WVU

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TECHNICAL QUARTERLY

AN EXCHANGE OF IDEAS
Editor:
Kathleen M. Jones

TRAFFIC BUTTONS AND BITUMINOUS ADHESIVE: A FASTER PLACEMENT METHOD

Raised pavement markers and reflective traffic buttons have proven to be valuable forms of roadway delineation. They clearly mark out the geometrics of the road for motorists in the dark or in heavy rain. They make gore areas easier to interpret. They provide a sensory warning, in the form of vibration, to the motorist if the vehicle drifts across them. Two things they don't do well, though, are retain reflectivity and remain on asphalt concrete pavement. The reflectivity loss is a critical one; however, the reflectivity doesn't matter much if the marker simply won't adhere to the ACP for more than a couple of months. As stated in Research Report 322-4F:

> The marker system is effective if 70-80 percent or more of the markers on the road are effective. The markers are semi-effective as long as 50-75 percent of the markers are on the road and are ineffective when

INSIDE...

FIGURE 1 The hand-pushed applicator.

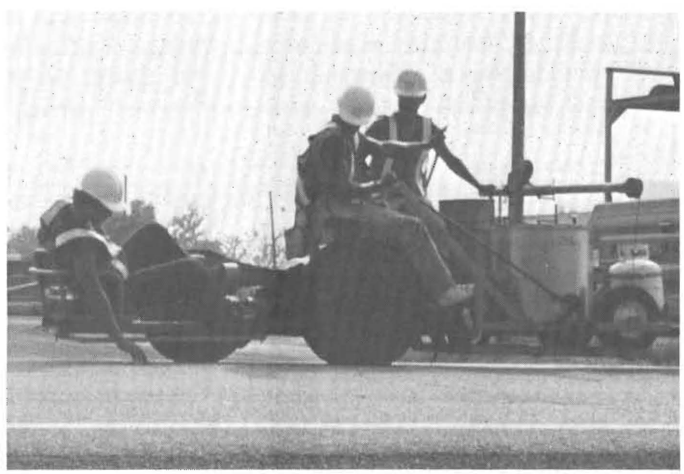

FIGURE 2 The modified-trailer applicator.

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Technology Transfer Subsection
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less than 50 percent of the markers are on the road regardless of the specific intensity levels.

Report 322-4F tentatively suggested that bituminous adhesives, like Bitumen®, might be a solution to the problem of marker retention. Research Study 477, headed by Dr. J. T. Tielking of Texas Transportation Institute, picks up where 322 left off in an attempt to find a workable solution. Some of the data being looked at in 477 has been gathered by Mr. Robert Price of the Materials and Tests Division (D-9) from Districts 1, 3, 8, 10, 15, 16 and 17. Table 1 below is a summary of this information pertaining only to ACP sites that compare bituminous adhesive and epoxy directly:

Mr. Price also examined approximately 5,220 markers of various types that were placed with bituminous adhesive, but did not have a nearby epoxy-placed control section. These markers had been in place, on the average, about 9 months on sections that have AADT's ranging from 2,700 to 13,000. The overall retention rate was 98.6 percent. These data appear to support the claim that bituminous adhesive works better on ACP than epoxy. Evidence does not seem to indicate that bituminous adhesive is more effective than epoxy on portland cement concrete, however.

Until recently one of the few unfavorable things about dealing with bituminous adhesive was that the melter/extruder had to be pushed by hand (Figure 1). Both the operator and the placer had to walk. Two minutes per button was an average placing time. Holding a line was difficult. Going uphill with the 400 pound machine was, to say the least,

FIGURE 3 The guide boom.

labor-intensive. District 10 personnel fixed the problem by converting an unused park mower trailer into a mobile platform for Bitumen® application. Given the go-ahead by Maintenance Foreman Don Hughes, Mr. Gordon Graham of the Athens Maintenance Section designed the trailer shown here (Figure 2). Mr. James Beard had a hand in the design of the guide boom on the front of the rig (Figure 3).

This trailer holds two to three people. One operates the Bitumen® applicator; one sits in the "low-rider" seat (Figure 4) placing buttons; and the third, if present, watches the level of melted Bitumen®, adding more as needed. The day's supplies of RPM's and Bitumen® are carried on the trailer. The applicator is anchored on a hinged platform that rides very low to the ground in work mode. Both the hinged platform and the "low-rider" seat are designed to be easy to handle and to switch from work

FIGURE 4 The "low-rider" seat.

TABLE 1. Field comparison of bituminous adhesive and epoxy.

Dst.	Hwy.	Adhesive	RPM/RTB type	total number	number lost	percent retained	time in place	AADT
*3	FM 369	Bitum.	Low-profile	283	112	60%	30 months	11,000 16,000
	"	Epoxy	"	283	63	78%	"	"
3	US 277	Bitum.	Low-profile	118	7	94%	30 months	13,000
	"	Epoxy	"	118	47	60%	"	"
8	SH 351	Bitum.	Low-profile (Stimsonite)	363	11	97%	29 months	11,500
	"	Epoxy	"	71	4	94%	"	"
10	I-20	Bitum.	Ceramic button	132	2	98%	13 months	19,400 (40-50%
	"	Epoxy	"	132	56	58%	"	trucks)
10	I-20	Bitum.	Cataguide	66	3	95%	13 months	19,400
	"	Epoxy	"	66	2	97%	"	
10	I-20	Bitum.	Low-profile (Stimsonite)	66	2	97%	13 months	19,400
	"	Epoxy	"	66	66	0%	"	
15	US 90	Bitum.	Low-profile (Stimsonite)	242	5	98%	30 months	7300
	"	Epoxy	"	245	130	47%	"	"
15	US 281	Bitum.	Low-profile (plus 50 4x4's)	183	8	96%	30 months	3200
	"	Epoxy	"	182	84	54%	"	"
16	SH 358	Bitum.	Low-profile	104	32	69%	27 months	30,000
	"	Epoxy	"	97	64	34%	"	
16	SH 44	Bitum.	Low-profile	233	31	87%	28 months	13,000 15,000
	"	Epoxy	"	234	74	68%	"	"

According to Robert Price, in his technical memorandum of April 15, 1986, "This is the first marker count, to my knowledge, where the epoxy-placed low-profiles have fared better. The bitumen-placed markers apparently are performing poorer at this location because of the nature of the pavement surface. The pavement is very dense and even at the surface and also very dirty. This smooth surface does not allow the adhesive any voids to fill and therefore lowers its effectiveness. Adhesion to a pavement of this nature might be improved if the bitumen is applied hotter or when the air temperature is higher, thus helping the bitumen to soften the existing pavement asphalt and flow better."

mode to traveling mode. The guide boom is long enough to make staying on line simple. The front wheel of the boom swivels to accommodate lateral motion; the pinned hinge 22½ inches out from the bumper accommodates changes in elevation. The side guides are adjusted to extend as far out as the applicator and are calibrated to the length of the truck and trailer.

The driver of the tow vehicle positions the guide boom on a paint stripe. The desired spacing determines which side guide is used. The driver stops when the desired spacing is reached. The applicator operator releases some Bitumen®, then hand signals the driver to roll forward until the button-placer is over the adhesive. The applicator operator signals for the driver to pause while the button is placed and signals for the rig to move on as soon as the button is down (Figure 5). With this arrangement, a rate of about 4 buttons per minute can be maintained all day. For safety, two shadow trucks, one with an arrow board, are used.

When the rig is on its way to or from a work site, the applicator does not ride on the forward platform low to the ground. With the aid of a telescoping winch built into the trailer, the hinged platform is lowered. The applicator is removed, taken to the back of the trailer, drawn by the winch up removable ramps and secured in back corner opposite the "low-rider" seat. The "low-rider" seat is also removed and stowed on the trailer for traveling. The forward hinged platform is folded up to give the trailer more than four inches of clearance. Once these tasks are performed the rig can be driven at highway speeds (Figure 6).

The Athens Maintenance Section built this trailer, which allows buttons to be placed eight times as fast, out of scrap and spare parts. A video tape, produced by District 10, of the trailer is available on loan from the D-10 Research Library.

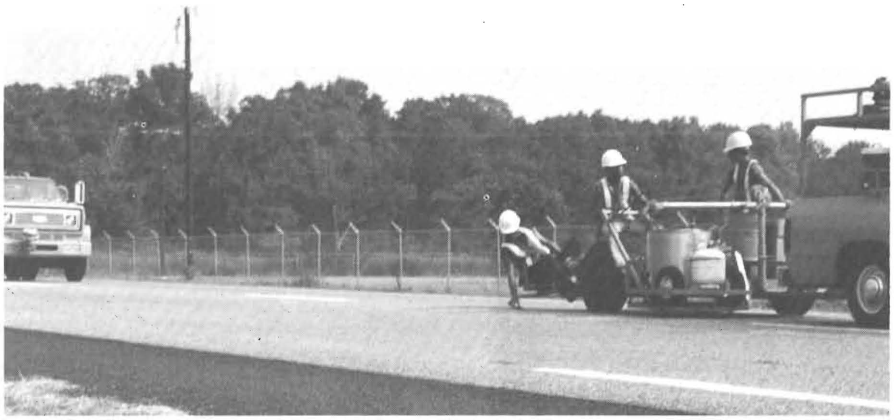


FIGURE 5 The rolling operation.

FIGURE 6 Hinged platform folded, seat stowed, applicator secured by winch.

