TECHNICAL QUARTERLY

"AN EXCHANGE OF IDEAS"

TQ8-3, OCTOBER 1993 *EDITOR: Kathleen M. Jones*

SAVE MONEY AND THE ENVIRONMENT WITH EL PASO DISTRICT'S INNOVATIVE ASPHALT/EMULSION RECLAIMER

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INTRODUCTION

The nozzles on asphalt distributors need to be cleaned and calibrated during any paving operation. You have to run asphalt or emulsion through the nozzles to check the spray patterns and run diesel through nozzles that are clogging. How do you calibrate the nozzles without harming the environment, and what do you do with the asphalt or diesel when you're done? You can't leave it on the roadside, and proper disposal of waste oils costs anywhere from $285 to $450 per 55-gallon barrel.

El Paso District has developed an innovative way of reclaiming these materials by modifying an existing Cimline crack sealing melting pot. By adapting additional fittings and hoses to the Cimline pot (Fig. 1), Hondo Pass Maintenance Yard personnel created an independent oil reclaimer that will collect and distribute emulsion or AC oils either back into the distributor or into the Cimline reservoir, with no hazard to the environment. Hondo Pass personnel have performed several tests with this equipment and have had good results. The modifications cost approximately $300 and require about 17 hours' labor. Using this reclaiming system, the department could save an average of $120.00 per day on reclaimed oils and diesel..

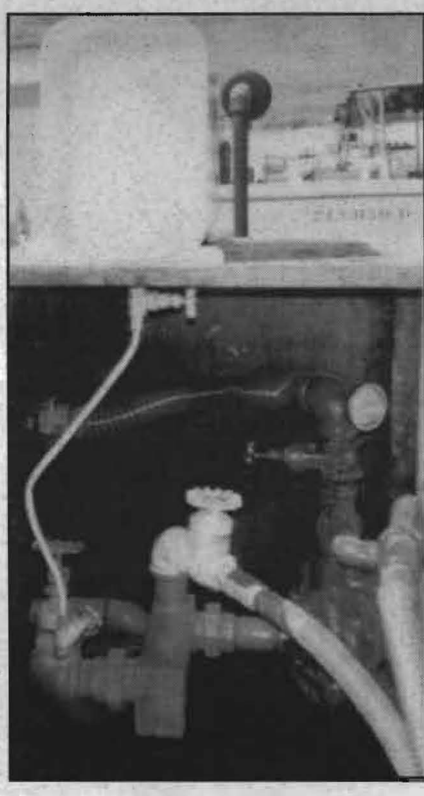

FIGURE 1: View of modified Cimline distribution area

HOW DOES IT WORK?

To use the reclamation system, workers position the flush tank (Fig. 2) beneath the asphalt distributor's nozzles. AC or emulsion is released into the flush tank until the nozzles are spraying properly. The reclaimer operator puts the suction hose of the reclaimer into the flush tank and starts the pump. The pump is capable of distributing twenty gallons a minute of emulsion at 90 degrees Fahrenheit. Depending on the requirements of the job, the material in the flush tank can be pumped straight back into the distributor or sent to the Cimline's tank by opening or closing the various discharge and suction valves. The reclaimer is also equipped with a 5-gallon diesel tank that is used to flush out the pump and hoses. Of course, caution must be taken when flushing any AC oils.

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information within the transportation community.

FIGURE 2: The flush tank, made from 16-gallon barrels, has hook grabs on each end for lifting off and on the trailer.

WHAT DO YOU NEED TO MAKE THE MODIFICATIONS?

Figures 3 through 7 show locations of the major modifications needed to make a Cimline pot into an asphalt reclaimer. Table 1 shows the type, cost, and order number (if applicable) of the items used in pump modification. The pump modification required about 5 hours of labor. Table 2 shows the type, cost, and order number (if applicable) of the items used to build the flush tank. Building the flush tank required about 12 hours of labor.

CONCLUSIONS

This system, used properly, is thoroughly safe and can save the department a considerable amount of money by reclaiming hundreds of gallons of emulsions or AC oils that would otherwise be wasted. By in-

FIGURE 3: Discharge valve (red) — sends material back into distributor or emulsion tank.

FIGURE 4: Suction valve (white) — valve in open position transfers material from flush tank to reservoir or back to distributor.

FIGURE 5: Return valve (red) — valve in the open position allows material to be stored in the reservoir.

FIGURE 6: Suction valve (blue) — valve in the open position transfers material held in the reservoir back to the distributor or to the emulsion tank.

FIGURE 7: Diesel valve (white) — used when flushing system

TABLE 1: Material for pump modification.

UNITS	DESCRIPTION	DHT #	UNIT PRICE	TOTAL PRICE
1 each	2-inch, 90-degree elbow	5046	1.48	1.48
2 each	2-inch close nipple	5057	1.20	2.40
1 each	2-inch gate valve	42422	23.75	23.75
1 each	2-inch to 1-inch reducer	N/A	3.29	3.29
1 each	1-inch female/male swivel	65530	72.25	72.25
1 each	1-inch coupling pipe	4995	.25	.25
5 feet	1-inch pipe	7229	.69	3.45
1 each	1-inch by 20-foot hose (suction)	N/A	93.00	93.00
2 each	3/8-inch valve	8835	2.26	4.52
1 each	3 to 5-gallon fuel tank	N/A	85.00	85.00
				289.39

TABLE 2: Flush tank materials.

UNITS	DESCRIPTION	DHT #	UNIT PRICE	TOTAL PRICE
7 each	16-gallon drums	N/A	N/C	N/C
2 joints	1 1/2-inch pipe	7235	19.80	39.69
10 feet	1/2-inch cold roll steel	36026	.23	2.30
2 each	3/8-inch hook grab	6567	.90	1.80
				43.70

corporating the reclaimer throughout the state, TxDOT could reduce the environmental hazards caused by spills or misuse of distributors. This inexpensive modification to an existing piece of equipment is a win-win innovation — TxDOT saves money on materials and reduced need for waste treatment while protecting the environment.

If you have questions concerning the construction and operation of the asphalt/emulsion reclaimer, call Gilbert Jordan at (915) 757-0663.

EDITOR'S NOTE:

A 5-minute video, produced by El Paso District, shows the reclaiming system in action. The tape is available on loan from the Research Library. Call Dana Herring at (512) 465-7644 to order it.

TXDOT EVALUATES NEW THERMOPLASTIC APPLICATION METHODS

by **Joe Raska, P.E.**
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Texas Department of Transportation
and **Chris Pankey**
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Prairie View A & M University

BACKGROUND

Since the early 1970s, many transportation agencies, including the Texas Department of Transportation (TxDOT), have steadily increased their use of thermoplastic marking materials (also known as hot-melt) for cost-effective, long-term, durable pavement markings. TxDOT has experienced thermoplastic material life spans of six plus years as skip line and 10 plus years as edge line on roadways exceeding 10,000 average daily traffic (ADT) per lane. This type of life is not only cost-effective, it greatly reduces exposure of TxDOT personnel to the hazards of working in traffic.

Material Content

Thermoplastic marking materials are a mixture of resins, pigments, and glass beads. By definition, a thermoplastic is a material that can be melted (Fig.1) and solidified several times without significantly changing its chemical and physical characteristics. Generally, for pavement marking materials, either alkyd or hydrocarbon thermoplastic resins are used. The alkyds are much less compatible with oil drippings from vehicles than hydrocarbons; therefore, alkyd type marking materials stay cleaner on the roadway.

Usage

When placed properly, paint, thermoplastic, and tape all provide good day and dry-night lane and edge line delineation. Costs varies significantly depending on the material. However, none of these materials currently used provide any wet-nighttime delineation. Therefore, most southern transportation agencies supplement these markings with raised, reflective markers to provide delineation and guidance during rainy conditions at night and use jiggle bars to produce an audible sound when one runs off the road.

New developments in thermoplastic marker placement equipment shows promise of a solution or another method to achieve wet-night reflectivity and an audible sound at the same time.

FIGURE 1: Thermoplastic is melted and transferred to the placement vehicle of the US 183 job.

WHAT'S UNDER EVALUATION

The Materials and Tests Division and the former Maintenance Operations Division (D-18) currently have three thermoplastic systems and one paint-type system under evaluation in the Austin area that should produce wet-night reflectivity and an audible sound (when run over by a vehicle). The word "should" is used because, due to our long dry spell, only the paint-type system has been viewed at night in rainy conditions. There is no reason, according to Joe Raska, why all four systems should not perform although there may be some variance in the degree of effectiveness.

Three Thermoplastic Systems

Two of the thermoplastic systems are placed on the roadway by modified extruders (Fig. 2). In one case, essentially what happens is two gates on the extruder raise momentarily to deposit two side-by-side bumps in the extruded line (Fig. 3). In the other case, a single gate is used, producing only one bump (Fig. 4). In either system the bumps are from 0.3 to 0.5 inches in height above the top plane of the marking. The longitudinal spacing of the bumps can be varied from approximately 8 inches to 24 inches. Temperature of the thermoplastic during placement is somewhat critical so the bumps will stand up as they should.

The third thermoplastic system (Fig. 5) is also an extrusion process but, in this case, a wheel is run down the extruded material right behind the extruder, but ahead of the beader. The wheel presses transverse slots the full width of the stripe at intervals approximately one and three-sixteenths of an inch apart.

