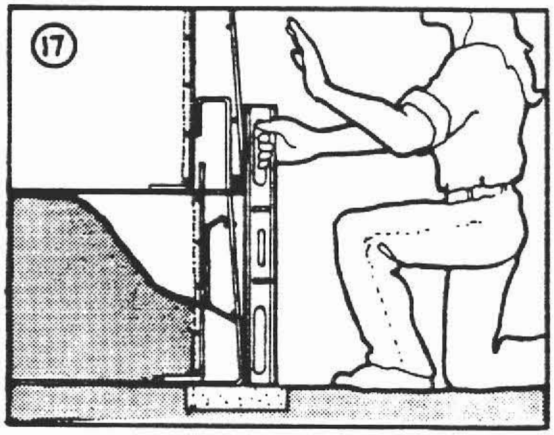
NOW SLIDE THE MATS BACK AGAINST THE BARS.

STAND THE BACKING MATS UP AGAINST THE PROJECTING HOOK WITH THE FOOT ON THE BACKING MAT TOWARD THE INSIDE OF THE WALL. BACKING MATS SPAN FROM CENTER TO CENTER OF REINFORCEMENT MATS AS SHOWN IN STEP ⑨.

CLIP IN PLACE WITH HOG RINGS.

UNROLL THE SCREEN AGAINST THE BACKING MATS AND CLIP IN PLACE.



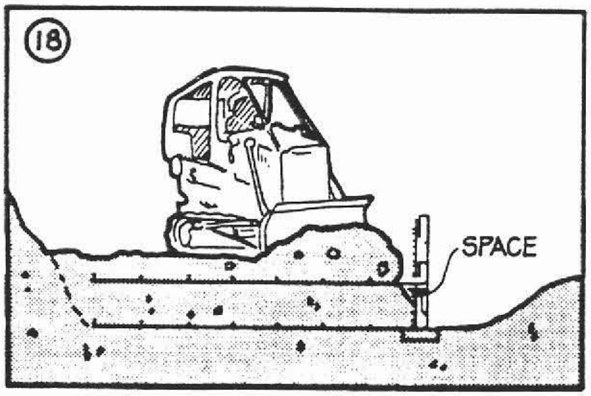


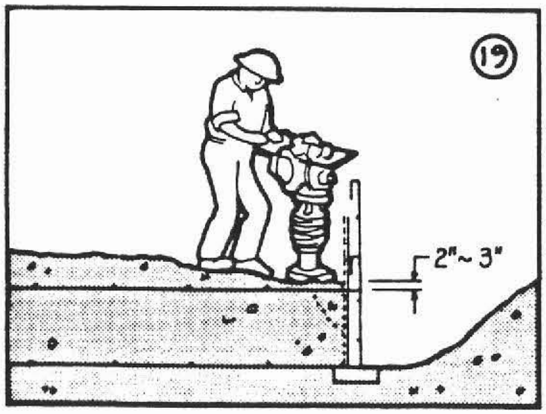
HOLD A HAND LEVEL AGAINST THE BASE OF THE LIFT BELOW AND THE BASE OF THE ONE YOU'RE INSTALLING AND SHIFT THE MAT UNTIL THE LEVEL SHOWS VERTICAL.

STAKE THE MATS TO HOLD THEM IN PLACE.

BEGIN LOADING BACKFILL AS IN STEP ⑩

AS YOU NEAR THE FRONT OF THE WALL WITH THE BACKFILL, PUSH FILL INTO THE SPACE IN THE LIFT BELOW THAT IS JUST BEHIND THE BACKING MATS.





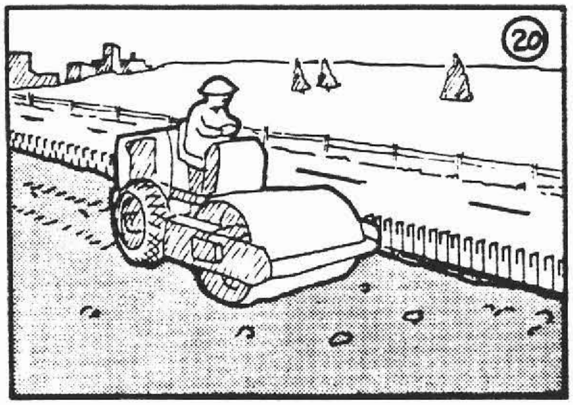
USE A HAND TAMPER TO COMPACT THE FILL BEHIND THE BACKING MAT IN THE LIFT BELOW.

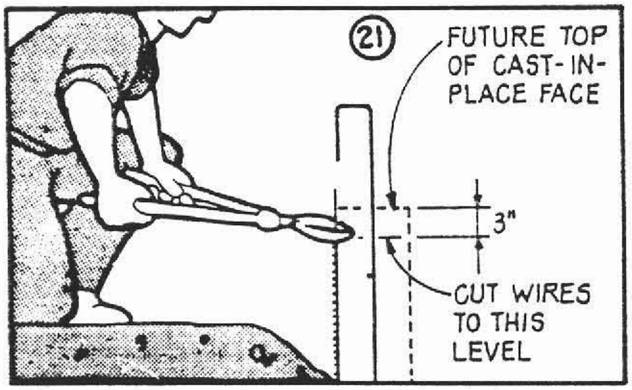
KEEP A 2-INCH TO 3-INCH CUSHION OF FILL OVER THE BASE WIRES AS YOU WORK TO PREVENT DAMAGE TO THE WIRE.

COMPLETE THE BACKFILL AS SHOWN IN STEPS ⑪ THRU ⑬.

COMPACT CAREFULLY.

REPEAT STEPS ⑭ THRU ⑳ TO THE FINAL LIFT.





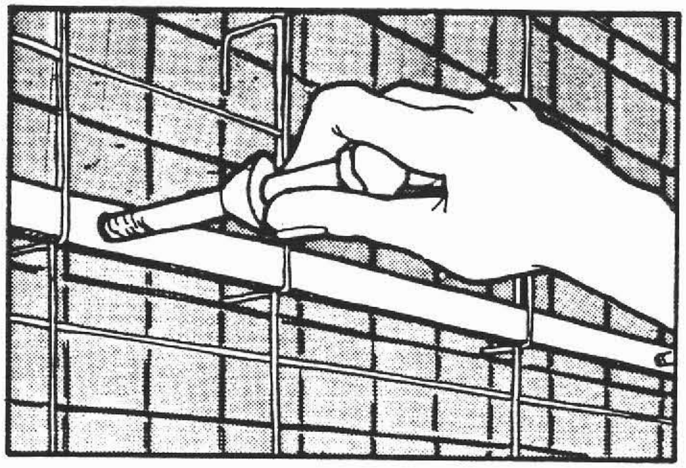
WHEN YOU HAVE PLACED THE FINAL (TOP) LIFT, YOU WILL FIND THAT THE WIRE PROJECTS ABOVE THE ELEVATION GIVEN IN YOUR PLANS FOR THE TOP OF THE CAST-IN-PLACE FACE.

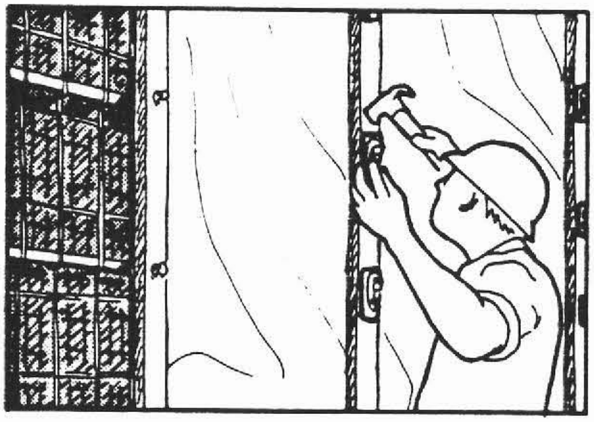
CUT ALL WIRE OFF 3 INCHES LOWER THAN THIS FUTURE ELEVATION.

ATTACHING THE FORMS

THREAD THE SNAPTIES INTO THE THREADED HOLES IN THE FLAT BARS, SPACING THEM ACCORDING TO YOUR JOB PLANS.

LINE UP THE CONE PARTS ON THE SNAPTIES USING A STRINGLINE.

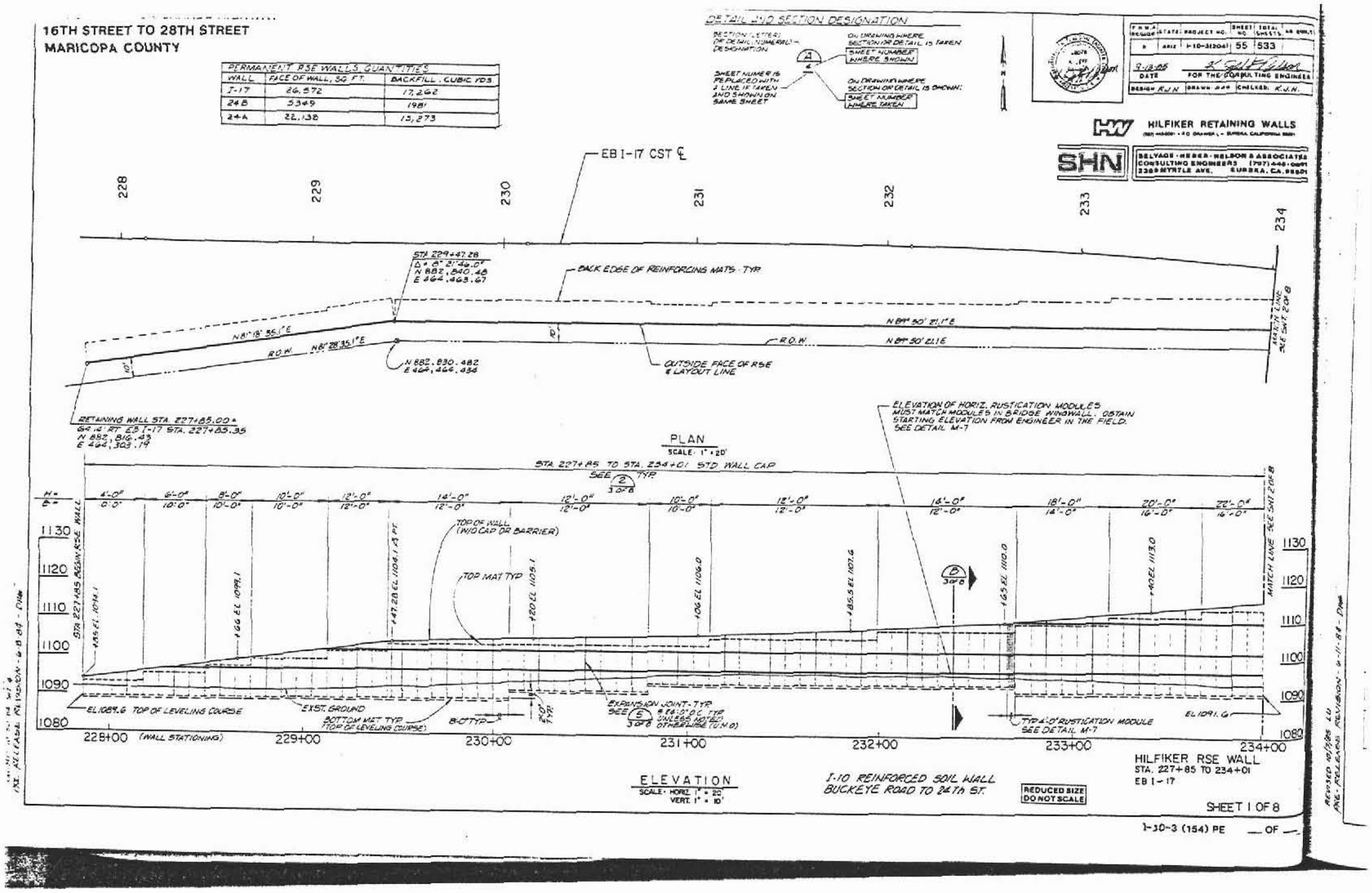




SLIDE THE FORMS ONTO THE SNAPTIES AND SECURE WITH METAL WEDGES.

CAST THE CONCRETE ACCORDING TO YOUR JOB SPECIFICATIONS.

APPENDIX D



PERMANENT RSE WALLS QUANTITIES		
WALL	FACE OF WALL, SQ FT.	BACKFILL, CUBIC YDS
I-17	26,572	17,262
24B	5349	1981
24A	22,138	15,273

PHOENIX - CASA GRANDE HIGHWAY
16TH STREET TO 28TH STREET
MARICOPA COUNTY

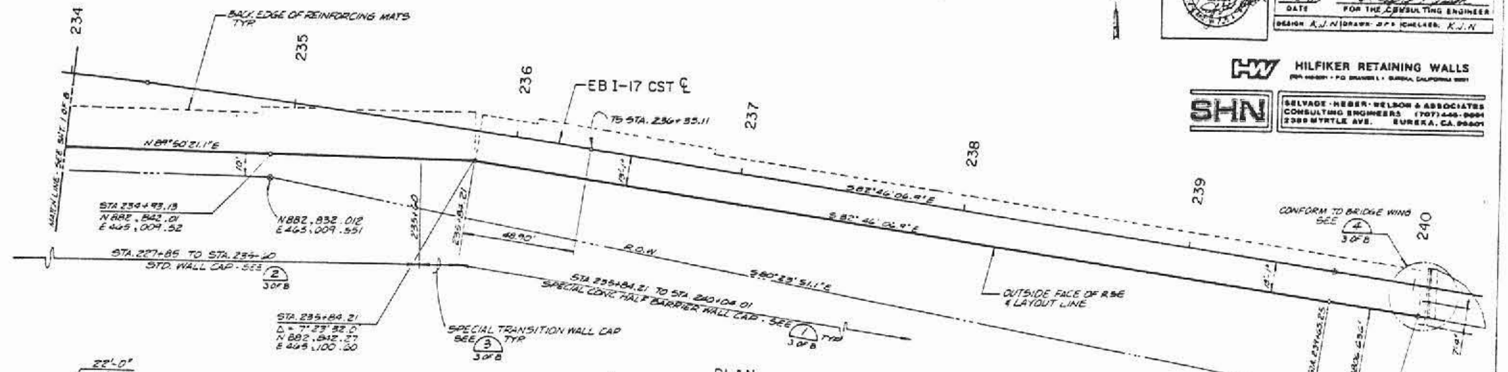
F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ	I-10-3(204)	56	533	

9-13-85
DATE
K. Jeff Nelson
FOR THE CONSULTING ENGINEER
DESIGN K.J.N | DRAWN D.F.S | CHECKED K.J.N

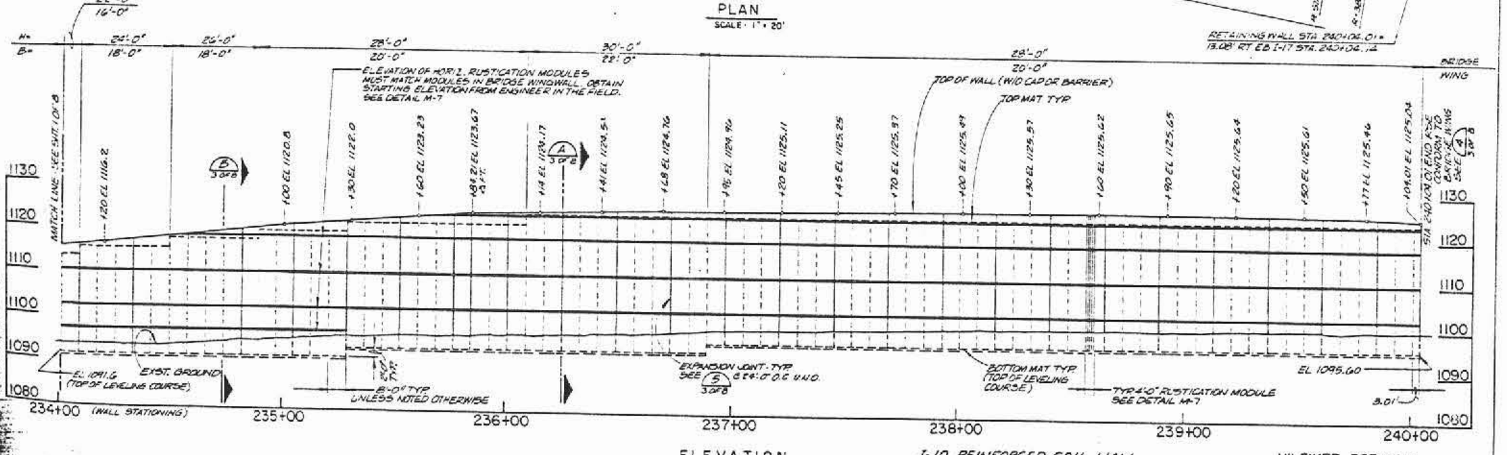
18078
K. JEFF NELSON

HILFIKER RETAINING WALLS
P.O. DRAWER L · EUREKA, CALIFORNIA

SHN
SELVAGE · HEBER · NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 443-8891
2380 MYRTLE AVE. EUREKA, CA. 95501



PLAN
SCALE: 1" = 20'



ELEVATION
SCALE: HORIZ. 1" = 20'
VERT. 1" = 10'

I-10 REINFORCED SOIL WALL
BUCKEYE ROAD TO 24Th ST.

REDUCED SIZE
DO NOT SCALE

HILFIKER RSE WALL
STA. 234+01 TO 240+04.14
EB I-17

SHEET 2 OF 8

I-10-3 (154) PE ___ OF ___

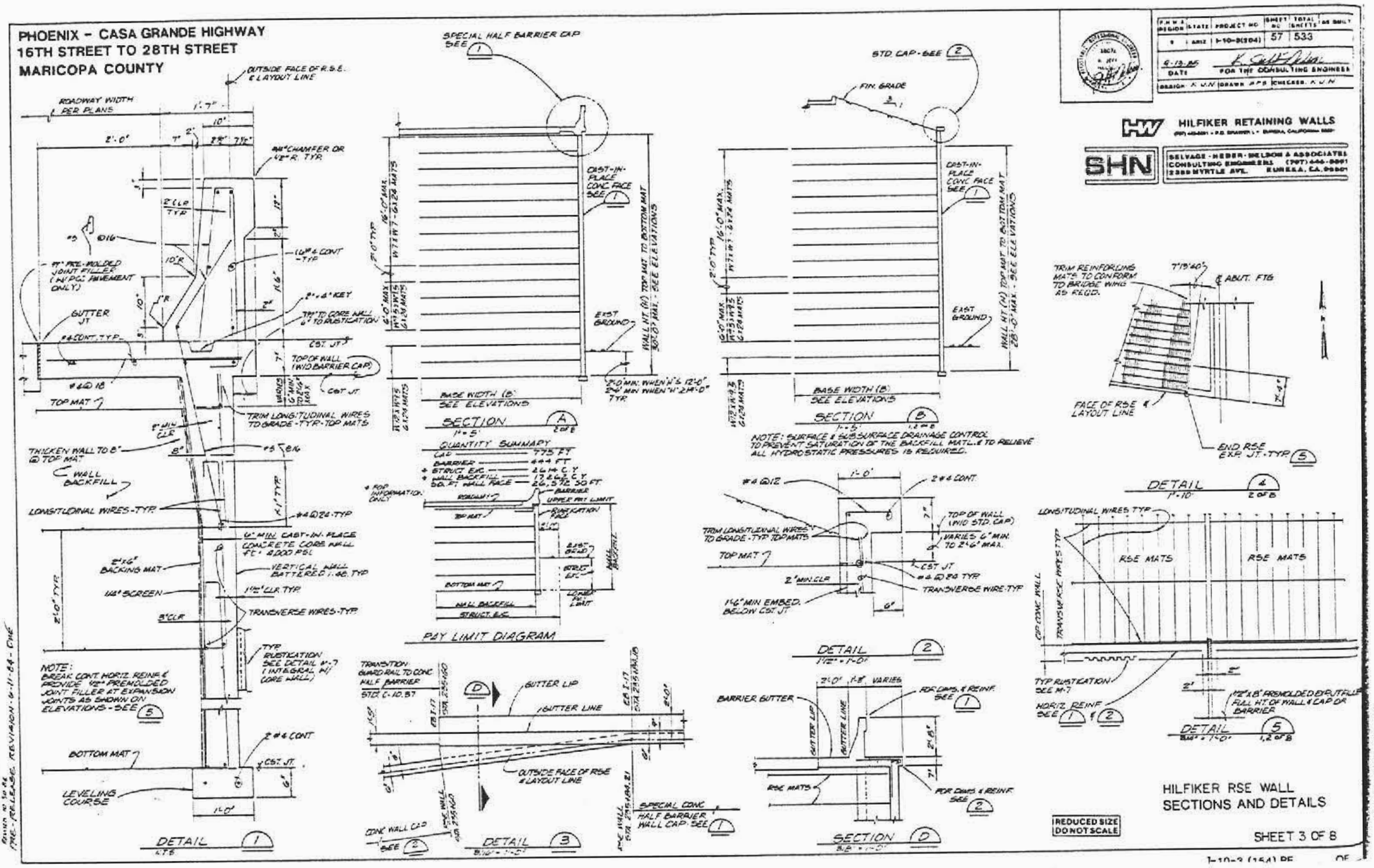
PHOENIX - CASA GRANDE HIGHWAY
16TH STREET TO 28TH STREET
MARICOPA COUNTY

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ	I-10-3(204)	57	533	

9-13-85
DATE
K. Scott Nelson
FOR THE CONSULTING ENGINEER
DESIGN K.U.N. DRAWN R.P.S. CHECKED K.U.N.

HILFIKER RETAINING WALLS

SELVAGE · HEBER · NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 444-8001
2380 MYRTLE AVE. EUREKA, CA. 95501



REDUCED SIZE
DO NOT SCALE

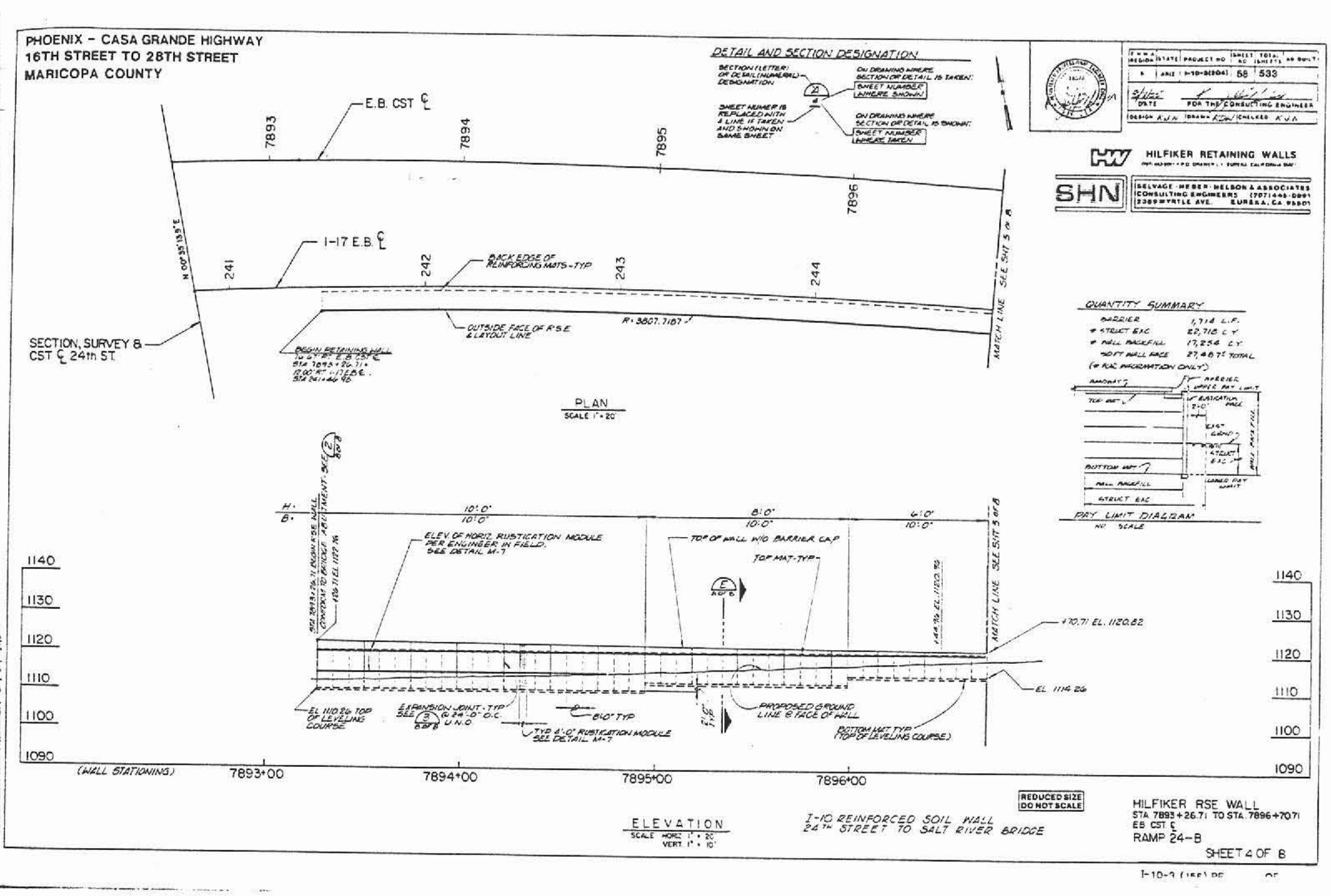
HILFIKER RSE WALL
SECTIONS AND DETAILS

SHEET 3 OF 8

REVISED 10.7.85 LU
PRE-RELEASE REVISION-6-11-84-CWE

REVISED 10-7-85 LU
GENERAL REVISION - SEE ALSO SHTS 2-5 - 6-8-84-RLE
PRE-RELEASE REVISION-6-7-84-CWE

I-10-3 (154) PE OF



PHOENIX - CASA GRANDE HIGHWAY
16TH STREET TO 28TH STREET
MARICOPA COUNTY

HILFIKER RSE WALL
STA 7893+26.71 TO STA 7896+70.71
EB CST ℄
RAMP 24-B
SHEET 4 OF 8

I-10 REINFORCED SOIL WALL
24TH STREET TO SALT RIVER BRIDGE

QUANTITY SUMMARY

BARRIER	1,714 L.F.
* STRUCT EXC	22,718 C.Y.
* WALL BACKFILL	17,254 C.Y.
SQ FT WALL FACE	27,487± TOTAL

(* FOR INFORMATION ONLY)

