DEEP VERTICAL FABRIC MOISTURE SEALS

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ABSTRACT

Expansive soils are a worldwide problem. They cause an estimated $4 billion damages in the United States. More than half these damages occur to transportation facilities, causing expensive, energy consuming repairs. Swelling soil research has been conducted around the world by universities, governmental agencies and private groups. The work being completed at the U.S. Corps of Engineers, Waterways Experiment Station is among the most extensive.

The Texas State Department of Highways and Public Transportation has also attacked the problem through the decades. Cooperating with state universities, it has sought swelling soil solutions. It has tried and tested lime treatment, ponding, stage construction, deep underdrains and horizontal fabrics.

Presently the effectiveness of a deep vertical fabric moisture seal is being studied. The first site chosen for this experimental section is located on Interstate Loop 410 in San Antonio, Texas. The roadway is a four lane divided urban freeway. The test section mainlane profile descends from a natural ground grade to a cut section about 20 ft.(6m) deep and is one half mile long.

A vertical fabric, DuPont Typar, was placed on the northbound lane through the zone of activity to a depth of 8 ft.(240cm) and backfilled with sand. The adjacent southbound lane received no fabric and served as the control section. Fabric placement began in December 1978. Moisture sensors were placed in May and June 1979 at eighteen locations. Initial observations have been completed and indicate less moisture change in the fabric protected areas. Sensor readings, cross sectioning, profilometer readings and a visual surface inventory will continue. Installation and post construction problems have occurred. The department has conducted further tests, plans additional installations and contract work. This cooperative project provides an opportunity to measure the effectiveness of vertical fabric moisture seals in controlling expansive soil movements.

INTRODUCTION - NATIONAL AND INTERNATIONAL EFFORTS

Expansive soils are costing the United States an estimated $4 billion a year. More than half of these damages occur to transportation facilities (1). Highways, railroads, airports, canals, bike paths and pedestrian walkways are all among the casualties stretching from coast to coast, border to border. Their repair is expensive and energy consuming.

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The problem of the expansive soils is an international one. The search for solutions reflect a similar scope. This is the Fourth International Conference on these soils. Studies have been conducted around the world on them; in the United States, Australia, South Africa, India, Israel and Canada, all have faced their damaging movements and have tried a variety of solutions.

In this country, studies have been conducted or sponsored by this professional society, federal agencies, universities, material associations, and a variety of states including Arizona, Colorado, Mississippi, South Dakota and Texas (2, 3, 4, 5, 6).

The recently completed Federal Highway Administration (FHWA) funded research by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) has provided an outstanding review of these international efforts as well as theoretical analyses and practical possible solutions (7). The study indicates expansive soil areas in the United States extend from border to border, coast to coast, a national problem. Intensively impacted areas are not uniformly distorted and damaged by thæ clays. Nor are areas seemingly lightly affected relatively free of the problem. El Paso, Texas would appear to be in a lightly impacted area (8). However, one residential neighborhood had over 100 houses damaged severely by the expansive soils. Some were total losses.

Texas has long been working on mitigating these damages to our highways that have become ever more costly. Among the agencies working cooperatively with the State Department of Highways and Public Transportation (SDHPT) have been the Center for Highway Research (CHR), at the University of Texas and Texas Transportation Institute (TTI) at Texas A&M University. The usual solutions of yesteryear, the asphaltic level up course, or more lately, the heater planner are becoming rapidly more costly. It is one thing to pay $6 a ton for asphaltic concrete in 1968 and another to pay $27 a ton in 1978 (9). The solutions are also very energy consuming, another matter of national interest.

Over the decades, the Texas SDHPT has tried a variety of methods to control the swelling clays. Ponding, a deep sand backfilled underdrain, horizontal and vertical fabric moisture seals, shallow lime subgrade treatment 6 in.(15 cm) deep and some lime pressure injection have been used.

THE TEXAS HIGHWAYS TEST SCENE

Many of these recent tests have been conducted in the San Antonio, Bexar County area of south central Texas, approximately 125 mi(200KM) from the Gulf Coast (Figure 1). Since the activity of the expansive soil, the meteorological conditions and the geology are significant problem elements, the area's characteristics are important. More active clays can cause more damages with less moisture changes than less sensitive ones. The drying and wetting cycles are elements in the soils movement patterns.

The San Antonio area is in a sub-tropical climatic zone. It averages daily maximum temperatures in the 90°'s F (30-35°C) between June and September with minimums in the fourties in November thru March. Record highs and lows vary from 107° in August 1909 to 0° in January 1949.