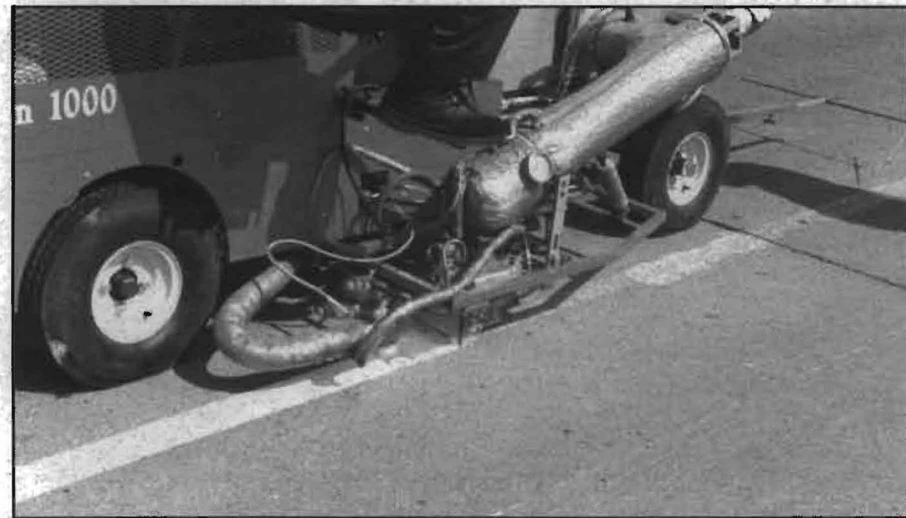

FIGURE 2: Forming the ridges within the stripe with a modified extruder.

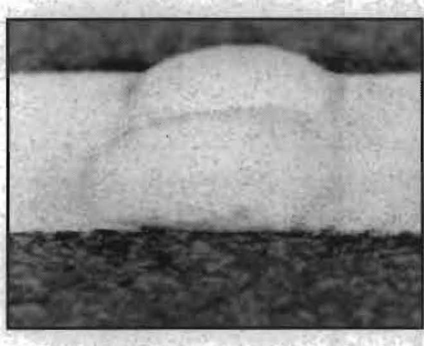

FIGURE 3: Close-up of side-by-side thermoplastic bumps on US 183.

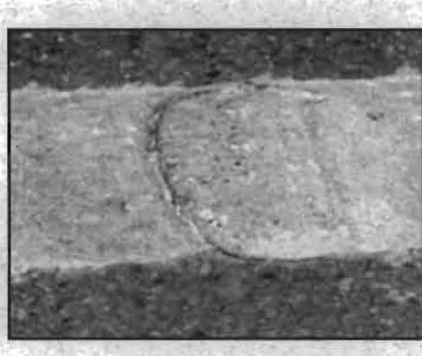

FIGURE 4: Example of a single transverse bump (US 183).

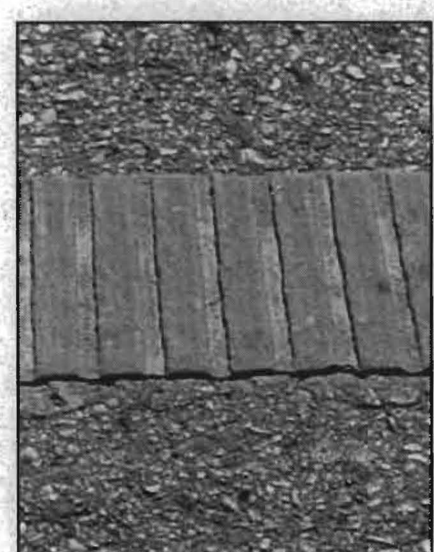

FIGURE 5: Transverse slots pressed into yellow thermoplastic.

FIGURE 6: The five transverse dots of methyl methacrylate that make up "Spot-Flex."

Edge and skip lines were placed on the above reference evaluation projects.

Thermoplastic Costs

Based on estimations from the thermoplastic manufacturers one ton (2000 lb) will yield approximately 6,000 linear feet of 4-inch stripe with the baseline being 0.060 inches thick and the raised portions being 8 to 20 inches apart. Installation costs of this type of stripe should be between 40 and 45 cents per liner foot on a project equivalent to 10 miles of four-lane divided roadway.

The Paint-Type System

The paint-type (100% solids methacrylate) is normally referred to as "Spot-flex." This system consists of a transverse series of five dots approximately one-half inch in diameter and five-thirty-secondths of an inch in height to form a four inch wide line (Fig. 2). The transverse rows of dots are spaced approximately two inches apart longitudinally down the road. When run over with a car at speeds greater than 30 miles per hour, this system produces an audible humming sound, the higher the speed the higher the pitch of the humming sound. A special type of gun is utilized in application to apply the dots.

SPECIAL PROVISION TO ITEM 666

The Materials and Tests Division has provided the Waco District with technical information that can be utilized as "plan notes" or as a "special provision" in conjunction with the TxDOT 1993 Standard Specifications for Construction of Highways, Streets and Bridges, Item 666, "Reflectorized Pavement Markings," for an experimental project.

If you would like to consider a project, please contact Cathy Wood, P.E., Traffic Operations Division, (512) 416-3158 or John Bassett, Acting Chemical Engineer, Materials and Tests Division, at (512) 465-7922. The plan notes or special provision have to be tailored for each project

1994 RESEARCH PROGRAM OUTLINED

Department personnel and university researchers submitted 450 research problem statements for consideration for the 1994 Texas Department of Transportation research program. Depending on the problem statement's subject, these preliminary problem statements are evaluated and scored by one of four Research Area Committees. The Area Committee then takes a closer look at the highest scoring one-third and ranks these problem statements according to department needs, combining similar problem statements into one. The chairman of each committee recommends to the TxDOT Research Development (R&D) Committee which problem statements should become proposals. The R&D Committee approved 27 research proposals for funding in 1994. They are as follows:

Area I: "Planning, Economics, Environment, and Transit"

Research Agency	Study Number	Study Title
TTI	0-1353	*An Evaluation of High-Occupancy Vehicle Projects in Texas*
CTR	0-1356	*Impacts of Current Financing Methods on Transit Systems and Evaluation of Alternative Financing Schemes*
TTI	0-1357	*Improving Assignment Results for Air Quality Analyses*
TTI	0-1358	*Congestion Management and Air Quality Benefits of Transportation Improvements*
TTI	0-1361	*Investigation of Land Use, Development, and Parking Policies to Support the use of High-Occupancy Vehicles (HOV) in Texas*

Area II: "Materials, Construction, Maintenance, and Pavement Design"

Research Agency	Study Number	Study Title
CTR	0-1367	*Performance Based Seal Coat Grade Asphalt Specifications*
UTEP	0-1369	*Testing Methods for Reclaimed Asphalt Pavement (RAP)*
TTI	0-1371	*Evaluation of Joint Sealants*
TTI	0-1377	*Improving Asphalt Maintenance Mixtures*
TTI	0-1378	*Development of Ride Quality Specification Criteria for ACP Overlays*
TTI	0-1379	*Temporary Erosion Control Methods*

Area III: "Traffic Operations, Geometric Design, and Right-of-Way"

Research Agency	Study Number	Study Title
TTI	0-1389	*Development of a Multi-Vendor Environment for Traffic Controllers*
TTI	0-1390	*Determination and Evaluation of Remainder Characteristics which Significantly Affect Right-of-Way Costs*
TTI	0-1392	*Effective Detector Placement for Computerized Traffic Management*
TTI	0-1393	*Determination of Capacity and Level of Freeway Frontage Roads*
CTR	0-1394	*Detection and Mitigation of Roadway Hazards for Bicyclists*
CTR	0-1441	*Mower-Thrown-Object Accidents*
TTI	0-1498	*Study of Visibility, Spacing, and Operational Issues of Freeway Lane Control Signals in Texas*

Area IV: "Structural Design"		
Research Agency	**Study Number**	**Study Title**
CTR	0-1404	*Instrumentation of Precast Segemental Box Girder Bridges on US183 in Austin*
CTR	0-1405	*Durability Design of Post-Tensioning Substructure Elements*
CTR	0-1407	*Rock Wall Anchor Retaining Wall Design Criteria*
TTI	0-1408	*Feasibility Study for Hydraulic Modeling Facility for Scour Problems*
CTR	0-1409	*Hydraulic Characteristics of Recessed Curb Inlets and Bridge Drains — Phase 2*
CTR	0-1410	*Aesthetic and Efficient New Structure Designs for Standard Bridge Systems*
CTR	0-1412	*Repair of Structural Concrete*
TTI	0-1442	*Treatment at Intersecting Streets and Drives — Bridge Railing End Treatments*
TTI	0-1443	*Overweight Permit Rules*

TXDOT RESEARCH YIELDS MEASUREMENT-BASED REVISIONS FOR SEGMENTAL BRIDGE DESIGN AND CONSTRUCTION SPECIFICATIONS

by **Carin Roberts Wollmann, Ph. D.**
from her dissertation,
Measurement Based Revisions for Segmental Bridge Design and Construction Criteria [Ref. 1].
Excerpted by **Pat Bachman, P.E.**
Bridge Software Development Engineer
Information Services Division
Texas Department of Transportation
and by **Kathleen Jones**
Information Specialist
Office of Research and Technology Transfer
Texas Department of Transportation

FIGURE 1: Beneath the "Y." The structure is so named because of the shape of the intersection of IH 35 and IH 10 in downtown San Antonio.

BACKGROUND

The San Antonio "Y," an urban viaduct admired for its aesthetics and its effective staged construction, is a research instrument as well as a structure (Fig.1). Over the course of four years, researchers have recorded and analyzed data from instrumented spans of this precast concrete, segmental post-tensioned structure. Results of this field study clarify and improve design assumptions and construction methods. Implementation of the improved criteria will result in material economies, streamlined construction, improved performance and decreased maintenance costs of this type of bridge.

Segmental post-tensioned concrete bridges like the "Y" have several advantages, particularly in urban and in environmentally sensitive areas (Fig. 2). They can be:

- adapted to any reasonable curvature (vertical or horizontal)
- erected with minimal disruption of ground level surroundings
- very aesthetically pleasing
- built in areas where right-of-way acquisition is limited

FIGURE 2: The "Y" was erected above existing travel lanes in very limited ROW. Construction innovations (like varying the width of the closure pour to keep transition boxes of a uniform size, shown here) reduced the overall cost.