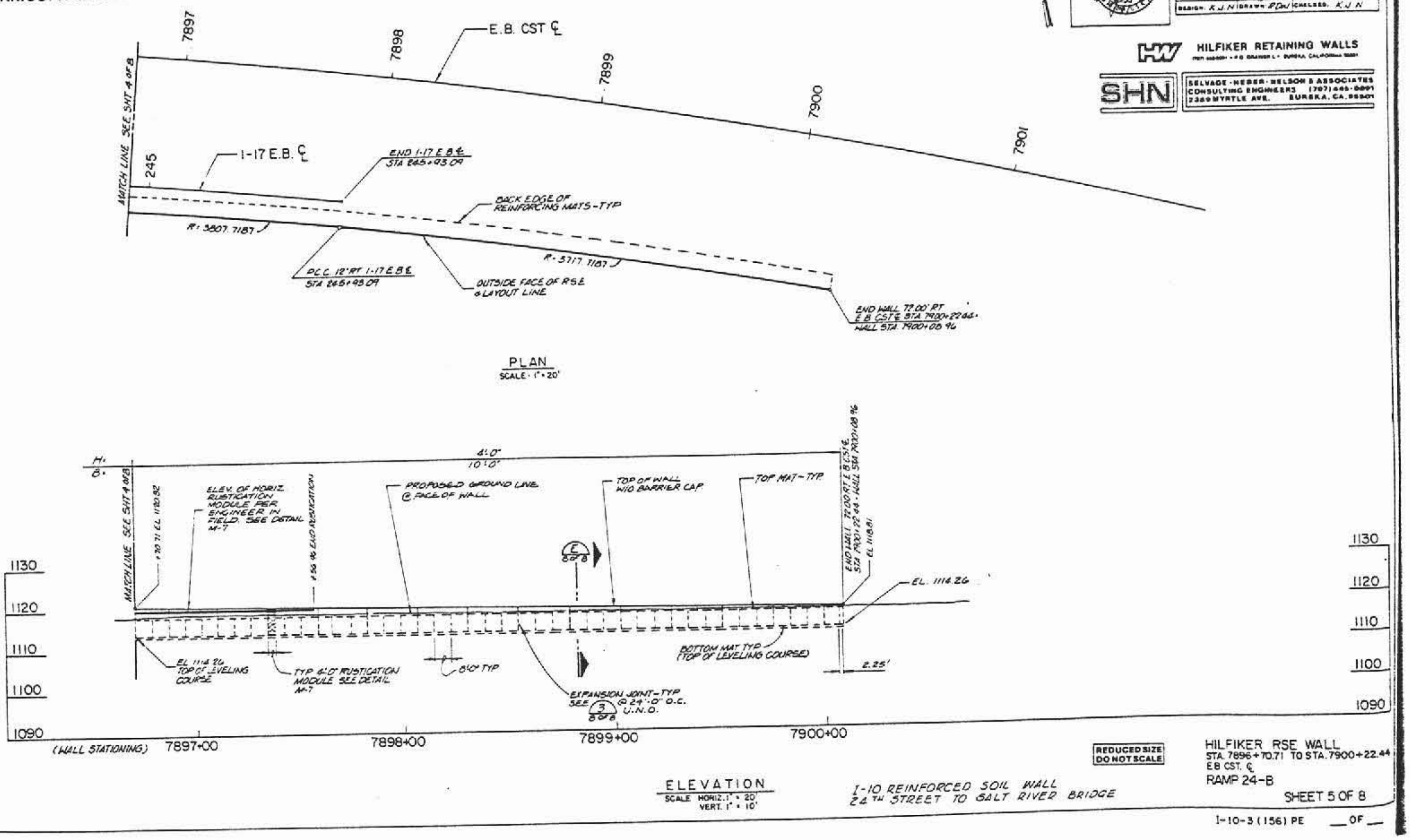
PHOENIX - CASA GRANDE HIGHWAY
16TH STREET TO 28TH STREET
MARICOPA COUNTY

F.H.W.A. REGION	STATE	PROJECT NO	SHEET NO	TOTAL SHEETS	AS BUILT
9	ARIZ	I-10-3(204)	59	533	

9/11/85 DATE
FOR THE CONSULTING ENGINEER
DESIGN K.J.N. DRAWN PDW CHECKED K.J.N.

HILFIKER RETAINING WALLS

SELVAGE · HEBER · NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 445-0891
2389 MYRTLE AVE. EUREKA, CA. 95501



REVISED 10-7-85 LU
OVERALL REVISION - 8-6-85 - PLE
PRE-RELEASE REVISION - 6-3-85 - LMW

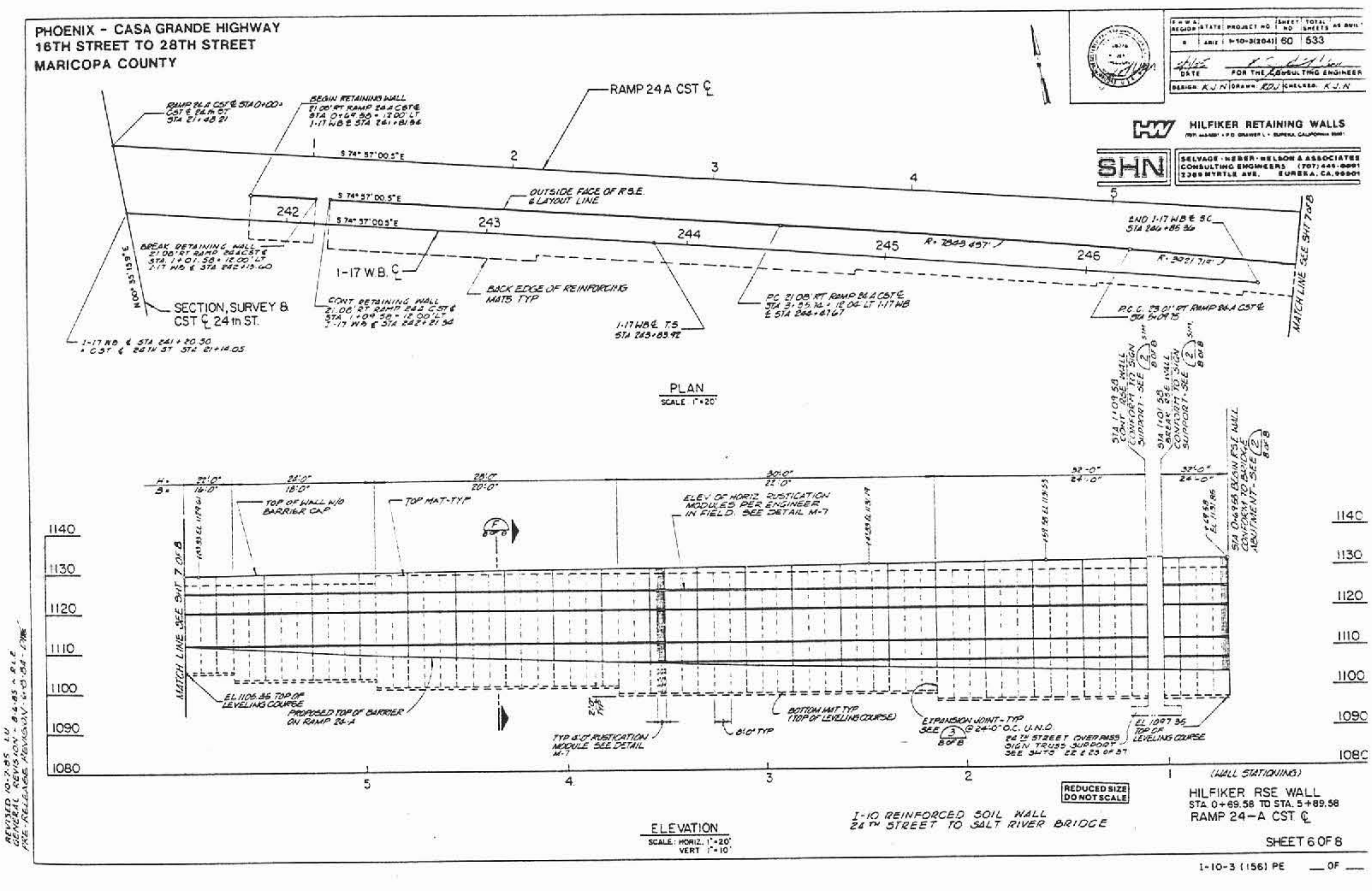
I-10 REINFORCED SOIL WALL
24TH STREET TO SALT RIVER BRIDGE

REDUCED SIZE
DO NOT SCALE

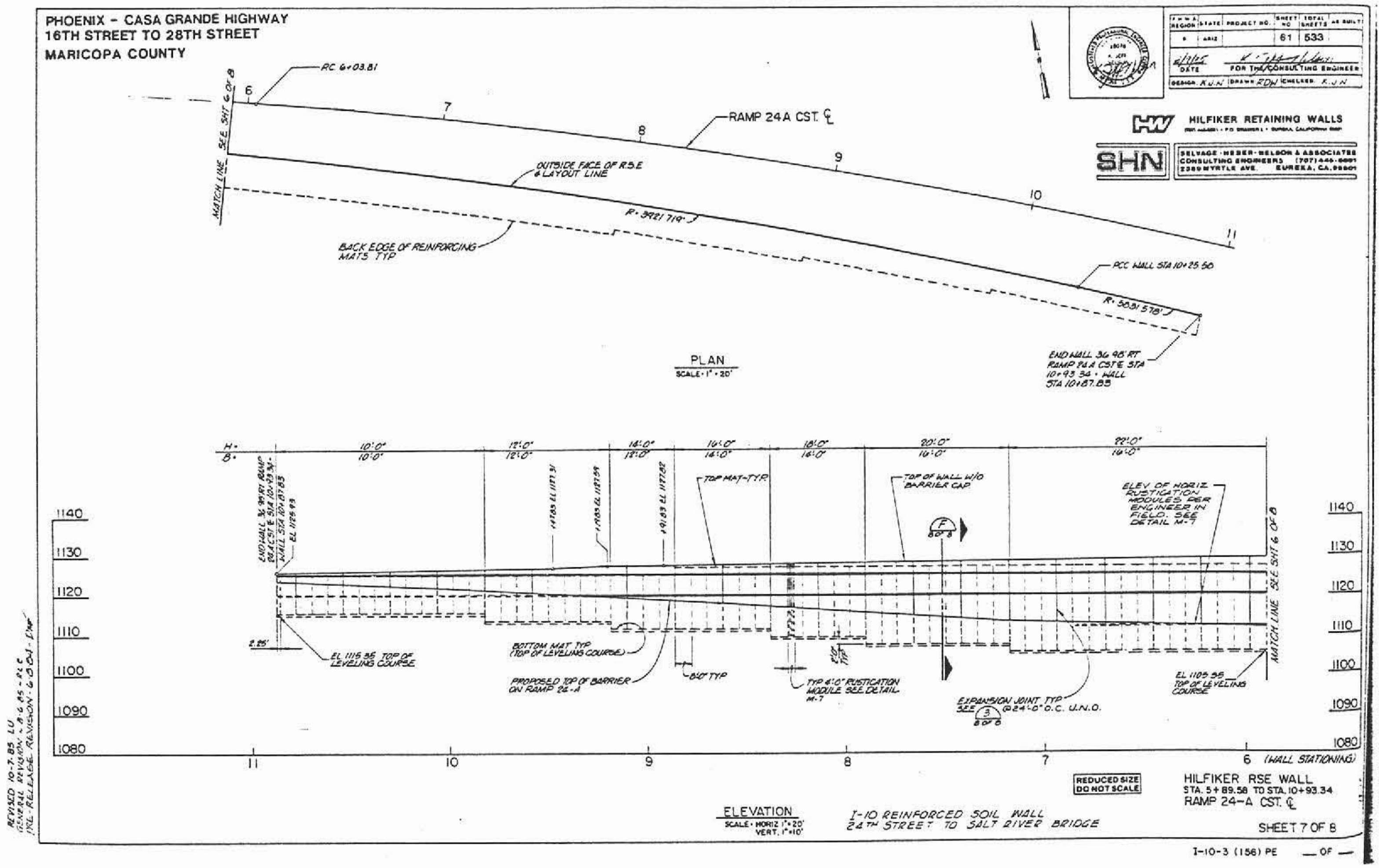
HILFIKER RSE WALL
STA. 7896+70.71 TO STA. 7900+22.44
EB CST. ℄
RAMP 24-B

SHEET 5 OF 8

I-10-3 (156) PE ___ OF ___


PHOENIX - CASA GRANDE HIGHWAY
16TH STREET TO 28TH STREET
MARICOPA COUNTY
F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | AS BUILT
8 | ARIZ | I-10-3(204) | 60 | 533
DATE
FOR THE CONSULTING ENGINEER
DESIGN K.J.N. DRAWN RDJ CHECKED K.J.N.
HILFIKER RETAINING WALLS
SHN
SELVAGE · HEBER · NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 445-8801
2389 MYRTLE AVE. EUREKA, CA. 95501
RAMP 24 A CST ℄
RAMP 24-A CST ℄ STA 0+00 = CST ℄ 24th ST STA 21+48.21
BEGIN RETAINING WALL 21.00' RT RAMP 24A CST ℄ STA 0+69.58 = 12.00' LT I-17 WB ℄ STA 241+81.56
S 74° 57' 00.5" E
OUTSIDE FACE OF R.S.E. & LAYOUT LINE
BREAK RETAINING WALL 21.00' RT RAMP 24A CST ℄ STA 1+01.58 = 12.00' LT I-17 WB ℄ STA 242+13.60
N 00° 35' 15.9" E
SECTION, SURVEY & CST ℄ 24th ST.
I-17 W.B. ℄
BACK EDGE OF REINFORCING MATS TYP
CONT RETAINING WALL 21.00' RT RAMP 24A CST ℄ STA 1+09.58 = 12.00' LT I-17 WB ℄ STA 242+21.56
I-17 WB ℄ STA 241+20.50 = CST ℄ 24TH ST STA 21+14.05
I-17 WB ℄ T.S. STA 243+83.92
PC 21.08' RT RAMP 24A CST ℄ STA 3+55.74 = 12.04' LT I-17 WB ℄ STA 244+47.67
R = 2849.457'
R = 3921.715'
END I-17 WB ℄ SC STA 246+85.36
P.C.C. 23.01' RT RAMP 24A CST ℄ STA 5+09.75
MATCH LINE SEE SHT 7 OF 8
242
243
244
245
246
2
3
4
5
PLAN
SCALE 1" = 20'
STA 1+09.58 CONT RSE WALL CONFORM TO SIGN SUPPORT - SEE 2/8 OF 8 SIM
STA 1+01.58 BREAK RSE WALL CONFORM TO SIGN SUPPORT - SEE 2/8 OF 8 SIM
STA 0+69.58 BEGIN RSE WALL CONFORM TO BRIDGE ABUTMENT - SEE 2/8 OF 8
H = 22'-0" 24'-0" 28'-0" 30'-0" 32'-0" 32'-0"
S = 16'-0" 18'-0" 20'-0" 22'-0" 24'-0" 24'-0"
TOP OF WALL W/O BARRIER CAP
TOP MAT-TYP
F/8 OF 8
ELEV OF HORIZ. RUSTICATION MODULES PER ENGINEER IN FIELD. SEE DETAIL M-7
MATCH LINE SEE SHT 7 OF 8
EL 1106.36 TOP OF LEVELING COURSE
PROPOSED TOP OF BARRIER ON RAMP 24-A
2'-0" TYP
TYP 6'-0" RUSTICATION MODULE SEE DETAIL M-7
6'-0" TYP
BOTTOM MAT TYP (TOP OF LEVELING COURSE)
EXPANSION JOINT - TYP SEE 3/8 OF 8 @ 24'-0" O.C. U.N.O.
24TH STREET OVERPASS SIGN TRUSS SUPPORT SEE SHTS 22 & 23 OF 57
EL 1097.36 TOP OF LEVELING COURSE
1+69.58 EL 1131.86
1140
1130
1120
1110
1100
1090
1080
5
4
3
2
1
(WALL STATIONING)
REDUCED SIZE DO NOT SCALE
ELEVATION
SCALE: HORIZ. 1" = 20' VERT 1" = 10'
I-10 REINFORCED SOIL WALL 24TH STREET TO SALT RIVER BRIDGE
HILFIKER RSE WALL
STA 0+69.58 TO STA. 5+89.58
RAMP 24-A CST ℄
SHEET 6 OF 8
I-10-3 (156) PE ___ OF ___
REVISED 10-7-85 LU
GENERAL REVISION - 8-6-85 - RLE
PRE-RELEASE REVISION 6-13-84 - DRE

PHOENIX - CASA GRANDE HIGHWAY
16TH STREET TO 28TH STREET
MARICOPA COUNTY



F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
8	ARIZ		61	533	

6/7/85
DATE
FOR THE CONSULTING ENGINEER
DESIGN K.J.N DRAWN RDW CHECKED K.J.N

HILFIKER RETAINING WALLS

SELVAGE - HESER - NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 445-8801
2389 MYRTLE AVE. EUREKA, CA. 95501

REVISED 10-7-85 LU
GENERAL REVISION - 8-6-85 - RLC
PRE-RELEASE REVISION - 6-3-85 - DMF

REDUCED SIZE
DO NOT SCALE

ELEVATION
SCALE: HORIZ 1" = 20'
VERT. 1" = 10'

I-10 REINFORCED SOIL WALL
24TH STREET TO SALT RIVER BRIDGE

HILFIKER RSE WALL
STA. 5+89.58 TO STA. 10+93.34
RAMP 24-A CST. ℄

SHEET 7 OF 8

I-10-3 (156) PE — OF —

PHOENIX - CASA GRANDE HIGHWAY
16TH STREET TO 28TH STREET
MARICOPA COUNTY

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ	I-10-3(204)	62	533	

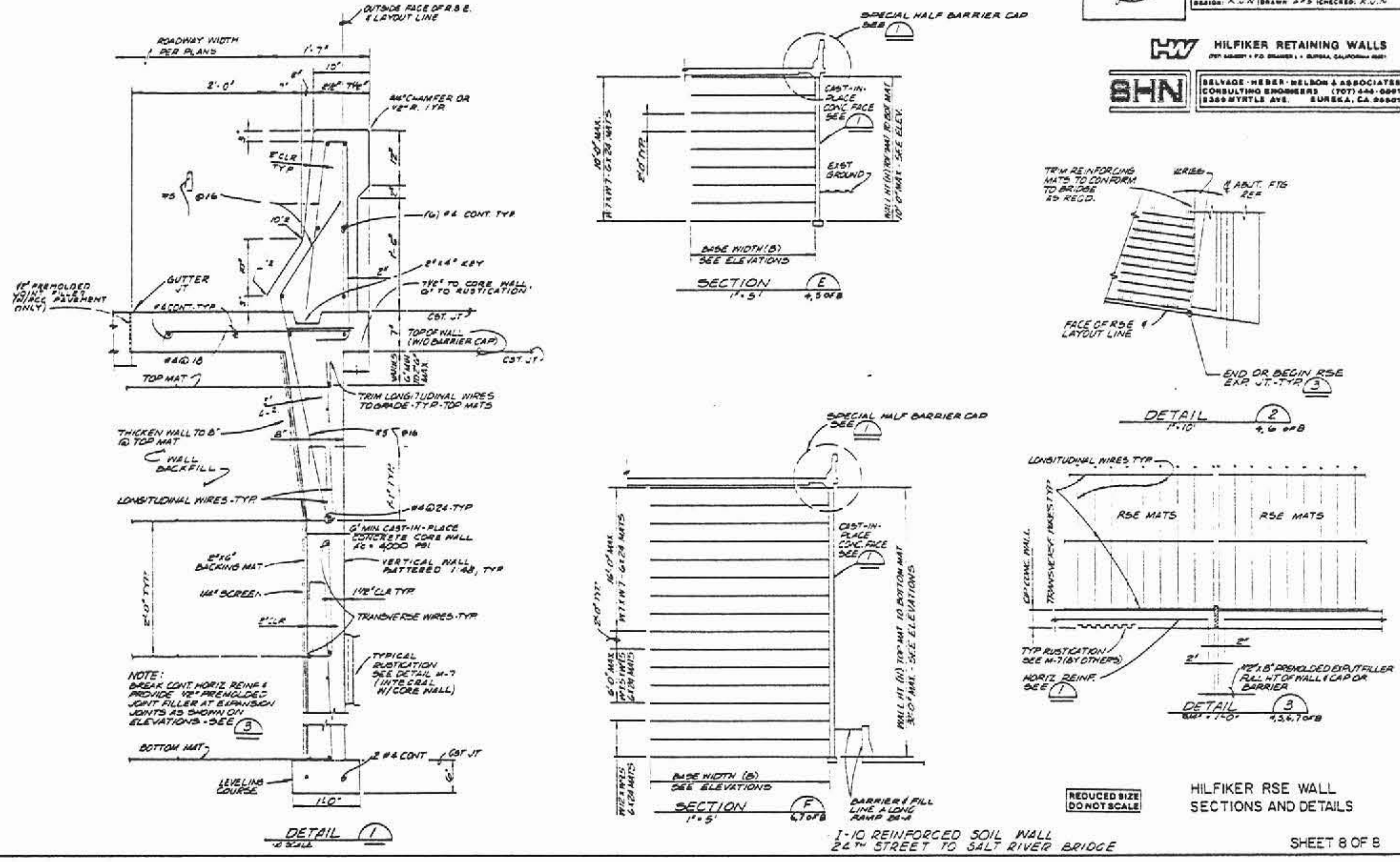
8/1/85
DATE

FOR THE CONSULTING ENGINEER

DESIGN: K.U.N | DRAWN: A.P.S | CHECKED: K.U.N

HILFIKER RETAINING WALLS

SELVAGE · HEBER · NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 444-0001
2380 MYRTLE AVE. EUREKA, CA 95501



REDUCED SIZE
DO NOT SCALE

HILFIKER RSE WALL
SECTIONS AND DETAILS

I-10 REINFORCED SOIL WALL
24TH STREET TO SALT RIVER BRIDGE

SHEET 8 OF 8

I-10-3 (156) PE ___OF___

PHOENIX - CASA GRANDE HIGHWAY
16 TH STREET TO 28 TH STREET
MARICOPA COUNTY

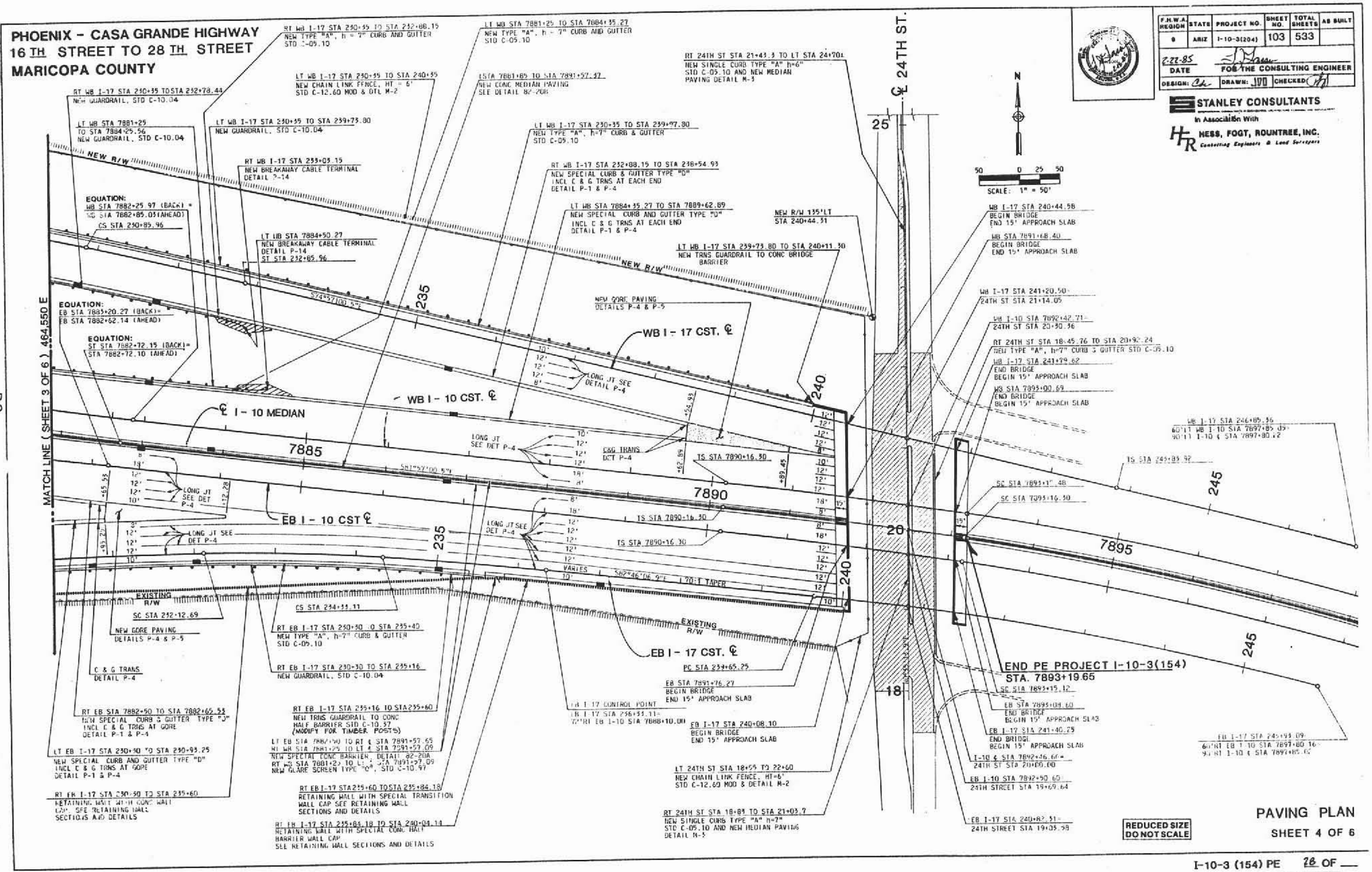
F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ	I-10-3(204)	103	533	