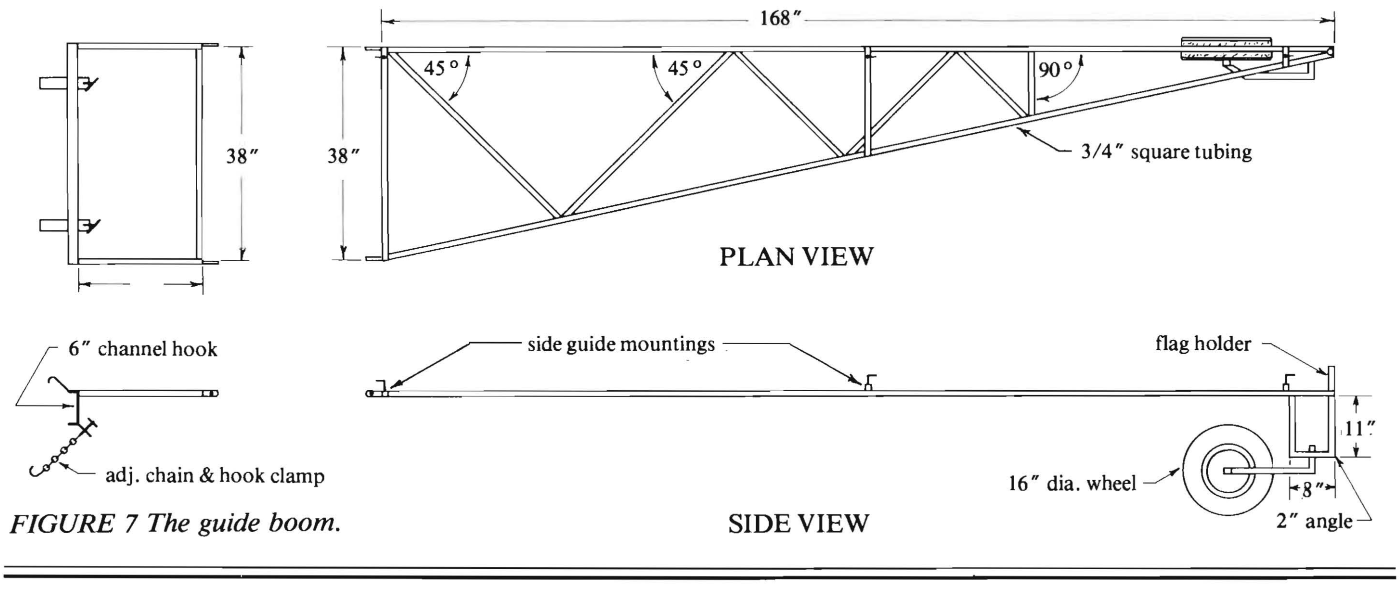
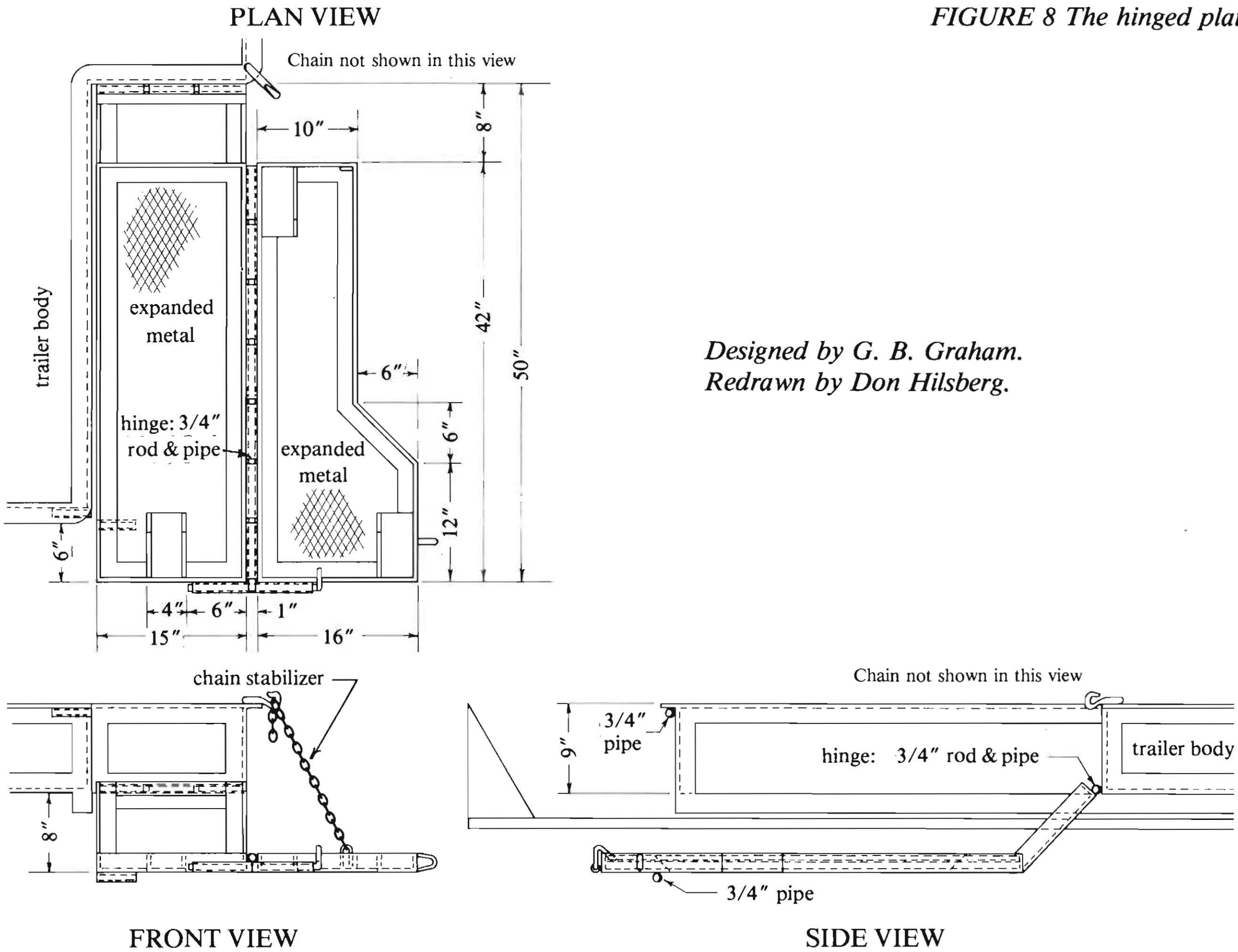


FIGURE 7 The guide boom.

FIGURE 8 The hinged platform.



Designed by G. B. Graham.
Redrawn by Don Hilsberg.

INNOVATIVE ROADWAY FINANCING IN TEXAS

M. A. Euritt and C. M. Walton,
Center for Transportation Research, University of Texas

Methods of financing roadway improvements have undergone significant changes since the early 1970s. For a variety of reasons, traditional sources of highway revenues have not kept pace with transportation needs. Alternative financing methods such as the two adopted by Texas in 1984—transportation corporations and road utility districts (RUDs)—provide for the development of transportation projects and give state and local agencies additional sources of revenue.

The 1970s were a period of transition for the transportation industry, particularly with regard to highway finance and development. The costs of highway development, chiefly maintenance and construction, are inextricably linked to fuel costs, and the rising fuel costs during this period significantly reduced the purchasing power of highway dollars. In addition, the problem was magnified with a decline in highway revenues. Transportation agencies were forced to reevaluate and downscope many projects and legislators were forced to consider new sources of funding.

Most state transportation agencies responded with increase in fees and taxes from traditional highway user charges. Since 1975, 46 states have increased their fuel taxes, and most states have also increased their vehicle registration fees. To supplement the more traditional sources of funding, many agencies, state and local, have attempted to involve private interests by such means as accepting donations, encouraging the participation of local merchants, and requiring developers to provide financial assistance to offset the additional traffic burden caused by growth and expansion.

For the most part, recent Texas highway development has followed a pattern similar to that of the rest of the country. House Bill 3, passed the 65th legislature in 1977, created a new mechanism for funding the activities of the SDHPT. This mechanism made possible increased funding without increasing highway user charges by utilizing some of the state budget surplus, which at that time was rather significant. House Bill 3 was designed to maintain a 1979 level of highway services by measuring and compensating for the impact of inflation on the costs of

Continued on page... 11

NEW MOUNTING METHOD FOR DOUBLE CHEVRONS

by Steven Golding,
Research Implementation Engineer,
Division 10

A new, relatively simple way of mounting two chevron signs on one post has been developed for use on curves. The mounting arrangement allows the signs to be independently aimed over a large range of angles.

An informal telephone survey of all District Maintenance Engineers indicated that many districts use chevron signs to delineate sharp curves. Several said that they have seen markedly reduced accident rates after installing the chevrons.

Since delineator use (including chevrons) is restricted to the outside of curves, several districts have developed methods for mounting chevrons for opposing directions of traffic on one post, reducing the number of posts required around the curve by half. Several mounting methods have been used with a good deal of success. However, some difficulties have remained in combining simplicity and sturdiness with the ability to aim each of the two chevron signs, over a large range of angles, at the oncoming traffic.

The following suggested method is based on an idea by Mr. T.J. Smith of the Johnson City Maintenance Section. He suggested the chevron signs be mounted off-center, near their edges. In this way the signs can be directly mounted to a post, with enough room for each of the two signs to be aimed independently over a large angle.

A variety of mounting arrangements are possible. Two configurations were reviewed with Mr. Lewis Rhodes, Supervising Traffic Engineer, D-18T. Both configurations use 12″ x 18″ or 18″ x 24″ chevron signs. Two holes are drilled in each sign, three inches from the top and bottom, three inches from the edge to which the chevron points (see drawing).