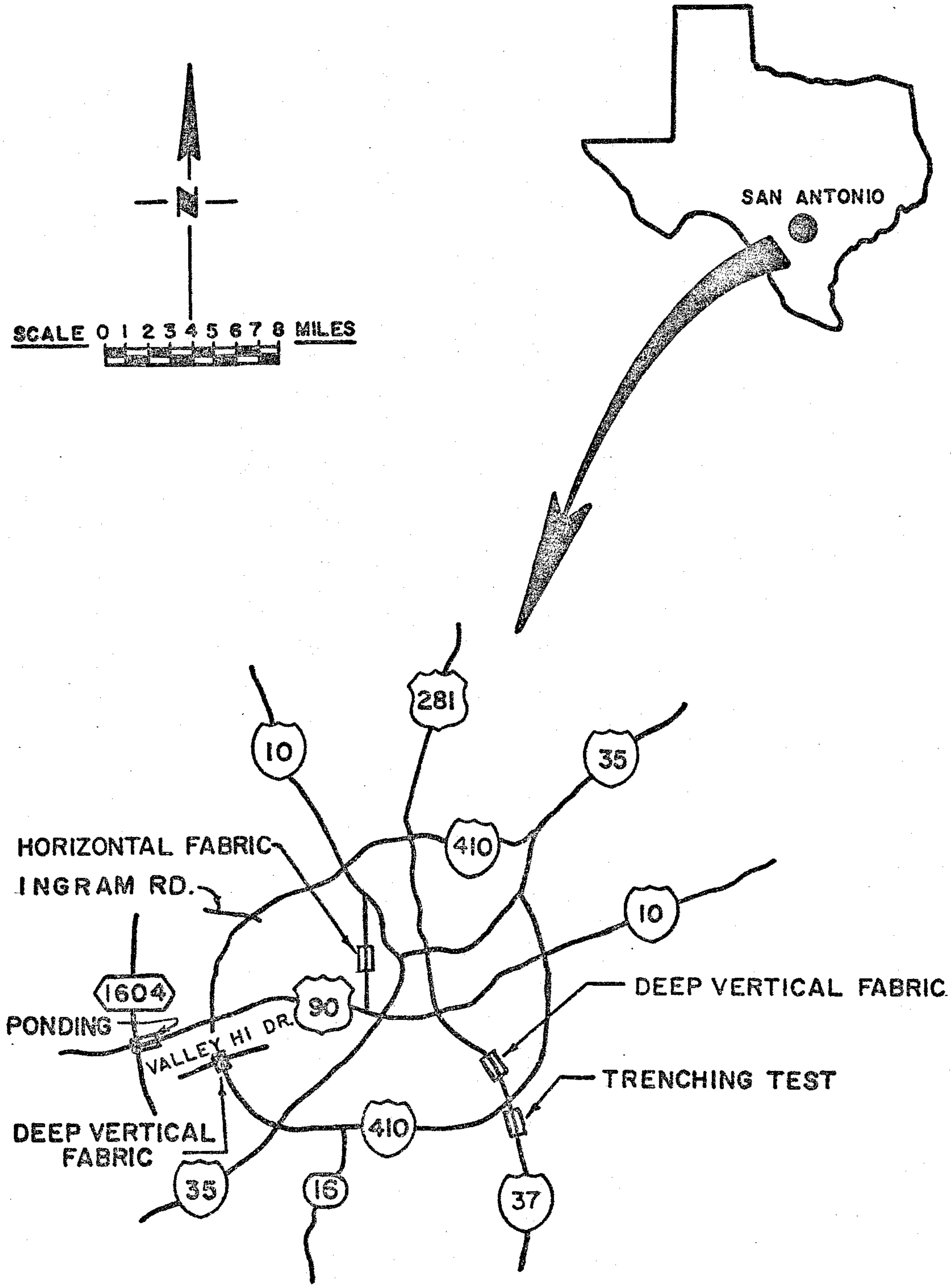

SAN ANTONIO
N
SCALE 0 1 2 3 4 5 6 7 8 MILES
HORIZONTAL FABRIC
INGRAM RD.
1604
PONDING
VALLEY HI DR.
DEEP VERTICAL FABRIC
DEEP VERTICAL FABRIC
TRENCHING TEST
10
281
35
410
10
90
410
35
16
37

FIGURE – I

On the yearly average, 116 days have a maximum of 90° or above while 21 days have a minimum of 32° or below. Precipitation averages 28 in (70 cm) per year. Between 1892 and 1974, 14 years had drought periods varying from 42 to 73 months. Rains are most likely in August or November, least likely in February, April, July or June.

Geologically, the county lies in two major provinces. The northwestern part is in the Edward Plateau, usually harder limestone formations of the cretaceous age with surface elevations to 1500 ft (450 m) above sea level. It is separated from the Gulf Coastal Plain by the Balcones escarpment which passes through the county in a northeast-southwest direction. The Balcones defines the regional dip and large faults of the zone. South of the escarpment are the softer clays, sands and sandy clay deposits, found in the Midway, Wilcox Hills, the Carrizo sands and the Gulf series (10). The clays are frequently montmorillonites, illites and sometimes bentonites. Elevations in the southern part of the county range from 500 to 600 ft (150-180 m) above sea level. Stream terrace deposits cover much of the Coastal plain section and they are usually of the tertiary and cretaceous ages (11). The county has twelve significant geological faults.

The ponding project on U.S. 90 in Bexar County confirmed what others have found. There is a zone of activity where major moisture changes and major movements occur. In the southwest San Antonio area this zone of activity extended from ground elevation to depth of about 10 ft (300 cm). Pavement surface inventories indicated less cracking, less repair work on the ponded areas over the more active subgrades than those areas predicted to be more passive. Ponding again has shown it helps diminish damages from expansive soils (12).

The horizontal fabric test section was part of a San Antonio city street rebuilding project over an expansive clay subgrade in 1977. The fabrics, DuPont Typar #3353 and #3153 weighing 5.0 and 2.5 oz (140 and 70 g per 0.8 m^2) per yd^2 respectively, were placed over sections where potential vertical rises up to 4½ in (11 cm) were estimated. These fabrics are sheet structures of polypropylene continuous filaments thermally bonded. Initial indications are promising as no significant upward movements have been observed either on the test or control sections.

However, ponding and horizontal moisture seals over subgrades are no solution where the pavement is already in place and are not to be reconstructed. Other remedies are required.