2-22-85
DATE

FOR THE CONSULTING ENGINEER

DESIGN: Ck DRAWN: JVD CHECKED

STANLEY CONSULTANTS
In Association With
HESS, FOGT, ROUNTREE, INC.
Consulting Engineers & Land Surveyors



REDUCED SIZE
DO NOT SCALE

PAVING PLAN
SHEET 4 OF 6

PHOENIX - CASA GRANDE HIGHWAY
16 TH STREET TO 28 TH STREET
MARICOPA COUNTY

SOIL BORING DATA

Project West Papago/Inner Loop Boring No. TP-1 Job No. 21833017
Elev. Top of Hole 1095.5 Datum N.G.S. Prepared By SMM Date 1/13/84
Type/Size of Boring 3' bucket Rig Type Case 980B Backhoe Driller JM Reviewed By MJL Date 1/20/84

Damp	GRAVELLY SAND; some silt, trace cobbles and boulders; dense, damp, FILL	SP	12"	T	5	30	55	10
Damp	SAND, GRAVEL, COBBLES, SOME BOULDERS; cohesionless, very dense, damp, material caves severely below 3' Possible fill No Debris Encountered	SP/GP	12"	5	20	30	40	5
	Stopped @ 11 feet due to severe caving of material below 3 feet							

SOIL BORING DATA

Project West Papago/Inner Loop Boring No. TP-2 Job No. 21833017
Elev. Top of Hole 1095.1 Datum N.G.S. Prepared By SMM Date 1/13/84
Type/Size of Boring 3' bucket Rig Type Case 980B Backhoe Driller JM Reviewed By MJL Date 1/20/84

Damp	GRAVELLY SAND; some silt, trace cobbles and boulders, dense, damp, FILL	SP	12"	T	5	30	55	10
	Landfill in sand, gravel and cobble material Massive concrete blocks 5-6 feet wide and 6-10 inches thick, asphalt, wood and metal scrap, mixed with sand, gravel, cobbles and boulders Hole caving severely as concrete blocks pulled out	SP/GP						
	*Forced to stop @ 18 feet while still in landfill due to severe caving. * Paving contractor adjacent to site estimated the approximate depth limit of the landfill at about 26 feet.							

SOIL BORING DATA

Project West Papago/Inner Loop Boring No. TP-3 Job No. 21833017
Elev. Top of Hole 1095.8 Datum N.G.S. Prepared By SMM Date 1/13/84
Type/Size of Boring 3' bucket Rig Type Case 980B backhoe Driller JM Reviewed By MJL Date 1/20/84

Damp	GRAVELLY SAND; some silt, trace cobbles and boulders, dense, damp, FILL	SP	12"	T	5	30	55	10
	Landfill Massive concrete blocks (5'6' across and 10" thick), asphalt, wood, metal, mixed with sand, gravel, cobbles, boulders. Also 5' lengths of 24" concrete pipe, bricks.	SP/GP						
Damp	SAND, GRAVEL, COBBLES, SOME BOULDERS; cohesionless, very dense, damp	SP/GP	12"	10	20	30	35	5
	Stopped @ 19 feet							

GROUNDWATER CONDITIONS

Date 1/13/84 No Groundwater Encountered X
Date ______ Time ______ Depth ______
Date ______ Time ______ Depth ______

SOIL BORING DATA

Project West Papago/Inner Loop Boring No. TP-4 Job No. 21833017
Elev. Top of Hole 1099.2 Datum N.G.S. Prepared By SMM Date 1/13/84
Type/Size of Boring 3' bucket Rig Type Case 980B backhoe Driller JM Reviewed By MJL Date 1/20/84

Damp	GRAVELLY SAND; some silt, trace cobbles and boulders, dense, damp, FILL	SP	12"	T	5	30	55	10
	Landfill Massive concrete blocks (5'-6' across and 10" thick), asphalt, wood and metal scrap, with sand, gravel, cobbles, boulders	SP/GP						
Damp	SAND, GRAVEL, COBBLES, SOME BOULDERS; cohesionless, very dense, damp	SP/GP	12"	10	20	30	35	5
	Stopped @ 13 feet							

SOIL BORING DATA

Project West Papago/Inner Loop Boring No. 84-135 Job No. 21833017
Elev. Top of Hole 1091.0 Datum N.G.S. Prepared By JPA Date 1/11/84
Type/Size of Boring 7" HSA Rig Type CME 55 Driller MH Reviewed By MJL Date 1/20/84

Damp	SILTY SAND WITH CLAY; dark brown	SM	1/2"	-	-	T	70	30
	begin hitting gravel and cobbles	GP	-	-	10	30	40	20
	Auger refusal @ 3 feet Backfilled 1/11/84							

SOIL BORING DATA

Project West Papago/Inner Loop Boring No. 84-136 (Test Pit) Job No. 21833017
Elev. Top of Hole 1091.6 Datum N.G.S. Prepared By SMM Date 1/13/84
Type/Size of Boring 3' bucket Rig Type Case 980B backhoe Driller JM Reviewed By MJL Date 1/20/84

Damp	GRAVELLY SAND; some silt, trace cobbles and boulders, dense, damp, FILL	SP	12"	T	5	30	55	10
	Landfill Debris mixed with sand, gravel, cobbles and boulders							
	SAND, GRAVEL, COBBLES; some boulders, cohesionless	SP/GP	12"	10	20	30	35	5
	Stopped @ 13 feet							

NOTE: THESE DATA REPRESENT CONDITIONS AT THE LOCATION ON THE DATE THE FIELD WORK WAS PERFORMED AND SHOULD NOT BE INFERRED TO REPRESENT OTHER LOCATIONS OR DATES. SUCH DATA HAVE BEEN OBTAINED EXCLUSIVELY FOR DESIGN PURPOSES AND SHOULD NOT BE CONSTRUED AS PART OF THE CONSTRUCTION PLANS OR AS DEFINING CONSTRUCTION TECHNIQUE.

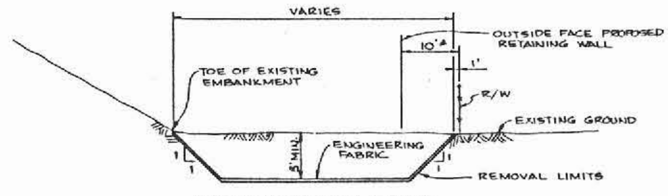
F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ	I-10-3(204)	38	533	

2-22-85
DATE

FOR THE CONSULTING ENGINEER

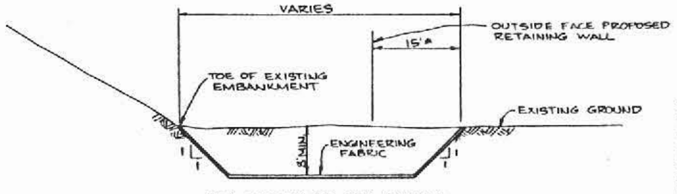
DESIGN: Cde DRAWN: LS CHECKED:

STANLEY CONSULTANTS
In Association With
HESS, FOOT, ROUNTREE, INC.
Consulting Engineers & Land Surveyors



STA. 230+98 TO STA. 235+00

* THIS DIMENSION VARIES BETWEEN STA. 235 & STA. 236



STA. 236+00 TO STA. 239+62

TYPICAL SECTIONS FOR LANDFILL REMOVAL

NO SCALE

APPENDIX E

REDUCED SIZE
DO NOT SCALE

LANDFILL REMOVAL
BORING DATA & SECTIONS

As fill material is placed behind panels, the panels shall be maintained in a vertical position by means of temporary wooden wedges placed in the joints at the junction of the two adjacent panels on the external side of the walls. External bracing will be required subject to the approval of the Engineer. Vertical tolerances (plumbness) and horizontal alignment tolerance shall not exceed 3/4 of an inch when measured along a ten foot straight edge. The maximum allowable offset in any panel joint shall be 3/4 of an inch. The overall vertical tolerance of the wall (plumbness from the top to bottom) shall not exceed 1/2 of an inch per ten feet of wall height.

Backfill Placement:

Backfill placement shall closely follow the erection of panels. At each reinforcing mesh level, backfill shall be roughly leveled before placing and attaching the mesh. Reinforcing mesh shall be placed normal to the face of the wall except for any special conditions shown on the project plans. The maximum lift thickness shall not exceed ten inches before compaction. The contractor shall decrease the lift thickness, if necessary, to obtain the specified density. Backfill compaction shall be accomplished without disturbance or distortion of reinforcing mesh and panels. The entire volume, as shown in the project plans, shall be compacted to 95 percent maximum density as specified in the Specifications. Compaction of the volume shall not be accomplished by sheep foot, grid rollers, or any other type of equipment employing a foot, which in the opinion of the Engineer could penetrate the material and damage the reinforcing mesh. At the end of each day's operation, the contractor shall shape the last level of backfill so as to permit runoff of rainwater away from the wall face.

Surface Stain Coating:

The retaining wall shall be stained in accordance with the requirements specified herein under Section 601.

Hilfiker Reinforced Soil Embankment:

Materials:

Reinforcing Wire and Steel:

All wire and welded wire fabric shall conform to the requirements of ASTM A-82 and ASTM A-185 and shall be galvanized in accordance with the minimum requirements of ASTM A 123.

Reinforcing steel shall conform to the requirements of ASTM A-615, Grade 40 and shall conform to the requirements of Section 1003.

Flat bar shall conform to the requirements of ASTM A-36 and shall be galvanized in accordance with the minimum requirements of ASTM A 123.

Concrete:

Concrete shall be Class S (f'c = 4,000) conforming to the requirements of the Specifications for Section 1006.

Backfill Material:

All backfill material used in the structure volume shall be reasonably free from organic and otherwise deleterious materials and shall conform to the following gradation limits as determined by AASHTO T-27.

Sieve Size	Percent Passing
6 inch	100
3 inch	75-100
No. 4	25 - 60
No. 200	0- 15

Backfill material shall meet the following corrosion requirements:

Resistivity	3,000 Ohm Centimeters (Minimum)
pH	4.5 to 9.5
Chlorides	200 PPM (Maximum)
Sulfates	1,000 PPM (Maximum)

The resitivity and pH shall be tested in accordance with Arizona Test Method 236. Chlorides and sulfate content will be tested in accordance with California Department of Transportation Test Methods 422 and 417 respectively.

Materials not conforming to these specifications shall not be used without the written consent of the Engineer.

The contractor shall furnish the Engineer a Certificate of Compliance certifying the above materials comply with the applicable contract specifications. A copy of all test results performed by the contractor or his supplier necessary to assure contract compliance shall also be furnished the Engineer.

Acceptance will be based on the Certificate of Compliance, accompanying test reports, and visual inspection by the Engineer.

Construction Requirements:

Erection of the reinforced soil embankment (RSE) retaining wall shall be in accordance with the requirements of the Hilfiker Company.

Backfill material shall be compacted to 90 percent of maximum density in accordance with AASHTO T-180. Maximum water content of any backfill material shall be less than or equal to 100 percent of the optimum moisture content as determined for use in accordance with AASHTO T-180.

Prior to the addition of the cast-in-place concrete facing, the wall shall be constructed to the full heights shown on the project plans and time shall be allowed for any anticipated short-term consolidation of foundation soils or construction settlement to occur.

At the end of each day's operations, the contractor shall slope the last level of backfill as to permit runoff of rainwater away from the wall face and off reinforcing mats.

Vertical tolerances (plumbness) and horizontal alignment tolerance prior to constructing the cast-in-place concrete facing shall not exceed 1 1/2 inches when measured along a 10-foot straightedge.

The overall vertical tolerance of the wall (plumbness from top to bottom) after the construction of the cast-in-place facing shall not exceed 3/4 inch per 10 foot of wall height.

Cast-in-place concrete facing shall be colored and textured as specified herein under Section 601.

Basis of Payment:

Payment for this work will be made at the contract lump sum price for ITEM 9140118 and ITEM 9140119, which price shall be full compensation for the items complete, including excavating, concrete leveling pad, special backfill material, cast-in-place cap, rustication, staining, and all materials, as described and specified herein and on the project plans.

Should a change in area of wall constructed be ordered by the Engineer, an adjustment in the lump sum price will be predicated on a square foot cost established by dividing the lump sum price bid by the area shown on the project plans for the particular retaining wall system selected for construction.

Concrete barrier will be paid for under Item 9100006.

SECTION 303 - AGGREGATE SUBBASES AND AGGREGATE BASES:

303-1 Description:

The work under this section shall consist of furnishing, placing and compacting aggregate subbases and aggregate bases in accordance with the details shown on the project plans and the requirements of these specifications.

Aggregate subbases and aggregate bases are designated as Class 1 through Class 6. The class of aggregate subbase and aggregate base will be shown on the project plans or specified in the special provisions.

303-2 Materials:

Aggregate for the various classes of aggregate subbases and aggregate bases shall consist of stone, gravel or other approved inert material of similar characteristics, and shall be clean and free from vegetable matter and other deleterious substances.

Aggregate subbases and aggregate bases shall conform to the requirements shown in the following table for the class specified:

TABLE 303-1
Percent Passing Sieve (Inch or No.)

CLASS OF AGGREGATE	3	1½	1	3/4	1/4	8	200	PI, MAX
1			100	90-100		35-55	0- 8.0	3
2		100	90-100			35-55	0- 8.0	3
3								
4	100				35-70		0-10.0	5
5	100				30-75		0-10.0	5
6								

Notes:

(1) The percentage, by weight, passing each sieve will be determined in accordance with the requirements of Arizona Test Method 201.

(2) The PI (Plasticity Index) will be determined in accordance with the requirements of AASHTO T 90.

(3) Classes 1, 2 and 3 are bases; Classes 4, 5 and 6 are subbases.

(4) The requirements for Class 3 and for Class 6 will be specified in the special provisions.

(5) For Class 1 through Class 4 aggregate, at least 30 percent, by weight, of the aggregate material retained on the No. 8 sieve shall have at least one rough and angular surface which has been produced by crushing, when tested in accordance with the requirements of Arizona Test Method 212.

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(6) Resis
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303-3

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Class 1 A

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Subbas

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303-4

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requirements

Payment for this work will be made at the contract price cubic yard for ITEM 2030201 - EXCAVATION (For Landfill Removal) whi price shall be full compensation for this item complete, including disposal of excavated material and proof rolling, as described and specified herein and on the project plans.

Filter fabric will be paid for under Item 8050111.

Backfill material will be paid for under Items 2030301 or 2030901.

ITEM 2030501 - STRUCTURAL EXCAVATION:
ITEM 2030506 - STRUCTURE BACKFILL:

Additional to the requirements of Subsection 203-5:

The quantities shown in the proposal for these items are for structural excavation and structure backfill for underpass structures and retaining walls.

Where specified on the project plans, structure backfill shall consist of materials conforming to the requirements of Aggregate Base Cl.2. Any overexcavation by the contractor shall be backfilled with the same material specified for structure backfill at that location, except as noted below.

The new pier for the structure supported by a spread footing shall be founded in the material known locally as S-G-C (Sand-Gravel-Cobbles). The S-G-C material is expected to be found at or above the elevation shown on the project plans. Upon excavation to that elevation, if undisturbed S-G-C is not found at or above the planned elevation, excavation shall be extended to undisturbed S-G-C material to the limits determined by the Engineer and unsuitable material removed. The resulting excavation between the elevation to which the excavation has been extended and the planned elevation of the bottom of the footing shall be filled with Class S, f'c = 3,000 concrete to the limit of the footing plan.

Structural excavation and structure backfill for the bridge structure will be paid for as herein specified under "CONSTRUCT STRUCTURES."

Overexcavation and concrete required to fill overexcavation back to planned elevation of bottom of footing for the structure will be paid for as specified under Section 104.03.

ITEM 2030851 - CONSTRUCT DITCH (Concrete Lined):

The work under this item consists of constructing ditches and lining these ditches with concrete at the location and in accordance with the details shown on the project plans. The work shall also include furnishing and installing the trash rack at station 10+55± of the concrete lined ditch.

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Engineer and the
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(B) Backfill:

(1) Structure Backfill:

Structure backfill material shall be selected from excavation or from a source selected by the contractor. It shall not contain frozen lumps, stones larger than three inches in diameter, chunks of clay or other objectionable material. Backfill material to be used for metal piles or similar items of metal shall have a value of resistivity not less than 3000 ohm-cm or the value shown on the project plans, whichever is less. When resistivity is not shown on the plans, the backfill material shall have a value of resistivity not less than that of the existing in-place material or 3000 ohm-cm whichever is less. Backfill material shall have a pH value between 6.0 and 9.0, inclusive, for all installations. Tests for pH and resistivity shall be in Tests for pH and resistivity shall be in accordance with the requirements of Arizona Test Method 236.

Structure backfill material shall conform to the following gradation:

Sieve Size	Percent Passing
3 inch	100
3/4 inch	60-100
No. 8	35- 80
No. 200	0- 12

The plasticity index shall not exceed 12 when tested in accordance with the requirements of AASHTO T 90.

(2) Use of Slurry:

As an alternate to the material requirements of Structural Backfill, the Engineer may allow material conforming to the following requirements to be used in a slurry mixture in situations where the slurry will be confined by free-draining soils:

Sieve Size	Percent Passing
1 1/2 inch	100
3/4 inch	90-100
No. 8	35- 80
No. 200	0- 8

The plasticity index shall not exceed 8 when tested in accordance with the requirements of AASHTO T 90.

If the cause of such condition is determined to have been unforeseeable and beyond the control of and without fault or negligence of the contractor, such further work shall be done as directed and will be paid for as extra work in accordance with the requirements of Subsection 109.04. Excess Moisture caused by irrigation water, storm drainage, weather, breakage of mains, or other similar cause will be considered as within the responsibility of the contractor.

205-3.02 Excavation:

Excavation shall conform with the requirements of Subsection 203-3.

205-3.03 Embankment:

The placement and compaction of embankment shall conform with the requirements of Subsection 203-10.

205-3.04 Compacting and Finishing:

The top six inches of the subgrade shall be compacted to a density not less than 95 percent of the maximum density as determined in accordance with the requirements of Arizona Test Methods 225, 226 and 227, except that when asphaltic concrete or portland cement concrete is to be placed directly on subgrade, the required density shall be 100 percent.

The surface of the subgrade shall be finished to a reasonably smooth and uniform surface and in reasonably close conformity to the lines, grades, dimensions and cross section shown on the project plans or established by the Engineer. The finished surface of the subgrade shall not vary by more than 0.04 of a foot above or below the grade established by the Engineer.

205-4 Method of Measurement:

Measurement of grading roadway for pavement will be made by the square yard of the area prepared and subsequently covered with a subbase, base, asphaltic concrete or portland cement concrete; however, when raised median islands are constructed, the area occupied by these islands will be included in the area measured for payment. Where the new pavement is not bounded by curb and gutter and additional shoulder work is necessary to construct the typical section shown in the project plans, such work shall be considered as incidental and the cost will be considered as included in the cost of the contract bid item Grading Roadway for Pavement.

205-5 Basis of Payment:

The accepted quantities of grading roadway for pavement, measured as provided above, will be paid for at the contract unit price per square yard for the work complete as specified herein and as shown on the project plans.

SECTION 206 - FURNISH WATER SUPPLY:

206-1 Description:

The work under this section shall consist of either developing or obtaining an adequate water supply and furnishing all water required for the work.

F7

Water to be used in the co
the watershed area of t
Association may be obtaine
or other sources within
expects to obtain water fr
an agreement with the ass
Water Exchange Permit.
sources until the contract
completely executed copy o
are available from Contrac

206-2 Blank

206-3 Construction Requi

The use of pressure pump
equipment used on the roa
gravity flow spray bars
permitted.

Material may be watered ei
at the option of the contr

If the contractor elects
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paid for on the basis of
ample notice of his inter
water, the contractor shal
may be necessary to enabl
determining the in-plac
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content of the material
moisture content of the
be deducted from the tota

206-4 Method of Measure

The work will be measured

206-5 Basis of Payment:

Payment for this work wi
price.

No adjustment of compens
for furnish water suppl
decrease in the quantity
reason for such increase

When it is required that
water for the suppressio
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for as in accordance with

The cost of providing a w
delivering the water; and
the compaction of the ma
but will be considered a
various contract items re

HILFIKER
IFR 10.3 (204)

#19	10-1-86	TO DIST Resist & pH only		
#20	10-1-86	TO DIST - MATL FROM Portable Screen used in pep & BM - AB02 used on Hilfiker Wall for plating. Resist & pH		
#21	10-10-86	[illegible] sample Taken of [illegible] pH & Resisty, informed D. Se[illegible]	Resist 2601 pH 8.8	RAMP #4 #4B 5'
#22	"	RESISTY 5469 pH 9.0		RAMP NW - #3B - 12'
#23	"	RESISTY 6670 pH 9.1		RAMP NW - #2B 30'
#24	"	RESISTY 6337 pH 9.0		RAMP NW #1B - 31
#25	"	RESISTY 6670 pH 9.1		RAMP #4 - 1A
#26	"	RESISTY 8004 pH 8.8		RAMP #4 2A
#27	"	RESISTY 10.339 pH 9.3		RAMP #4 - 3A
28	10-16-86	STKPL - TANNER would like to use it RESISTIVITY - 2001 pH - 8.8		10-21-86

Roadway Exc.

Contractor [illegible] the [illegible] would not [illegible] sample.