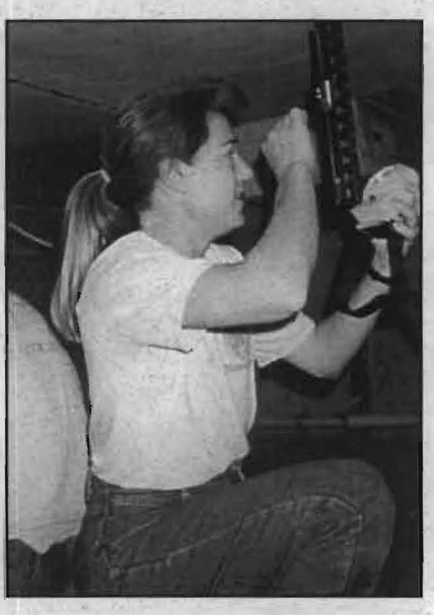

FIGURE 3: Insider information. Dr. Carin Roberts and team measure deflections during live load testing.

Why was research needed?

Post-tensioning of precast segmental concrete is, however, a relatively new construction technique. Both construction experience and field verification of design assumptions are limited. Engineers have many questions concerning the design and construction of this type of bridge. ***The AASHTO Guide Specification for the Design and Construction of Segmental Concrete Bridges*** outlines areas of uncertainty. These areas include:

- prestress losses in external tendons
- effects of thermal gradients
- shear lag
- transverse diffusion of post-tensioning forces
- joint behavior,
- post-tensioning anchor zone behavior
- deviator behavior

All of these areas would benefit from studying an instrumented span-by-span segmental winged box girder bridge like the San Antonio "Y."

Significance to TxDOT

The Texas Department of Transportation (TxDOT) pioneered precast segmental box girder construction in the U. S. by building the J. F. K bridge in Corpus Christi, (opened to traffic in 1973). Florida opened the first U. S. externally post-tensioned precast segmental box-girder bridge in 1981, the Florida Keys bridges. In 1989, partially in response to the unexpected serious maintenance and serviceability problems that the Florida Keys bridges developed after only 6 years in service, TxDOT, in cooperation with the Federal Highway Administration (FHWA), funded an ambitious research proposal to:

- devise an instrumentation plan that would not interfere significantly with construction of the San Antonio "Y"
- collect construction, environmental, and long-term behavior data
- analyze the data
- propose changes to the ***AASHTO Guide Specification for the Design and Construction of Segmental Concrete Bridges*** (here after in this article referred to as the ***AASHTO Guide Specification)*** based on the field measurements.

Drs. Jack Breen and Mike Kreger supervised then-doctoral-candidate Carin Roberts in research study 0-1234, ***Instrumentation of Segmental Box Girder Bridges and Multipiece Winged Boxes*** (Fig. 3), at the Center for Transportation Research, The University of Texas at Austin. Study 0-1234, which ended in August 1993, has yielded results of international significance that will be of direct aid to TxDOT's newest segmental structure, Austin District's US 183 urban viaduct. These results will also affect the design of a 350-foot main span, balanced cantilever structure to be built in Surfside, Texas.

The TxDOT Bridge Design Section was particularly interested in having:

- a creep model for long-term moment distribution
- an analysis of semicontinuous unit behavior ("poor-boy" continuity)
- an analysis of dual box behavior (interaction of adjacent spans transversely post-tensioned)
- solutions to construction erection problems caused by deformations of segments that occur during match casting.

INSTRUMENTING THE "Y"

Researchers spent much of the first year identifying (or devising) instrument systems that were accurate, reliable, and rugged enough to hold up to field testing. Thermocouples and electrical resistance strain gages on reinforcing steel, for instance, had to survive being cast into a box girder and had to remain working through actual span erection in order to be useful.

Forces in post-tensioned tendons are generally difficult to obtain, even in the lab, but the researchers had to have post-tensioned tendon force data for most of the analyses TxDOT needed [Ref. 2]. One of the notable innovations the research team developed was a dual system (Fig. 4) to field measure the average strain of an external tendon using both electrical resistance strain gauges and 16-inch mechanical extensometers (Fig. 5). The system consists of two large, high-strength epoxy sleeves with locator disks for the mechanical extensometer (Fig. 6). The sleeves are cast around the tendon. Electrical resistance strain gages are fixed on the tendon strands between the epoxy sleeves. A redirection tube enables the grouting of the cable to take place after post-tensioning (Fig.7). The system is very rugged and reliable.

The investigators also developed a taut-wire baseline system for measuring deflections. Located, like most of the systems, inside the box girder, this system allows researchers to collect fast, accurate deflections of the bridge under actual traffic conditions.

Other instrument systems measure joint openings, concrete strain, concrete temperature, reinforcing steel strain, bearing movement, and solar radiation

CONSTRUCTION

Working with the designers and contractors, the researchers developed special contract provisions that allowed four instrumented spans to be cast, erected and monitored in Project II-C (Fig. 8) of the San Antonio "Y" with minimum delay in the construction schedule. The precast box girders in Project II-C are trapezoidal with long cantilevered wings (Fig. 9). They contain a mixture of external and internal post-tensioning tendons. The concrete is normal weight and averaged 9000 psi at time of erection. The contractor erected the bridge using span-by-span techniques.

The researchers and the contractors maintained a very cooperative relationship that helped casting and erection proceed smoothly. The project experienced no significant or unexpected delays due to the instrumenting of the segments.

The researchers collected valuable data pertaining to construction loading and prestressing losses through stressing hardware during the erection phase. They then monitored the bridge at regular intervals through August 1993. Since the instrument systems remain protected within the box girder, more data can be collected in the future.

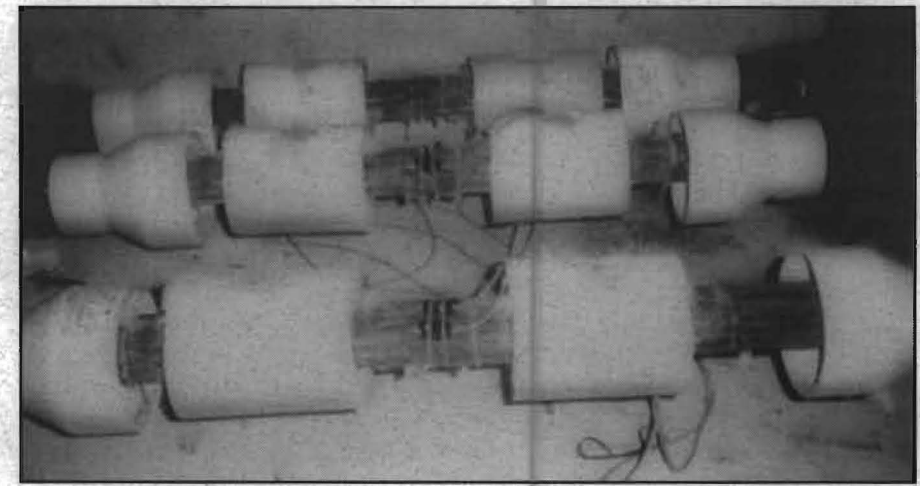

FIGURE 4: The dual system for measuring post-tensioned tendon force (prior to grouting).

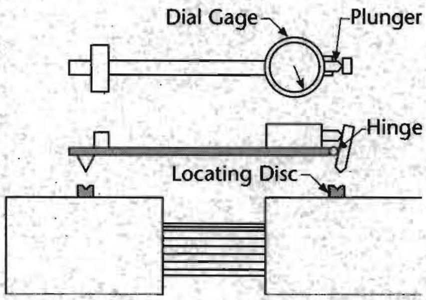

FIG. 5: Schematic of a mechanical extensometer.

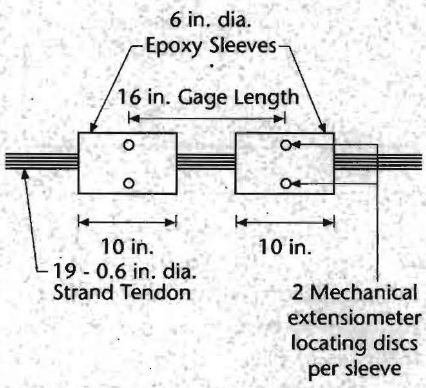

FIG. 6: Plan view of epoxy sleeve.

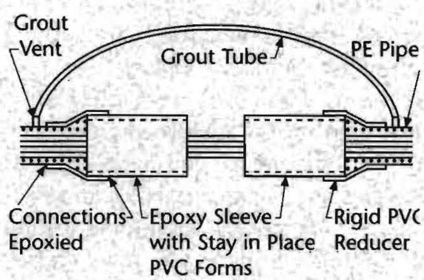

FIG. 7: The grouting arrangement.