A 2-inch galvanized steel pipe can be used, with two sign clamps attached to each sign. After the clamps for the first sign are attached to the pipe, the second pair of clamps are placed just above the first pair, so that one sign is slightly higher than the other. With this arrangement, the signs can be adjusted so that they are anywhere from parallel up to a 58° angle to each other. This sign configuration is quite sturdy and it is anticipated that it will withstand high winds. As usual, the pipe is set in concrete with a frangible pipe coupling.

The off-center chevron signs can also be mounted on delineator posts with bi-directional (U-shaped) brackets. This configuration has not yet been tested. A minimum 2-pound per-foot delineator post should be used. The 2-pound-per-foot post offers the advantage of being easily driven into the ground, and it may be acceptable for most of the state, except where wind-loading is a problem. Chevron signs placed on 3-pound-per-foot delineator posts with bi-directional brackets are expected to be sturdy. As usual, an E-Z-Erect 3-piece breakaway base should be used.

Sign height may be 4 feet vertical distance from the pavement edge to the bottom of the sign. The FHWA approved this height because chevron

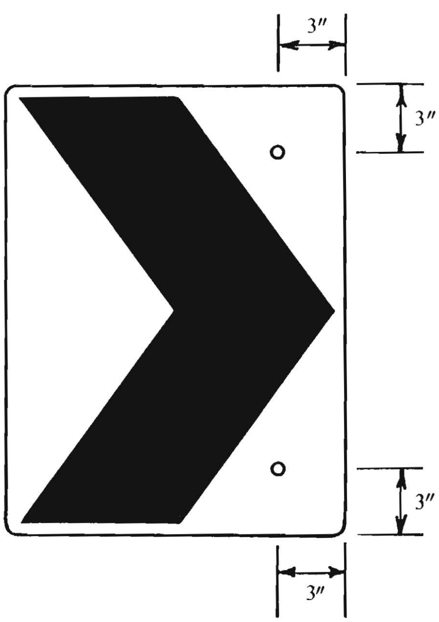


FIGURE 1 Spacing of the holes.

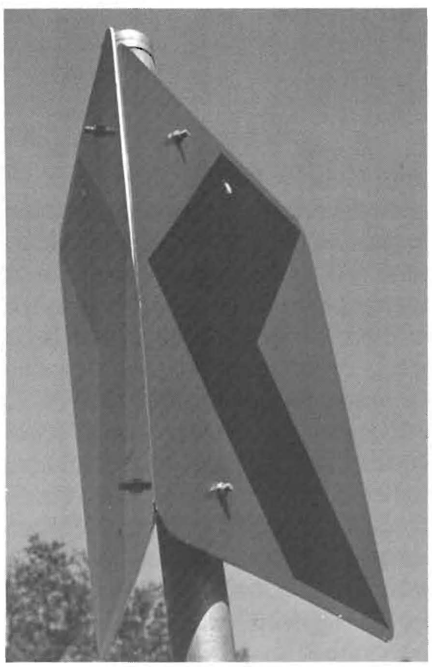


FIGURE 2 Maximum angle, front.

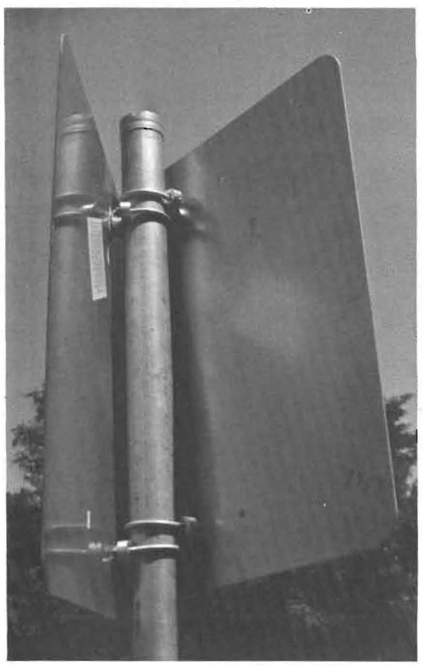


FIGURE 3 Maximum angle, rear.

signs are used as delineation devices rather than signs, and the lower height improves headlight illumination of the chevrons. The shorter post also increases the sturdiness of the chevron sign installation.

If you have questions about this design, please contact either Mr. Lewis Rhodes, Supervising Traffic Engineer, D-18T, (512) 465-6330, TEX-AN 823-8330 or Mr. Steve Golding, Implementation Engineer, D-10R, (512) 465-7908.

SIGN TRUCK SAVVY

Back injuries are among the most common types of on-the-job injuries sustained by SDHPT personnel. The Monthly Accident Statistics Report for September 1985 through August 1986 lists 167 back injuries this fiscal year. The next closest in frequency are eye injuries, which have totaled 133, and finger injuries, 121. Many of the back injuries are related to work activities involving lifting and straining. Sign maintenance is just such work.

About five years ago, Mr. Clarence Lee of the Quitman Maintenance Section (Figure 1) was one of the back injury statistics. He was removing a damaged pipe-mounted, Type C ("wishbone") sign by the usual hand tool method; in the process he strained his back and damaged some vertebral disks. Mr. Lee wanted to continue working with the Quitman sign truck, and he had always enjoyed inventing things that improved the efficiency of his sign truck, so he came up with some ideas that would spare his back. Not only do the items he came up with help a person who has had a back injury, but also they help prevent back injuries by reducing the amount of lifting and straining associated with sign work.

FIGURE 1 Mr. Clarence Lee.

The Quitman sign truck that Mr. Lee drives is a 6-cylinder Chevrolet with well over 100,000 miles on the engine. It has a 1962 modified bed. Mr. Lee prefers his ordinary cab pickup with its 36-inch-from-the-ground seat to the tailer cabs of the heavy-duty trucks because climbing in and out of the tall cabs all day is painful.

A primary addition to the sign truck's equipment was the 3500 pound capacity electric winch mounted on the modified, heavy-duty bumper of the truck. Two pieces of equipment, designed by Mr. Lee and built in the District 10 shop, are often used with the winch. The first (Figure 2) is called "Bearclaws." The open side is slipped around a 4-by 4-inch wooden post (Figure 3). The winch cable is hooked into the slot opposite the open side. As pressure is applied, the teeth dig into the wood and the post is pulled. The second device (Figure 4) is a very ver-

FIGURE 2 Wooden post puller.

FIGURE 3 "Bearclaws" in action.

FIGURE 4 *A multi-sized pipe puller.*

FIGURE 5 Top view of gear teeth.

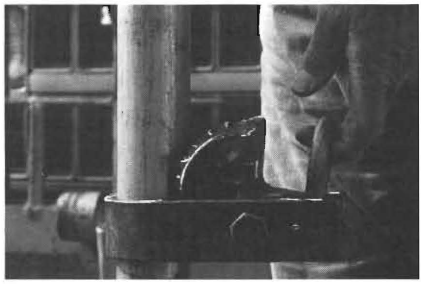


FIGURE 6 Pressure is applied.

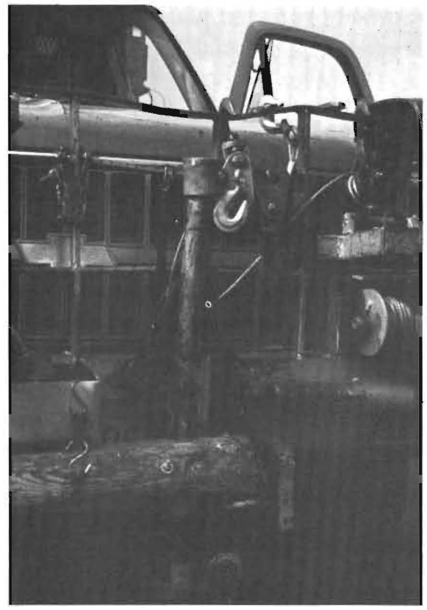


FIGURE 7 The gin pole.

satile pipe puller. It can accommodate anything from a standard galvanized delineator post up to a 2 1/2-inch round pipe (Figure 5). The inclined-toothed jaws, made from a gear out of a "Sidewinder" brush shredder, have a loop welded to the rear quarter. The gear and loop assembly pivots on an eccentrically placed axle which runs through a 1/4- by 2-inch U-shaped bracket. As pressure is applied to the loop (Figure 6) the jaws roll forward until the pipe being pulled is securely clamped between the jaws and the U-shaped bracket. The electric winch is able to pull a post or straighten a delineator in a matter of seconds while the operator stands safely to the side handling it by remote control.

Five pulley blocks, that can be attached to the front grill in several different patterns, allow Mr. Lee to vary the mechanical advantage or the direction the force is being applied to a pole or post. He also, at times, uses a gin pole mounted on the front of the truck for pulling poles with the winch (Figure 7). Another adaptation he has made is a large, horizontally mounted, telescoping pulley (Figure 8). This pulley comes into play when a delineator or sign near a bridge or other obstruction needs to be straightened. Since it isn't safe or practical to park on the bridge, the truck can be parked further away where the shoulder widens. The side pulley can be extended and the winch cable can be run through it back (or forward) to the damaged post.