None Cl_2 & SO_4

44-3934 4/77 (Formerly 44-9115)

II R (10-3(204)

ARIZONA DEPARTMENT OF TRANSPORTATION
MATERIALS SERVICES
MISCELLANEOUS DATA CARD

Sample taken 9-12-86

Not From Stockpile

TANNER ~~Bo~~ Dug Test ~~at~~ holes different ~~ft~~ Elevation

#11 9-16-86 Hole #1 approx 6' depth Hi Ramp (EM)

Dist - 3685 Taken to Central Lab to run Resistivity
PH - 8.1 Recom Info 9-16-84
ADOT #11 - 3183 TANNER - 3640

#12 9-16-86 Hole # 3 ≈ 18' deep - (EM)
Recom Info 9-16-84
Dist 3350 rerun * ADOT #12 - 2801 TANNER - 3150
PH - 8.5

Test site
#13 ~~Hole~~ #5 ≈ 4' deep - EM - Hi Ramp
CONTRAL
Dist 10 050 ADOT #13 - 9338 TANNER - 9800
pH 8.5

Test Site
#14 ~~Hole~~ #7 ≈ 2' - EM - Hi Ramp
9-16-84 CONTRAL
Dist - 4087 after rerun * ADOT #14 - 3802 TANNER - 10,500
pH 7.9

Test ~~a~~ site
#15 ~~Hole~~ #9 ≈ 15' (EM) Hi Ramp
9-16-86 9-16-84 Central
Dis - 5427 ADOT #15 - 4736 TANNER 5390
pH 9.1

Test Site
#16 ~~Hole~~ #11 ≈ 10' (EM) Hi Ramp
9-16-84 9-16-84 Central
Dist - 3953 ADOT #16 - 3168 TANNER - 3640
pH 8.8

#17 Test Site #13 ≈ 3' (EM) Hi Ramp
Dist - 6633 ADOT #13 - TANNER - 5740
pH 8.5

#18 Test Site # 15 ≈ 8' (EM) Hi Ramp
Dist 5561 ADOT #18 TANNER - 5110
pH 8.9

† ● 44-3934 4/77 (Formerly 44-9115)

White ☒ Jbs
Yellow ☐
Blue ☐

MATERIALS SERVICES
BF

0269069 ORG 4841
I-10-3(204) P/N P
TS20 A.C. 96970 Fund Code 81603
9/19/86 Amt. 427.00

Received 9-18-86 Test Commenced 9-19-86 Material Soil/Aggregate
Identification 454-461 Sampled 9-12-86 Lab. No. 86-27921
Submitted by Schotka Sampled by Jenkens Project No. I-IR10-3(204)
Source of Sample project Quantity
Location of Supply Tanner
Project Name Phoenix - Casa Grande Hwy Contractor Tanner
Specifications Governing
Remarks

Test Results

	#11 454	12 455	13 456	14 457	15 458	16 459
Chloride:	none	none	none	none	none	none
Sulfate:	none	none	none	none	none	none
	17 460	18 461				
Chloride:	none	none				
Sulfate:	none	none				

Douglas A. Forstie
SEP 23 1986
MATERIALS TESTING ENGINEER

CAPITAL LETTERS

LAB NUMBER	PROJ CODE	MATL	TYPE	PURPOSE	TESTING LAB	SPEC #	SIZE	SIZE %
G 1 481	1167	SB		A	C	2		

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO. DAY YEAR	TIME
32		JENKINS	08 02 87	0930

LIFT NO.	SAMPLED FROM	RDWY	STATION	PLUS
	HILLEKER - STEPL C. PLT			

IF MILEPOST INPUT DECIMAL IN COL. 69

P = PIT
E = EXC.
I = IN PLACE

ORIGINAL SOURCE	RDWY	STATION OR PIT NO.	PROJECT NUMBER	PROJECT ENGINEER
P		CALMAT	IIR10 3(214)	SCHOTT

IF MILEPOST, INPUT DECIMAL IN COL. 78

REMARKS **USE CAPITAL LETTERS**

G 2 NEED CL + SO4 ASAP

Spec Prov pg 310

CENTRAL 3Bs

KEYPUNCH INSTRUCTIONS: Duplicate col. 3 thru 7 on all cards

G 3 % OVERSIZE ARIZ 201 +3" D +6" D COARSE FACTOR (no punch)

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3" ☐	0				
2½"	460				
2"	700				
1½"	920				
1"	500				
3/4"	1000				
1/2"	1110				
3/8"	580				
1/4"	660				
#4	380				
-#4	9130				
Total	15440				

G 4 WT PASS #4 SPLIT FINE SIEVE FACTOR (no punch)

	WEIGHTS RETAINED	% RET.	% PASS		
#8					
#10					
#16					
#30					
#40					
#50					
#100					
#200					
-#200					
Total	Dry Weight				
Elutriation					

T = AASHTO Tests
C & D = ASTM Tests

			SPECS
Liquid Limit, (LL)	T-89 D-423		
Plastic Limit (PL)	T-90 D-424		
Plasticity Index (PI) = LL − PL	T-90 D-424		

Abrasion (A,B,C,D,)	T-96 C-131		
@ 100 Revolutions		%	%
@ 500 Revolutions		%	%

Absorption, H_2O	ARIZ 211 T 85 C 128	%	
Specific Gravity, SSD			
Specific Gravity, OD			

Sand Equivalent,	T-176 D-2419 ARIZ 242 (MAFC)		

Fractured Faces Weight (W_f)	(np)	g	
Total Sample Weight (Wa)	(np)	g	
Fractured Faces FF = $\frac{W_f}{W_a} \times 100$	ARIZ 212	%	%

Wet Weight (W)	(np)	g	
Dry Weight (D)	(np)	g	
Moisture Content = $\frac{W-D}{D} \times 100$	T-255 C-566	%	

FLAKINESS INDEX	ARIZ 233	%	%

ph	Ariz 236 or 237	7.4	
Resistivity (ohm-cm) Ariz 236		5360	

FINENESS MODULUS = $\frac{\text{TOTAL CUMULATIVE \% RET.}}{100}$

NECESSARY FOR ALL FA & CA

chloride: 24ppm
sulfate: none

TEST OPERATOR

LABMAN, PROJECT SUPERVISOR, OR RESIDENT ENGINEER

44-9353 R5/86

SEE BACK ALSO

SOIL, AGGREGATE, & ASPHALTIC MIXES

USE CAPITAL LETTERS

LAB NUMBER	PROJ CODE	MATL	TYPE	PURPOSE	TESTING LAB	SPEC #	SIZE	SIZE %
G 1 3081	1167	SB		A	D	2		

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO. DAY YEAR	TIME
32		JENKINS	080287	0930

LIFT NO.	SAMPLED FROM	RDWY	STATION	PLUS
	HILFIKER - STKPL @ PIT			

IF MILEPOST INPUT DECIMAL IN COL 69

P = PIT
E = EXC.
I = IN PLACE

ORIGINAL SOURCE	RDWY	STATION OR PIT NO.	PROJECT NUMBER	PROJECT ENGINEER
P		~~CAL-MAT~~	ITER10-3(201)	SCHOTKA

IF MILEPOST, INPUT DECIMAL IN COL. 78

REMARKS USE CAPITAL LETTERS

G 2 NEED RESIST, PH, Cl_2 + SO_4 (ASAP)

Spec Prov pg 310

DIST [illegible]

KEYPUNCH INSTR [redacted] thru 7 on all ca

KEYPUNCH INSTRUCTIONS: Duplicate col. 3 thru 7 on all cards

"100%

% OVERSIZE ARIZ 201

	+3" ☐	+6" ☐	COARSE FACTOR (no punch)
G 3			.007157

J ✓
13

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3" ☐	~~0~~	~~0~~	100	75-100	
2½"	~~0~~	~~0~~	100		
2"	854	6	94		
1½"	817	6	88		
1"	749	5	83		
3/4"	874	6	77		
1/2"	999	7	70		
3/8"	491	4	66		
1/4"	636	5	61		
#4	309	2			
-#4	8244		59	25-60	
Total	13973				

	WT PASS #4	SPLIT	FINE SIEVE FACTOR (no punch)
G 4	474		.124473

	WEIGHTS RETAINED	% RET.	% PASS		
#8	38	5	54		
#10	8	1	53		
#16	31	4	49		
#30	127	16	33		
#40	79	10	23		
#50	68	8	15		
#100	66	8	7		
#200	22	3			
-#200	7		4.4	0-15	
Total	440 Dry Weight				
Elutriation	34				

T = AASHTO Tests
C & D = ASTM Tests

			SPECS
Liquid Limit, (LL)	T-89 D-423		
Plastic Limit (PL)	T-90 D-424		
Plasticity Index (PI) = LL − PL	T-90 D-424		
Abrasion (A,B,C,D,)	T-96 C-131		
@ 100 Revolutions		%	%
@ 500 Revolutions		%	%
Absorption, H_2O	ARIZ 211 T 85 C 128	%	
Specific Gravity, SSD	" "		
Specific Gravity, OD	" "		
Sand Equivalent,	T-176 D-2419 ARIZ 242 (MAFC)		
Fractured Faces Weight (W_f)	(np)	g	
Total Sample Weight (Wa)	(np)	g	
Fractured Faces FF = $\frac{Wf}{Wa} \times 100$	ARIZ 212	%	%
Wet Weight (W)	(np)	g	
Dry Weight (D)	(np)	g	
Moisture Content = $\frac{W-D}{D} \times 100$	T-255 C-566	%	
FLAKINESS INDEX	ARIZ 233	%	%
ph	Ariz 236 or 237	8.9	4.5-9.5 X
Resistivity (ohm-cm) Ariz 236		5360	3000 X

File

K3
8.14

FINENESS MODULUS	

FINENESS MODULUS = $\frac{\text{TOTAL CUMULATIVE \% RET.}}{100}$

NECESSARY FOR ALL FA & CA

PLL 8/14

TEST OPERATOR

Phillip Zladuvich

LABMAN, PROJECT SUPERVISOR, OR RESIDENT ENGINEER

44-9353 R5/86

SEE BACK ALSO

G 5

ARIZONA DEPARTMENT OF TRANSPORTATION

DAILY COMPACTION LOG

JANUARY 10, 1987

PROJECT # = I-IR-10-3(204)

NAME = 16TH ST - 28TH ST

RE/SUPERVISOR = D. A. SCHOTKA

CONTRACTOR = TANNER

MATERIAL = BACKFILL 01

SPEC. = 50 %

TEST NO	DATE	TESTED BY	LOCATION OF TEST	SOURCE OF MATERIAL	P #	M	ABS	SP. GR	OPT H20 --NO 4	PROCTOR --NO 4	%RET NO 4	ADJ. PROC	FIELD MOISTURE --NO 4	ADJ	FIELD DENSITY	% COMP
1	09/30	NICHOLS	24ST SW WALL		1	L	0.00	2.66	9.8	123.8	48.2	136.2	3.3	5.6	141.0	%103.5
		Hilfiker Wall, material from Union Rock														
2	09/30	NICHOLS	24ST SW WALL		1	L	0.00	2.66	9.8	123.8	47.7	136.1	3.9	5.6	131.8	96.8
		Hilfiker Wall, matl from Union Rock														
3	10/02	CRAFT	8' BK WALL		1	L	0.00	2.60	9.8	123.8	33.8	131.3	4.4	6.8	126.1	96.0
		Hilfiker Wall, Ramp 24 A														
4	11/03	AUER	RT C/L I-10		1	L	0.00	2.60	9.8	123.8	45.9	134.0	6.2	5.8	134.8	%100.6
		Hilfiker Wall, SW wall 24ST														
5	10/03	CRAFT	11' BK FC WALL		1	L	0.00	2.60	9.8	123.8	24.3	129.2	5.2	7.7	130.9	%101.3
		Hilfiker Wall, Ramp 24 A														
6	10/03	CRAFT	9' BKFC		1	L	0.00	2.60	9.8	123.8	36.2	131.9	4.1	6.6	130.6	99.0
		Hilfiker Wall, Ramp 24 A														
7	10/06	CRAFT	9' BKFC WALL		1	L	0.00	2.60	9.8	123.8	52.4	135.5	5.7	5.2	130.5	96.3
		Hilfiker Wall, Ramp 24 A														
8	10/07	MCCANDLE	SW WALL 24TH ST		1	L	0.00	2.60	9.8	123.8	47.9	134.5	3.3	5.6	136.0	%101.1
		Hilfiker Wall														

PROJECT LABMAN ____________ DATE 1-10-87 RE/SUPERVISOR ____________ DATE 2-13-87

4-16-87

6

LAB NUMBER	PROJ CODE	MATL	TYPE	PUR-POSE	LAB	SPEC #	SIZE	
G 1	1167	BF	AB	V	P			

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO. DAY YEAR	TIME
.6		WAlKER	09 08 87	13:00

LIFT NO.	SAMPLED FROM	RDWY	STATION	PLUS
	Hilfiker RAmp 2A-B		7893	50

P = PIT
E = EXC.
I = IN PLACE

ORIGINAL SOURCE	RDWY	STATION OR PIT NO.	PROJECT NUMBER
I			IIR10-3-(204)

IF MILEPOST, INPUT DECIMAL IN COL. 78

IF MILEPOST, INPUT DECIMAL IN COL. 69

REMARKS

USE CAPITAL LETTERS!

G 2 permanent wall Step 1 lift 2

KEYPUNCH INSTRUCTIONS: Duplicate col. 3 thru 7 on all cards

G 3 14.06-1.88 8.19-1.88

A. TOTAL WET WEIGHT OF MATERIAL FROM THE HOLE	12.18	LB
B. WET WEIGHT OF MATERIAL RETAINED ON #4 SIEVE	5.92	LB
C. WET WEIGHT OF MATERIAL PASSING THE #4 SIEVE = A - B	6.26	LB
D. MOISTURE OF THE MATERIAL PASSING THE #4 SIEVE	5.8	%
E. MOISTURE CORRECTED FOR MATERIAL RETAINED ON #4	3.5	%

a. RETAINED ON #4 = $\frac{B}{A} \times 100$ 48.6 %

IF RETAINED ON #4 IS MORE THAN 50% (60%, IF AB), GO NO FURTHER

$E = \frac{D(100 - a) + a}{100}$; if M > 4.00, $E = \frac{D(100 - a) + a M}{100}$ 51.4

VOLUMETER DENSITY

FINAL	.768	CF
G. BEGINNING	.072	CF
H. VOL. OF HOLE = F - G	.096	CF
I. WET DENSITY = $\frac{A}{H}$	126.9	PCF
J. DRY DENSITY = $\frac{I}{100 + E} \times 100$	122.6	PCF

PROCTOR DENSITY

PROCTOR NUMBER		
PROCTOR METHOD (A, C, D, or I)		
K. OPTIMUM MOISTURE	.	%
L. MAXIMUM DRY DENSITY	.	PCF

ADJUSTMENT FOR RET. #4 & COMPACTION CALCULATION

M. ABOSRPTION OF RET. #4 (AASHTO T-85 & ASTM C-127)	.	%
N. SPECIFIC GRAVITY OF RET. #4 (OVEN DRY BASIS)	2.625	
O. ADJUSTED OPTIMUM MOISTURE	5.8	%
P. ADJUSTED MAX DRY DENSITY	134.9	PCF
COMPACTION = $\frac{J}{P} \times 100$ OR $\frac{J}{L} \times 100$	90.8	%
COMPACTION SPECIFICATION	90.0	%

G 4

ONE POINT PROCTOR (ARIZ 232)

b. WEIGHT OF MOLD & SOIL	.	LB
c. WEIGHT OF MOLD	.	LB
d. WEIGHT OF COMPACTED SOIL = b - c	.	LB
e. WET DENSITY = d x 30	.	PCF
f. WEIGHT OF WET SOIL	.	LB
g. WEIGHT OF DRY SOIL	.	LB
h. WEIGHT OF WATER = f - g	.	LB
MOISTURE CONTENT = $\frac{h}{g} \times 100$	.	%
FAMILY OF CURVES NUMBER	1	
K. OPTIMUM MOISTURE	10.3	%
L. MAXIMUM DRY DENSITY	123.0	PCF

FOR METHOD A OR ONE-POINT ONLY

$O = \frac{K(100 - a) + a}{100}$; if M > 4.00, $O = \frac{K(100 - a) + a M}{100}$ 51.4

$P = \frac{(100 - a) L + 56.2 a N}{100}$

Don Walker

DENSITY TEST OPERATOR

MATERIALS SERVICES

VOLUMETER DENSITY (ARIZ 231)

44-9348 R1/81

H2

RESIDENT ENGINEER, PROJECT SUPERVISOR, OR LABMAN

APPENDIX I

Introduction

For more than 20 years, Symons has been perfecting the products and methods essential to successful architectural concrete. Today, Symons Form Liners, Chemicals and comprehensive Form Liner Application Guides are your best assurance of aesthetically pleasing, economical, trouble-free and efficiently formed architectural concrete in the full range of industrial, commercial, institutional, municipal and residential applications.

ELASTO-TEX® Form Liners are Symons finest form liners, combining great resilience and high tensile strength. They provide superior toughness and wear resistance so that reproduction of even the most difficult undercut designs and complex textures is consistent, even after many re-uses.

Form Liners are not difficult to use; they do, however, require attention to details. This application information is provided to highlight these details and to provide general procedures to assure aesthetically pleasing results and maximum economy in using form liners.

Form Joints

Most liners are supplied in large sheets. 4' x 10' and 4' x 12' (122 x 305cm and 120 x 365cm), to minimize the number of joints and maximize the reuse of the liner.

When textured areas of greater overall height than the form liner are required, a special liner length should be ordered or a rustication strip should be used. Liners butted end to end will leave a visible line. particularly noticeable with random or vertical patterns.

When using textures with a strong vertical pattern, such as ribbed and fractured rib looks. the pattern dimensions should be constantly considered to achieve an overall balanced design and to avoid joints at any points other than along one of the liners' main features. All form liner joints should be made along the liner's main features.

Pattern features should also be anticipated when forming boxouts for doors, windows, mechanical openings, etc., to assure a proper finished appearance.

In general, butt joints between liners. either horizontal or vertical, should be avoided. It is very difficult and time-consuming to match the features of a liner to make it appear continuous. Very slight differences in shape, thickness, texture, etc., between the ends of liners will produce a distinguishable mark on the finished concrete, even from distances of 30' (10m) or more. It is more advisable and easier to use a rustication strip to accentuate the joint, rather than attempt to hide it.

Certain liner designs having random patterns, cannot be matched either horizontally or vertically. A rustication strip is always advised when making joints with such patterns.

If it is necessary to make a butt joint with liners, care should be taken to eliminate grout leakage, even if the surface is to be sandblasted later. Sandblasting the concrete to clean up grout leakage at a butt joint can rarely be done to exactly match the original pour.

Cold Joints

Horizontal rustication strips should be used for all cold joints. In certain cases, these strips can be built into the form liner, reducing misalignment or leakage risks. A pour should never be stopped part way up a liner; the joint will be very apparent in the finished concrete.

Rustication Strips

Rustication or feature strips, if made of wood, must be beveled, kerfed, sealed and well oiled, to facilitate stripping. New wood, if not sealed or prewashed with cement and water slurry, may cause stains or dusting on the concrete the first few times used.

Symons offers over 20 different types of rustication strips, in 10' (305cm) lengths, of ELASTO-TEX material molded around a wood or metal-strip core.

This construction provides a strip which resists concrete pressures without reinforcing, is stiff, straight and yet can be readily bent to conform to radius forms. It is also reusable many times.

All strips can be secured to wood-faced forms with 6d or 8d finishing nails on 10" to 12" (25 to 30cm) spacing. The ELASTO-TEX material allows the nail heads to be embedded and hidden.

Rustication strips with 1" (25mm) or wider cores can also be attached with screws inserted from the back of the form through predrilled holes in the plywood or steel form faces; or, by counter-sinking bolts or screw heads in the face of the strip, and securing through predrilled holes in the form face.

Formwork

ELASTO-TEX Form Liners can be used with any concrete forming system; however, the most economical results can be obtained with ganged forms. Gang-form application, using adhesive for liner attachment, allows many reuses from a one-time attachment of liner pieces; and, also minimizes the number of joints to caulk on each use. Liners can be attached directly to loose or fixed plywood, which is then mechanically attached to the forms. Symons also can provide form liners, factory-attached to plywood.

NOTE: Adhesive will not adhere adequately to plywood or forms that have been treated with form release oil.

Attaching Liners

For best results, liners should have beveled edges to eliminate grout leakage at joints and should overhang forms and/or plywood approximately 1/32" (1mm) at all beveled edges to assure a tight joint during form erection. Recommended adhesive is RESI-CHEM P-1241, 2-part system.

ELASTO-TEX Form Liners expand and contract with temperature changes. For this reason, these liners are supplied with 1" to 2" extra trim length. It is best to install ELASTO-TEX Form Liners in ambient temperature conditions near the higher level expected during placing of concrete. Liners must be adequately secured as described above, but if the liner is installed warm, it will simply contract when cooled. Care must be taken to prevent the liner from attaining a temperature of 140° F (60° C), at which point thermal deformation will take place. Liners attached cold, then subjected to heat, will buckle unless adhesive is applied according to manufacturer's instructions.

Never apply the adhesive at temperatures below 50° F or above 95° F (10-27° C) air or surface (form and/or liner) temperature. If the temperature is too low, the adhesive will not cure properly. If the surface temperature is too high, the adhesive will set quickly. Keep plywood and liner from exposure to direct sunlight, which can raise the temperature of the surface well above actual air temperature.

Methylene chloride can be used for cleaning adhesive off tools and forms. Serrated trowels should be cleaned between each use to avoid build-up.

Installing Liners on Gang Forms

(*Liners with Butt Joints*)

NOTE: A kit is available from Symons to facilitate attachment of liner to plywood. It includes trowel, cleaning solvents, measuring cups, cotton rags, a carpet knee kicker and other items.

1. Level the form so that liner can be glued in a horizontal rather than vertical plane. Square lines and liner joint lines should be snapped prior to liner installation.
2. Brush off the form and the back side of the liner to remove dirt and dust. It is also advisable to roughen the surface of HDO plywood and the liner to provide better key for the adhesive. Remove any grease or oil from form faces with M.E.K., tyluol, xylol or a mixture of aromatic solvents (Chem Central #10, Ashland Chemical #100 or equal). Clean the back of ELASTO-TEX Form Liner of any dust and dirt and wash with methylene chloride. Use 100% cotton rags with any of the above solvents. Rubber or plastic gloves and other protective clothing should be used as recommended by solvent manufacturer.
3. Postion the liner on the form so that its grooves and joints are aligned with the form.
4. Roll back half of the liner onto itself.
5. Prepare the adhesive in the quantity needed. The coverage rate varies, but is usually 80 to 100 sq. ft./gal. when troweled, and up to 150 sq. ft./gal. when applied by roller in a thin coat.
6. With a paint roller, spread the adhesive uniformly onto the plywood form face and the back of the liner in a moderately thin coat.
7. Check along edges and at corners to be sure adequate adhesive has been applied to assure adhesion at these critical locations.
8. Roll half the liner back onto the tacky adhesive as soon as possible after applying the adhesive. This rolling action tends to eliminate air bubbles between the liner and the form.
9. Position edges and corners, and secure them with wooden tack strips secured with crating staples or box nails, approximately 3" o.c. Allow 1/32" (1mm) overhang at edges of gang form. Liners can be stretched or compressed to fit the form dimensions. A carpet-laying tool can be used for this step. Additional tack strips should be installed on approximate 12" centers, or as liner configuration dictates to assure dimensional stability.
10. Repeat the process with the other half of the liner immediately. Do not leave a liner piece half-glued. Assembled liner must be kept flat and out of direct sunlight for 48 hours to prevent buckling or blistering during the curing process.
11. Before adhesive sets, clean off excess at liner joint line, and along form sides, so it will not harden and interfere with the resilient properties of the liner edges, or add dimension to gang form.
12. Carefully position the next liner, butting it firmly against the glued liner. This joint should be compressed as tightly as possible without buckling the liner.
13. Check that edges, grooves and joints are aligned with the first piece and the form.
14. Hold the half of the liner that is farthest from the joint firmly in place with tack strips. Then, roll back the half of the liner butting against the previously placed piece.
15. Repeat steps 6 through 11 until the gang is covered.
16. If any dressing of the liner at gang edges is required, use a sander with #36 or #24 grit belts or discs. If trimming is required, liner can be cut with utility knife or a knife blade in a saber saw.
17. When adhesive is set and at least 70% cured (next day), remove all tack strips, nails, staples, or other mechanical attachments. Remove any dirt or debris, and oil the liner. Care should be taken that the oil

reaches and adheres to all facets of liner face. This may require scrubbing or brushing, depending on pattern and number of uses.

CAUTION: If liner is not to be used immediately, cover to prevent sunlight deterioration.

Installing Liners on Hand-Set Forms

1. Assemble and brace the architectural side of the formwork first. Do not set ties.
2. Attach form liners before setting opposite side, or ties.
3. Position the liner against the form so that its edges, grooves and joints are aligned with the form or squared lines.
4. Tack top edge of liner to forms with finishing nails on 6" (15cm) centers (approximate).
5. Using finishing nails, nail one side edge of the liner to the form.
6. Check overall form liner alignment dimensions and position.
7. Continue using finishing nails across the liner, starting at the edge previously nailed.
8. Counter-sink all finishing nails below liner face, and add nails if necessary to assure secure attachment to form.

Installing Liners on Loose Plywood for Mechanical Attachment to Forms

1. Liners are attached to 1/2" or greater plywood in the same way as on gang forms. Proceed with steps 1 through 11 of method for gang forms, allowing 1/32" (1mm) liner overhang at edges.
2. Positive anchorage is required to facilitate stripping without overly stressing the form or liner. Countersunk bolts or anchors should be installed prior to gluing, if positive stripping is to be assured. These fasteners should be spaced 12" apart around the perimeter of plywood, with no less than four equally spaced fasteners in the center of the plywood sheet. It is also essential to allow at least a 1/8" gap between all plywood sheets in both directions to accommodate expansion and contraction of plywood by moisture gain or loss. If this is not allowed, plywood buckling will most likely occur if ambient moisture levels are high.
3. Subsequent sheets should be butted tightly against installed sheet, compressing the liner overhang to make a tight joint. Special care should be taken to assure proper alignment since formwork may be reused many times.

Factory Installed Liners

Liners can be permanently attached to plywood sheets in the factory if desired. This is done on a custom basis, and therefore the contractor must approve drawings in advance of attachment of the liner. This assures that the liner will be properly positioned to account for tie holes, fasteners, joints, etc.

Tie Placement

Formwork should be planned so that ties are located at rustications, grooves, reveals or other areas to minimize visual effect. Allow for the depth of the liner and/or ribs when calculating the break-back of ties.

When using a rib pattern liner, locate ties at the high point of the liner rib so they will appear in the recess of the concrete and be less visible. For best results, provide a minimum 1" (25mm) concrete cover from tie break-back on exposed exterior walls. If cones are used, the diameter of the cone should be less than its depth to facilitate patching. Maximum diameter of the cone should not exceed the minimum width of the rib. The same constraints should be applied to she-bolts and taper ties.

Due to the rubber-like nature of ELASTO-TEX Form Liners, they will tend to self-seal around tie holes. Holes for STEEL-PLY® ties, taper ties, she-bolts, etc., are made by drilling a hole in the liner 1/16" smaller diameter than the tie. The hole in the plywood should be enlarged to 1/4" larger diameter than tie for better gasketing action.