HIGHLIGHTS OF THE RESULTS

Study 0-1234 recommends several significant measurement-based revisions to the ***AASHTO Guide Specification.***

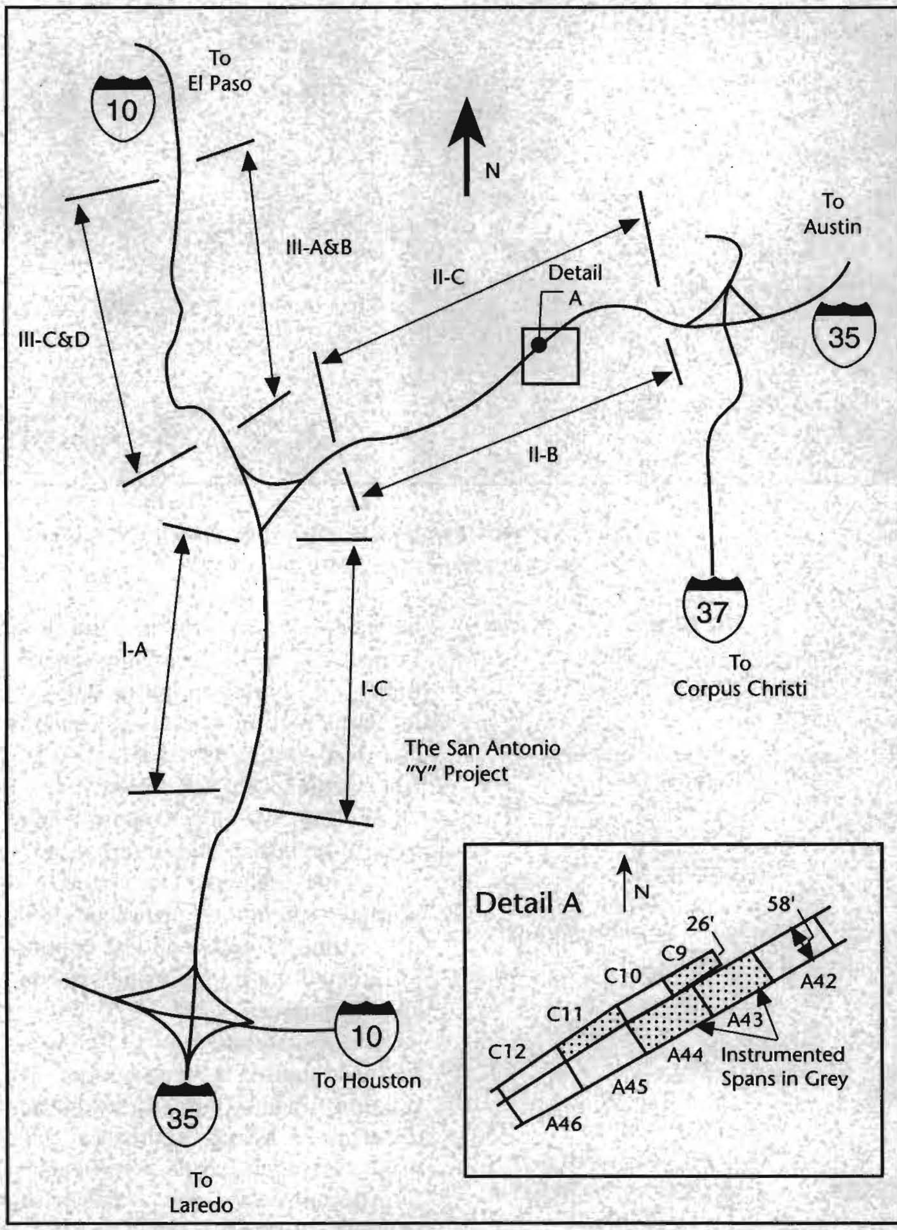

FIGURE 8:The "Y" construction phasing with detail of instrumented spans.

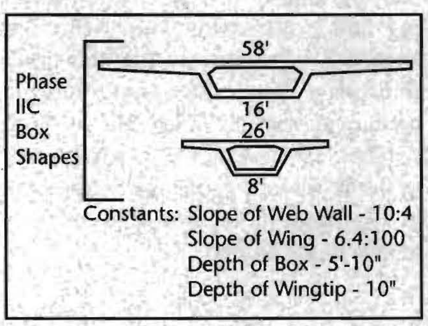

FIG. 9: Phase II-C box shapes.

Prestress Losses in External Tendons

External tendon efficiency is directly affected by prestressing loss. Bridge designers must estimate the magnitude of prestressing force loss correctly to ensure that a bridge performs as expected at service loads. If the designer underestimates the losses, the deck can crack under service loads; joints can open or droop; or tendons may experience excessive stress ranges resulting in fatigue problems. If the designer overestimates, the bridge may show excessive camber and increased creep.

Prestress losses can happen either immediately or over an extended period. Study 0-1234 monitored a total of sixteen tendons in three instrumented spans. Except for prestress losses due to stressing hardware and friction losses, researchers confirmed that current design criteria predictions are suitably close to measured values.

Hardware. Nowhere in the present AASHTO code are prestress losses due to stressing hardware mentioned, even though contractors have long known such losses occur and are equipment dependent. Study 0-1234 was able to measure this type of prestress loss and recommends that a loss of 3 percent should be assumed unless the equipment is known to warrant another value.

Deviators. Researchers observed a higher-than-expected average loss of stress across deviators, due in part to duct misalignment. This misalignment caused the actual angle changes to be more acute than the design value, causing higher friction, therefore greater loss of force The study recommends the addition of an inadvertent angle change factor at each deviator.

Creep and Long-Term Moment Distribution

The TxDOT designers used a time-dependent, highly specialized frame solver, "Bridge Designer," to calculate the long-term behavior of the "Y." They wanted to compare their predicted values with the actual changes in camber and concrete stresses, along with the changes in post-tensioning forces. The measured deflections agreed reasonably well with the deflections as calculated by "Bridge Designer." However, since the designers did the analysis before construction, it contained some design assumptions that did not occur, such as higher than actual tendon forces, lower than actual concrete modulus, and a very optimistic construction schedule.

THERMAL GRADIENTS

In the past, some segmental bridges have suffered cracking attributed to thermal gradients through the girder depth. NCHRP Report 276, ***Thermal Effects in Concrete Bridge Superstructures,*** proposed positive thermal gradients (deck warmer than webs) based on U. S. weather station data and a finite difference, one-dimensional heat flow program. The authors of NCHRP 276 based negative thermal gradients (deck cooler than webs) on the British Standard BS 5400. AASHTO incorporated these gradients into the ***AASHTO Guide Specification*** in 1989.

Many designers feel the gradients are too harsh — complicated and extreme and not required in the design of other types of concrete bridges. The San Antonio results appear to bear out this opinion.

A Campbell 21X automatic data acquisition system logged data from thermocouple arrays (Fig. 10) from 16 July 1992 to 25 March 1993

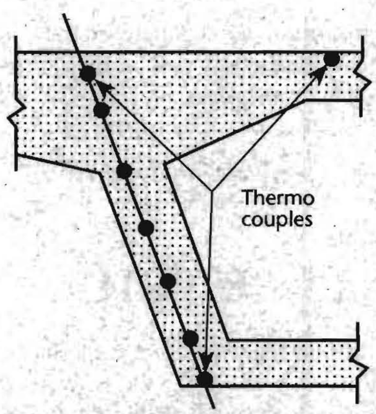

FIG. 10: Schematic of thermocouple array in segment.

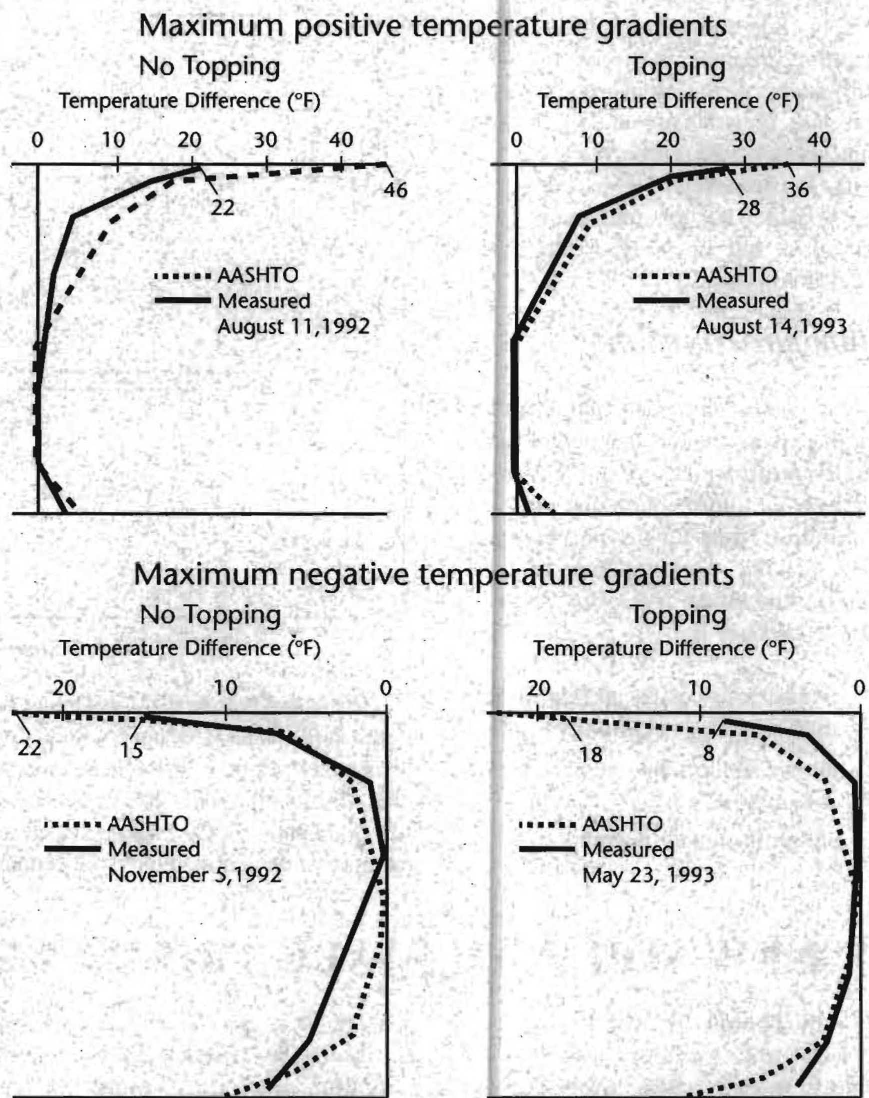

FIG. 11: Maximum positive and negative thermal gradients

without asphalt covering the deck and again from 26 March 1993 to 14 May 1993 with a 2-inch asphalt overlay on the deck. Researchers determined bridge response by measuring bridge deflections and concrete strains on four separate occasions for 12 to 14 hours. During these observations, they connected a solar radiation pyrometer to the data acquisition system and also recorded temperatures (using a hand-held thermometer) inside, underneath, and on top of the bridge.