A deep sand backfilled underdrain field test attempted to repeat a successful Israeli experience in controlling clays (13). Placed along one crown of an existing pavement on U.S. 90 in Medina County about 60 miles west of San Antonio, it also appears to be succeeding. Vertical movement along the underdrain crown is about a third that of unprotected pavement edge (14).

A DEEP VERTICAL FABRIC - I.H. 410

The most recent attempts at minimizing the swelling clay movement have been with the deep vertical fabric moisture seal. The idea is to minimize movement by minimizing subgrade moisture changes beneath pavement structures. A good idea, not a new one, it has been used on building foundations and at a shallow depth, on a South Dakota highway. (15) (5)

The first Texas highway test section is on I.H. 410 in southwestern San Antonio. It is in an intermediate physiographic area, the Blacklands Prairie, in the Taylor and Navarro Group, lying between the Edwards Plateau to the north and the Gulf Coastal Plain to the southeast. The soils are the Houston Black and Houston Association, deep calcareous and gravelly clays. Their surface layers are usually grayish brown, about 14 in (35 cm) thick with 8 to 15% gravel in the upper horizons occurring in some profiles 20 in (50 cm) to 40 in (100 cm) deep. There is a gradual change to a gray calcareous clay subsoil 30 in (75 cm) thick. It has peds or natural aggregates of medium size, angular and blocky with shiny surfaces. Small rounded quartzite gravels occur in the surface layers and range from a few up to 30%. The clays are firm when moist, very sticky and plastic when wet. They have a very high shrink swell ratio. Their Plasticity Indeces (PI) range from 35 to 50; Liquid limits (LL) from 56 to 72. Atterberg limits from one test hole indicated PI's from 43-48; LL's from 70-71 (Table).

The fabric moisture seal was part of a state funded project on I.H. 410 from Ingram Road to State Highway 16 south. The fabric test section was located in the Valley Hi Drive interchange area south of U.S. 90. The mainlanes in the half mile (0.8 KM) section move from elevations close to natural grade to a 20 ft (600 cm) deep cut beneath the underpass structure (Figure 2).

The project's mainlanes, built in 1960, have 16 in (40 cm) of foundation course material, 8 in (20 cm) of flexible base, with 3 in (7.5 cm) of Type A and 2 in (5 cm) of Type C Hot Mix Asphaltic Concrete (HMAC). The northbound and southbound lanes each have two 12 ft (360 cm) driving lanes, 10 ft (300 cm) outside and 4 ft (120 cm) inside shoulders, separated by a 44 ft (1320 cm) grassed median (Figure 3).

Since its construction, subgrade activity has been reflected in repeated asphalt level ups of the pavement, continued surface distortions, irregularity in the curb profiles and a pressure injected lime section.

This rehabilitation contract 15.2 mi (24.4 KM) long was awarded in June 1978 at low bid of $3.8 million. Work consisted of an asphalt seal coat, 1¼ in (3.1 cm) Type C HMAC as a level up, and 3/4 in (1.8 cm) Type D HMAC finish course. The level up actually varied from 1 in (2.5 cm) to 1 ft (30 cm). The fabric test section was placed through the zone of activity to a depth of 8 in (240 cm), at the edges of the northbound lanes outside and inside shoulders. Installation includes tacking 2 ft (60 cm) of the fabric to the paved shoulder with an asphalt emulsion. The finish course of asphaltic concrete surfacing was laid over the fabric. A waterproofed fabric, DuPont Typar (T063) spun bonded Polypropylene with EVA coating was used. The fabric delivered in rolls is 117 in (292 cm) wide. The roll diameter is 10-3/4 in (27 cm) with a 3 in (7.5 cm) core. The material is 15.5 mils thick and weighs 7½ oz per yd^2 (210 g/0.8 m^2).