Cutting and Drilling

ELASTO-TEX Form Liners can be cut and drilled in the same manner as rubber, similarly, too much friction will cause melting and gum up tools.

A utility knife or a knife blade in a saber saw will cut the material; however, knife edge should be kept as sharp as possible. Liners should be securely clamped down and a cutting guide nailed or clamped to the surface.

Cut ends can be dressed with either a disc or belt sander using #36 or #24 grit sandpaper. Remove sanding dust from the liner to prevent marring the concrete surface.

Release Agents

To prevent build up on liners and to facilitate stripping, apply a light coat of a chemically neutral form release agent such as Magic Kote® Form Release. Magic Kote will not react with the concrete or the liner; it provides consistent, easy release, protects the liners and prolongs their useful life. It will not stain or discolor the concrete and leaves no residue, virtually eliminating any concrete dusting or build-up on the liner face.

ELASTO-TEX Form Liners should be coated with Magic Kote® fairly close to concrete placement time, as the liner is slightly oil absorbent, allowing the release agent to soak in, leaving the surface without coating. Ideally, form release should be applied on the same day as concrete placement.

Poor quality release agents, improperly formulated releases and some reactive types of release agents can damage liners, hinder consolidation, cause stripping difficulties, discolor the concrete and cause excessive dusting. In no event should liners be coated with surface retarders containing methylene chloride, toluene or xylene. It is strongly recommended that liners be cleaned with Magic Kote before initial use. This coat should be sprayed on and then scrubbed into the liner with a scrub brush or street broom to remove any mold release remaining on the liner which could deposit a fine film on the concrete.

Liners should be coated before each use. For best results, apply the release agent with a fog sprayer or a natural bristle brush. A brush is recommended for all deep profile or rough texture liners. If a sprayer is used, be sure to vary the spraying angle so as to cover all surfaces.

Ideally, form release should be applied the same day as concrete placement. Symons will provide, if desired, a special wand extender and side-outlet nozzle with check valve for use with standard sprayers for applying release agents where limited access is available.

One 55 gal. (208 liter) drum of Magic Kote will coat approximately 50,000 sq. ft. (4645 sq. m) of form surface. It should be recognized that a 4' x 10' (122 x 305 cm) rough texture liner could have a surface area up to 160 sq. ft. (15 sq. m).

Form Placement and Alignment

It is important that forms for exposed architecturally textured concrete be aligned and in common planes. A stack-up of manufacturing tolerances and/or liner wear can result in forms being in different planes, even when properly aligned. This will result in a "step" in the finished surface which will be noticeable, particularly with shallow texture patterns.

Formwork should not be lapped over previous pours which have uneven architectural surfaces (also see: Cold Joints). Such lapping will result in an uneven surface, and grout leakage will occur, further marring the appearance.

All formwork should be sufficiently rigid to remain sealed during concrete placement and vibration: all joints and tie holes should be sealed by caulking or gasketing to prevent grout leakage. Further recommendations are contained in ACI Standard "Recommended Practice for Concrete Formwork", ACI 347-68.

Boxouts by Modification

Anticipate the desired location of liner features before fabricating boxouts.

Boxouts by Closure

Boxouts can be achieved without cutting the liner simply by placing the boxout over the liner, and using sufficient sheet or rod stock foam materials, or wood and caulking to fill the voids between the boxout and the low spots in the liner. The materials used will be dependent on the configuration of the liner and the concrete pressures exerted at this point.

Corners by Modification

It is important to anticipate the desired location of liner features and their effect when liners are installed on both sides of a corner. Brick liners should be modified so as to avoid a mortar line at an outside corner.

Corners by Closure

A smooth reveal at an inside or outside corner is highly recommended to simplify corner construction and minimize misalignment of the liner at the corner. The smooth reveal will produce a most-pleasing architectural concrete finish.

Reinforcing Steel

Reinforcing steel in concrete exposed to weather should be accurately located to insure proper cover, and reduce the possibility of rust stains on the surface.

The clear distance between the maximum diameter of the bar and the concrete surface should be at least 2" (51mm). Since some form liner patterns have as much as 1 3/4" (45mm) relief and rustication strips vary to over 2" (51mm) in depth, care must be taken to insure that the 2" (51mm) is maintained at these points.

A minimum of 5" (127mm) clear opening should be provided throughout for the proper placement and consolidation of the concrete; this is particularly important when low-slump mixes are used. Maximum, rather than nominal, diameters should be used in calculating steel spacing and open areas. Horizontal bars should be placed on the outside, the exposed concrete face side, of the vertical steel to allow greater open areas.

Wires used for tying reinforcing steel should be bent back and tucked behind joints away from the formed surface.

Plastic-coated chairs or spacers should be used throughout to prevent surface rust-staining. Chairs should not be used to space the steel away from the forms.

CRSI publications should be consulted for further recommendations.

Concrete Mix

Architectural concrete requires mix proportions which will provide maximum workability consistent with strength requirements. The workability of the concrete has a direct relationship with the occurrence of surface blemishes. However, the water-cement ratio should not exceed 0.46 by weight.

Architectural concrete should conform to the following standards and guides:

Water/cement ratio—ACI 301, Chapter 13, Section 13.2.2

Sand/aggregate ratio—ACI 211, Table 5.3.6 with asterisks

Surface voids—ACI 309, Chapter 7, Sections 7.6.2 and 7.7

Heat of Hydration—PCA Bulletin CB9, "Concrete for Mass Structures", Computation 2 (page 12)

Interesting effects can be obtained in Architectural Concrete through the use of gap-graded or colored aggregates in the mix.

Concrete Placement

Architectural concrete should be placed using a pump or conveyor with a drop chute to avoid separation of the mix and possible spatter on other parts of the liner.

Concrete should be placed in lifts of no more than 2' (61cm) and should not be moved horizontally, since such movement will cause flow lines in the finished concrete. Concrete should not be dropped, as that can cause segregation, rock pockets, and honey-comb.

Vibration

Proper consolidation is critical to successful architectural concrete and is normally accomplished by internal vibration of the concrete.

The vibrator should be inserted vertically at intervals of 12" to 18" (30 to 45cm), depending on the properties of the mix and the radius of influence of the vibrator. The area affected by the vibrator should overlap the previously vibrated area by a few inches, or insertions should be made at 1.5 times the radius of influence.

Generally, recommended practice calls for vibrating one lift at a time, extending the vibrator at least 6" (15cm) to 12" (30cm) into the preceding lift. After a momentary pause, the vibrator should be withdrawn slowly, at a rate of about 1" to 2" (25 to 50mm) per second, remembering that this ACI recommended procedure assumes a flat concrete form. With a deeply textured liner surface, the rate of withdrawal should be proportionately decreased. It is almost impossible to overvibrate a well-designed, low-slump architectural mix.

To avoid variations in color and texture, it is important that a constant time interval be maintained from the time of placement, to the time vibration commences for each lift, throughout an entire project.

Since architectural concrete requires extensive vibration, formwork, ties and sealing procedures should be designed to resist the greater stresses caused by such vibration. Symons form liner rigidity is based on full 10' (3mm) liquid head unless otherwise noted.

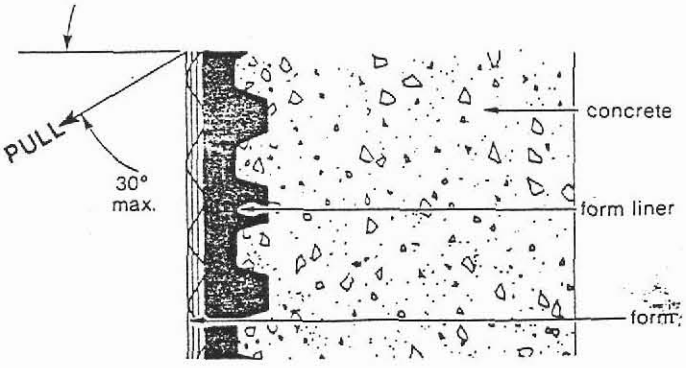
External vibration, if properly accomplished, will produce excellent results, however, such methods exert much greater forces on the formwork and seals. These forces must be taken into account in the formwork design.

Stripping Forms

Formwork with architectural form liners should be stripped within twenty-four hours after concrete placement.

The setting of concrete is an exothermic reaction; a considerable amount of heat can be generated particularly where massive amounts of concrete are being formed. This heat, together with the effect of sun shining on the forms, can cause the liners to reach temperatures above the allowable limits and cause permanent deformation.

Forms should always be stripped with a force at right angles to the form; a horizontal push or pull in the case of vertical forms. In stripping ELASTO-TEX Form Liners, advantage can be taken of the resiliency of the material, allowing the forms essentially to strip themselves. When the liner is securely glued to the form, use a jack, preferably hydraulic, to separate the top of the form from the concrete. Allow the jack to remain in place for approximately 15 minutes. The form will tend to resume its original shape, and strip itself away from the concrete, down the form. If for some job circumstance, jacking perpendicular to form face is impossible, pulling from the back side of the form is very difficult if the stripping angle varies more than 30° from perpendicular to the form face.



Special care should be taken in stripping deep profile liners to avoid damaging the concrete fins. Pivoting of forms can cause severe damage to both the liners and the concrete. The force required to strip a form will depend not only on the surface area of the form face, but also on the percentage of the face at right angles to the direction of stripping. A low profile liner will be easier to strip than a rough texture or high profile liner.

A uniform time from concrete placement to stripping is essential to avoid variations in color of concrete due to differential moisture loss. To further facilitate consistency of color, a consistent time interval between stripping and application of a suitable curing compound is also essential.

Further recommendations are contained in ACI Standard "Recommended Practice for Concrete Formwork", ACI 347-68.

Tie Hole Patching

Tie holes can be patched with epoxy mortar or a specially mixed grout. Grout from subsequent pours will not match in color due to different evaporation rates and hydration, and water/cement ratios.

Tie hole patches should be slightly recessed for best results. Care should be taken to avoid smearing the fill material on the surrounding surface of the concrete.

Repairing Liners

Liner tears can be repaired by gluing the liner back to the plywood sheet with RESI-CHEM P-1241 adhesive and depositing RESI-CHEM P-1241 adhesive in the tear joint. After setting, the hardened RESI-CHEM P-1241 adhesive should be sanded to avoid producing a gloss at the surface of the concrete. The elastomer can also be used for a torn joint. Refer to Item 12 of Installing Liners on Gang Forms.

Care and Handling of Form Liners

Liners should be stored flat and out of the sunlight. Long-term storage should be inside a building to avoid the effect of weathering.

Once attached to forms, liners should be stored on edge. Care should be taken to avoid striking the face of the liner with heavy, sharp or heated objects.

Liners, on or off forms, should never by stored in locations where their temperature could exceed 140° F (60° C). Permanent deformation will occur at higher temperatures.

WARNING

> Most plastics degrade when exposed to intense sunlight for extended periods of time which can in some conditions with form liners cause discoloration of the concrete surface. To avoid objectionable discoloration and subsequent cleaning costs, cover the form liner surface with a tarpaulin or black plastic to shade the sunlight off of the forming surface. This tarp should completely cover the form liner surface at all times whenever the form liner is not in use or being cleaned or oiled. This will prolong the life of the form liner material and produce maximum cleanliness of the forming surface.

Liners should be adequately protected, preferably by crating, for shipment.

Curing and Sealing

Special care should be taken to assure the proper curing of architectural concrete and to avoid differences in color of the finished surface. Color variations can be minimized by establishing a consistent method and period of curing.

Curing can be achieved using Quad Cure®, Cure and Hard, or Cure and Seal. Quad Cure and Cure and Hard both react with the free lime in the fresh concrete, becoming an integral part of the concrete. They diminish the tendency of the concrete to effloresce, and being inorganic, they will not darken or discolor the concrete. Since neither are membrane-forming compounds, they will not impede further cementitious bonding, so these compounds can also be applied to the top of a wall, construction joints or tie holes.

It is also strongly recommended that all architectural concrete be sealed to protect and preserve the surface. Cure and Seal and ACS (Architectural Concrete Sealer) provide a hard transparent surface for long-lasting protection.

These sealers resist moisture absorption, ultraviolet light discoloration, dusting, mildew, fungus, air pollution, rust, grease and oils. They also permit removal of graffiti, smoke and stains.

Cure and Seal may be applied any time after stripping; concrete should be cured for minimum of 28 days before applying ACS. Although spraying is the most commonly used method of application, either can also be rolled or brushed on the surface. All curing, hardening and sealing compounds are specially formulated to be compatible with Magic Kote and with each other. For instance, Quad Cure could be used for curing protection, then Cure and Seal or ACS used later for surface sealing.

Painting and Staining

Acrylic latex-based paints, which offer a high resistance to sunlight, are available for painting concrete as soon as 10 days after placing. A variety of effects can be obtained by using a short-nap roller, coating only the outer surface.

Alkyd resin (oil-based) paints are also available, however, they should not be applied until the concrete is completely dry, approximately 6 months after placing.

Paint-based stains that are absorbed into the concrete surface are available in both latex and alkyd resin.

Pre-Cast and Tilt-Up Forms

Symons form liners can be used for pre-cast and tilt-up forms; however, special attention is required for possible thermal expansion of the liners if liners are not attached to forms. A Symons representative should be consulted when considering such applications.

[illegible]ew of Admixtures and Weights indicates this design meets requirements. Approval of this Mix Design shall not relieve the Contractor of Full Responsibility for the Results.

PAC 9/24/86

The Tanner Companies, United Metro Materials Division, P.O. Box 20128, Phoenix, Arizona 85036. (602) 262-1211

ARIZONA DEPARTMENT OF TRANSPORTATION - MATERIALS SERVICES
CLASS STRUCTURAL CONCRETE MIX DESIGN
"S"

PROJECT NO: I-IR-10-3(204) & (221) PROJECT NAME: I-10 BETWEEN 16TH ST. TO 28TH ST.

CONTRACTOR: TANNER CONTRACTING CONCRETE SUPPLIER: UNITED METRO #1

MIX DESIGN DATE: 9/17/86 MIX DESIGN BY: H. WRIGHT

DESIGN STRENGTH (F'c) 4000 PSI AT 28 DAYS

CEMENT TYPE: II LOW ALKALI SOURCE: SUNBELT TORREON

POZZOLAN TYPE: "F" SOURCE: PAGE

FINE AGG FINENESS MODULUS: 2.75 SOURCE: SALT RIVER

COARSE AGGREGATE AASHTO SIZE DESIGNATION #7

COARSE AGG #1 100 % 1/2" INCH MAX SIZE SOURCE: SALT RIVER

COARSE AGG #2 % INCH MAX SIZE SOURCE:

AIR ENTRAINING AGENT TYPE: SOURCE: RATE-OZ/CY:

WATER REDUCING AGENT TYPE: HYCOL OR DARATARD-17 SOURCE: W.R. GRACE RATE-OZ/CWT: 5.00-7.00

OTHER ADMIXTURE TYPE: SOURCE: RATE-OZ/CWT:

MATERIALS	WEIGHT/CU. YD.	SPECIFIC GRAVITY	VOLUME CU. FT./CU. YD.
CEMENT	559 LB.	3.15	2.84
POZZOLAN	119 LB.	2.30	0.83
WATER	316 LB.	1.00	5.06
FINE AGGREGATE	1299 LB. (SSD)	2.65	7.86
COARSE AGGREGATE #1	1722 LB. (SSD)	2.65	10.41
COARSE AGGREGATE #2	LB. (SSD)		
AIR CONTENT	%		
OTHER ADMIXTURE	LB.		
TOTAL	4015 LB.	CU. FT. =	27.00

[illegible] ONLY

SLUMP 6+/- 1 INCHES CODE NUMBER: 24004-01

Review of Admixtures and Weights indicates this design meets requirements. Approval of this Mix Design shall not relieve the Contractor of Full Responsibility for the Results.

PAC 10/16/86

The Tanner Companies, United Metro Materials Division, P.O. Box 20128, Phoenix, Arizona 85036, (602) 262-1211

ARIZONA DEPARTMENT OF TRANSPORTATION - MATERIALS SERVICES
CLASS S STRUCTURAL CONCRETE MIX DESIGN

PROJECT NO: I-IR-10-3(204) & (221) PROJECT NAME: I-10 BETWEEN 16TH ST. TO 28TH ST.

CONTRACTOR: TANNER CONTRACTING CONCRETE SUPPLIER: UNITED METRO #1

MIX DESIGN DATE: 10/09/86 MIX DESIGN BY: H. WRIGHT

DESIGN STRENGTH (F'c) 4000 PSI AT 28 DAYS

CEMENT TYPE: II LOW ALKALI SOURCE: SUNBELT TORREON

POZZOLAN TYPE: "F" SOURCE: PAGE

FINE AGG FINENESS MODULUS: 2.75 SOURCE: SALT RIVER

COARSE AGGREGATE AASHTO SIZE DESIGNATION #7

COARSE AGG #1 57% 1/2" INCH MAX SIZE SOURCE: SALT RIVER

COARSE AGG #2 % INCH MAX SIZE SOURCE:

AIR ENTRAINING AGENT TYPE: SOURCE: RATE-OZ/CY:

WATER REDUCING AGENT TYPE: HYCOL OR DARATARD-17 SOURCE: W.R. GRACE RATE-OZ/CWT: 3.00-5.00

OTHER ADMIXTURE TYPE: DARACEM-100 SOURCE: W.R. RATE-OZ/CWT: 6.00-8.00

MATERIALS	WEIGHT/CU. YD.	SPECIFIC GRAVITY	VOLUME CU. FT./CU. YD.
CEMENT	559 LB.	3.15	2.84
POZZOLAN	119 LB.	2.30	0.83
WATER	300 LB.	1.00	4.81
FINE AGGREGATE	1317 LB. (SSD)	2.65	7.96
COARSE AGGREGATE #1	1746 LB. (SSD)	2.65	10.56
COARSE AGGREGATE #2	LB. (SSD)		
AIR CONTENT	%		
OTHER ADMIXTURE	LB.		
TOTAL	4041 LB.	CU. FT. =	27.00

SLUMP 6 +/- 1 INCHES CODE NUMBER: HILFIKER 24052-01 FLOWABLE

APPROVED BY: DATE:

The Tanner Companies, United Metro Materials Division, P.O. Box 20128, Phoenix, Arizona 85036, (602) 262-1211

ARIZONA DEPARTMENT OF TRANSPORTATION - MATERIALS SERVICES
CLASS S STRUCTURAL CONCRETE MIX DESIGN

3-30-87

PROJECT NO: I-IR-10-3(204) &(221) PROJECT NAME: I-10 BETWEEN 16TH ST. & 28TH ST.

CONTRACTOR: CONCRETE SUPPLIER: UNITED METRO PLANT 1

MIX DESIGN DATE: 03/07/87 MIX DESIGN BY: H. WRIGHT

DESIGN STRENGTH (F'c) 4500 PSI AT 28 DAYS

CEMENT TYPE: II LOW ALKALI SOURCE: SUNBELT TORREON

POZZOLAN TYPE: "F" SOURCE: PAGE

FINE AGG FINENESS MODULUS: 2.75 SOURCE: SALT RIVER

COARSE AGGREGATE AASHTO SIZE DESIGNATION #57

COARSE AGG #1 70 % 1 INCH MAX SIZE SOURCE: SALT RIVER

COARSE AGG #2 30 % 1/2 INCH MAX SIZE SOURCE: SALT RIVER

AIR ENTRAINING AGENT TYPE: SOURCE: RATE-OZ/CY:

WATER REDUCING AGENT TYPE: HYCOL OR DARATARD-17 SOURCE: W.R. GRACE RATE-OZ/CWT: 3.0-5.0

OTHER ADMIXTURE TYPE: DARACEM-100 SOURCE: W.R. GRACE RATE-OZ/CWT:6.0-12.0

MATERIALS	WEIGHT/CU. YD.	SPECIFIC GRAVITY	VOLUME CU. FT./CU. YD.
CEMENT	499 LB.	3.15	2.54
POZZOLAN	106 LB.	2.30	0.74
WATER	267 LB.	1.00	4.28
FINE AGGREGATE	1382 LB. (SSD)	2.65	8.36
COARSE AGGREGATE #1	1283 LB. (SSD)	2.65	7.76
COARSE AGGREGATE #2	549 LB. (SSD)	2.65	3.32
AIR CONTENT	%		
OTHER ADMIXTURE	LB.		
TOTAL	4087 LB.	CU. FT. =	27.00

PLEASE ORDER BY CODE NUMBER ONLY

SLUMP 6 +/-1 INCHES CODE NUMBER: 14522

Building tomorrow today.

APPROVED BY: ________________________________ DATE: _________

APPENDIX K

N·E·Wall

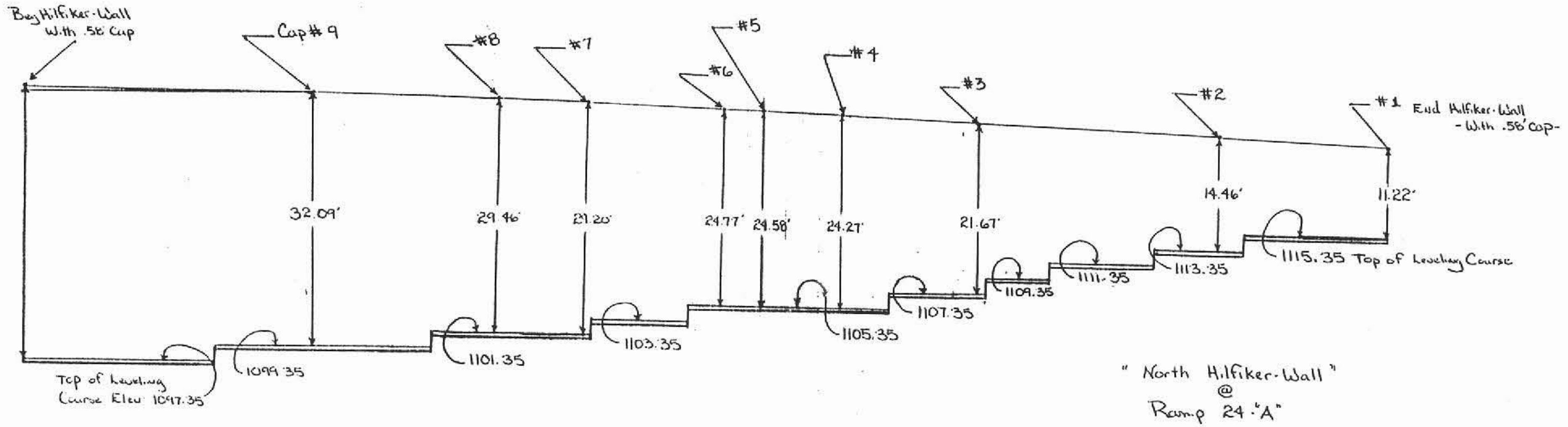
Research (Hilfiker Ramp 24A)

Med ℄ station	Cap #		Y coordinate (ground)	X coordinate (ground)
7902+81^{25} 101.^{71}Lt	①		882,677.^{663} ✓	466,626.^{039} ✓
"?"	②		882,731.^{194}	466,504,^{454}
7899+82^{69} 101.^{86}Lt	③		882,795.^{241}	466,343.^{060}
7898+81.^{15} 101.^{76}Lt.	④		882,830.^{010}	466,244.^{780}
7898+24^{54} 101.^{88}Lt.	⑤		882,848.^{415}	466,189.^{651}
7897+99.^{66} 101.^{71}Lt	⑥		882,856.^{035}	466,165.^{274}
7896+~~36^{27}~~ KM 99^{50} 101.^{77}Lt	⑦		882,885.^{818}	466,066,^{852}
7896+36.^{27} 102.^{39}Lt	⑧		882,903.^{835}	466,004.^{485}
7894+97.^{91} 105.^{35}Lt.	⑨		882,941.^{243}	465,867.^{345}

Research (Chilfiker Ramp 24-A)

Alum. Cap No.	Med ℄ ~~KM~~, I-10 station	Azimuth ∡ from "Mohave" (back sight)	Distance from ⊼	Elevation
1	KM ~~7955+55~~ 7902+81.25 101.71 Lt	108 56 25 ✓	230.39	1126.569
2		108 01 35 ✓ Recheck. ~~108° 01' 25"~~		1127.806
3	7899+82.69 101.86 Lt.	106 49 35	524.925	1129.021
4	7898+81.15 101.76 Lt.	106 10 05	420.835	1129.623
5	7898+24.54 101.88 Lt.	105 48 05	362.75	1129.931
6	7897+99.66 +101.71 Lt.	105 41 00	337.22	1130.115
7	7896+99.50 101.77 Lt.	105 10 40	234.42	1130.545
8	7896+36.27 102.59 Lt.	104 49 10	169.515	1130.814
9	7894+97.91 105.35 Lt.	102 32 45	27.39	1131.437