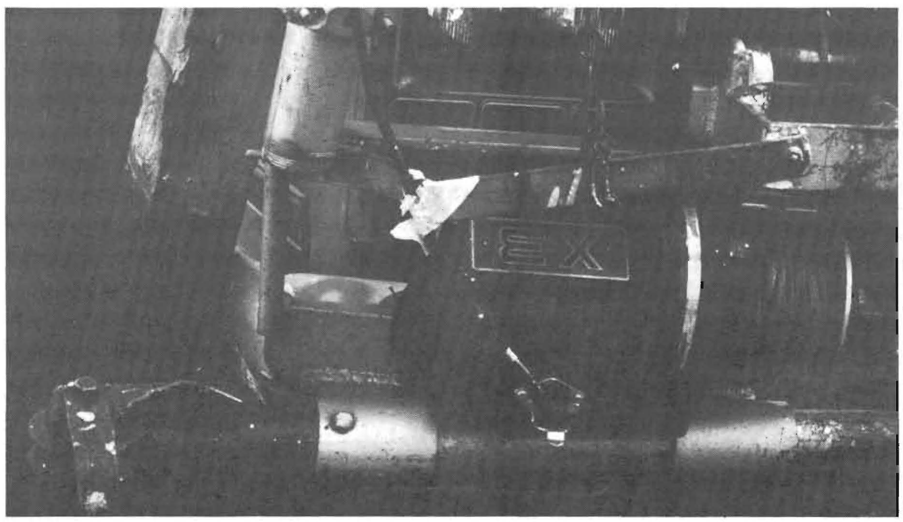


FIGURE 8 The side pulley.

Other useful items he employs on a daily basis include a template, mounted on the front grill at a comfortable height, for drilling holes in mailboxes to adapt them to the new safety mountings; three small levels with magnets on each side (he can attach them to posts and step back to read the level, avoiding stooping); and a grate that folds out over the roof of the cab for working on tall signs.

Mr. Lee pays close attention to the organization and placement of his tools. He arranges duplicate sets of certain tools like 5-pound sledge hammers and crescent wrenches at workstations fore and aft of the truck. This duplication saves him time because the wrench or hammer needed is always at hand instead of at the opposite end of the truck, as so often seems to happen otherwise. He has rigged an electric power outlet at each end of the truck for the same reason. He sees to it that the truck is routinely supplied with all the items needed in a normal day so that he won't have to come back to the warehouse during the day unless he is faced with a very unusual situation. Drawings of an idealized sign truck and its bed compartment layout, based on Mr. Lee's specifications, are available from the editor of TQ.

DURABILITY OF STOCKPILED SYNTHETIC AGGREGATE

by Kenneth W. Fults,
Supervising Planning Engineer
District 11

Several years ago, District 11 personnel began to suspect the durability of long-term stockpiled synthetic aggregate. Various reports from the field indicated a loss of structural integrity of synthetic aggregates that had been retained in open air stockpiles in the East Texas environment. This 'rotting' effect resulted in a number of small surface treatment failures due to fracturing of aggregate particles, but it was not until a major failure occurred on US 59 near Shepherd, Texas, in the late summer of 1983 that investigative research was initiated by District 11 laboratory personnel.

The mode of failure, as noted above, was fracturing of individual aggregate particles. One result of the fracturing was that asphalt bled through the reduced, nominal-sized covering lowering the roadway's skid resistance. The fracturing was to the extent of complete disintegration of the particle to a coarse dust. The dust was then swept about the roadway causing further hazardous driving conditions due to restricted visibility, as well as a slickened surface.

The disintegration phenomenon was reported to both the producer of the aggregate and the Materials and Tests Division. It appeared that this was the first indication of a problem that had been made to either the Austin office or the producer. It was therefore decided to secure as many samples from the field as possible with varying stockpile lives and to test them for conventional durability-related characteristics. The tests used were Los Angeles abrasion, for determining resistance to wear by traffic action; freeze-thaw cycling, for determining resistance to disintegration by weathering; and pressure-slaking, for evaluating the amount of dehydration that has occured in the production of a synthetic aggregate which has been fired in a rotary kiln.

A memo was directed to the various maintenance foremen in District 11 advising them of the proposed research activity and requesting information regarding known stockpile locations and requisition receipts. There was a tremendous response from within the District; numerous samples were secured and identified. Since the District Laboratory had tested all of the material at the time of delivery for pressure-slaking value, they decided to perform the pressure-slaking test on the stockpiled material also as a consistency measure. The LA abrasion and freeze-thaw tests on the stockpiled material were performed by Materials and Tests Division in Austin. A summary of the test results is included as Table 1.

It is significant to note that there is a definite time-related trend indicated by the rapidly escalating freeze-thaw test results. As can be seen, all of the original freeze-thaw (FT) test results were passing with a safe margin (maximum allowable FT loss = 7 percent); however, after several months of stockpile life, the FT values rose sharply with most approaching or exceeding the allowable 7 percent loss. There was also a less significant but noticeable trend in rising (though still acceptable) LA abrasion loss values. On the other hand, the pressure-slaking (PS) value appears to improve with time. The improvement may be attributed to the environmental flaking away of the 'unglued' or dandruff-like silica particles that constitute the PS loss.

A recent literature search failed to reveal any published reports on the problem of loss of structural integrity of stockpiled synthetic aggregate. District 11 laboratory personnel would like to know how many (if any) other districts have experienced similar synthetic aggregate deterioration and whether additional research to establish the cause for these phenomena should be implemented.

TABLE 1 Summary of Test Results.

REQ.	REC'D	INITIAL RESULTS			STOCKPILE RESULTS			
NO.	DATE	LA	FT	PS[1]	MONTHS	LA	FT	PS[1]
9-840(1)	4/80	18	2.8	1.0	48	18	6.0	1.6
9-840(10)	6/80	18	2.8	6.4*	46	26	5.2	2.2
9-1090(2)	6/80	18	1.8	2.7	54	19	10.3*	2.0
9-1200(5)	10/79	18	1.8	2.7	54	19	10.3*	2.0
1-80(6)	9/80	15	1.6	1.2	43	25	6.7	2.0
1-770(1)	5/81	18	3.0	4.7*	35	25	12.1*	1.3
1-780(1)	5/81	18	3.0	3.5	35	24	13.3*	1.5
1-890(1)	7/81	19	1.5	3.2	33	20	10.6*	1.4
1-890(2)	7/81	19	1.5	1.9*	33	23	8.6*	0.8
1-1130(9)	8/81	19	1.5	4.9	32	23	5.1	2.0
1-1150(1)	8/81	19	1.5	5.2	32	23	8.9*	1.9
1-1150(2)	8/81	19	1.5	5.7	32	19	8.3*	1.5
2-700(1)	8/82	26	1.0	1.7	20	28	11.9*	1.5
2-881(1)	10/82	24	1.0	2.2	18	23	8.6*	0.8

[1] Test performed by Dist. 11 (Max allowable 4.0%)
* Fails specification allowable.

Call for Problem Statements

What's been troublesome this construction season? Has a recurring maintenance problem got you puzzled? Would you like to see a particular aspect of traffic control studied more closely or a specific type of bridge rehabilitation scrutinized? What about how certain additives affect AC pavement design? Be part of the answer: send Research your problem statements.

The Research Section of the Transportation Planning Division is gathering problem statements for possible study under the Department's Cooperative Research Program. This is your chance to clue Research in on what your work-related problems are. The deadline for problem statements is November 1, 1986.

Once your problem statement is received in D-10R, it will be channeled to the appropriate one of five Research Area Committees. The five committees are:

Area A—Planning, Policy and Management;

Area 1—Geometric and Environmental Design, Safety, Traffic, Right-of-Way and Economics;

Area 2—Materials, Construction and Maintenance;

Area 3—Pavement Design;

Area 4—Structural Design.

After the problem statements are reviewed by the committees, selections will be made based on several criteria such as feasibility, past research on similar problems, urgency and potential benefits. These selected problem statements will be sent to various universities. The universities respond to the problem statements with research proposals. The proposals selected at the Research and Development Committee Meeting for inclusion in the research program will become research studies on September 1, 1987.

Submit your problem statements on a First-Stage Research Problem Form (available from D-10R) to the following address:

Mr. Alvin R. Luedecke
State Transportation Planning Engineer
Transportation Planning Division
Attn: D-10R
P.O. Box 5051
Austin, TX 78763

Questions should be directed to:

Mr. Jon Underwood, Engineer of Research and Development;

Mr. Rick Norwood, Research and Development Administrator; or

Mrs. Marilyn Markow, Asst. Research and Development Administrator, at TEX-AN 886-7403 or (512) 465-7403.

Remember, the deadline is November 1!

Articles, techniques or ideas about any facet of highways or public transportation are welcomed. If you have a new way to handle an old problem, a helpful hint for making better use of a standard procedure or product or new application of a common item, send it to us. It doesn't have to be an earthshaker to be useful and appreciated.

If you have an idea to share, a comment to make or materials to request, use the tear sheet in this issue or call Kathleen Jones at (512) 465-7947 or TEX-AN 886-7947.

TECHNICAL QUARTERLY
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(We'll call you to get the details.)

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FIELD METHODS

LAB METHODS

VIDEO'S NOT JUST FOR EXPERIMENTAL METHODS

A lot of experienced people are going to retire in the next five to ten years. Don't let their expertise be lost. If there's someone in your district who's really got a handle on correct ***Manual of Testing Procedures*** laboratory methods, set up a video recording session. Let that person demonstrate the way he/she arranges the lab equipment and schedules tests for the most efficient usage of time and equipment. Have the person explain what some of the common pitfalls are and how to avoid them. If there's someone with good, solid techniques for field operations, get those techniques on tape. You may want to have the person run through the procedure or explain it in detail, so you'll have a good idea of where to place the camera to get the most definitive shot of the action. Why "re-invent the wheel" over and over again; let the next generation of lab technicians and maintenance personnel build on what you already have.

The D-10 Research Library would appreciate copies of any video, film or slide show you make or have made. If you don't want to deal with keeping and cataloging a tape library, go ahead and send the originals to Debbie Hall, (512) 465-7684; TEX-AN 886-7684 or Kevin Marsh, (512) 465-7644; TEX-AN 886-7644.

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Continued from page...4

construction, maintenance, and operations—the three functional areas of highway activity.