As Dr. Roberts observes in her dissertation:

The positive thermal gradients for the untopped condition measured over the course of many months in San Antonio never approached the NCHRP design gradient. In fact the top surface temperature difference for the unsurfaced condition never attained more than 50 percent of the NCHRP value. While it might be remotely possible that the design gradient might occur, for the San Antonio "Y" project with the light colored concrete and roughened surface, its occurrence is unlikely. Once the topping was laid the gradients became larger and more closely approached (approximately 80 percent) the design gradient (Fig. 11). The NCHRP and New Zealand design gradients indicate that the gradient should decrease with the addition of a topping, while the current measurements indicate that the opposite is true ....

The erratic agreement of the predicted and actual thermal gradients could indicate errors in the original analysis which was used to develop the gradients. The original work was confirmed with only two days of measurements on a bridge with an asphalt topping. No further confirmation was provided ....

...A possible approach to allow for the extreme improbability of the positive design gradient ever occurring would be to allow a substantial reduction in design gradient based on local conditions such as city pollution, very windy areas, known absorptivity constants, or high traffic volumes which cause air stirring. [Ref. 1, pp. 267 – 273]

The measured negative gradient for the untopped case was approximately 80 percent of the design negative gradient; while for the case with topping, the measured gradient was less than 50 percent of the design gradient. Based on the study results, the researchers concluded that the negative design gradient is conservative, but possibly appropriate, for San Antonio.

POOR-BOY CONTINUITY

One 2-span unit was actually two simple spans made continuous by a mildly reinforced top slab continuing over an intermediate pier with no continuous post-tensioning tendons (Fig. 12). This unusual form of continuity, known as "poor-boy," is desirable because it:

- is easier to design and construct than a multispan continuous unit
- allows single spans to be replaced if damaged.
- simplifies tendon layout

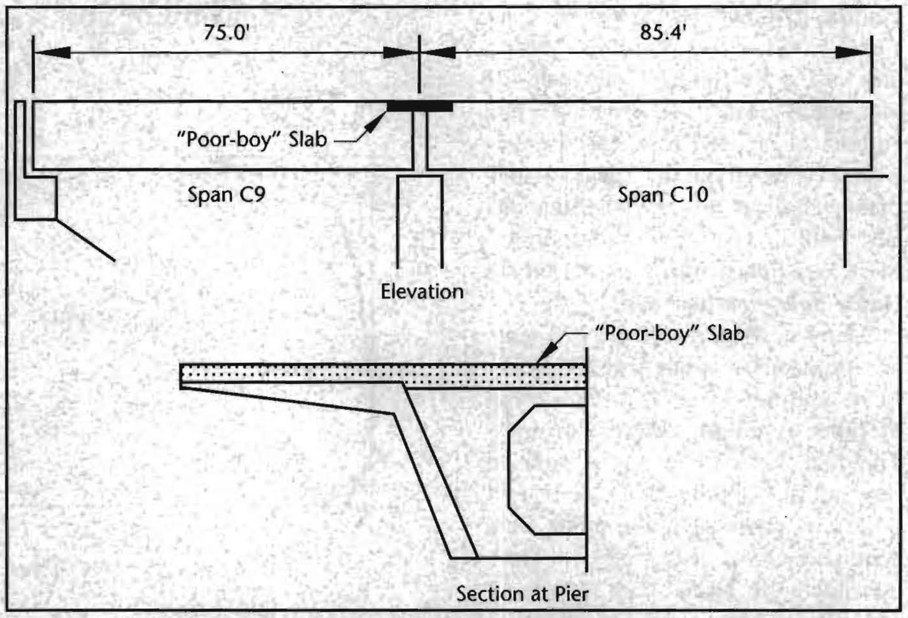

FIGURE 12: Schematic of poor-boy closure slab.

The actual behavior of this feature interested the TxDOT designers since they plan to use all poor-boy construction on the US 183 project. The top closure (Fig. 13) and slab C9 both contained instrumentation that monitored deflections, web strains, and continuity-slab surface strains. Researchers took readings before loading, with trucks on span C9, with

Continued on page 18

NEW SOIL NAIL WALL TRIED IN DALLAS DISTRICT

by **Thomas R. Elliott, Jr.**
Field Research Technician
Office of Research and Technology Transfer

BACKGROUND

The French first developed soil nailing in the early 1970's. Soil nailing is a construction technique that uses closely spaced structural inclusions ("nails"), which are not pretensioned, to improve the soil's overall shear strength. It has been used extensively in Europe and Great Britain, principally for temporary support of excavations. Permanent soil nail walls are now being constructed in the United States and elsewhere. Permanent soil nail walls offer significant potential savings over conventional earth retaining systems because of the ease of construction and the structural benefits of spreading the face loads over a large number of nails.

Texas Department of Transportation (TxDOT) has one such project on IH 30 at SH 205 near Rockwall in the Dallas District. The geometric situation required a U-turn lane for the eastbound service road of IH 30. The embankment under the bridge had to be removed to provide the additional space (Fig. 1). Due to the limited space and obstacles, the design engineers selected soil nail walls to retain the slope.

FIGURE 1: The completed soil nail wall on IH 30 at SH 205.

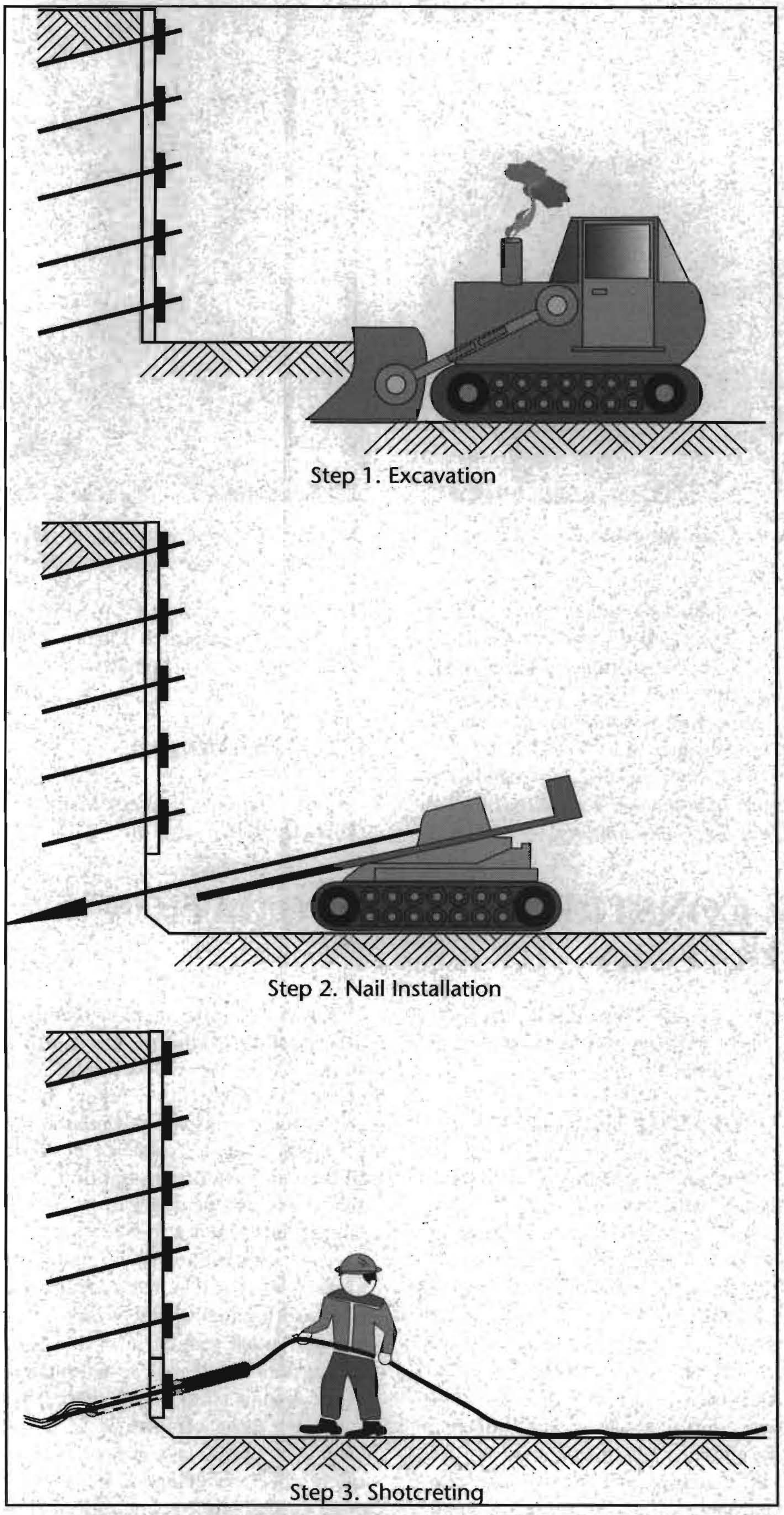

FIGURE 2: Soil nailing construction schemtic. Steps 1 through 3 are repeated until the desired elevation is reached.

The Dallas District soil nailing project provides a good example of the construction phases on this type of retaining wall. These walls, constructed from the top down, provide their own support during erection (Fig. 2). This construction feature is an obvious advantage, eliminating the need for temporary supports and thus reducing construction costs. The use of soil as part of the wall further reduces the overall cost. The soil nails also allow a certain amount of flexibility in construction. Workers can avoid existing structures or obstacles by repositioning the nails, averting costly time delays.