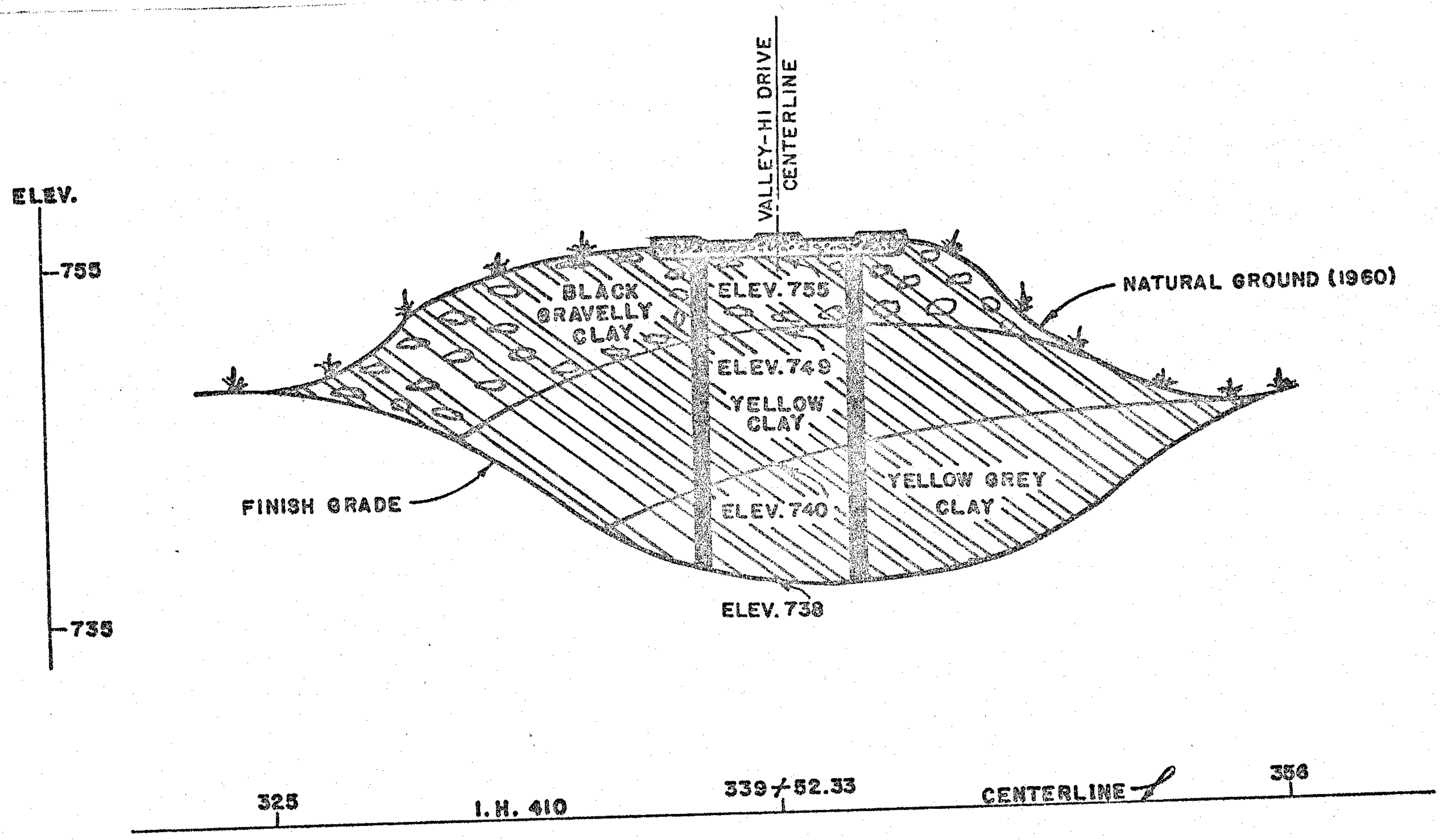
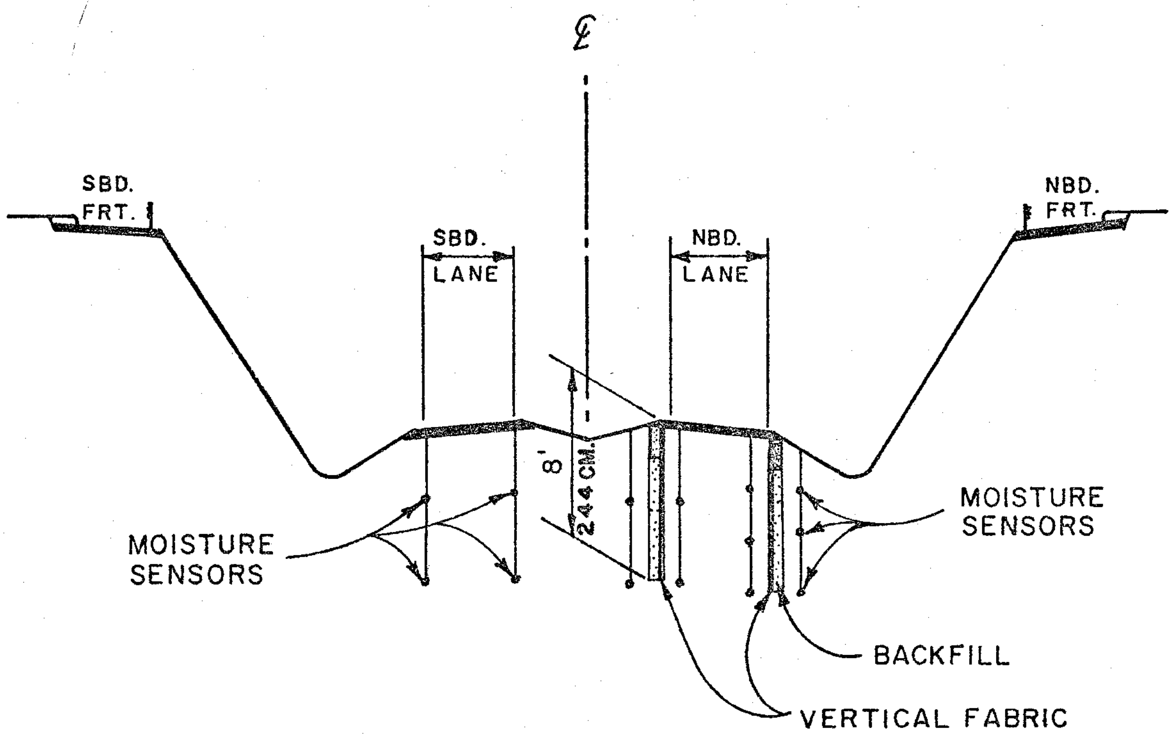

ELEV.
755
735
VALLEY-HI DRIVE
CENTERLINE
NATURAL GROUND (1960)
BLACK GRAVELLY CLAY
ELEV. 755
ELEV. 749
YELLOW CLAY
YELLOW GREY CLAY
ELEV. 740
FINISH GRADE
ELEV. 738
325
I.H. 410
339+52.33
CENTERLINE
356

FIGURE - 2



INTERSTATE 410 SECTION

FIGURE – 3

TABLE I

ATTERBERG LIMITS

(I.H. 410 - San Antonio)

Hole #	Depth ft.	Depth cm.	Liquid Limit	Plastic Limit	Plasticity Index	USCS* Classification
10	2	60	71	28	43	CH
	5	150	72	24	48	CH
	8	240	70	26	44	CH