This new mechanism, however, did not accomplish its intended results. As indicated in Figure 1, total SDHPT revenues have been declining steadily in both current and constant dollars. Similarly, this decline forced a reduction in highway development outlays, as indicated in Figure 2. In 1980, disbursements accounted for 73 percent of state highway funds; in 1983, disbursements used up 88 percent of available highway funds. These trends have been even more pronounced in the major urban areas.

Consequently, the legislature was forced to reevaluate Texas highway finance, and, during a special session in 1984, it rescinded House Bill 3 in favor of increasing traditional highway user charges. The legislature still recognized, however, the need for new approaches and new sources for highway funding. Thus it enacted House Bill 125 and Senate Bill 33 authorizing the creation of transportation corporations and road utility districts, respectively, in order to supplement the increase in fuel taxes and registration fees.

A transportation corporation is a non-profit entity acting as an instrumentality of the state for the purpose of assembling right-of-way and financial support toward completion of state highways. The creation of a transportation corporation must be approved by the SDHPT Commission. Corporations are governed by Boards of Directors serving without compensation and are subject to the same open records provisions as other state agencies. They may work directly with property owners, governmental agencies, and elected officials to develop and promote their projects.

Since the enactment of House Bill 125, several transportation corporations have been formed. The first, Grand Parkway Association, was created to assist in the planning and development of additional hurricane and emergency evacuation routes from low-lying areas in Galveston and Brazoria Counties. The MOKAN Corridor Association is planning the development of a 30-mile corridor to provide highway and express transit access from Austin to north of Georgetown. The corridor will cost an estimated $60 to $100 million; the Association expects to raise $19 million for right-of-way and engineering costs. In addition to these, the SDHPT Commission has approved the Galveston-Alvin-Pearland, MOPAC South, and Plateau Region (the latter two from the Austin area) as transportation corporations, and a sixth organization, known as the San Marcos Parkway Association, plans to file

FIGURE 1 Texas State Highway Funds

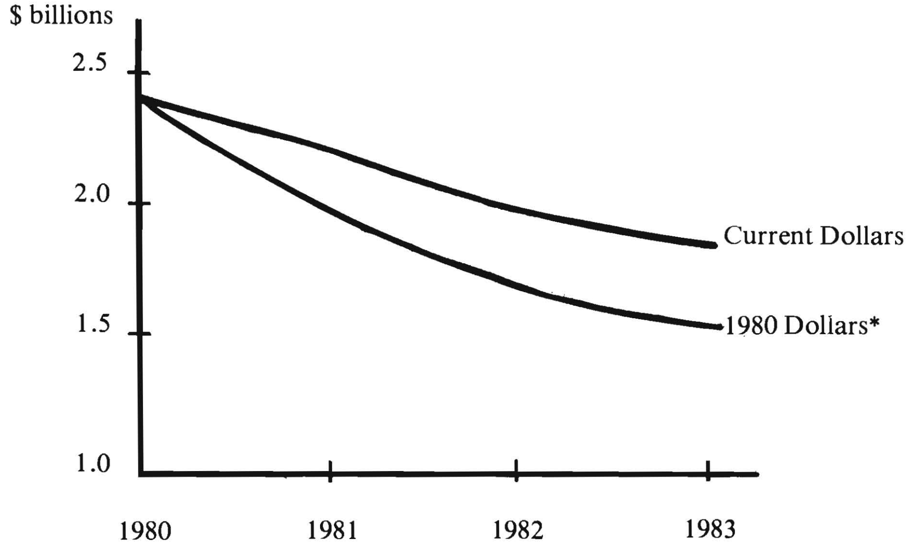
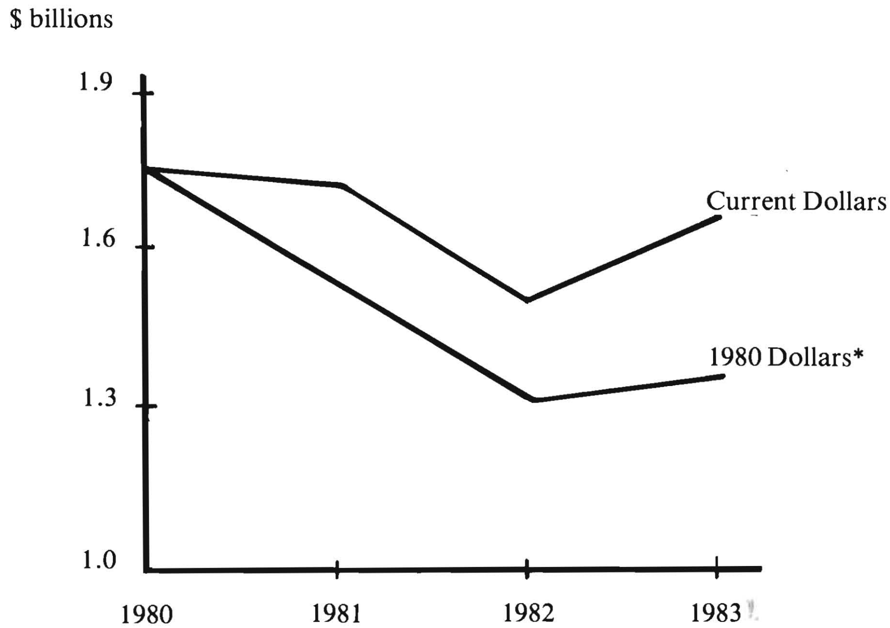


FIGURE 2 Texas State Highway Disbursements



Source: Texas SDHPT. **Texas Transportation Facts 1984**. p. 66.

* The Texas State Gross Product Deflator is used as the index.

for approval during mid-1986. These examples illustrate the potential impact of private interests on the highway development process and ways in which private efforts can expedite the completion of transportation projects.

Senate Bill 33 encourages private participation in road development at the local rather than the state level. It authorizes the creation of Road Utility Districts (RUDs) for the purpose of financing, construction, acquiring, and improving arterial or main feeder roads and related projects. Similar to Municipal Utility Districts (MUDs), RUDs may issue bonds supported by levying property taxes or assessing fees.

The requirements for creating an RUD are more stringent than those for creating a transportation corporation, and to date there are few RUDs in Texas, although it appears that interest in them is growing. The RUD concept has been successful in Arapahoe County, Colorado, where a coalition of metropolitan districts financed, through bonds supported by property tax levies, the building of an overpass. In view of the bond and taxing authority of a District, and RUD can have a significant impact on local road development.

These two alternative financing methods enacted by the Texas legislature are indicative of ways in which organizations can raise funds to assist in highway development. The potential for these arrangements is significant and should help alleviate the funding dilemma faced by many transportation agencies.

TEMPERATURE EFFECT ON SKID RESISTANCE

by D-10R Technical Services Group

In the past the districts have shown some concern over the effects of temperature on skid measurements. Therefore, the Roadway Data group of D-10's Technical Services decided to collect temperature and skid measurements during the normal testing and checking of the skid equipment.

A group of test sections, approximately 0.4 mile in length, were set up to monitor skid resistance at various temperatures. These skid sites were selected to reflect various pavements. There were 13 test sections; 2 CRCP, 2 sealcoats, and 9 HMAC in Austin, Texas. Five skids per section were taken at seventeen different temperatures ranging from 42°F to 88°F. Skid tests were taken from February 1985 through April 1985.

Figure #1 is a plot of the data collected on one of the 0.4 mile CRCP test sections. The vertical line indicates the range of the 5 skids taken on this section at this temperature. The point on the line is the average of the 5 skids.

Figure #2 is the same as figure #1, except that the surface is a light weight aggregate seal coat.

Figure #3 is the same as figure #1,

FIGURE 1 Concrete.

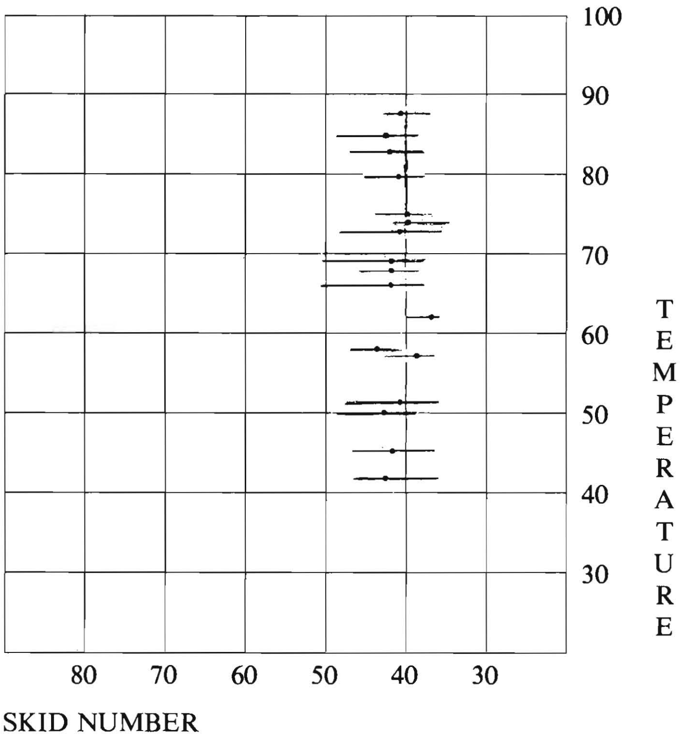


FIGURE 2 Light weight seal coat.