The wall has 516 twenty-foot nails. These nails are #6 epoxy-coated Dywidag threaded bar. At its highest point, the wall has six rows of nails, with the nails approximately 2.5 feet apart. The nail holes are drilled at 10 degrees below horizontal, are 20 feet long and 6 inches in diameter. Each of the 20-foot nails has four 6-inch plastic spacers designed to keep the threaded bar in the center of the hole. With the nail in place, workers use a 20-foot piece of 1-inch PVC pipe to shoot the grout into the hole from the inside out. They do not remove the pipe from the hole until the hole is almost filled with grout. Keeping the pipe in ensures that the hole has no voids. After completing one horizontal row, workers place a 6-inch x 6-inch welded wire fabric to reinforce the cut face. With the welded wire fabric placed, workers apply a 3.5-inch layer of shotcrete to the cut face, providing additional support. Workers then place a 6-inch x 6-inch x .25-inch bearing plate and nut on the threaded bar once the shotcrete is applied (Fig. 3).

Originally, the plans called for drainage mats between the soil and the shotcrete. District personnel discovered that the prefabricated drainage mats could not be placed next to the soil before the shotcrete was applied because the mats were damaged when the shotcrete was chipped away after drying. Instead, they placed weep holes in the shotcrete and put the drainage mats over the weep holes. Then they erected a 9-

FIGURE 3: Detail of welded wire fabric and bearing plate arrangement.

FIG. 4: Gathering strain gauge and other data for performance evaluation.

inch permanent concrete wall to complete the project.

For evaluation purposes, the district modified the plans for this project to include instrumentation (Fig 4). The modification called for a total of two inclinometers and 60 strain gauges placed throughout the wall. These strain gauges also have temperature reading capability.

Construction ended on the wall in July 1993, and it is functioning satisfactorily. The instrumentation is working properly. Henley and Johnston Engineering is gathering the data for future evaluation by TxDOT.

For more detailed information, request ***International Technology: FHWA Tour for Geotechnology — Soil Nailing***, publication number FHWA-PL-93-020, from the Research Library. Call Dana Herring at (512) 465-7644.

SPECIAL THANKS TO:

Gary Andrews, Project Manager, Dallas District.

A LOOK AT THE CONSTRUCTION AUTOMATION LABORATORY, UT AUSTIN

by **Dr. Carl Haas**
Assistant Professor of Civil Engineering
The University of Texas at Austin

Technology in the construction industry is changing rapidly. Preassembly and modularization are changing the way facilities are put together. Information technology is improving, and safety has become a top priority. Real needs exist for the introduction of automation technologies that can improve safety and productivity and also exploit the possibilities introduced by technologies such as site positioning systems and advanced sensing and computing. Focusing on construction, maintenance, and operations in transportation, the Construction Automation Group at the University of Texas at Austin is active in several research, development, and implementation projects. This article describes four of those projects and how they relate to TxDOT.

AUTOMATED ROAD MAINTENANCE

The nation's highway network is aging, while the volume of traffic that it supports is increasing. Environmental regulations are becoming stricter, and the costs of road maintenance are on the rise. Road maintenance technology, however, has remained largely unchanged for decades. Maintenance typically involves small scale, dispersed activities performed under traffic conditions by relatively low skilled laborers with basic equipment. Conventional road maintenance methods will be seriously strained to meet the increasing demands of the future.

Automated road maintenance has tremendous potential to improve this situation. Safety in particular can benefit by removing workers from dangerous conditions, and related reductions in labor costs can be very significant. Fuel consumption and user costs can be reduced by minimizing interference between traffic and maintenance crews, enabling nighttime maintenance operations, and ensuring high quality work. Automated crack sealing, movable barrier systems, and mobile automated traffic signals show real potential for achieving these benefits as do automated line painting and mechanized safety cone placement. A number of other promising technologies also exist.

Current work at UT is focused on

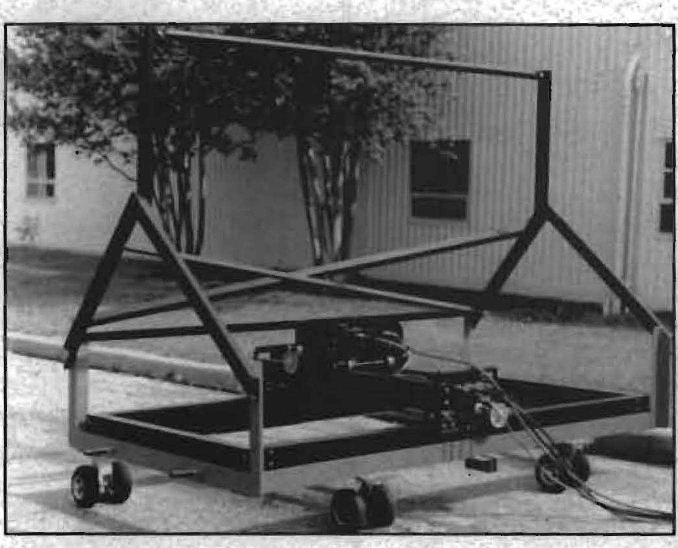

FIGURE 1: Prototype crack sealing unit.

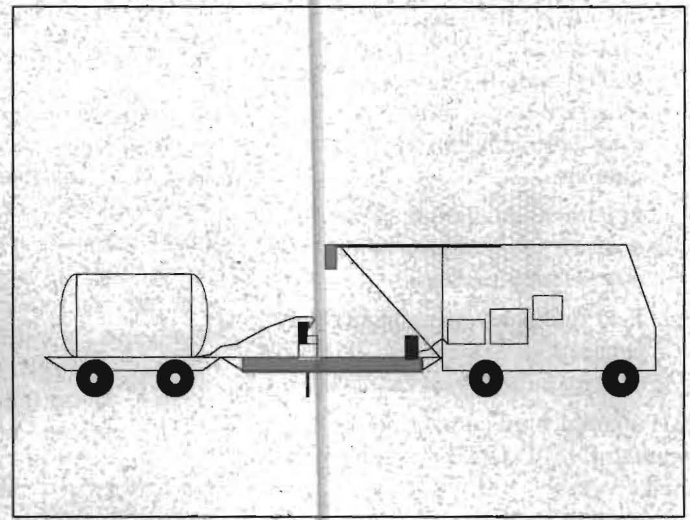

FIGURE 2: Proposed crack sealing system.

reducing both the operational and user costs of road maintenance while enhancing safety and environmental features. An economic analysis by Carnegie Mellon University estimates nationwide savings of several million dollars per year for automated crack sealing alone. The corresponding reductions in user costs and fuel consumption are predicted to be much greater. Working with TxDOT personnel in an effort to improve current maintenance methods, several tasks have been recently completed, including:

- a comprehensive survey of automated road maintenance equipment in prototype and commercial stages,
- the generation of a model to analyze the costs and benefits of automated road maintenance,
- the acquisition of detailed data on TxDOT road maintenance methods and expenditures in order to identify automation needs,
- a study of productivity and contracting practices for crack sealing in Texas,
- an evaluation of multisensor strategies for crack mapping including use of a laser-radar (LASAR(tm)) sensor, single axis range sensors, and partially automated alternatives, and
- the generation of a model to rank the potential of automated systems including costs, safety and environmental benefits, and technical feasibility.

LARGE-SCALE MANIPULATORS

Large-scale manipulators (LSMs) show tremendous promise in construction. Their forms vary from automated backhoes to multilink, single purpose concrete pumps.

At the University of Texas, an 8-link manipulator with a 65-foot working radius is used as an experimental test bed for LSM research (Fig. 3). This hydraulically powered manipulator is unique because of its large dimensions, multiple degrees of freedom, and multifunctional potential. Researchers began a pioneering program in 1987 to develop enhanced control technology for the manipulator and to assess its usefulness in industrial and heavy construction. Some of the work completed to date includes:

- design and fabrication of an "ergo-stick" concept of an intuitive user friendly man/machine interface for control,
- design and development of a digital control system which allows

FIGURE 3: Prototype manipulator system.

the use of the "ergo-stick" concept and also provides the adaptability needed for implementing other advanced control concepts such as straight line and recorded motions,

- graphical simulation of the manipulator using commercially available software packages,
- field studies involving productivity comparisons of the manipulator and a cherry picker for various tasks.

Potential applications of the manipulator in TxDOT operations include:

- sandblasting and painting structures — Removing workers from close proximity to these operations improves safety. With its large lift capacity, the manipulator can be fitted with blasting AND containment equipment that will reduce the distribution of blast particulate into the atmosphere.
- large rebar and rebar cage placement on bridge decks — Improving productivity by reducing labor intensity lowers operational costs. More importantly, project duration may be reduced thus reducing user costs related to construction.
- concrete distribution on bridge decks — By attaching concrete pumping hardware to the manipulator, it can become multifunctional, thus speeding up bridge construction and repair operations.
- placing overhead signs and structures from beside the road — Removing workers from this operation can improve safety.
- remote inspection of complex structures — With eight degrees of freedom and a tremendous reach, the manipulator (fitted with video cameras and other sensing devices) can access difficult areas for inspection and surface finishing.
- worker placement for manual inspection.

AUTOMATED SURFACE REFINISHING

Automating surface finishing for large storage tanks can yield significant cost, environmental, and safety improvements over conventional sandblasting and repainting methods. The conventional procedures can contaminate the environment and are hazardous, exposing workers to dust, harmful paint components, and possible injuries due to falls. Strenuous working conditions and worker fatigue contribute to an inconsistent quality of the applied coating.