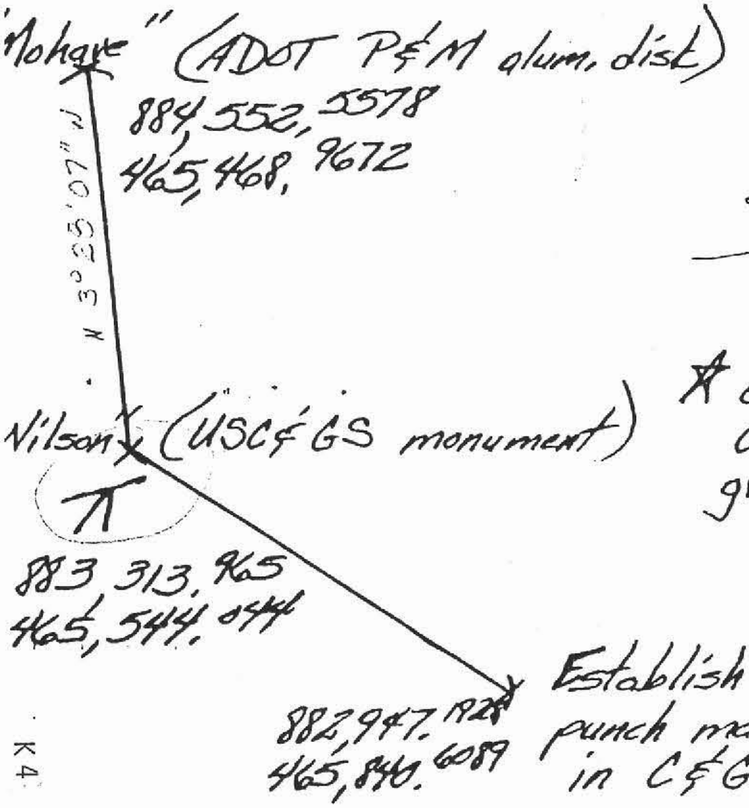
K3



" North Hilfiker-Wall "
@
Ramp 24 "A"

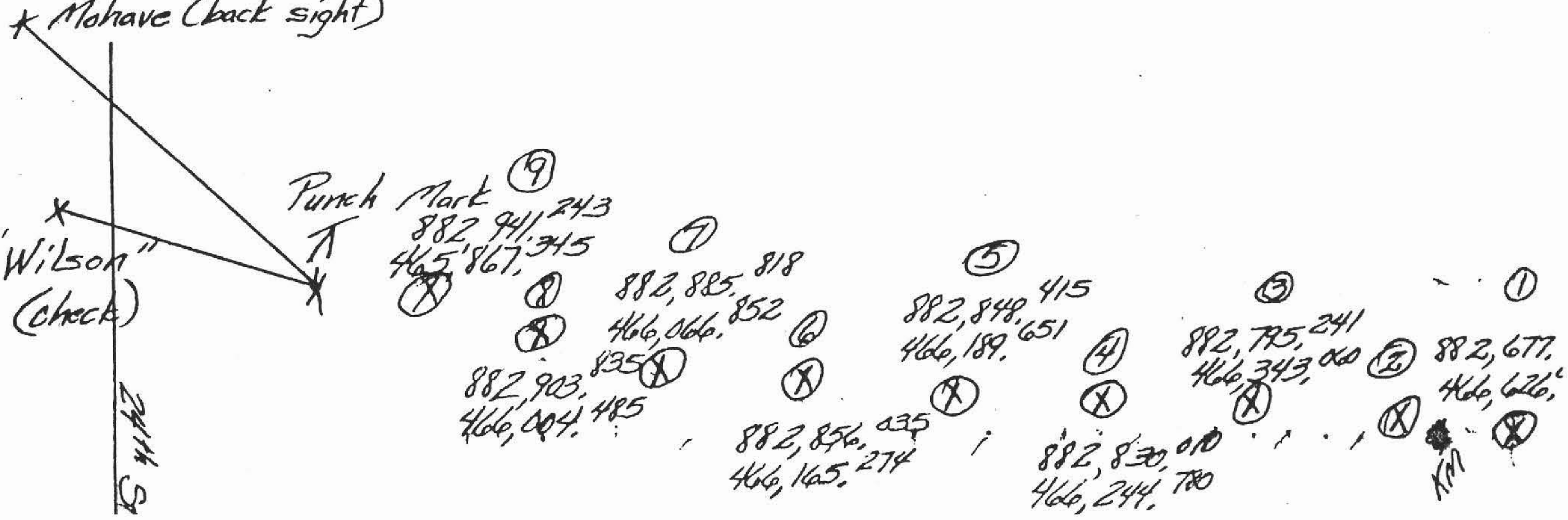
* "Theoretical : Top of Leveling Course Elev.
-To- Original Cap Elev.

Research (Hilfiker Ramp 24-A)



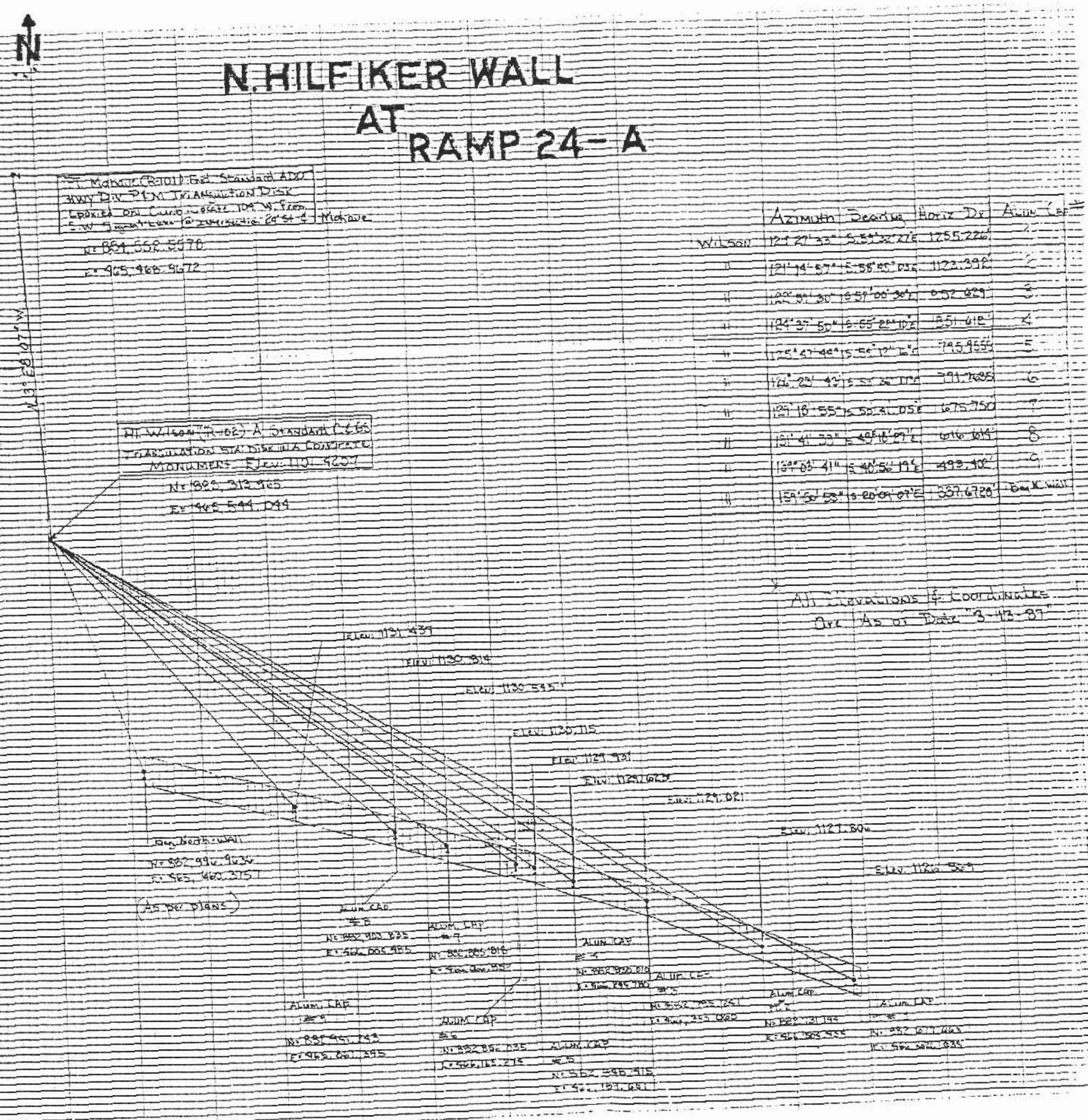
★ Ground Control coords corrected (1.00016) from grid coords acquired from ADOT P&M ★

⊼ D. Coffman
ϕ E. Aponte
⛉ K. McKelvy TC



K4

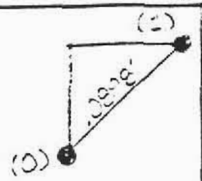
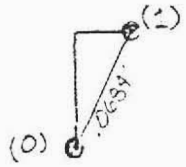
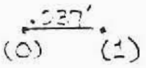
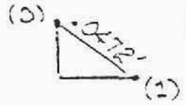
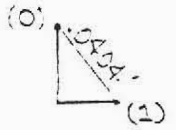
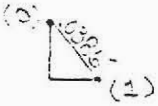
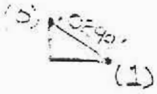
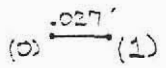
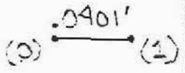
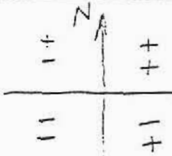
N. HILFIKER WALL AT RAMP 24-A

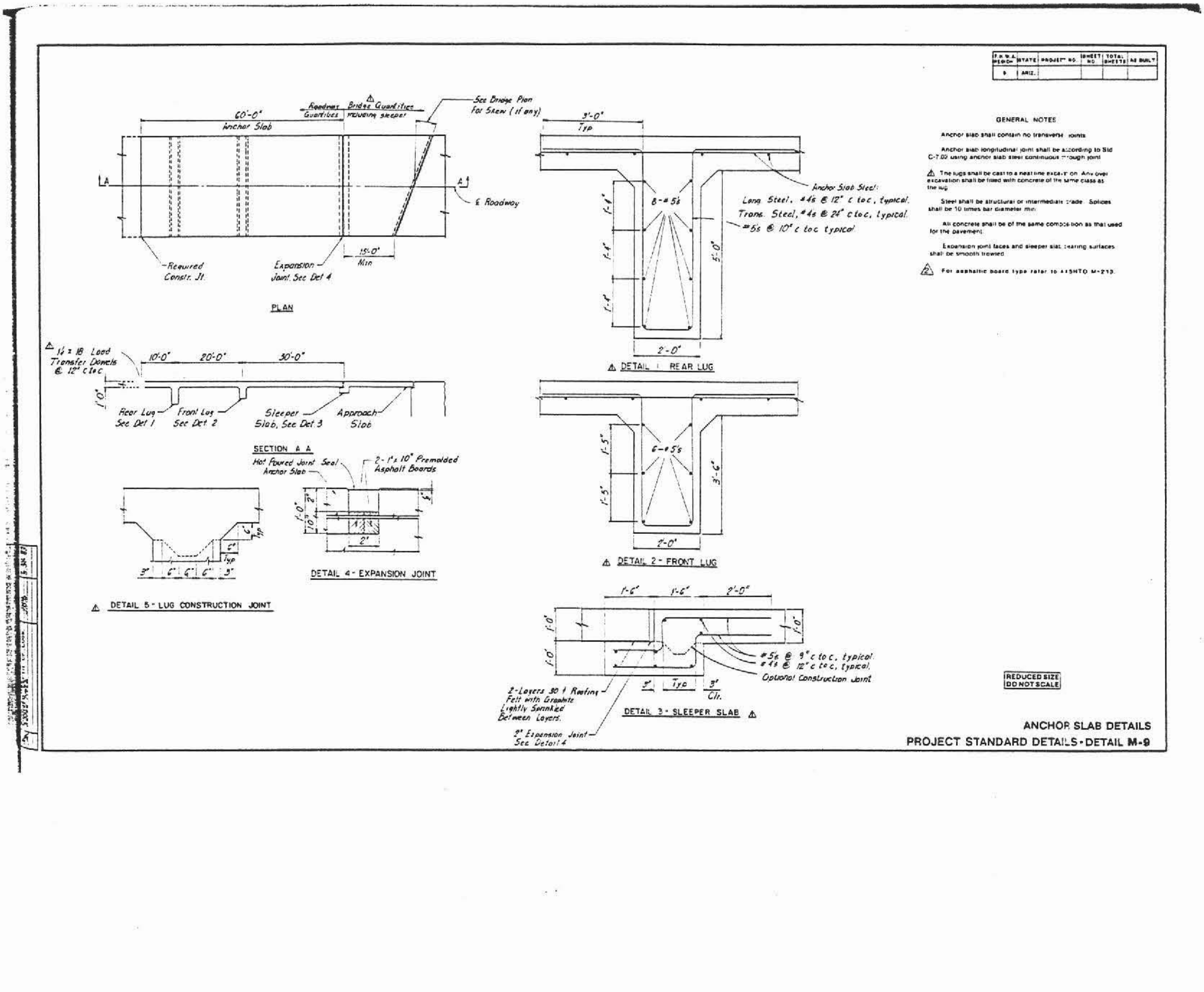


	Azimuth	Bearing	Horiz. Dt.	Alum. Cap #
Wilson	121°27'33"	S 58°32'27"E	1255.226'	1
"	121°14'57"	S 58°45'03"E	1123.392'	2
"	122°59'30"	S 57°00'30"E	952.929'	3
"	124°37'50"	S 55°22'10"E	851.612'	4
"	125°47'44"	S 54°12'16"E	795.9555'	5
"	126°23'43"	S 53°36'17"E	791.7685'	6
"	129°18'55"	S 50°41'05"E	675.750	7
"	131°41'33"	S 48°18'27"E	616.614'	8
"	139°03'41"	S 40°56'19"E	493.402'	9
"	159°50'53"	S 20°09'07"E	337.6728'	Beg. N. Wall

All Elevations & Coordinates Are As of Date "3-13-87"

CAP No.#	Original Elev:	1st Re-Check Elev:	Diff: (ft)	done on 6-29-87
#1	1126.569	1126.552	-.017	
#2	1127.806	1127.793	-.013	
#3	1129.021	1129.003	-.018	
#4	1129.623	1129.604	-.019	
#5	1129.931	1129.902	-.029	
#6	1130.115	1130.061	-.054	
#7	1130.545	1130.513	-.032	
#8	1130.814	1130.772	-.042	
#9	1131.437	1131.390	-.047	

CAP No.#		Survey #1 "N & E"	Original Survey "N & E"	Diff. (coordinate)	N ↑ E →	
#1	N	882,677.726	882,677-663	+.063'		
	E	466,626.103	466,626.039	+.064'		
#2		882,731.256	882,731.194	+.062'		
		466,504.483	466,504.454	+.029'		
#3		882,795.243	882,795.241	+.002'		
		466,343.097	466,343.060	+.037'		
#4		882,829.982	882,830.010	-.028'		
		466,244.818	466,244.780	+.038'		
#5		882,848.381	882,848.415	-.034'		
		466,189.673	466,189.651	+.022'		
#6		882,856.004	882,856.035	-.031'		
		466,165.297	466,165.274	+.023'		
#7		882,885.805	882,885.818	-.013'		
		466,066.879	466,066.852	+.027'		
#8		882,903.837	882,903,835	+.002'		
		466,004.512	466,004.485	+.027'		
#9		882,941.240	882,941.243	-.003'		
		465,867.385	465,867.345	+.040'		
		"Hilfiker Wall" RT. of Ramp "24-A" Movement ("As Per Calc. Coordinates")			(0) Original-Check (1) First-Check 7-21-87 g.R.	
		Re-Check Date 6-29-87				



F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.				

GENERAL NOTES

Anchor slab shall contain no transverse joints.

Anchor slab longitudinal joint shall be according to Std C-7.02 using anchor slab steel continuous through joint.

⚠ The lugs shall be cast to a neat line excavation. Any over excavation shall be filled with concrete of the same class as the lug.

Steel shall be structural or intermediate grade. Splices shall be 10 times bar diameter min.

All concrete shall be of the same composition as that used for the pavement.

Expansion joint faces and sleeper slab bearing surfaces shall be smooth trowled.

⚠2 For asphaltic board type refer to AASHTO M-213.

ANCHOR SLAB DETAILS

PROJECT STANDARD DETAILS - DETAIL M-9

APPENDIX M

M 1

I-10 INNER LOOP- 24 ST. TO SALT RIVER RETAINING WALLS
APRIL 5 1984
STABILITY CALCULATIONS
HILFIKER RETAINING WALLS
JOB # 84051

REINFORCED SOIL EMBANKMENT WALLS :

RAMP 24A - 6,10,14,18,22,26,30,32,34, FEET

RAMP 24B - 6,10, FEET

REGISTERED PROFESSIONAL ENGINEER
KENNETH JEFFREY NELSON
No. 31998
CIVIL
STATE OF CALIFORNIA

SELVAGE, HEBER, NELSON & ASSOC., INC.
CONSULTING ENGINEERS
2389 MYRTLE AVENUE
EUREKA, CALIFORNIA
(707) 445 - 0891

```
         CORROSION ALLOWANCE
        ********************

I-10 INNER LOOP: 24 TO SALT RIVER
APRIL 4 1984
84051

DESIGN LIFE : 75 YRS.
SOIL PH RANGE : 6.5 TO 9.5
SOIL RESISTIVITY : 3000 OHM-CM MIN.

CORROSION RATE = .26 OZ./SQ. FT./YR.

         RSE:  CAST-IN-PLACE
         ------------------

 .26 OZ./SQ. FT./YR. FOR : 75 YRS.

         W7 DIAM. : 0.299 TO: .239 IN.

USE 60 MILS SACRIFICIAL STEEL
  ( REINFORCING RATIO = 1.00 )
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


         PROJECT INFORMATION
        *********************

I-10-3 RAMP 24A
APRIL 5,1984
JOB #84051


         WALL GEOMETRY

TOTAL WALL HEIGHT = 6 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 3 FT


         SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


         EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


         DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 3 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED
```

M 4

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
        ******************

WALL HT. = 6 FT
BASE WIDTH = 8 FT

    DEAD LOADS
    ----------

VERTICAL      MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  5.76          4          23.04
  2.39          4.02       9.6
----------                --------
  8.15                     32.64

HORIZONTAL    MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  1.3           2.83       3.68

FACTOR OF SAFETY FOR OVERTURNING = 8.87
FACTOR OF SAFETY FOR SLIDING = 3.62
FOOTING PRESSURE = 1.15 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL      MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  5.76          4          23.04
  2.39          4.02       9.6
  1.44          5          7.2
----------                --------
  9.59                     39.84

HORIZONTAL    MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------
  1.3           2.83       3.68
```

```
   1.91                       6.27


   FACTOR OF SAFETY FOR OVERTURNING = 6.36
   FACTOR OF SAFETY FOR SLIDING = 2.9
   FOOTING PRESSURE = 1.37 KSF


          INTERNAL STABILITY
          *******************

       DEAD LOADS
       ----------

   MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
   NO.   FT.    FT.          KSF      WIRE  WIRE     KSI     FT.     F.S.
   ------------------------------------------------------------------------

    1    0       2          .2        W 7   W 7     4.45     8        1.9
    2    2       2          .36       W 7   W 7     8.02     8        1.99
    3    4       2          .51       W 7   W 7     11.36    8        2.65
    4    6       2          .66       W 7   W 7     14.7     8        3.31

   FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.68

       DEAD & LIVE LOADS
       -----------------

   MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
   NO.   FT.    FT.          KSF      WIRE  WIRE     KSI     FT.     F.S.
   ------------------------------------------------------------------------

    1    0       2          .35       W 7   W 7     7.79     8        1.93
    2    2       2          .5        W 7   W 7     11.13    8        2
    3    4       2          .65       W 7   W 7     14.47    8        2.65
    4    6       2          .8        W 7   W 7     17.82    8        3.11

   FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.56
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
       *********************

I-10-3 RAMP 24A
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 10 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 3 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .63
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 3 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
       *******************

WALL HT. = 10 FT
BASE WIDTH = 10 FT

    DEAD LOADS
    ----------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
------------------------------

  12              5         60
  2.99            5.02      15
----------               --------
  14.99                     75

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
------------------------------

  2.81            4.17      11.72

FACTOR OF SAFETY FOR OVERTURNING = 6.4
FACTOR OF SAFETY FOR SLIDING = 3.08
FOOTING PRESSURE = 1.78 KSF


    DEAD & LIVE LOADS
    ----------------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
------------------------------

  12              5         60
  2.99            5.02      15
  1.92            6         11.52
----------               --------
  16.91                     86.52

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
------------------------------
  2.81            4.17      11.72
  .9              6.25      5.63
```

```
  3.71                          17.35


FACTOR OF SAFETY FOR OVERTURNING = 4.99
FACTOR OF SAFETY FOR SLIDING = 2.63
FOOTING PRESSURE = 2.07 KSF


         INTERNAL STABILITY
        ********************

     DEAD LOADS
     ----------

MAT   DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS   MAT LG. PULLOUT
NO.    FT.     FT.        KSF      WIRE   WIRE     KSI      FT.      F.S.
--------------------------------------------------------------------------

 1     0       2          .2       W 7    W 7      4.45      10      1.93
 2     2       2          .35      W 7    W 7      7.79      10      1.99
 3     4       2          .51      W 7    W 7      11.36     10      2.65
 4     6       2          .66      W 7    W 7      14.7      10      2.69
 5     8       2          .82      W 7    W 7      18.26     10      3.11
 6     10      2          .97      W 7    W 7      21.6      10      3.25

FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.82


     DEAD & LIVE LOADS
     -----------------

MAT   DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS   MAT LG. PULLOUT
NO.    FT.     FT.        KSF      WIRE   WIRE     KSI      FT.      F.S.
--------------------------------------------------------------------------

 1     0       2          .35      W 7    W 7      7.79      10      1.95
 2     2       2          .5       W 7    W 7      11.13     10      2
 3     4       2          .65      W 7    W 7      14.47     10      2.63
 4     6       2          .81      W 7    W 7      18.04     10      2.69
 5     8       2          .96      W 7    W 7      21.38     10      2.93
 6     10      2          1.11     W 7    W 7      24.72     10      3.11

FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.71
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
       ********************

I-10-3 RAMP 24A
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 14 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 6 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 10 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



       EXTERNAL STABILITY
      ******************

WALL HT. = 14 FT
BASE WIDTH = 12 FT

    DEAD LOADS
    ----------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
-------------------------------

 20.16           6          120.96
 3.59            6.02       21.6
----------                 --------
 23.75                      142.56

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
-------------------------------

 4.9             5.5        26.95

FACTOR OF SAFETY FOR OVERTURNING = 5.29
FACTOR OF SAFETY FOR SLIDING = 2.8
FOOTING PRESSURE = 2.44 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
-------------------------------

 20.16           6          120.96
 3.59            6.02       21.6
 2.4             7          16.8
----------                 --------
 26.15                      159.36

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
-------------------------------
 4.9             5.5        26.95
 1.19            8.25       9.82
----------                 --------
```

```
   6.09                    36.77


 FACTOR OF SAFETY FOR OVERTURNING = 4.33
 FACTOR OF SAFETY FOR SLIDING = 2.48
 FOOTING PRESSURE = 2.79 KSF


          INTERNAL STABILITY
         *******************

      DEAD LOADS
      ----------

 MAT   DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
 NO.    FT.     FT.         KSF      WIRE  WIRE     KSI     FT.      F.S.
 -------------------------------------------------------------------------


  1     0       2          .2       W 7    W 7     4.45     12      1.94
  2     2       2          .35      W 7    W 7     7.79     12      1.99
  3     4       2          .51      W 7    W 7     11.36    12      2.64
  4     6       2          .66      W 7    W 7     14.7     12      2.69
  5     8       2          .82      W 7    W 7     18.26    12      3.11
  6     10      2          .98      W 7    W 7     21.82    12      2.94
  7     12      2          1.13     W 7    W 7     25.16    12      3.13
  8     14      2          1.29     W 7    W 7     28.73    12      3.35

 FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.94


      DEAD & LIVE LOADS
      -----------------

 MAT   DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
 NO.    FT.     FT.         KSF      WIRE  WIRE     KSI     FT.      F.S.
 -------------------------------------------------------------------------


  1     0       2          .35      W 7    W 7     7.79     12      1.96
  2     2       2          .5       W 7    W 7     11.13    12      2
  3     4       2          .65      W 7    W 7     14.47    12      2.65
  4     6       2          .81      W 7    W 7     18.04    12      2.69
  5     8       2          .96      W 7    W 7     21.38    12      2.92
  6     10      2          1.11     W 7    W 7     24.72    12      2.8
  7     12      2          1.27     W 7    W 7     28.28    12      3.02
  8     14      2          1.42     W 7    W 7     31.62    12      3.27

 FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.83
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
        *******************

I-10-3 RAMP 24A
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 18 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 6 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 10 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 13
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
       *******************

WALL HT. = 18 FT
BASE WIDTH = 14 FT

    DEAD LOADS
    ----------

VERTICAL      MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  30.24           7         211.68
  4.19            7.02      29.4
----------                --------
  34.43                     241.08

HORIZONTAL    MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  7.56            6.83      51.63

FACTOR OF SAFETY FOR OVERTURNING = 4.67
FACTOR OF SAFETY FOR SLIDING = 2.63
FOOTING PRESSURE = 3.13 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL      MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  30.24           7         211.68
  4.19            7.02      29.4
  2.88            8         23.04
----------                --------
  37.31                     264.12

HORIZONTAL    MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------
  7.56            6.83      51.63
  1.48            10.25     15.17
----------                --------
```