*Unified Soil Classification System

TABLE II

MOISTURE CONTENTS

DEPTH ft.	DEPTH cm.	Hole No. 1	2	3	4	5	6
2	60	8.6	27.6	30.5	24.1	7.7	32.5
5	150	31.3	28.6	*	27.7	28.7	*
8	240	28.9	26.6	27.8	27.2	29.6	29.3
		7	8	9	10	11	12
2	60	32.7	28.2	12.8	33.7	30.8	15.4
5	150	28.3	30.4	28.4	29.3	30.8	29.7
8	240	28.7	32.2	29.2	28.8	29.7	30.8
		13	14	15	16	17	18
2	60	29.9	33.7	34.1	23.9	*	*
5	150	29.1	26.9	*	25.1	*	*
8	240	26.5	30.4	23.6	31.2	*	21.7

*Not Reported

A sand backfill was selected, based on the assumption that it would be easily placed and compacted in a narrow trench. Construction problems presented themselves. The contractor's initial attempt to place the material in December 1978 was not successful. A small rubber tired tractor type backhoe with outriggers and a D14 caterpillar maintainer with a special attachment for fabric placement was used. The maintainer had a specially built steel frame that carried the fabric roll horizontally and was capable of rotating the material into the vertical position for trench placement. Unfortunately, it was never used for placement on this project. After excavating 20 ft (600 cm) to a 10 ft (300 cm) depth, a slide occurred filling the trench before any fabric was placed. The clay had considerable gravel, serving as a reminder that site soils frequently are not uniform and may cause unexpected happenings.

A second effort was made by a subcontractor beginning on February 19, 1979. A larger crawler type John Deere 690-B backhoe with a 2 ft (60 cm) bucket was used. A Deere 920-930 front end loader placed the sand backfill, and loaded the excavated material onto dump trucks for haul to a waste site. The first day efforts resulted in 120 ft (36 M) of excavation when a slide occurred. A sliding steel shoring using ¼ in (0.6 cm) plate which held the fabric roll vertically and was pulled by the backhoe, was then used to solve that problem. Cutting and filling a 3 ft (90 cm) wide trench 9 ft (270 cm) deep, placement averaged 350 to 400 ft (105 to 120 M) per day. Fabric placement was completed on March 28, 1979. The $20 per ft (30 cm) bid price reputedly did not cover costs.

Following fabric placement, department personnel placed moisture sensors inside and outside the protected area, as well as under the adjacent southbound lane control section on May 30, 31 and June 28, 1979. Holes, 12 inD (30 cm) were drilled 8 ft (24 cm) deep by the District Laboratory's Texoma Rotary rig at 18 locations, 16 along the northbound mainlane and two along the southbound control section (Figure 4). Soil samples were taken from each hole for determination at TTI of Atterberg limits, moisture contents, and sensors calibration. The 46 sensors were placed, two or three, at each location at depths ranging from 2 to 8 ft (60 to 240 cm), their wires extended, and the hol backfilled. Slots for the wires were sawn in the pavement. The sensor wires were then gathered in plastic bags at control sites drilled 3 ft (90 cm) deep. A section of 8 in (20 cm) polyvinyl chloride pipe provided a housing for the wire recovery and reading with a soil test OHM meter 305 B. The sensors used were Soil Test Moisture Cells MC 374 and were calibrated at TTI. In the fabric sections they were located 3 ft (90 cm) on either side of the material.

The sensors are 1 in x 2 in x 22 gauge (2.5 cm x 5. cm x 22 gauge) and have two stainless steel plates separated by a processed fiberglass pad which attracts moisture to the fiber surfaces. The moisture accumulates there until an energy equilibrium is reached between moisture on the fibers and in the soil. This reduces the electrical resistance of the fiberglass material between the plates. The resistance reading was made with a battery operated 90 cycle AC type meter. Sensors calibrated at TTI in a potassium chloride solution relating resistance