Fundamental technology for automated tank refinishing is being developed at UT. A prototype system has been built for use on large diameter tanks (Fig. 4). The system is comprised of a control station and a remotely operated cart with paint and blast overspray hoods. The cart, which is manipulated over the tank wall with cables (Fig. 5), will blast and paint the vertical, exterior areas that are not restricted by pipes,

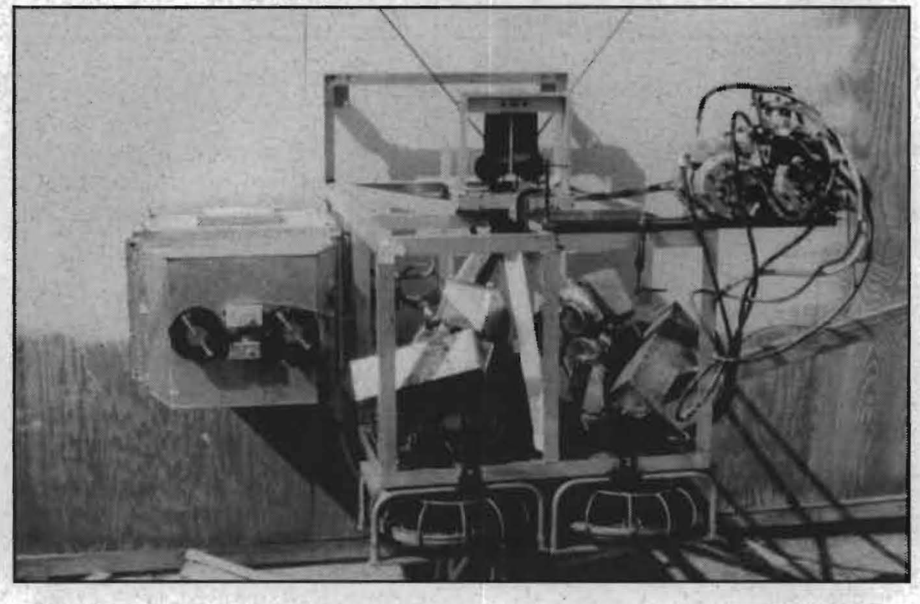

FIGURE 4: Prototype automatic repainting unit.

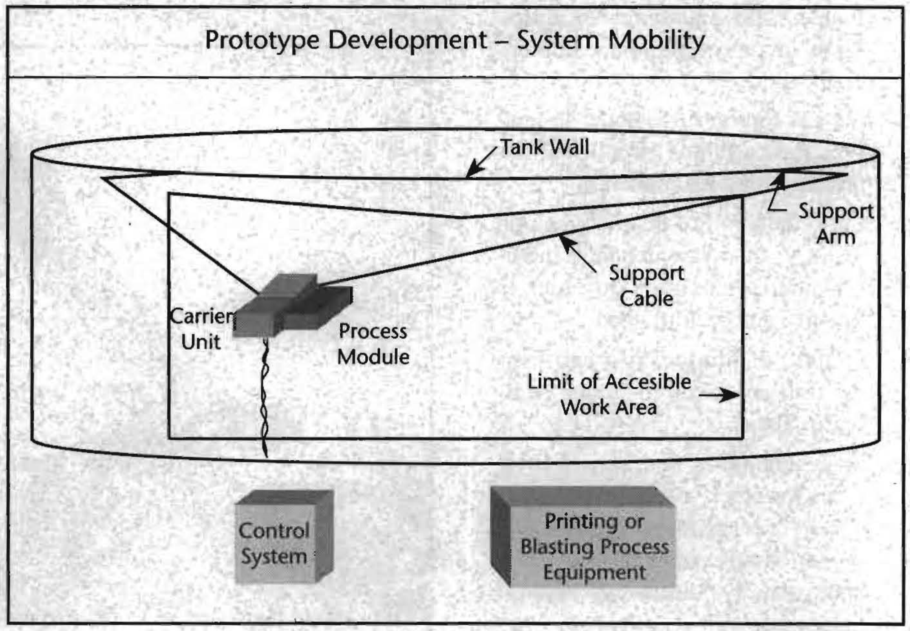

FIGURE 5: Prototype automatic repainting system.

stairs, or other structures. The control station is located on the ground to remove the operator from the hazardous conditions as much as possible. Although initially developed for tanks, this technology can be extended to include other large, uniform structures. Quality is improved over manual work, and initial observations reveal significant productivity improvements.

Applications of the technology to TxDOT property such as cleaning and recoating concrete median barriers in high traffic areas are likely though adaptations would be required..

COMPUTER-AIDED CRITICAL LIFT PLANNING

Hundreds of millions of dollars are spent annually in the United States by industrial owners and contractors on critical lifts. While the number of critical lifts is increasing yearly, the number of experts who plan these lifts is decreasing. At the same time, lift planning is becoming more complex, and owner tolerance of the risk of catastrophic damage to their operating facilities is decreasing. These problems have motivated planners to explore the use of computer technology to aid in the lift planning process. For example, two- and three-dimensional graphics are used to check clearance much as two-dimensional cut-outs were used manually in the past for the same purpose. However, such direct automation of manual processes exploits only a fraction of the potential of computer technology in this domain.

UT is developing the fundamental technology for computer-aided critical lift planning. Researchers are exploring the potential to lower lift planning and execution costs, the potential to improve lift reliability, and the transparent automation of laborious calculating and drawing tasks to enhance the planner's capabilities. Results to date include documentation of fundamental planning procedures, a graphical simulation shell, a dynamic relational database link, and interactive planning algorithms.

Girder lifting and placement for overpass and bridge construction may benefit from computer-aided planning tools. Graphical simulation of critical construction sequences such as work around busy intersections may also benefit the planning and communication processes.

SUMMARY

Several technologies being developed by the Construction Automation Group at the University of Austin can likely be adopted to improve current TxDOT construction, maintenance, and operations activities. Facilities used in automation research and technology development at UT include several PCs, workstations, and output devices, as well as the large-scale manipulator, the crack sealer, an image processing workstation, sandblasting and painting equipment, and a test wall for automated surface finishing. The Construction Automation Group is eager to put these facilities to use for the benefit of the Texas Department of Transportation.

EDITOR'S NOTE

For more information on TxDOT and robotics, please see the lead article in ***Focus on Research 1-2*** concerning Study 0-1440, ***Application of Robotics and Other Automated Techniques to the Construction, Maintenance, and Inspection of Highway Systems***. Call the ***TQ*** editor for a copy (512) 465-7947.

Segmental Bridge Design and Construction ... continued from page 12.

FIG. 13: Slab C9 poor-boy closure.

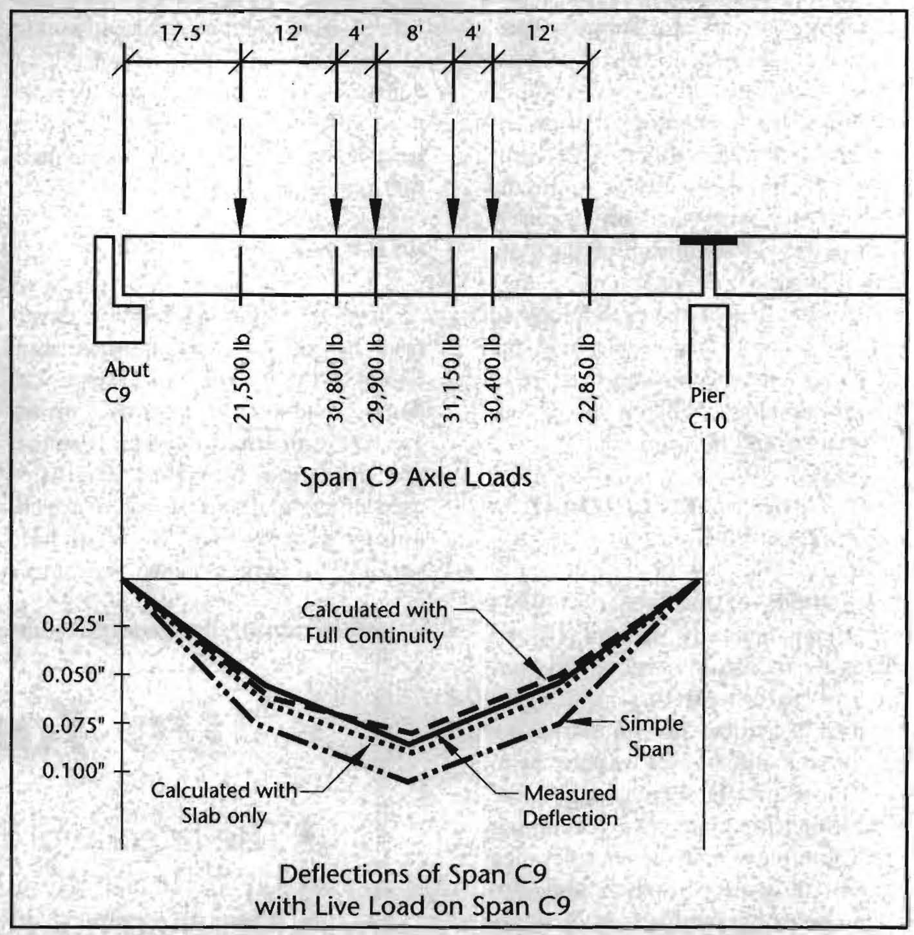

FIGURE 14: Measured poor-boy deflection vs. full continuity and simple span calculations.

trucks on span C10, and final readings with no load on C9 or C10.

The average measured deflection is smaller than either of the calculated deflections (Fig. 14). The measured top slab strains were quite small, and no cracking occurred under full live load.

These facts indicate at least partial continuity between the two spans in the poor-boy continuous unit. Tension in the top slab coupled with friction between the fixed bearings and the bottom slab creates that continuity. The degree of continuity can be modeled with a suitable two-dimensional elastic frame program like "FRAME2D" [Ref. 3].