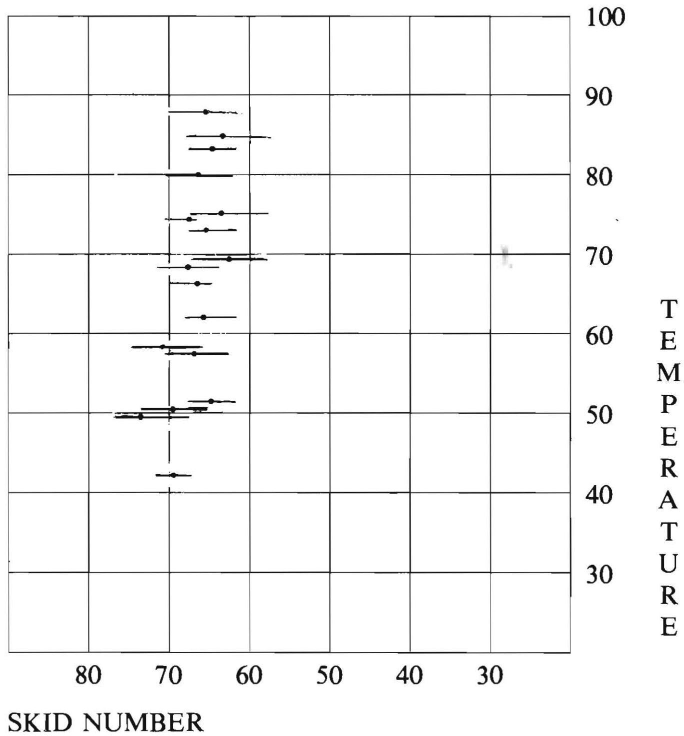


FIGURE 3 *Hot mix asphalt concrete.*

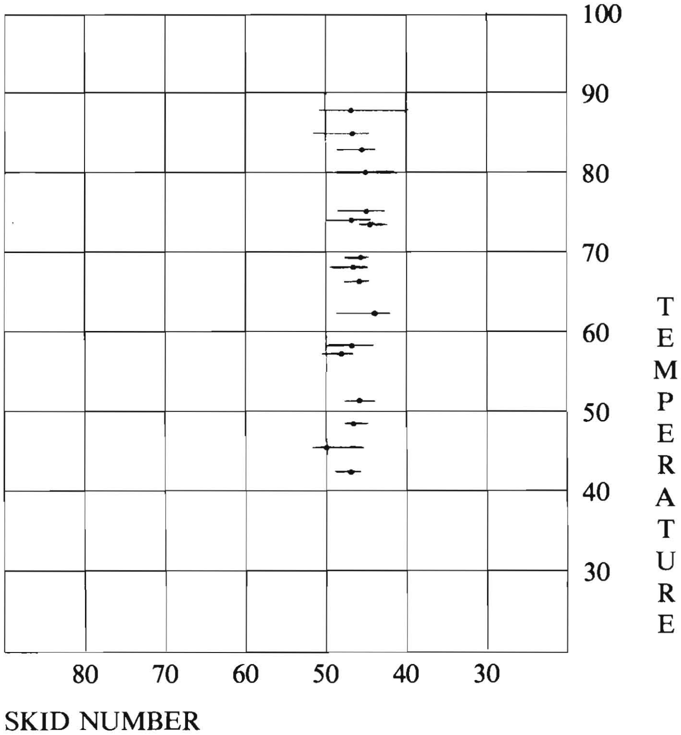
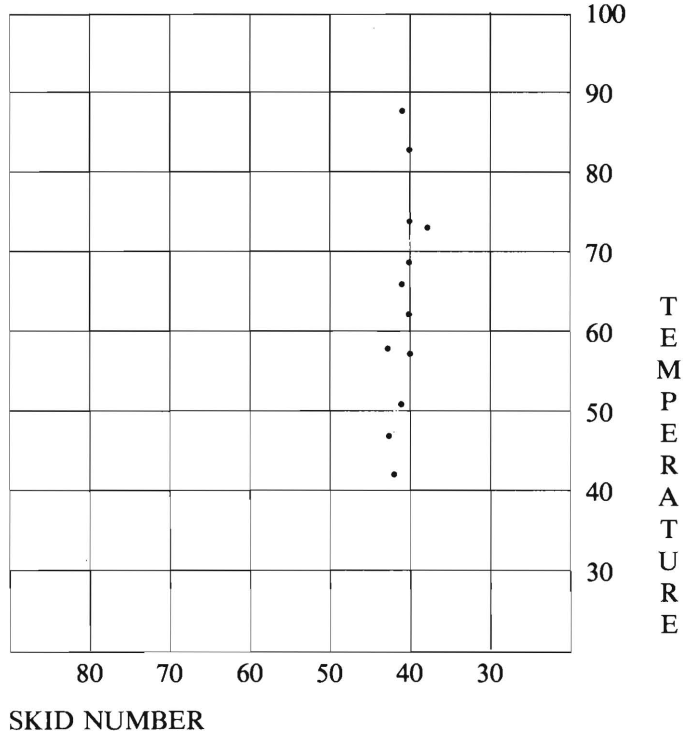


FIGURE 4 *Average all Sections.*



except that the surface is HMAC.

Figure #4 is a plot of the average skid number of all test sections. Each point represents the average of 65 skids at the indicated temperature (i.e., 13 test sections with 5 skids per section).

Note that there are only 12 temperatures on this plot. Due to road conditions, we could not skid every section each time. The point was plotted only if there was a complete set of data at that temperature.

We found that the skid number variation from day to day due to variables other than temperature (i.e., wheel path, tire compound, driver, etc.) affected the skid number as much, if not more, than the temperature.

It seems that each pavement type reacts differently to temperature changes. Some seem to be affected slightly while others are not affected.

It appears that the temperature might affect a pavement with a high skid number differently from a pavement with a low skid number.

From the results of the tests, it was decided not to use an equation to compensate for temperature in the skid program.

USING EPOXY IN STRUCTURAL CRACKS

The following article is an excerpt from NCHRP 109, **HIGHWAY USES OF EPOXY WITH CONCRETE,** by Howard L. Furr, Texas Transportation Institute, Texas A&M University. This report does not constitute a standard, specification or regulation.

The use of epoxy for highway concrete repair in the United States grew rapidly from the early 1950s, the time of its introduction, through the 1970s. This growth was due largely to the use of epoxy for spall repairs in areas of high traffic intensity where there were severe restrictions on lane-closure time. By the middle of 1960, very large quantities of epoxy were being used for concrete bridge deck overlays, waterproof coatings, and patching for spalled areas. The material was used before knowledge of its service behavior was well developed. It was probably oversold as a "cure-all" for bridge decks that were deteriorating at an alarmingly fast rate.

It was soon learned that the formulations used for many of the initial applications were not compatible with concrete under the severe weather conditions in service. The coatings and overlays cracked and eroded severely under traffic, and epoxy repairs pulled away from the concrete in particles and in large sheets. Although formulators gave explicit instructions for applications, the workers did not always appreciate their exacting requirements. Poor workmanship, resulting from the workers' unfamiliarity with epoxy, was the cause of many failures.

Today, there are far fewer applications of epoxy as overlays and coatings for bridge decks than in earlier years. Epoxy has gained in popularity as a patching mortar,

Continued on page... 17

FLEX-FIVE, A VERSATILE SPRAYER HEAD

Not only is late summer/early fall the time of the year to be taking one last whack at Johnsongrass with Roundup® before the bluebonnet seeds germinate, it's also the time to be thinking about new equipment for next year's right-of-way maintenance effort. A new generation of truck-mounted herbicide sprayer heads is available from the Equipment and Procurement Division (D-4). The Model 85 spray unit now has an electrically actuated spray head called the Flex-Five (Figure 1). Mr. Roy Smith of the Safety and Maintenance Operations Division (D-18) came up with the concept and D-4 designed and machined it. The Model 85 spray unit has been in production for over a year now. With the Flex-Five head, it represents an advanced, highly controllable, easy to operate herbicide sprayer.

FIGURE 1 The Model 85 with Flex-Five head.

FIGURE 2 The Flex-Five.

The Flex-Five spray head (Figures 2 and 3) is composed of five independent nozzle groups that can be used together for maximum wide coverage or in various combinations to suit terrain and wind velocity demands. Not only can different combinations of nozzle groups be used to control the pattern, but also the entire head can be tilted approximately 70° up or 40° down electronically from inside the cab to make spraying cut or fill slopes easier and more accurate (Figure 4).

The spray nozzles for the Flex-Five head are required to be calibrated to deliver 25 gallons per acre at a speed of 11.36 mph at a standard operating pressure of 30 psi. To aid in pressure regulation, the newer system has one master pressure gauge and one pressure gauge after each solenoid. All the gauges are oil filled. Each solenoid has a flow regulator valve. This arrangement enables the herbicide applicator to set independently each spray nozzle group at 30 psi. Speed is indicated by an electric monitor which is calibrated to the truck's transmission, rather than the drive shaft the way earlier models are. The speed is displayed as a digital read-out (Figure 5). The Model 85 spray unit is equipped with a centrifugal spray pump powered by an independent engine, so the pump is no longer highly sensitive to the truck's speed as it is in the Swinglok with the W-4 boom.

The Flex-Five spray head is not intended for use with long term residual herbicides such as Velpar®. The lower nozzles (Figure 6), which are

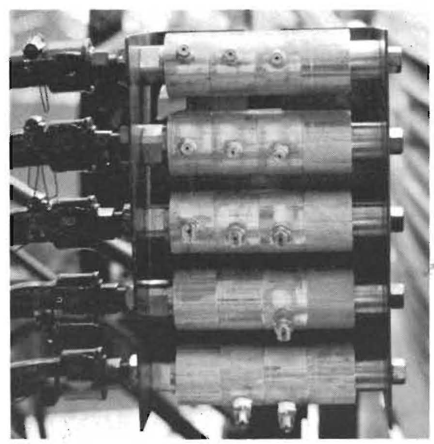


FIG. 3 Independent nozzle groups.