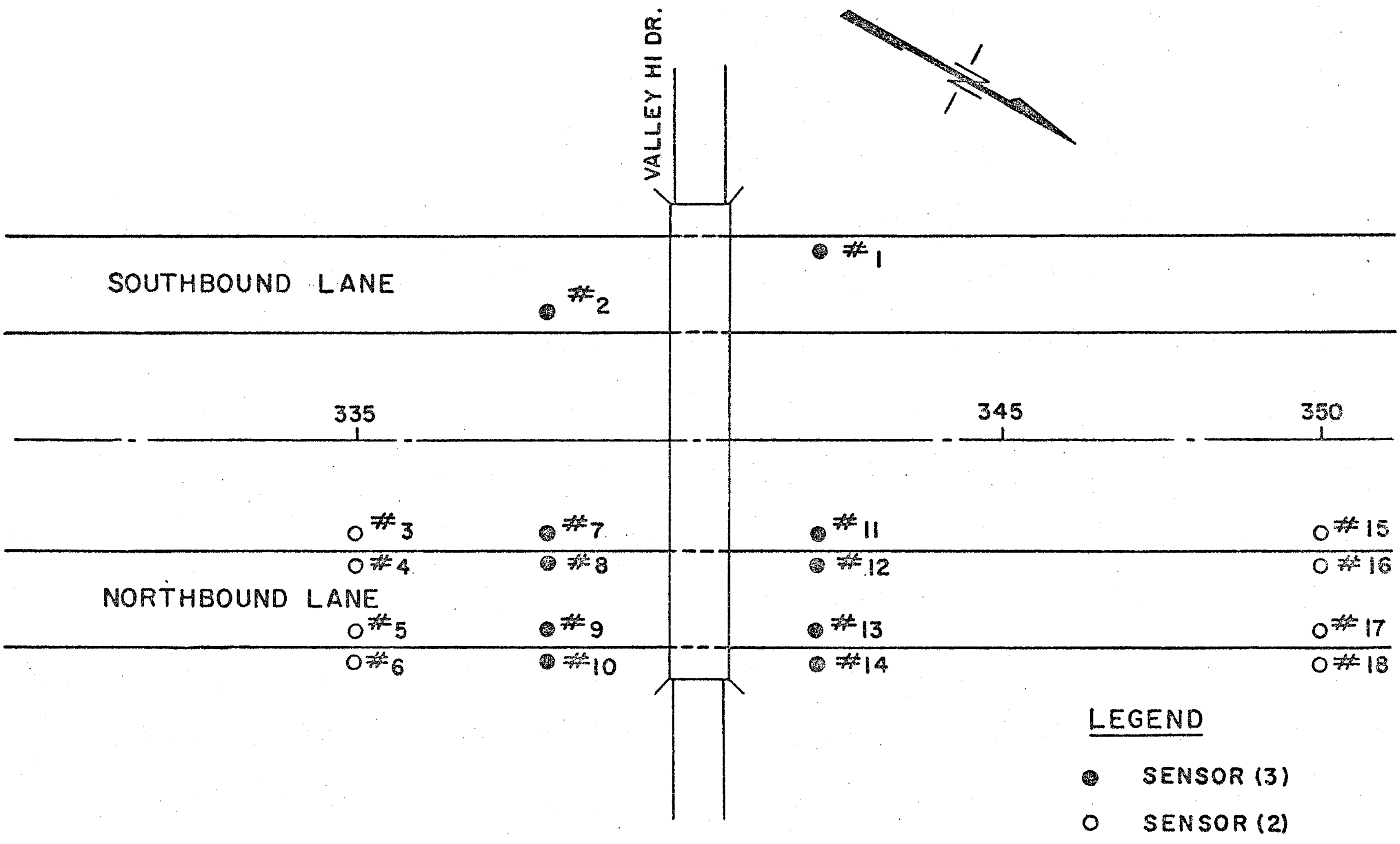

VALLEY HI DR.
SOUTHBOUND LANE
#1
#2
335
345
350
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
#16
#17
#18
NORTHBOUND LANE
LEGEND
SENSOR (3)
SENSOR (2)
HOLE NUMBER

FIGURE-4

in ohms to Suction.

The moisture contents of soil samples indicate similar patterns with indigenous clays in the county. Moisture contents at 8 ft (240 cm) depth vary from 21.7 to 34.2%. Those at the 2 ft (60 cm) level vary from 7.7 to 34.1% moisture (Table II). The pattern of previous testing in the area indicates surface - 2 to 3 ft (60 to 90 cm) - moisture content variations from 5 to 35%. The variations at greater depths were much less.

Project contract work was completed on July 19, 1979.

Post construction problems have also appeared. The backhoe trench was 3 ft (90 cm) wide. On individual occasions two tractor trailer trucks and a trailer house have sunk into the soft sand. "Soft shoulder" signs were to no avail in these cases. Cement stabilized base placement in the top 2 ft (60 cm) of the trench has been discussed.

OBSERVATIONS

Moisture sensor and profilometer readings have been taken, as have cross sections, roadway surface inventories, and photographic records. Regular testing schedules are planned.

For moisture determinations the wires from the sensors are attached to the ohmmeter and readings taken. The higher the reading the greater the resistance and the suction, which reflects a reduction in moisture content of the soil sampled, or a drying condition compared to initial possibly saturated situations.

The first sensor readings took place on May 30, 1979. Sensors were placed that day in holes that could be drilled from the pavement as the shoulder subgrade was too wet from recent rains to support the equipment. The first readings indicated fairly high values, a reflection of suction conditions, indicating the sensors had not been saturated yet.

The ohmmeter resistance readings of May 31 for the sensors placed the previous day, all decreased. The sensors were absorbing the moisture of the soil around them, reflecting less suction and a higher moisture content. Sensors newly placed that day showed similar low to no ohm readings with indications of high moisture content.

Following a drying trend in the weather, the portable augur rig was able to drill the rest of the test hole sites on June 28, 1979. These newly placed sensors were all along the northbound lane outside of the fabric protected subgrade. Their readings indicated significant ohmmeter registrations, reflecting their dry condition at placement, and their not absorbing soil moisture at that time.

The August 15, 1979 observations followed a rainy spell. All sensors read indicated no resistivity values, a high moisture condition.

The latest readings took place on November 14 and 15, 1979. Fourteen of the 46 sensors read indicated resistance reflecting a drying condition. Three of 6 sensors under the southbound control lane, - 50%, indicated drying. This was shown at depths of 2 and 3 feet (60 and 90 cm). Eleven of the remaining 40 sensors showed drying conditions along the northbound lane. Only 4 of the 11 were inside the fabric protected area. This would initially indicate the fabric protected subgrade is less likely to have moisture changes that could result in pavement elevation changes.

Of the 14 locations indicating drying, 10 were at a 2 ft (60 cm) and 1 was at 3 ft (90 cm). Drying does occur sooner, closer to the surface. Also where 50% of the sensors under the unprotected southbound lane show signs of drying, a little more than 33% showed similar drying along the northbound lane outside the fabric, and 20% indicated a similar situation inside the barrier. These are initial readings and indications only (Table III).