```
. 9.04                          66.8


FACTOR OF SAFETY FOR OVERTURNING = 3.95
FACTOR OF SAFETY FOR SLIDING = 2.38
FOOTING PRESSURE = 3.53 KSF


        INTERNAL STABILITY
        ******************

      DEAD LOADS
      ----------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE   WIRE     KSI     FT.      F.S.
------------------------------------------------------------------------

 1    0       2          .2       W 7    W 7     4.45     14      1.94
 2    2       2          .35      W 7    W 7     7.79     14      1.99
 3    4       2          .51      W 7    W 7     11.36    14      2.64
 4    6       2          .66      W 7    W 7     14.7     14      2.68
 5    8       2          .82      W 7    W 7     18.26    14      3.1
 6    10      2          .98      W 7    W 7     21.82    14      2.93
 7    12      2          1.13     W 7    W 7     25.16    14      3.12
 8    14      2          1.29     W 7    W 7     28.73    14      3.04
 9    16      2          1.44     W 7    W 7     32.07    14      3.29
 10   18      2          1.6      W 9.5  W 9.5   24.54    14      4.09

FACTOR OF SAFETY FOR OVERALL PULLOUT = 3.16


      DEAD & LIVE LOADS
      -----------------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE   WIRE     KSI     FT.      F.S.
------------------------------------------------------------------------

 1    0       2          .35      W 7    W 7     7.79     14      1.96
 2    2       2          .5       W 7    W 7     11.13    14      2
 3    4       2          .65      W 7    W 7     14.47    14      2.65
 4    6       2          .81      W 7    W 7     18.04    14      2.68
 5    8       2          .96      W 7    W 7     21.38    14      2.92
 6    10      2          1.11     W 7    W 7     24.72    14      2.8
 7    12      2          1.27     W 7    W 7     28.28    14      3.02
 8    14      2          1.42     W 7    W 7     31.62    14      2.96
 9    16      2          1.57     W 7    W 7     34.96    14      3.23
 10   18      2          1.73     W 9.5  W 9.5   26.53    14      4.04

FACTOR OF SAFETY FOR OVERALL PULLOUT = 3.05
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
       ********************

I-10-3 RAMP 24A
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 22 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 6 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 10 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
     ******************

WALL HT. = 22 FT
BASE WIDTH = 16 FT

    DEAD LOADS
    ----------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT       FT-KIPS
-------------------------------

  42.24           8         337.92
  4.79            8.02      38.4
----------                --------
  47.03                     376.32

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT       FT-KIPS
-------------------------------

  10.8            8.17      88.24

FACTOR OF SAFETY FOR OVERTURNING = 4.26
FACTOR OF SAFETY FOR SLIDING = 2.51
FOOTING PRESSURE = 3.84 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT       FT-KIPS
-------------------------------

  42.24           8         337.92
  4.79            8.02      38.4
  3.36            9         30.24
----------                --------
  50.39                     406.56

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT       FT-KIPS
-------------------------------
  10.8            8.17      88.24
  1.76            12.25     21.56
                          --------
```

M 17

```
 12.56                    109.8


FACTOR OF SAFETY FOR OVERTURNING = 3.7
FACTOR OF SAFETY FOR SLIDING = 2.32
FOOTING PRESSURE = 4.28 KSF


          INTERNAL STABILITY
          ******************

        DEAD LOADS
        ----------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE   WIRE     KSI     FT.      F.S.
--------------------------------------------------------------------------

 1    0       2          .2       W 7    W 7     4.45      16       1.95
 2    2       2          .35      W 7    W 7     7.79      16       1.99
 3    4       2          .51      W 7    W 7     11.36     16       2.64
 4    6       2          .66      W 7    W 7     14.7      16       2.68
 5    8       2          .82      W 7    W 7     18.26     16       3.1
 6    10      2          .98      W 7    W 7     21.82     16       2.93
 7    12      2          1.13     W 7    W 7     25.16     16       3.11
 8    14      2          1.29     W 7    W 7     28.73     16       3.04
 9    16      2          1.44     W 7    W 7     32.07     16       3.29
 10   18      2          1.6      W 9.5  W 9.5   24.54     16       3.72
 11   20      2          1.75     W 9.5  W 9.5   26.84     16       4.06
 12   22      2          1.91     W 9.5  W 9.5   29.29     16       4.41

FACTOR OF SAFETY FOR OVERALL PULLOUT = 3.42


        DEAD & LIVE LOADS
        -----------------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE   WIRE     KSI     FT.      F.S.
--------------------------------------------------------------------------

 1    0       2          .35      W 7    W 7     7.79      16       1.96
 2    2       2          .5       W 7    W 7     11.13     16       2
 3    4       2          .65      W 7    W 7     14.47     16       2.64
 4    6       2          .81      W 7    W 7     18.04     16       2.62
 5    8       2          .96      W 7    W 7     21.38     16       2.91
 6    10      2          1.11     W 7    W 7     24.72     16       2.79
 7    12      2          1.27     W 7    W 7     28.28     16       3.01
 8    14      2          1.42     W 7    W 7     31.62     16       2.96
 9    16      2          1.57     W 7    W 7     34.96     16       3.22
 10   18      2          1.73     W 9.5  W 9.5   26.53     16       3.67
 11   20      2          1.88     W 9.5  W 9.5   28.83     16       4.02
 12   22      2          2.04     W 9.5  W 9.5   31.29     16       4.38

FACTOR OF SAFETY FOR OVERALL PULLOUT = 3.32
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


          PROJECT INFORMATION
         ********************

I-10-3 RAMP 24A
APRIL 4,1984
JOB #84051


          WALL GEOMETRY

TOTAL WALL HEIGHT = 26 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 6 FT


          SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


          EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


          DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 10 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


          REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
       *******************

WALL HT. = 26 FT
BASE WIDTH = 18 FT

    DEAD LOADS
    ----------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
-------------------------------

  56.16          9         505.44
  5.39           9.02      48.6
----------               --------
  61.55                    554.04

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
-------------------------------

  14.62          9.5       138.89

FACTOR OF SAFETY FOR OVERTURNING = 3.99
FACTOR OF SAFETY FOR SLIDING = 2.43
FOOTING PRESSURE = 4.56 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
-------------------------------

  56.16          9         505.44
  5.39           9.02      48.6
  3.84           10        38.4
----------               --------
  65.39                    592.44

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
-------------------------------
  14.62          9.5       138.89
  2.05           14.25     29.21
```

```
  16.67                          168.1


FACTOR OF SAFETY FOR OVERTURNING = 3.52
FACTOR OF SAFETY FOR SLIDING = 2.26
FOOTING PRESSURE = 5.04 KSF


          INTERNAL STABILITY
         ********************

      DEAD LOADS
      ----------

MAT   DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS   MAT LG. PULLOUT
NO.    FT.      FT.        KSF      WIRE   WIRE     KSI      FT.      F.S.
---------------------------------------------------------------------------

 1     0        2         .2       W 7    W 7     4.45      18       1.94
 2     2        2         .35      W 7    W 7     7.79      18       1.99
 3     4        2         .51      W 7    W 7     11.36     18       2.64
 4     6        2         .66      W 7    W 7     14.7      18       2.67
 5     8        2         .82      W 7    W 7     18.26     18       3.1
 6     10       2         .98      W 7    W 7     21.82     18       2.92
 7     12       2         1.13     W 7    W 7     25.16     18       3.11
 8     14       2         1.29     W 7    W 7     28.73     18       3.03
 9     16       2         1.44     W 7    W 7     32.07     18       3.28
 10    18       2         1.6      W 9.5  W 9.5   24.54     18       3.72
 11    20       2         1.75     W 9.5  W 9.5   26.84     18       4.06
 12    22       2         1.91     W 9.5  W 9.5   29.29     18       4.05
 13    24       2         2.07     W 9.5  W 9.5   31.75     18       4.41
 14    26       2         2.22     W 12   W 9.5   25.77     18       4.87

FACTOR OF SAFETY FOR OVERALL PULLOUT = 3.69


      DEAD & LIVE LOADS
      -----------------

MAT   DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS   MAT LG. PULLOUT
NO.    FT.      FT.        KSF      WIRE   WIRE     KSI      FT.      F.S.
---------------------------------------------------------------------------

 1     0        2         .35      W 7    W 7     7.79      18       1.95
 2     2        2         .5       W 7    W 7     11.13     18       1.99
 3     4        2         .65      W 7    W 7     14.47     18       2.64
 4     6        2         .8       W 7    W 7     17.82     18       2.68
 5     8        2         .96      W 7    W 7     21.38     18       2.91
 6     10       2         1.11     W 7    W 7     24.72     18       2.79
 7     12       2         1.27     W 7    W 7     28.28     18       3.01
 8     14       2         1.42     W 7    W 7     31.62     18       2.95
 9     16       2         1.57     W 7    W 7     34.96     18       3.22
 10    18       2         1.73     W 9.5  W 9.5   26.53     18       3.67
 11    20       2         1.88     W 9.5  W 9.5   28.83     18       4.02
 12    22       2         2.04     W 9.5  W 9.5   31.29     18       4.02
 13    24       2         2.19     W 9.5  W 9.5   33.57     18       4.38
 14    26       2         2.34     W 12   W 9.5   27.17     18       4.84

FACTOR OF SAFETY FOR OVERALL PULLOUT = 3.59
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
        *******************

I-10-3 RAMP 24A
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 30 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 6 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 10 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
       ********************

WALL HT. = 30 FT
BASE WIDTH = 20 FT

    DEAD LOADS
    ----------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
--------------------------------

 72             10        720
 5.99           10.02     60
----------              --------
 77.99                    780

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
--------------------------------

 19.01          10.83     205.88

FACTOR OF SAFETY FOR OVERTURNING = 3.79
FACTOR OF SAFETY FOR SLIDING = 2.37
FOOTING PRESSURE = 5.3 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
--------------------------------

 72             10        720
 5.99           10.02     60
 4.32           11        47.52
----------              --------
 82.31                    827.52

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
--------------------------------
 19.01          10.83     205.88
 2.34           16.25     38.02
```

```
 21.35                   243.9


FACTOR OF SAFETY FOR OVERTURNING = 3.39
FACTOR OF SAFETY FOR SLIDING = 2.23
FOOTING PRESSURE = 5.3 KSF


          INTERNAL STABILITY
          ******************

     DEAD LOADS
     ----------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
NO.   FT.      FT.        KSF      WIRE  WIRE     KSI     FT.      F.S.
-------------------------------------------------------------------------


 1    0        2          .2       W 7    W 7     4.45     20      1.94
 2    2        2          .35      W 7    W 7     7.79     20      1.99
 3    4        2          .51      W 7    W 7     11.36    20      2.63
 4    6        2          .66      W 7    W 7     14.7     20      2.67
 5    8        2          .82      W 7    W 7     18.26    20      3.09
 6    10       2          .98      W 7    W 7     21.82    20      2.92
 7    12       2          1.13     W 7    W 7     25.16    20      3.11
 8    14       2          1.29     W 7    W 7     28.73    20      3.03
 9    16       2          1.44     W 7    W 7     32.07    20      3.23
 10   18       2          1.6      W 9.5  W 9.5   24.54    20      3.71
 11   20       2          1.76     W 9.5  W 9.5   26.99    20      4.05
 12   22       2          1.91     W 9.5  W 9.5   29.29    20      4.04
 13   24       2          2.07     W 9.5  W 9.5   31.75    20      4.4
 14   26       2          2.22     W 12   W 9.5   25.77    20      4.5
 15   28       2          2.38     W 12   W 9.5   27.63    20      4.88
 16   30       2          2.53     W 12   W 9.5   29.37    20      5.26

FACTOR OF SAFETY FOR OVERALL PULLOUT = 3.96


     DEAD & LIVE LOADS
     -----------------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS  MAT LG. PULLOUT
NO.   FT.      FT.        KSF      WIRE  WIRE     KSI     FT.      F.S.
-------------------------------------------------------------------------


 1    0        2          .35      W 7    W 7     7.79     20      1.95
 2    2        2          .5       W 7    W 7     11.13    20      1.99
 3    4        2          .65      W 7    W 7     14.47    20      2.64
 4    6        2          .8       W 7    W 7     17.82    20      2.67
 5    8        2          .96      W 7    W 7     21.38    20      2.9
 6    10       2          1.11     W 7    W 7     24.72    20 .    2.78
 7    12       2          1.27     W 7    W 7     28.28    20      3.01
 8    14       2          1.42     W 7    W 7     31.62    20      2.95
 9    16       2          1.57     W 7    W 7     34.96    20      3.21
 10   18       2          1.73     W 9.5  W 9.5   26.53    20      3.66
 11   20       2          1.88     W 9.5  W 9.5   28.83    20      4.01
 12   22       2          2.04     W 9.5  W 9.5   31.29    20      4.01
 13   24       2          2.19     W 9.5  W 9.5   33.59    20      4.37
 14   26       2          2.34     W 12   W 9.5   27.17    20      4.48
```

```
 16   30    2          2.65   W 12   W 9.5   30.77     20     5.24
FACTOR OF SAFETY FOR OVERALL PULLOUT = 3.86
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
       *********************

I-10-3 RAMP 24A
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 32 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 6 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 10 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
       *******************

WALL HT. = 32 FT
BASE WIDTH = 22 FT

    DEAD LOADS
    ----------

VERTICAL      MOMENT ARM   MOMENT
LOAD-KIPS         FT       FT-KIPS
------------------------------

  84.48          11         929.28
  6.59           11.02     72.6
----------               --------
  91.07                    1001.88

HORIZONTAL    MOMENT ARM   MOMENT
LOAD-KIPS         FT       FT-KIPS
------------------------------

  21.42          11.5      246.33


FACTOR OF SAFETY FOR OVERTURNING = 4.07
FACTOR OF SAFETY FOR SLIDING = 2.45
FOOTING PRESSURE = 5.49 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL      MOMENT ARM   MOMENT
LOAD-KIPS         FT       FT-KIPS
------------------------------

  84.48          11         929.28
  6.59           11.02     72.6
  4.8            12        57.6
----------               --------
  95.87                    1059.48

HORIZONTAL    MOMENT ARM   MOMENT
LOAD-KIPS         FT       FT-KIPS
------------------------------
  21.42          11.5      246.33
  2.48           17.25     42.78
                           --------
```

```
  23.9                          289.11


FACTOR OF SAFETY FOR OVERTURNING = 3.66
FACTOR OF SAFETY FOR SLIDING = 2.32
FOOTING PRESSURE = 5.97 KSF


         INTERNAL STABILITY
        *******************

      DEAD LOADS
      ----------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS  STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE   WIRE    KSI      FT.     F.S.
-----------------------------------------------------------------------

 1    0       2         .2       W 7    W 7     4.45     22      1.98
 2    2       2         .35      W 7    W 7     7.79     22      2.63
 3    4       2         .51      W 7    W 7     11.36    22      2.67
 4    6       2         .66      W 7    W 7     14.7     22      3.31
 5    8       2         .82      W 7    W 7     18.26    22      3.12
 6    10      2         .98      W 7    W 7     21.82    22      3.25
 7    12      2         1.13     W 7    W 7     25.16    22      3.14
 8    14      2         1.29     W 7    W 7     28.73    22      3.36
 9    16      2         1.44     W 7    W 7     32.07    22      3.31
 10   18      2         1.6      W 9.5  W 9.5   24.54    22      4.11
 11   20      2         1.76     W 9.5  W 9.5   26.99    22      4.09
 12   22      2         1.91     W 9.5  W 9.5   29.29    22      4.44
 13   24      2         2.07     W 9.5  W 9.5   31.75    22      4.44
 14   26      2         2.22     W 12   W 9.5   25.77    22      4.9
 15   28      2         2.38     W 12   W 9.5   27.63    22      4.92
 16   30      2         2.53     W 12   W 9.5   29.37    22      5.3
 17   32      2         2.69     W 12   W 9.5   31.23    22      5.62
FACTOR OF SAFETY FOR OVERALL PULLOUT = 4.32


      DEAD & LIVE LOADS
      -----------------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS  STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE   WIRE    KSI      FT.     F.S.
-----------------------------------------------------------------------

 1    0       2         .35      W 7    W 7     7.79     22      1.98
 2    2       2         .5       W 7    W 7     11.13    22      2.63
 3    4       2         .65      W 7    W 7     14.47    22      2.67
 4    6       2         .8       W 7    W 7     17.82    22      3.11
 5    8       2         .96      W 7    W 7     21.38    22      2.93
 6    10      2         1.11     W 7    W 7     24.72    22      3.12
 7    12      2         1.27     W 7    W 7     28.28    22      3.04
 8    14      2         1.42     W 7    W 7     31.62    22      3.28
 9    16      2         1.57     W 7    W 7     34.96    22      3.25
 10   18      2         1.73     W 9.5  W 9.5   26.53    22      4.06
 11   20      2         1.88     W 9.5  W 9.5   28.83    22      4.05
 12   22      2         2.04     W 9.5  W 9.5   31.29    22      4.4
 13   24      2         2.19     W 9.5  W 9.5   33.59    22      4.41
 14   26      2         2.34     W 12   W 9.5   27.17    22      4.88
```

```
 15   28     2          2.5     W 12   W 9.5   29.03      22      4.9
 16   30     2          2.65    W 12   W 9.5   30.77      22      5.28
 17   32     2          2.81    W 12   W 9.5   32.62      22      5.66

FACTOR OF SAFETY FOR OVERALL PULLOUT = 4.22
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
        *********************

I-10-3 RAMP 24A
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 34 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 6 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 10 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
       *******************

WALL HT. = 34 FT
BASE WIDTH = 24 FT

    DEAD LOADS
    ----------

VERTICAL      MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
------------------------------

  97.92          12         1175.04
  7.19           12.02      86.4
----------                --------
  105.11                    1261.44

HORIZONTAL    MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
------------------------------

  23.98          12.17      291.84


FACTOR OF SAFETY FOR OVERTURNING = 4.32
FACTOR OF SAFETY FOR SLIDING = 2.53
FOOTING PRESSURE = 5.7 KSF


    DEAD & LIVE LOADS
    ----------------

VERTICAL      MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
------------------------------

  97.92          12         1175.04
  7.19           12.02      86.4
  5.28           13         68.64
----------                --------
  110.39                    1330.08

HORIZONTAL    MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
------------------------------
  23.98          12.17      291.84
  2.63           18.25      48
-----------               ---------
```

```
  26.61                 339.84


FACTOR OF SAFETY FOR OVERTURNING = 3.91
FACTOR OF SAFETY FOR SLIDING = 2.39
FOOTING PRESSURE = 6.15 KSF


          INTERNAL STABILITY
          ********************

     DEAD LOADS
     ----------

MAT   DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS   MAT LG. PULLOUT
NO.    FT.     FT.        KSF      WIRE   WIRE     KSI      FT.      F.S.
--------------------------------------------------------------------------

 1     0       2          .2       W 7    W 7      4.45     24       2.01
 2     2       2          .35      W 7    W 7      7.79     24       2.66
 3     4       2          .51      W 7    W 7      11.36    24       3.3
 4     6       2          .66      W 7    W 7      14.7     24       3.34
 5     8       2          .82      W 7    W 7      18.26    24       3.46
 6     10      2          .98      W 7    W 7      21.82    24       3.28
 7     12      2          1.13     W 7    W 7      25.16    24       3.47
 8     14      2          1.29     W 7    W 7      28.73    24       3.39
 9     16      2          1.44     W 7    W 7      32.07    24       3.64
 10    18      2          1.6      W 9.5  W 9.5    24.54    24       4.14
 11    20      2          1.76     W 9.5  W 9.5    26.99    24       4.48
 12    22      2          1.91     W 9.5  W 9.5    29.29    24       4.48
 13    24      2          2.07     W 9.5  W 9.5    31.75    24       4.83
 14    26      2          2.22     W 12   W 9.5    25.77    24       4.94
 15    28      2          2.38     W 12   W 9.5    27.63    24       5.32
 16    30      2          2.53     W 12   W 9.5    29.37    24       5.34
 17    32      2          2.69     W 12   W 9.5    31.23    24       5.72
 18    34      2          2.85     W 12   W 9.5    33.09    24       6.1

FACTOR OF SAFETY FOR OVERALL PULLOUT = 4.67


     DEAD & LIVE LOADS
     -----------------

MAT   DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS   STRESS   MAT LG. PULLOUT
NO.    FT.     FT.        KSF      WIRE   WIRE     KSI      FT.      F.S.
--------------------------------------------------------------------------

 1     0       2          .35      W 7    W 7      7.79     24       2.01
 2     2       2          .5       W 7    W 7      11.13    24       2.66
 3     4       2          .65      W 7    W 7      14.47    24       3.31
 4     6       2          .8       W 7    W 7      17.82    24 .     3.14
 5     8       2          .96      W 7    W 7      21.38    24       3.27
 6     10      2          1.11     W 7    W 7      24.72    24       3.18
 7     12      2          1.27     W 7    W 7      28.28    24       3.37
 8     14      2          1.42     W 7    W 7      31.62    24       3.31
 9     16      2          1.57     W 7    W 7      34.96    24       3.58
 10    18      2          1.73     W 9.5  W 9.5    26.53    24       4.09
 11    20      2          1.88     W 9.5  W 9.5    28.83    24       4.44
 12    22      2          2.04     W 9.5  W 9.5    31.29    24       4.44
```

```
  14   26     2         2.34   W 12   W 9.5   27.17    24    4.92
  15   28     2         2.5    W 12   W 9.5   29.03    24    5.3
  16   30     2         2.65   W 12   W 9.5   30.77    24    5.32
  17   32     2         2.81   W 12   W 9.5   32.62    24    5.7
  18   34     2         2.96   W 12   W 9.5   34.37    24    6.09

FACTOR OF SAFETY FOR OVERALL PULLOUT = 4.57
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
       ********************

I-10-3 RAMP 24B
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 6 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 3 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
     EQUIV. SOIL DEPTH = 2 FT
     WIDTH OF LOADED AREA = 58 FT
     SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 3 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



        EXTERNAL STABILITY
       ********************

WALL HT. = 6 FT
BASE WIDTH = 8 FT

    DEAD LOADS
    ----------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
--------------------------------

  5.76           4          23.04
  2.39           4.02       9.6
----------                --------
  8.15                      32.64

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
--------------------------------

  1.3            2.83      3.68


FACTOR OF SAFETY FOR OVERTURNING = 8.87
FACTOR OF SAFETY FOR SLIDING = 3.62
FOOTING PRESSURE = 1.15 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL     MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
--------------------------------

  5.76           4          23.04
  2.39           4.02       9.6
  1.44           5          7.2
----------                --------
  9.59                      39.84

HORIZONTAL   MOMENT ARM  MOMENT
LOAD-KIPS        FT      FT-KIPS
--------------------------------
  1.3            2.83      3.68
  .61            4.25      2.59
----------                ---------
```

```
  1.91                          6.27


FACTOR OF SAFETY FOR OVERTURNING = 6.36
FACTOR OF SAFETY FOR SLIDING = 2.9
FOOTING PRESSURE = 1.37 KSF


         INTERNAL STABILITY
         ******************

     DEAD LOADS
     ----------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG  TRANS  STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE  WIRE    KSI     FT.      F.S.
-----------------------------------------------------------------------

 1    0       2          .2       W 7   W 7     4.45     8       1.9
 2    2       2          .36      W 7   W 7     8.02     8       1.99
 3    4       2          .51      W 7   W 7     11.36    8       2.65
 4    6       2          .66      W 7   W 7     14.7     8       3.31

FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.68

     DEAD & LIVE LOADS
     -----------------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG  TRANS  STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE  WIRE    KSI     FT.      F.S.
-----------------------------------------------------------------------

 1    0       2          .35      W 7   W 7     7.79     8       1.93
 2    2       2          .5       W 7   W 7     11.13    8       2
 3    4       2          .65      W 7   W 7     14.47    8       2.65
 4    6       2          .8       W 7   W 7.    17.82    8       3.11

FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.56
```

```
HILFIKER RETAINING WALLS: REINFORCED SOIL EMBANKMENT
SELVAGE, HEBER, NELSON & ASSOC., CONSULTING ENGINEERS


        PROJECT INFORMATION
       *********************

I-10-3 RAMP 24B
APRIL 4,1984
JOB #84051


        WALL GEOMETRY

TOTAL WALL HEIGHT = 10 FT
BATTER ON WALL FACE = 0
MINIMUM MAT LENGTH = 8 FT
MAXIMUM BASE WIDTH = 24 FT
MINIMUM TOE BURY = 3 FT


        SOIL PROPERTIES

BACKFILL: 6-INCH MINUS, NON-SATURATED, GRANULAR MAT'L
  MAX. P.I. = 10
BACKFILL UNIT WT. = 120 PCF
INTERNAL FRICTION ANGLE = 34 DEG
COEF. OF INTERNAL EARTH PRESS. = .65
FRICTION ANGLE AT BASE = 30 DEG
EQUIV. FLUID PRESS. = 36 PCF


        EXTERNAL LOADS

FILL: LEVEL AT 2.5 FT
  FULL DEPTH AT .1 FEET BEYOND WALL FACE
NO. OF LIVE LOADS = 1
  LOAD # 1 :
    EQUIV. SOIL DEPTH = 2 FT
    WIDTH OF LOADED AREA = 58 FT
    SET BACK FROM WALL FACE = 2 FT