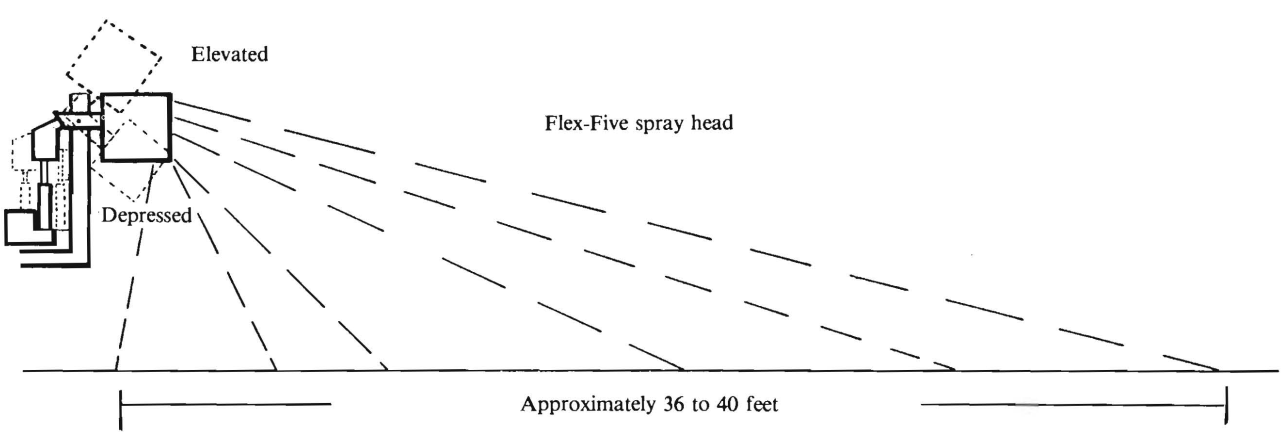


FIGURE 4 Wide coverage spray diagram.

Jessica Swisher

FIGURE 5 Digital display and spray pump throttle.

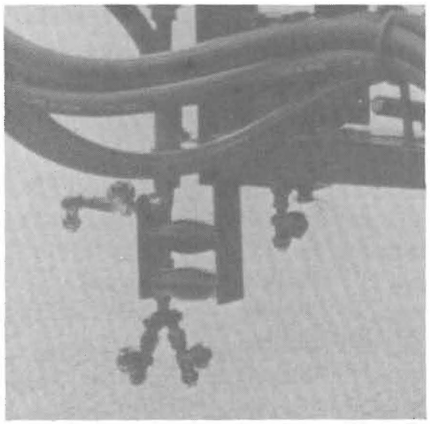


FIGURE 6 The Velpar® nozzles.

calibrated for a truck speed of 5 mph, or a special smaller head should be used. The Flex-Five head is easy to change out for the smaller head, requiring the shifting of two pins and one electrical hook-up. The hoses all have quick coupling connectors. The lower nozzles are fitted with 20 psi diaphragm check valves to stop the flow of herbicide quickly when the unit is stopped and to prevent dripping.

The Model 85 spray system has a bypass valve, Tee-jet agitators and two 3-way valves which are used in either mixing or spraying (Figure 7). The bypass valve is opened when mixing and closed when spraying the right-of-way (Figure 8). The lower 3-way valve allows suction from the herbicide tank bottom or the clean water tank. This 3-way valve should be positioned to pump out of the herbicide tank during normal spray operations. The valve can be positioned to pump clean water out of the water tank to flush the pump and spray nozzles at the end of a day or before storing the unit. The upper 3-way valve allows suction from a point 10 to 12 inches above the bottom of the herbicide tank. This valve is used when the tank contains a mixture of Roundup® plus Oust® which has been left over night. Once the upper 3-way valve and the bypass valve are opened, the Roundup® / Oust® mixture can be agitated. The ability to agitate thoroughly any mix helps assure that the herbicide is applied at the proper concentration. After agitating the mix, the bypass valve and the upper 3-way valve are closed, then the lower 3-way valve is opened to draw from the bottom of the herbicide tank. The herbicide is now being pumped to the front of the truck and is ready for spraying.

Computer injection for the Model 85 spray unit is being worked on by the Automation Division (D-19). Units installed in the last year will be able to be retro-fitted with computers. Well over 50 units are now in the field. Most districts that have it report that the Model 85 with the Flex-Five head is highly satisfactory. For more information call either Mr. Roy Smith, D-18, (512) 465-6301, TEX-AN 823-8301 or Mr. Dolye Johns, D-4, (512) 465-7536, TEX-AN 886-7536.

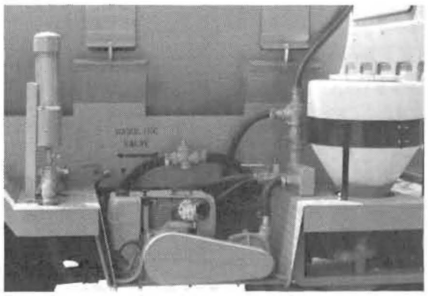


FIGURE 7 Bypass valve, Tee-jet agitators and 3-way valves.

FIGURE 8 Bypass manifold; bypass valve in upper right.

ROADSHOW

The Roadshow, a new training opportunity offered by Texas Transportation Technology Transfer for cities and counties, contains a number of programs that would be of interest to SDHPT residencies and maintenance sections. Examples of programs of interest, particularly for training new crews, are: "Pneumatic Tire Roller Operation," five segments including (1) daily checks, (2) start-up and warm-up, (3) basic operation, (4) rolling techniques and (5) shutdown; "Distributor: Preventive Maintenance & Operation," covers the basics of preventive maintenance and operation of a 600-gallon asphalt spreader; and "Traffic Control—Flagging," location, procedures and coordination of flagging operations.

An extensive library of videotapes and slide/tape programs on a variety of road construction and maintenance topics is listed in ***Milepost '86,*** Vol. 2, No. 3, Summer: 1986. This issue of ***Milepost '86*** is available from the editor of ***TQ*** or from Texas Transportation Technology Transfer, Public works Training Division, Texas Engineering Extension Service, The Texas A&M University System, College Station, TX 77843-8000; telephone (800) 824-7303 or (409) 845-4369.

EVALUATION OF CHACE AIR INDICATOR

by R. G. Henley, D. Malkemus, D. Fowler and A. H. Meyer,
Center for Transportation Research, University of Texas.

Research Study 3-9-83-363 was an evaluation of the Chace Air Indicator (CAI) for use in portland cement concrete construction. The CAI indicated higher values than the pressure method at low air contents and lower values at high air contents. The CAI readings corrected for mortar contents and Chace factors produced values approximately 15 percent higher than the pressure method over all ranges of air contents. A regression analysis procedure was used to determine a curve correction to account for the difference between the Chace factor-mortar corrected reading and the pressure meter. An indication of the reliability of the results was represented by confidence intervals.

Specifically, this study investigated the use of the CAI in determining the amount of entrained air in structural portland cement concrete (PCC). The objectives of the study were the following:

(1) To determine the calibration and correlation requirements for the CAI;
(2) To identify the limits or tolerances for the use of the CAI for either job control or as an indicator as it is presently used; and
(3) To determine if the CAI can measure the amount of entrained air with sufficient accuracy for job control purposes.

For purposes of this study, job control was defined as "the measurement of the air content of PCC with accuracy equal to that measured by a pressure meter."

The study consisted of a laboratory phase and a field phase. The laboratory phase permitted the investigation of many design variables under controlled conditions; they included air content range, slump range, temperature range, cement types, admixture types, aggregate types, operator variability, and CAI variability. The field phase allowed for testing to establish the effect of normal variations encountered in field operations. Variables investigated in the field phase included (1) variation within ready-mix trucks loaded to different levels, (2) variation between ready-mix trucks, (3) day-to-day variations, (4) transit time, (5) concrete mix temperature, (6) ambient temperature, (7) slump, (8) variation in mortar content, (9) air content, (10) variability between CAI units, and (11) variability between operators.

Thirty-seven field visits were made and 232 batches of concrete were sampled. Six CAI readings and one pressure meter reading were taken on each sample. A total of 1392 CAI readings and 232 pressure meter readings was recorded.

CAI readings were corrected for mortar contents and Chace factors as suggested by a previous study (Virginia Council of Highway Investigation and Research, 1960). A curve correction was determined using a regression analysis procedure. Three separate regression analyses were performed to determine curve corrections for (1) the first of three CAI readings, (2) an average of two CAI readings, and (3) an average of three CAI readings.

The results of the field phase were comparable to the laboratory phase. The data from the field and the laboratory were combined, and a new curve correction was determined. This curve correction is the recommended equation for air content determination. Recommended modifications to the CAI test procedure were developed to improve the accuracy of the instrument.

It should be noted that the SDHPT tolerance and the CAI confidence interval preclude the use of the CAI for actual air content estimation. The SDHPT tolerance for air content of fresh concrete is ± 1.5 percent. The 95 percent confidence interval for the average of three Chace factor-mortar corrected and curve corrected CAI readings is 2.7 percent or ± 1.4 percent. The difference of ± 0.1 percent between the tolerance and the confidence interval is not large enough to justify the use of the CAI for the estimation of actual air content.

The study brought forth following conclusions:

(1) Instrument and operator variability after training were not significant.
(2) Recommended modifications to the test procedure improved the precision and accuracy of results.
(3) If the recommended procedure for performing a Chace Air Indicator test is followed, the CAI can be used in the field to provide an indication of the range (high, medium, or low) of air content of fresh concrete.