Profilometer readings taken in July and November 1979 indicate surface irregularities both initially and subsequently. Serviceability index values will be computed to convert analog to digital form at a later date.

TRENCHING TEST

The use of the trenching machine was recommended instead of the backhoe. The IH 410 contractor decided against it. A test was conducted on Interstate Highway 37 about one mile south of Loop 13 in southeast San Antonio. A Vermeer 600 was used. It had a special attachment to its boom that held a roll of fabric vertically, 8 ft (240 cm) into the trench. Steel plate about 1/8 in (0.3 cm) thick was used with a frame pivoted on the trenching machine boom. The roll was held in a vertical position in the trench and the material spread out behind it as the trenching machine advanced. About a 1 ft (30 cm) wide trench was maintained. The first afternoon's trial averaged 2 to 3 ft (60 to 90 cm) of trench excavation and fabric placement a minute. The second day's average was about 3 to 3½ ft (90 - 105 cm) per minute in a clay that had considerable gravel. A slide occurred on the second day about 20 ft (600 cm) behind the machine. The slide was 20 ft (600 cm) long and resulted in a 10 to 12 in (25 to 30 cm) vertical drop of the roadway shoulder 3 to 4 ft (90 to 120 cm) back from the trench. Possibly backfilling immediately behind the trenching and fabric placement would have avoided the slide. The fabric placement was not impeded. Representatives providing the demonstration felt that in a clay without the gravel, they could excavate an 8 ft (240 cm) deep trench at a rate of 6 ft (180 cm) per minute. In a 10 hour workday, this would average 3600 ft (1080 M) considerably better than 350 - 400 ft (105-120 M) on Loop 410. The excavated material was bladed back into the trench as backfill.

NEW FABRIC PROJECTS - I.H. 37

Currently the largest Texas highway placement of the deep vertical moisture seal fabric is part of a contract on I.H. 37. North of the trenching test, the project area has been experiencing substantial swelling clay movements since its construction 11 years ago. These sections of I.H. 37 are generally clays in the Houston Black Series. Their plasticity indices averaged 54 and liquid limits averaged 86.1. These clays are very active.(16)

TABLE III

I.H. 410 - Deep Vertical Fabric - OHM Meter Readings

Hole #	Sensor #	Depth ft.	Depth cm.	5-30	5-31	6-28	8-15	11-14 & 11-15
SOUTHBOUND LANE								
1	001	7	210	260K	20K	0	0-A	0
	002	5	150	28K	9K	0	0-A	0
	003	2	60	280K	10K	0	0-A	63K
2	004	7.5	225	120K	0	0	0-A	0
	005	3	90	300K	0	0	0-A	5K
	006	2	60	165K	0	0	0-A	11K
NORTHBOUND LANE								
3	007	8	240			500K	0	0
	008	2	60			45K	0	1500K
4	009*	7	210	800K	17K	0	0	0
	010*	2	60	45K	9K	0	0	0
5	011*	7	210	220K	0	0	0	0
	012*	2	60	350K	0	0	0	0
6	013	7	210			47K	0	0
	014	2	60			50K	0	0
7	015	8	240			70K	0-A	10K
	016	5	150			150K	0-A	0
	017	2	60			130K	0-A	0
8	018*	5	150		0	0	0-A	0
	019*	4	120		0	0	0-A	0
	020*	2	60		0	0	0-A	0
9	021*	7	210		0	0	0-A	0
	022*	5	150		0	0	0-A	0
	023*	2	60		0	0	0-A	0
10	024	8	240			0	0-A	0
	025	5	150			38K	0-A	0
	026	2	60			196K	0-A	1500K
11	027	8	240			300K	0-A	71K
	028	5	150			450K	0-A	0
	029	2	60			5K	0-A	40K
12	030*	6	180	25K	0	0	0-A	1K

continued

TABLE III

I.H. 410 - Deep Vertical Fabric - OHM Meter Readings

Hole #	Sensor #	Depth ft.	cm.	5-30	5-31	6-28	8-15	11-14 & 11-15
NORTHBOUND LANE								
12	031*	3	90	175K	0	0	0-A	0
	032*	2	60	200K	6K	0	0-A	4K
13	033*	7	210	0	0	0	0-A	0
	034*	4	120	280K	0	0	0-A	0
	035*	2	60	425K	0	0	0-A	3K
14	036	8	240			282K	0-A	0
	037	5	150			72K	0-A	0
	038	2	60			775K	0-A	0
15	039	8	240			600K	0	0
	040	2	60			450K	0-A	40K
16	041*	7	210	150K	0	0	0	0
	042*	2	60	800K	80K	0	0-A	2K
17	043*	7	210	0	0	0	0-A	0
	044*	2	60	0	0	0	0-A	0
18	045	8	240			0	0	0
	046	2	60			260K	0-A	6K

A = Assumed
K =1000 OHMS

* All sensors outside fabric unless noted with asterisk

I.H. 37 is an eight lane divided freeway. The mainlanes are separated by a sodded median from 28 to 36 ft (840 to 1080 cm) wide with a 3 ft (90 cm) concrete riprap ditch and steel median barrier guard rail. (Figure 5) Each lane is 12 ft (360 cm) wide with 10 ft (300 cm) outside and 6 ft (180 cm) inside shoulders. The mainlanes were constructed on 6 in (15 cm) of lime stabilized subgrade, 8 in (20 cm) of cement stabilized base and 8 in (20 cm) of concrete pavement. Their gradeline through the project limits varies from a 20 ft (600 cm) embankment to a 22 ft (660 cm) excavation below natural ground. Over the years the active clays have caused considerable pavement distortion and slope slides. They have been met by repeated asphaltic concrete level up, work with the heater planner and construction of retaining walls.