        DESIGN CRITERIA

FACTOR OF SAFETY FOR SLIDING = 1.5
FACTOR OF SAFETY FOR OVERTURNING = 2
FACTOR OR SAFETY FOR PULLOUT = 1.5
MAX. FOOTING PRESSURE = 3 KSF
SURFACE & SUBSURFACE DRAINAGE CONTROL REQUIRED


        REINFORCING MAT DETAILS
```

```
INITIAL MAT SPACING = 2 FT
MESH SPACING: 6 IN. LONG X 24 IN. TRANS
REINFORCING RATIO = 1
MAX. WIRE SIZE = W 18
MIN. WIRE SIZE = W 7
CORROSION ALLOW = 60 MILS
MAX. WIRE STRESS = 55 % OF YIELD



         EXTERNAL STABILITY
        *******************

WALL HT. = 10 FT
BASE WIDTH = 10 FT

    DEAD LOADS
    ----------

VERTICAL      MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  12              5         60
  2.99            5.02      15
----------                --------
  14.99                     75

HORIZONTAL    MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  2.81            4.17      11.72

FACTOR OF SAFETY FOR OVERTURNING = 6.4
FACTOR OF SAFETY FOR SLIDING = 3.08
FOOTING PRESSURE = 1.78 KSF


    DEAD & LIVE LOADS
    -----------------

VERTICAL      MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------

  12              5         60
  2.99            5.02      15
  1.92            6         11.52
----------                --------
  16.91                     86.52

HORIZONTAL    MOMENT ARM  MOMENT
LOAD-KIPS         FT      FT-KIPS
--------------------------------
  2.81            4.17      11.72
  .9              6.25      5.63
----------                --------
```

```
  3.71                        17.35


FACTOR OF SAFETY FOR OVERTURNING = 4.99
FACTOR OF SAFETY FOR SLIDING = 2.63
FOOTING PRESSURE = 2.07 KSF


         INTERNAL STABILITY
         ******************

     DEAD LOADS
     ----------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS  STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE   WIRE    KSI     FT.      F.S.
-----------------------------------------------------------------------


 1    0       2          .2       W 7    W 7    4.45     10      1.93
 2    2       2          .35      W 7    W 7    7.79     10      1.99
 3    4       2          .51      W 7    W 7    11.36    10      2.65
 4    6       2          .66      W 7    W 7    14.7     10      2.69
 5    8       2          .82      W 7    W 7    18.26    10      3.11
 6    10      2          .97      W 7    W 7    21.6     10      3.25

FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.82


     DEAD & LIVE LOADS
     -----------------

MAT  DEPTH MAT-SPACE  HORIZ.LOAD  LONG   TRANS  STRESS  MAT LG. PULLOUT
NO.   FT.     FT.        KSF      WIRE   WIRE    KSI     FT.      F.S.
-----------------------------------------------------------------------


 1    0       2          .35      W 7    W 7    7.79     10      1.95
 2    2       2          .5       W 7    W 7    11.13    10      2
 3    4       2          .65      W 7    W 7    14.47    10      2.65
 4    6       2          .81      W 7    W 7    18.04    10      2.69
 5    8       2          .96      W 7    W 7    21.38    10      2.93
 6    10      2          1.11     W 7    W 7    24.72    10      3.11

FACTOR OF SAFETY FOR OVERALL PULLOUT = 2.71
```

HILFIKER RSE SPECIFICATIONS

1. WALL HEIGHT (H) = DISTANCE FROM TOP MAT TO BOTTOM MAT. SEE WALL ELEVATIONS AND TYPICAL SECTION.

2. DESIGN ASSUMES:

   WALL BACKFILL OF 120 P.C.F. IN-PLACE DENSITY
   INTERNAL FRICTION ANGLE OF 34 DEGREES
   EQUIVALENT FLUID PRESSURE OF 36 P.C.F.
   FRICTION ANGLE FOR SLIDING AT BASEMENT SOILS OF 30 DEGREES

3. DESIGN ASSUMES SURFACE AND SUBSURFACE DRAINAGE CONTROL AS REQUIRED TO PREVENT SATURATION OF THE BACKFILL MATERIAL AND TO RELIEVE ALL HYDROSTATIC PRESSURES. DRAINAGE CONTROL IS NOT INCLUDED IN THE WALL DESIGN.

4. NATIVE FOUNDATION SOILS OF STRENGTH NOT SUFFICIENT TO SUPPORT IMPOSED WALL LOADS SHALL BE REMOVED AND RECOMPACTED TO 95% OF THE MAXIMUM DENSITY AS DETERMINED BY AASHTO T-180, AND SHALL PROVIDE MINIMUM ALLOWABLE BEARING CAPACITIES FOR VARIOUS WALL HEIGHTS AS FOLLOWS:

HEIGHT	RSE WALLS
$H \leq 6$ FT.	1.37 KSF
$6 < H \leq 10$ FT.	2.07 KSF
$10 < H \leq 14$ FT.	2.79 KSF
$14 < H \leq 18$ FT.	3.15 KSF
$18 < H \leq 22$ FT.	3.90 KSF
$22 < H \leq 26$ FT.	4.66 KSF
$26 < H \leq 30$ FT.	5.80 KSF
$30 < H \leq 34$ FT.	6.15 KSF

5. MATERIALS:

   MATERIAL FOR THE HILFIKER REINFORCED SOIL EMBANKMENT (RSE) SHALL BE AS SPECIFIED BY THE HILFIKER COMPANY. ALL WIRE AND WELDED WIRE FABRIC SHALL CONFORM TO ASTM A-82 AND ASTM A-185. DEFORMED REINFORCING BARS SHALL BE GRADE 60 CONFIRMING TO ASTM A-615. HILFIKER RETAINING WALLS ARE COVERED BY PATENT NO. 4324508 (RSE).

   CONCRETE FACE: CONCRETE SHALL MEET THE REQUIREMENTS OF PORTLAND CEMENT CONCRETE, CLASS "S", AS SPECIFIED IN THE STATE OF ARIZONA STANDARD SPECIFICATIONS. CONCRETE SHALL HAVE A 28 DAY COMPRESSION STRENGTH OF 4000 POUNDS PER SQUARE INCH MINIMUM. CONCRETE FACE OF THE HILFIKER RSE WALLS SHALL BE COLORED AND TEXTURED IN CONFORMANCE WITH SECTION 601 OF THE PROJECT SPECIAL PROVISIONS.

BACKFILL MATERIAL: BACKFILL MATERIAL FOR THE HILFIKER RSE WALL SHALL CONSIST OF HARD, DURABLE STONES AND ROCKS, OF ACCEPTED QUALITY, FREE FROM OBJECTIONABLE MATTER. SANDSTONE ROCK SHALL BE CONSIDERED AS ACCEPTABLE: HOWEVER, SHALE WILL NOT BE CONSIDERED ACCEPTABLE. BACKFILL MATERIAL SHALL MEET THE FOLLOWING GRADATION:

SIEVE DESIGNATION	PERCENT BY WEIGHT PASSING SQUARE MESH SIEVE
6-INCH	100
3-INCH	75-100
NO. 200	*35-0

*IF THE PERCENT PASSING THE NO. 200 SIEVE IS GREATER THAN 10%, THE PROPOSED MATERIAL MUST CONFORM TO THE FOLLOWING ADDITIONAL REQUIREMENTS:

A. THE PLASTICITY INDEX (P.I.) AS DETERMINED BY AASHTO T-90 SHALL NOT EXCEED 10.

B. THE FRACTION FINER THAN 15 MICRONS (0.015 MM) AS DETERMINED BY AASHTO T-88 SHALL NOT EXCEED 15 PERCENT.

C. THE MATERIAL WHEN COMPACTED TO 95% OF AASHTO T-99 AT OPTIMUM MOISTURE CONTENT SHALL EXHIBIT AN ANGLE OF INTERNAL FRICTION OF NOT LESS THAN 34 DEGREES AS DETERMINED IN A STANDARD DIRECT SHEAR TEST (AASHTO T-236).

BACKFILL MATERIAL FOR THE WELDED WIRE AND RSE WALLS SHALL MEET THE FOLLOWING CORROSION REQUIREMENTS:

RESISTIVITY: 3000 OHM CENTIMETERS (MINIMUM)
pH: 6.5 TO 9.5
CHLORIDES < 200 MG/KG
SULFATES < 1000 MG/KG
SULPHIDES < 300 MG/KG

MATERIALS NOT CONFORMING TO THESE SPECIFICATIONS SHALL NOT BE USED WITHOUT THE CONSENT OF THE ENGINEER.

6. WALL ERECTION AND BACKFILL PLACEMENT: ERECTION OF THE HILFIKER RSE WALLS SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE HILFIKER COMPANY. BACKFILL MATERIAL SHALL BE COMPACTED TO 90% OF MAXIMUM DENSITY AS DETERMINED BY AASHTO T-180. MAXIMUM WATER CONTENT OF ANY BACKFILL MATERIAL TO BE INSTALLED SHALL BE 100% OF THE OPTIMUM MOISTURE CONTENT AS DETERMINED FOR USE IN AASHTO TEST PROCEEDURE T-99.

AT THE END OF EACH DAY'S OPERATIONS, THE CONTRACTOR SHALL SHAPE THE LAST LEVEL OF BACKFILL AS TO PERMIT RUNOFF OF RAINWATER AWAY FROM THE WALL FACE AND OFF REINFORCING MATS.

7. REFERENCE DRAWINGS:

EVANS, KUHN & ASSOCIATES, INC.
IN ASSOCIATION WITH
HOWARD, NEEDLES, TAMMEN & BERGENDOFF
PLANS & CROSS SECTIONS
FOR
PHOENIX - CASA GRANDE HIGHWAY
24TH STREET BRIDGE TO SALT RIVER BRIDGE
MARICOPA COUNTY
I-10-3 (156) P.E.
NO DATE

APPENDIX N

ARIZONA DEPARTMENT OF TRANSPORTATION

HIGHWAYS DIVISION

District 1
48th Street Engineering Field Office
2600 West Broadway Road
Tempe, Arizona 85282

EVAN MECHAM
Governor
CHARLES L. MILLER
Director

W.O. FORD
State Engineer

October 28, 1987

Howard, Needles, Tammen & Bergendoff
2207 E. Camelback Rd. Suite 400
Phoenix, Arizona 85016

ATTN: Jay Maqbool

RE: I-IR-10-3(204)
Phoenix - Casa Grande Highway
(16th Street - 28th Street)

EROSION AT S.W. HILFIKER WALL

Gentlemen:

This letter is to inform you of a potential erosion problem which may exist along the Southwest Hilfiker wall between EB I-17, Station 227+85 and Station 235+60.

In this area the Hilfiker wall cap diverges from the edge of roadway. This leaves an open area between the edge of pavement and the Hilfiker wall cap. At present all the rain which falls in this area runs across this area and up against the Hilfiker coping. The run-off then runs along the coping creating an erosion problem. (Please see attached plan sheet.)

Could you please examine this situation and incorporate any necessary corrective action into the upcoming landscape contract.

Should you have any questions or require any additional information regarding this matter, please contact me at 255-8114.

Very truly yours,

Diane A Schott

DIANE A. SCHOTKA
Acting Resident Engineer

DAS/JC/tl

Attachment

cc: Project File

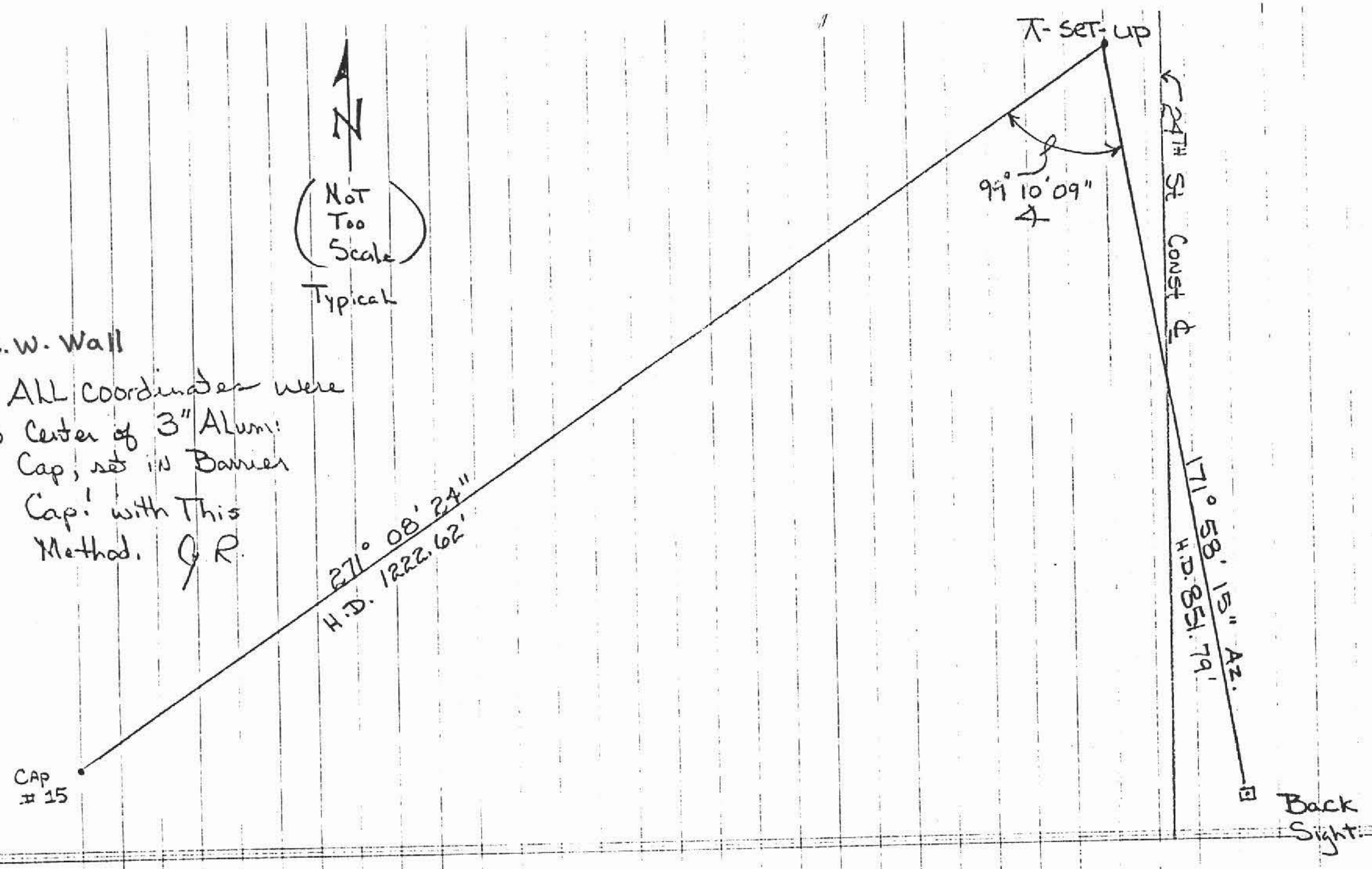
HIGHWAYS • AERONAUTICS • MOTOR VEHICLE • PUBLIC TRANSIT • ADMINISTRATIVE SERVICES • TRANSPORTATION PLANNING

APPENDIX O

South-West Hilfiker Wall Dec. 15th 1987

E. B. I-17 Wall Stations (I-IR-10-3(204)

Hilfiker Wall Station(s)	(N.) (Calc)	(E.) (Calc)	Azimuth (Actual)	Dx./FT. (Actual)	(Elev. Top of CAP)	Cap#
⊼-Set-up	882,791.6860	465,526.3991	171° 58' 15"	851.79'	N/A	
(BACK) Sight 0	881,948.246	465,645.3747				
239+20.137	882,802.0231	465,434.1138	276° 25' 19"	92.87'	1126.366	#1
238+29.031	882,814.2511	465,343.8283	277° 02' 45"	183.96'	1126.256	#2
237+66.93	882,822.3006	465,282.2511	277° 08' 50"	296.06'	1126.076	#3
236+68.22	882,834.7976	465,184.3352	277° 11' 00"	344.77'	1125.465	#4
235+87.031	882,844.1099	465,103.6774	277° 04' 10"	425.96'	1124.40	#5
235+84.21	℄ Point (Hilfiker-Wall Lay-Out Line)(Given)					
235+60.787	882,841.7357	465,077.1785	276° 21' 25"	452.03'	1123.805	#6
235+31.174	882,841.7084	465,047.5649	275° 57' 50"	481.44'	1122.558	#7
235+01.128	882,841.6817	465,017.5192	275° 36' 40"	511.33'	1121.35	#8
234+93.130	℄ Point (Hilfiker-Wall Lay-Out Line) (Given)					
234+20.803	882,841.5083	464,937.1918	274° 50' 00"	591.31'	1116.78	#9
233+40.623	882 841.2668	464,857.0128	274° 14' 10"	671.22'	1113.58	#10
232+36.162	882,841.0504	464,752.5520	273° 39' 00"	775.42'	1109.719	#11
231+57.083	882,840.6579	464,673.4738	273° 17' 10"	854.33'	1107.67	#12
230+68.250	882,840.4463	464,584.6406	272° 57' 50"	943.02'	1106.254	#13
229+48.039	882,840.0645	464,464.4305	272° 36' 30"	1063.07'	1104.751	#14
229+47.28	882,840.48	464,463.6700	℄ point (Given)			
227+85.759	882,816.0107	464,304.0205	271° 08' 24"	1,222.62'	1094.813	#15



S.W. Wall

* ALL coordinates were To Center of 3" Alum: Cap, set in Barrier Cap! with This Method. J.R.

Southwest Hilfikerwall

E.B. I-10 & Hilfiker wall Stations

Sta.	Cap #	Cap Elev: ft.	-TOP- Leveling Course ft.	-Total- Wall Height ft.
239+20.14	#1	1126.366	1095.60	**30.77'**
238+29.03	#2	1126.256	1095.60	**30.66'**
237+66.93	#3	1126.076	1095.60	**30.48'**
236+68.22	#4	1125.465	1093.60	**31.87'**
235+87.03	#5	1124.40	1093.60	**30.80'**
235+60.79	#6	1123.805	1093.60	**30.21'**
235+31.17	#7	1122.558	1093.60	**28.96'**
235+01.13	#8	1121.35	1091.60	**29.75**
234+20.80	#9	1116.78	1091.60	**25.18'**
233+40.62	#10	1113.58	1091.60	**21.98'**
232+36.16	#11	1109.719	1093.60	**16.12'**
231+57.08	#12	1107.67	10.93.60	**14.07'**
230+68.25	#13	1106.254	1091.60	**14.65'**
229+48.04	#14	1104.751	1089.60	**15.15'**
227+85.76	#15	1094.813	1089.60	**5.21'**

⊼ - Coffman
ϕ - Mc Kelvy
⊞ - Rodriguez
Clear (60's)

Southeast Hiitikerwall
E.B.I-17 & E.B.I-10
A.D.O.T. 3"Alum. Cap Set on Wall (Original Readings)

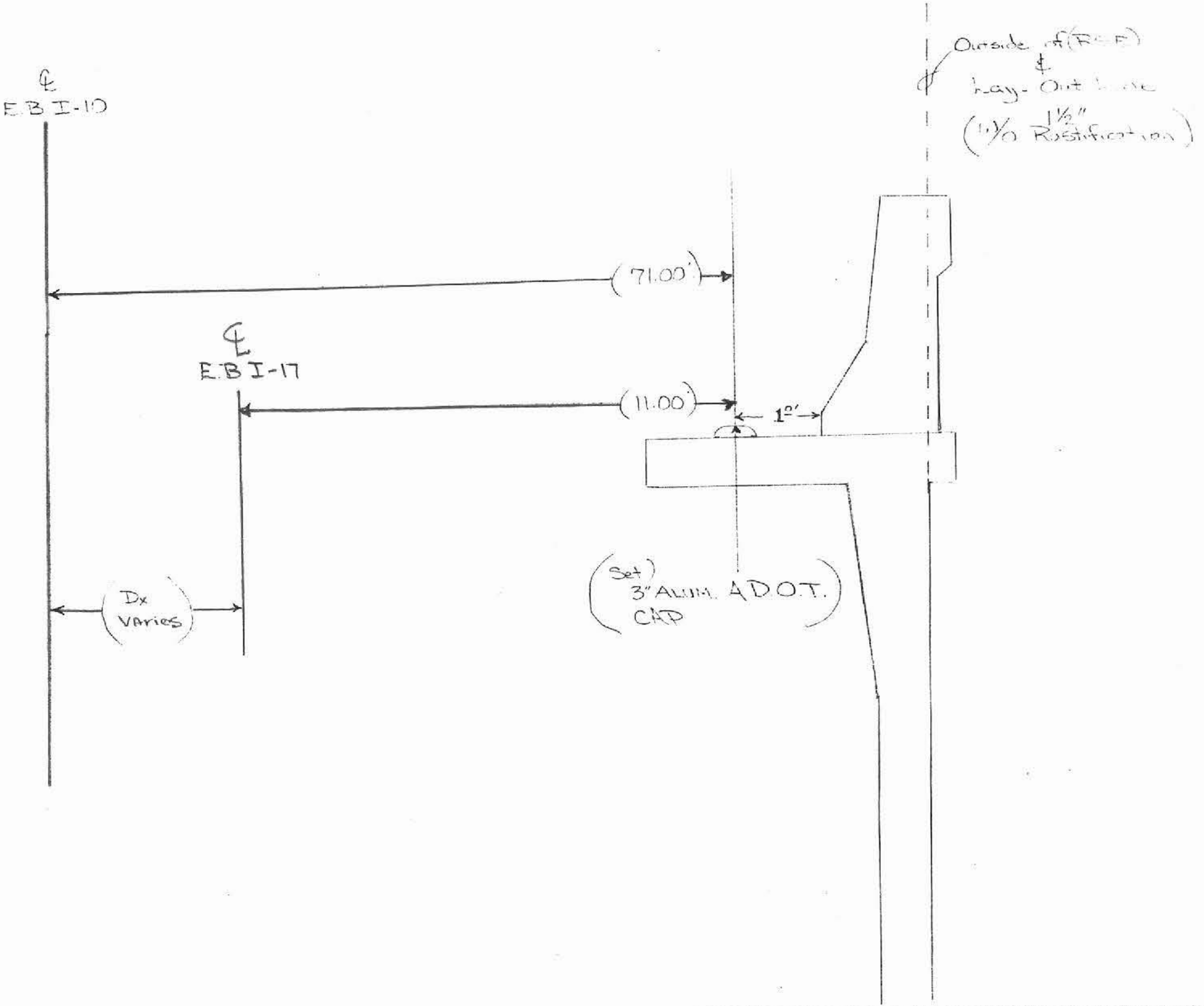
Jan. 13-1988

Sta. & Cap #	Offset RT. Const. ℄	(N)	(E)	Azimuth	Dx/Ft.	Elev: (Top of Cap)
#16 241+46.98 E.B.I-17	11.00'	882,769.290	465,658.031	99°39'21"	133.52'	1123.510
#17 242+47.32 E.B.I-17	11.00'	882,750.697	465,756.340	100°06'26"	233.57'	1122.896
#18 243+70.24 E.B.I-17	11.00'	882,724.412	465,876.050	100°53'27"	356.06'	1122.212
#19 244+66.32 E.B.I-17	11.00'	882,701.192	465,968.993	101°33'20"	451.75'	1121.686
#20 244+92.16 E.B.I-17	11.00'	882,694.549	465,993.886	101°44'18"	477.47'	1121.554
✳ #21 7897+85.85 E.B.I-10	Switch 71.00'	To E.B.I- 882,665.365	10 Stationing 466,095.875	& offsets 102°30'25"	583.32'	1120.940
#22 7899+01.35 E.B.I-10	✳ 71.01'	882,629.795	466,203.484	103°26'49"	696.17	1120.257
#23 7899+38.80 E.B.I-10	71.00'	882,617.565	466,238.133	103°44'49"	732.72	1120.002
#24 7900+22.44 E.B.I-10	71.00'	882,589.008	466,315.079	104°24'44"	814.31'	1119.506
⊼ Instrument Set-Up Back Sight		882,791.686 881,948.246	465,526.3991 -To- 465,645.3747	171°58'15"	851.79'	

JAN. 14- 1988
I-IG 10-3 (204)
S/E Hilfikerwall

*

Cap(s) No# 16, 17, 18.
19 & 20, were referenced
To E.B. I-17 const ℄.
(Station & Offset)
Due, To E.B.I-17 Ending
@ Sta: 245+93.09. Cap(s)
No# 21-Thru-24 were
Referenced To E-B I-10
Const ℄ Joe R.
TCSS



Southeast Hilfikerwall

E.B. I-10 Stations & Offsets

Sta:	Cap #	Cap Elev. - ft.	-Top- Leveling Course ft.	= -Total- Wall Height ft.	Offset ft
7893+26.70	#16	1123.510	1110.26	**13.25'**	75.67'
7894+28.78	#17	1122.896	1110.26	**12.64'**	74.73'
7895+53.78	#18	1122.212	1112.26	**9.95'**	73.50'
7896+51.46	#19	1121.686	1114.26	**7.43'**	72.46'
7896+77.72	#20	1121.554	1114.26	**7.29'**	72.17
7897+85.85	#21	1120.940	1114.26	**6.68'**	71.00'
7899+01.35	#22	1120.257	1114.26	**6.00'**	71.01'
7899+38.80	#23	1120.002	1114.26	**5.74'**	71.00'
7900+22.44	#24	1119.506	1114.26	**5.25'**	71.00'