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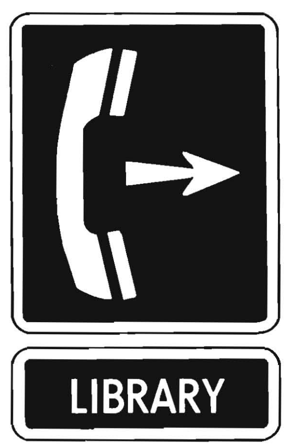

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(4) The 95 percent confidence interval decreased from 4.8 percent to 2.7 percent as the number of CAI readings increased from 1 to 3.
(5) If the Chace factor of an instrument has been determined, there is no need for daily correlation with pressure meter.
(6) With the present SDHPT tolerances for air content of ±1.5 percent, the CAI is not sufficiently accurate to measure the air content of concrete for job control purposes.

In summary, then, Research Study 3-9-83-363 indicated that the CAI should not be used for a determination of **actual** air content of fresh concrete.

However, if the recommended modifications to the CAI test procedure developed in the study are followed, the Chace Air Indicator can be used in the field to provide an indication of the **range** (high, medium, or low) of air content of fresh concrete.

Continued from page... 13

however, because of the demand for quick-set, durable materials on heavily travelled installations. [Epoxy is also favored as a structural crack repair material.]

Structural Cracks

Cracks are not planned, they are not wanted, and they are caused by an action that was not anticipated when the concrete was placed. If the action that caused the crack to form persists, it is likely that it will cause other cracks if the existing one is repaired. For this reason, the cause of the crack should be identified before any repair is made. If shrinkage caused it and if that shrinkage is not complete, the repair should be a temporary one or it should be delayed until the shrinkage is complete. If the crack was caused by live-load stresses, the repair could result only in other cracking under continuing live load. The analysis made in determining the source of the crack might call for measures that would relieve the condition as well as those for repairing the crack. Once the cause is removed, by whatever means, the crack can be repaired. The best policy is to repair only those cracks that are inactive (4).

Cracks that are wide enough can be grouted with epoxy mortar using hand tools. The sand in the mortar not only reduces the cost of the material, it also reduces the coefficient of thermal expansion, increases the modulus of elasticity, and stiffens the uncured material making it easier to place. The grout might need support before it cures to prevent it from flowing out of the crack. The walls of the crack must be clean, as pointed out earlier. The side walls of the crack should be primed with epoxy and the mortar should be placed before the prime coat becomes hard. If the walls are thoroughly wet with the epoxy prime coat and the mortar is well compacted in place, the cured material will have the strength to transfer stresses and it will be durable.

Injection techniques can be used to fill narrow cracks down to about 0.005-in. (0.13-mm) wide, and sometimes narrower. This technique forces the epoxy under pressure to fill the crack, coat the surfaces, and bond the surfaces together when cured. This has developed into one of the most successful methods of concrete repair with epoxy.

Epoxy injection requires that the crack be sealed on the surface of the concrete, leaving openings for introducing the epoxy into the crack. An epoxy paste is usually used for this seal. The entry port can be a hole drilled through the seal into the crack or a short tube with its opening spanning the crack. The tube is temporarily stuck in place with contact cement, then bonded to the concrete and sealed with the crack surface seal to prevent leakage. Epoxy is injected through the open end of the tube.

A drilled entry port must provide a seat for a gasket on the injecting gun and the hole must be thoroughly cleaned of dust so that it will not block the entry of epoxy. After epoxy has been injected and has cured in the crack, the surface seal is removed from the concrete and the surface cleaned.

The injection-port spacing will depend on the depth of the crack or the delaminated area, the thickness of the cracked slab or wall, the temperature, the viscosity of the epoxy, and the pressure used for injection. If the crack penetrates through a wall or slab and is to be completely filled, the spacing of ports should not be less than the slab or wall thickness. The idealized situation in Figure 1 shows that a lesser spacing would result in voids in the crack. The outlines of a delamination crack should be marked and entry ports be located so that the crack will be completely filled when injected.

The injection pressure should only be high enough to ensure that the crack will be completely filled, because excessive pressure could rupture the concrete. A low pressure, possibly 20 to 30 psi (140 to 210 kPa), might be adequate if a low-viscosity epoxy is used and the crack is not less than about 0.06-in. (1.5-mm) wide. Ports must be spaced closer when pressures are low. For difficult conditions, pressures up to 100 psi (690 kPa) might be needed but care must be taken to prevent damage to the concrete. Usually, pressures under 100 psi are needed (17).

Details covering epoxy injection are given in Reference 4 and typical applications of crack repair by epoxy injection are described by Gaul and Smith (17).

A unique solution to a structural crack problem in bridges where the cracking forces were still active has been developed by the Kansas Department of Transportation (18, 19). Continuous reinforced concrete highway bridge girders developed shear cracks at approximately 45 degrees in regions of high shear adjacent to supports. The Kansas DOT

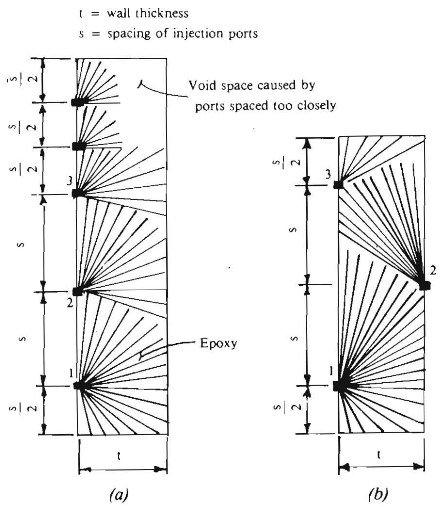

FIGURE 1 Spacing of injection ports on a full-depth crack in a wall: (a) injection ports on one side, $s \geq (t/2)\sqrt{5}$'; and (b) injection ports on two sides, $s \geq 2t/\sqrt{3}$'.

drilled a series of holes at 45 degrees with the deck to cross the cracks at approximately 90 degrees. These drilled holes extended beyond the cracks about 18 in. (460 mm) and dust was removed as the holes were drilled. A special drill with a hollow stem, carbide-tipped vacuum bit, and a supporting stand was developed for this purpose. The bar extended at least 18 in. on each side of the cracks to develop its strength by bond. This system provides No. 4 reinforcing bars at 6-in (150-mm) centers in 3/4-in. (19-mm) diameter holes across the cracks. The bridges have been strengthened by this repair and no relative movement across the repaired cracks could be detected after 17 months of service. Figure 2 illustrates this repair technique.

Continued monitoring showed no relative movement across the repaired cracks after seven years. The technique has evolved into the use of commercially developed equipment. No. 6, grade 60 steel reinforcing bars cut 3 to 4 in. (75 to 100-mm) shorter than full hole depth are now used in 1-in. (25-mm) diameter vacuum-drilled holes. The concrete girders are reinforced from one end of the bridge to the other. Design analysis indicates that this raises the shear-carrying capacity of the girders to about ten percent above the 1981 AASHTO specifications. The as-built condition was as much as 36 percent below those specifications.

In the work by Kansas DOT discussed above, a very interesting phenomenon was revealed in the hardening of epoxy. In laboratory work, a particular epoxy was found to harden rapidly in a plastic beaker. When it was pumped into a hole in concrete containing a reinforcing bar, it took quite a long time to harden. After tests to discover the cause, it was found that much of the heat from the reaction was absorbed by the re-bar. The system was deprived of the heat that accelerated the reaction without the bar and, consequently, the curing time was increased.

A structural crack-repair epoxy has requirements far different from those of the patch or overlay. This material is required to bond tightly, transfer a considerable load, and deform little. It does not have the erosion problem of a pavement surface patch and the shrinkage problem is not as great because the temperature range is smaller. Shrinkage should always be kept as low as practicable. This calls for slow curing and epoxies with low exotherms.

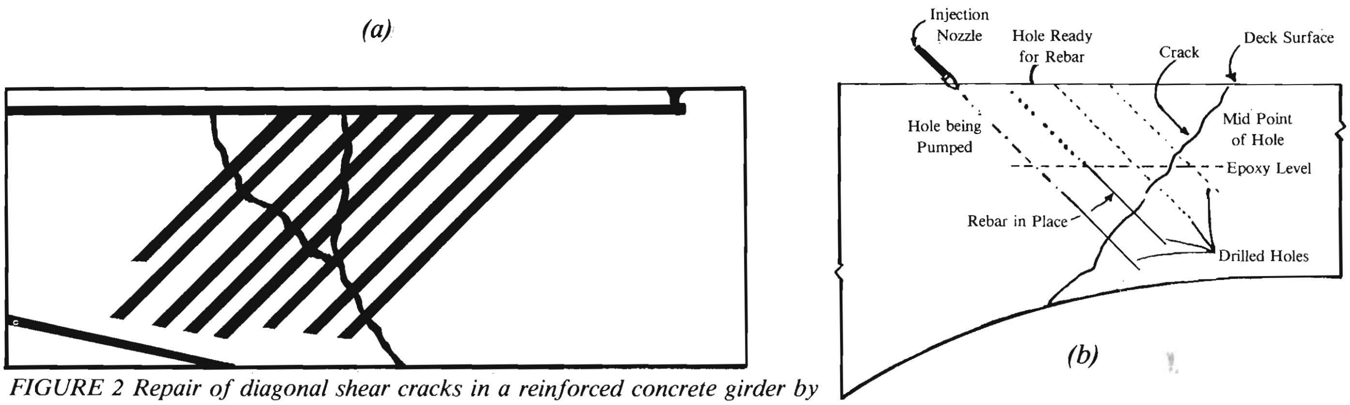

FIGURE 2 Repair of diagonal shear cracks in a reinforced concrete girder by adding reinforcing bars and injecting epoxy: (a) reinforcing bar orientation (4); (b) epoxy level when reinforcement was placed (18).

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