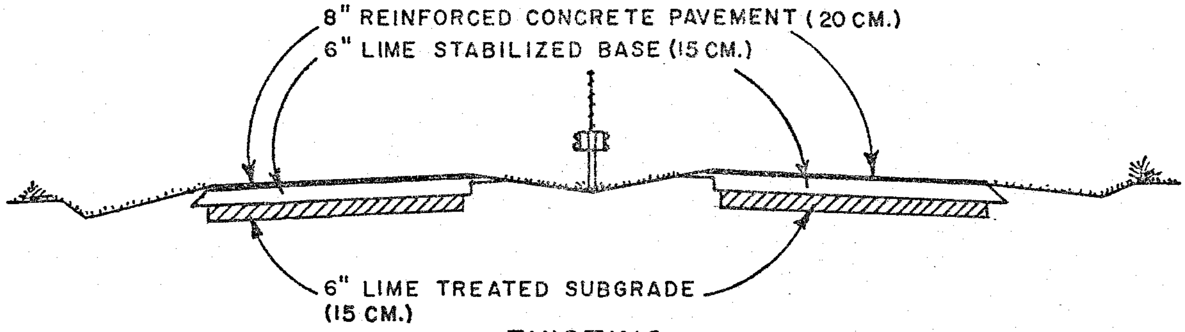
The present rehabilitation contract includes asphaltic concrete level ups and finish course, reconstruction of the median to provide positive drainage from the built up section with a concrete "Jersey" type median barrier. It will also include placement of a deep vertical fabric moisture seal. A DuPont Typar T063 EVA fabric or equal is specified. It is to be placed 8 ft (240 cm) deep in trenches along the outside shoulders of north and southbound lanes. A 6 in (15 cm) perforated underdrain pipe is placed at the bottom of the fabric trench. Backfill specified is a gravel.

The project contract calls for an estimated 23,753 yd^2 (19000 M^2) of the fabric. A testing schedule has already begun with the first profilometer runs prior to contract work. Future profilometer tests will be supplemented by psychrometer moisture readings both inside and outside the fabric protected sections, cross sections, roadway surface inventories and photographs will all be continued. The areas monitored will be those within the contract limits as well as sections one half mile in each direction to serve as partial control elements.

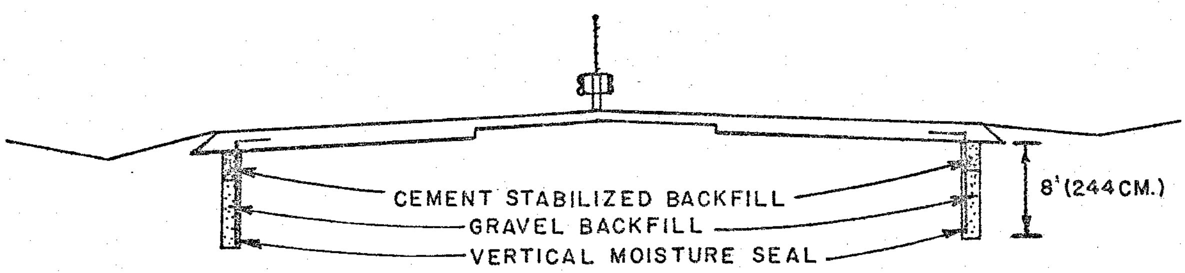
The contract bids were opened on October 26, 1979 on I.H. 37. The low bidders price was \$21 per yd^2. This compared not unfavorably with \$20 per ft bid for this work on Loop 410 2 years before. Cost effectiveness is a concern. However, knowledgeable professionals estimated costs plus 50% for contingencies would have resulted in a \$16 ft (480cm)

U.S. 90

The Department is also planning another placement of the deep fabric seal on U.S. 90, a four lane freeway with a 24 ft (720 cm) sodded median. Also in southwest San Antonio, the area has steadily reflected the negative impacts of the swelling clays. In the construction stages a pronounced hump developed in the westbound lane in the vicinity of the 90 Business Route underpass. The subgrade had 6 in (15 cm) of lime treatment and cement stabilized base. The swell developed prior to placement of the Portland Cement concrete pavement. Test holes were drilled in the adjacent ditch line, and a gravel backfilled underdrain with two pipes was placed (17). Water flow was perceptible from the underdrains. The concrete pavement was placed in 1970 and all seemed well. In the past several years considerable distortion of the pavements in the areas has occurred. Repeated "level ups" of asphaltic concrete have failed to do more than temporarily mitigate the difficulties. The fabric will be placed down the inside and outside shoulders of the east and westbound lanes. The excavated material will be



EXISTING



PROPOSED

INTERSTATE 37 SECTIONS

FIGURE — 5

used to minimize past post construction problems.

CONCLUSION

Expansive soils can be controlled. Whether the deep vertical fabric moisture seal can be included in these solutions for existing pavements have not been fully substantiated in field tests to date. They have been placed in active areas and they are being monitored. Early results indicate less moisture changes inside the protected area than outside. This is encouraging. Placement problems of the fabric seem surmountable and the seals hold promise. They have been evolved from the work of many engineers from many places and agencies. Other methods may control clays as well or as economically. Clays are not beyond control and existing structures may be spared further damages.

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KEY WORDS

Expansive Soils , Swelling Soils, Clays, Fabrics, Deep Vertical Moisture Barriers, Seals, Highways, Pavements.

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