DUAL BOX BEHAVIOR

Many of the ramp transition areas of the "Y" contain two adjacent spans transversely post-tensioned together (Fig. 15). TxDOT designers wanted to know how the two interacted. The research team measured the response of the ramp span first with it under load and then with the mainlane adjacent span under load. The measured deflection was 15 percent greater than the calculated deflection that assumed the boxes are working as one unit and 55 percent less than the calculation that assumed the two boxes were acting independently. The measured stress changes in tendons and the web strains were both quite small.

These results show that adjacent boxes transversely post-tensioned do work together to carry loads placed on one box only, although the interaction is less than predicted. Researchers attribute the lower-than-expected interaction to slight shrinkage or cracking of the closure slab.

HEAT DEFORMATION OF MATCH CASTINGS

"In general," Dr. Roberts reports, "all casting operations proceeded smoothly. The casting crews were very experienced. ...The yard ran much like a manufacturing operation as opposed to a construction operation. The quality control team worked hard to ensure a very high quality product, since superior segment production results in fewer erection problems." [Ref. 1 p. 38]

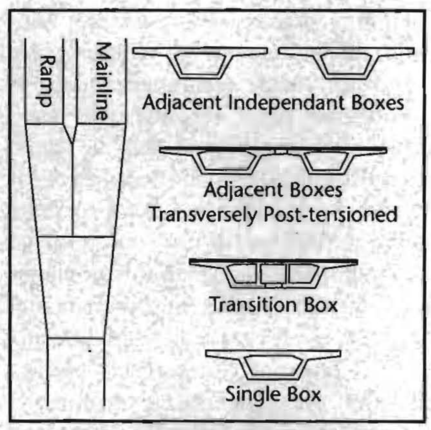

FIG. 15: Schematic of a ramp split showing position of adjacent post-tensioned boxes.

Even this experienced and diligent crew, however, turned out some match castings with one face inexplicably curved. When the erection crews applied temporary post-tensioning to these segments, the joints gapped and were difficult to close (Fig. 16). The gapping led to reductions in closure pour size and raised questions about joint durability. Since bowed match castings had occurred on early phases of the "Y," TxDOT requested that Dr. Robert's team study the problem and determine how to avoid it.

Heat of hydration in the newly cast segment is the culprit. The high heat of hydration warms the adjacent face of the older casting causing it to expand faster at the edges than the center. This expansion causes the older casting to bow. The new casting, still in a plastic state, conforms to the bowed face and sets that way (Fig. 17). The older casting returns to its original shape as it cools.

The research team devised an ingenious system of precision rulers, mirrors, and taut piano wire to measure actual deformations of the faces during setting. Researchers recorded temperature changes from two lines of eight thermocouples cast into each segment of the instrumented spans. They read temperatures and deformations at hourly intervals for several days following casting. The critical deformation (the one resulting in a permanent bow) occurred approximately six hours after casting. The amount of deflection is dependent on the:

- concrete mix design
- width-to-length ratio of the segment
- ambient temperature (cooler is worse)
- time of casting (morning is better than evening)
- age of the segment being matched (older segments' temperatures are stable, reducing the gradient).

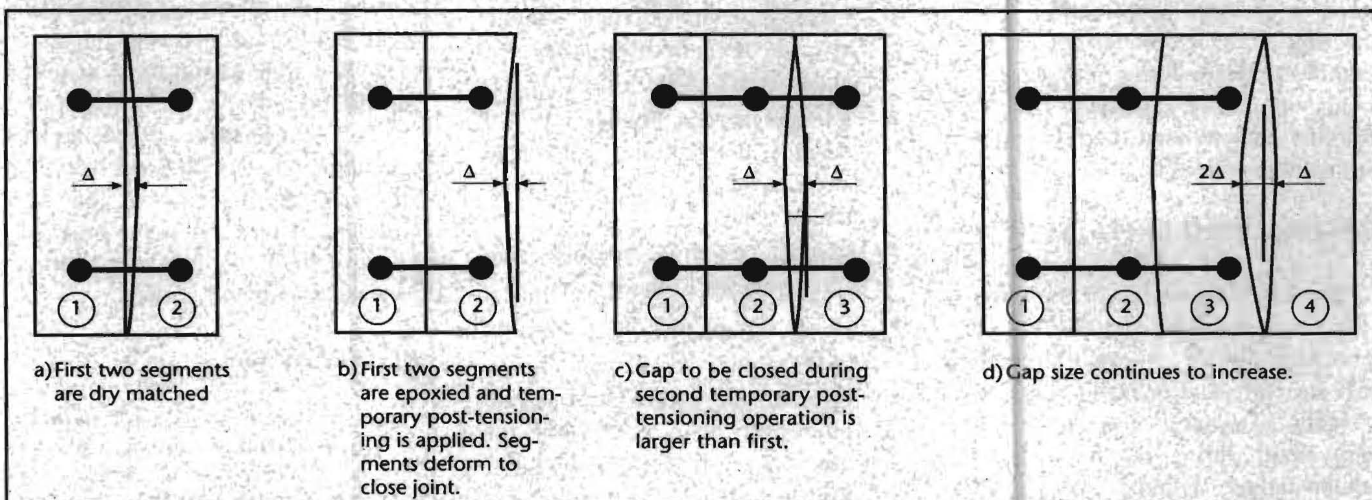

FIGURE 16: Joint gapping during construction caused by bowed segments.

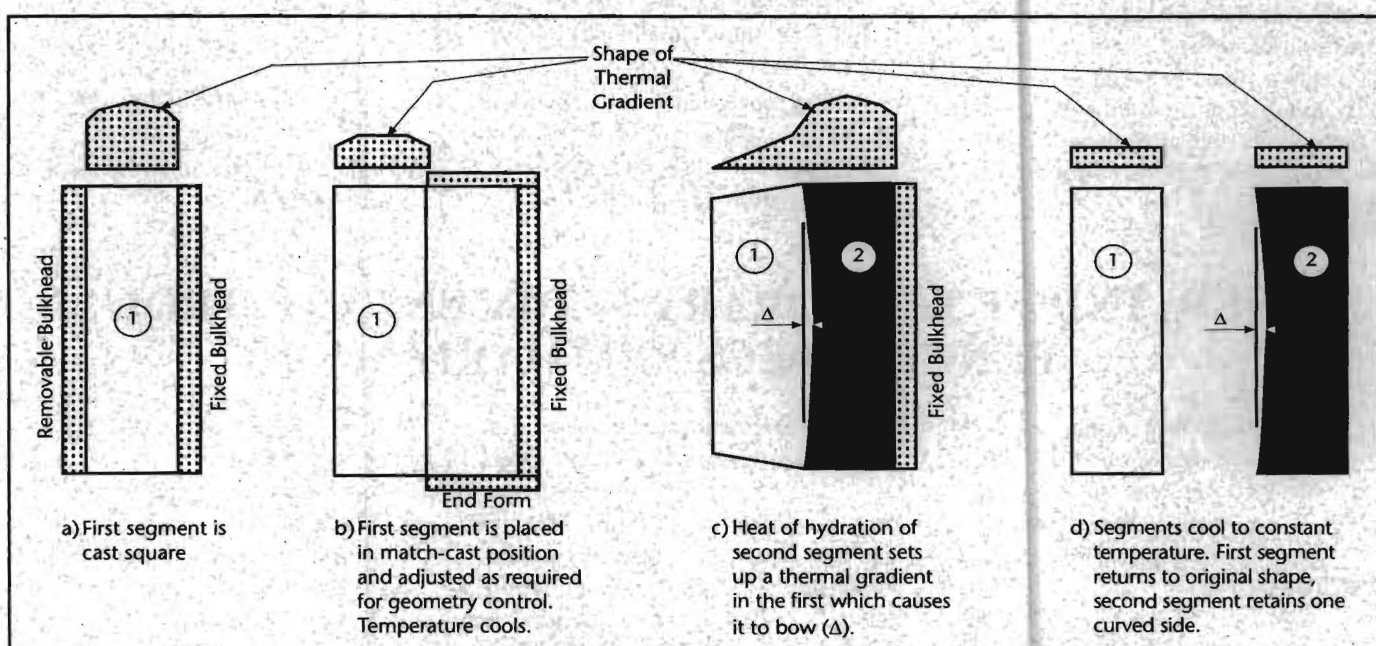

FIGURE 17: How bowed segments occur in match casting.

Measures to Reduce Deformation

Study 1234 outlines a design and construction approach that includes determining the worst case design gradient, calculating the segment deformation at the time on concrete set and the cumulative deformation for all segments within a span, and requiring measures to reduce the thermal gradient during casting if the cumulative span deformation exceeds 0.75 inches or any one span's deformation is above 0.05 inches.

Any reasonable means of warming the segment being matched should help reduce thermal-gradient-induced bowing. Isothermal enclosures or curing blankets and plastic sheeting may be enough in Texas. Continued steam curing may be necessary in colder climates. The researchers recommend thermocouples to monitor internal heating.

GENERAL OBSERVATIONS

The live load testing of the three-span continuous unit showed that the San Antonio "Y" is an extremely stiff structure and behaved very predictably. External tendon stresses are very small during live loading, so tendon fatigue should not be a problem.

The researchers observed no opening of the epoxied joints during construction testing or under traffic. The epoxy joints behaved very similarly to adjacent monolithic concrete. Epoxy joints appear to have a higher capacity for direct shear force than dry joints.

Field measurements indicate that strut-and-tie modeling can be used to design safe, serviceable heavy end diaphragms and deviators.

SUMMARY OF RECOMMENDATIONS MADE TO AASHTO

The following is a bare-bones summary of Study 1234's measurement-based revisions recommended for the ***AASHTO Guide Specification.***

- Account for 3 percent loss in prestress through stressing hardware.
- Increase theoretical angle change at each deviator by inadvertent angle break of 0.04 radians.
- Reduce thermal gradients by 20 percent, and increase allowable stresses outside precompressed tensile zone
- Simplify and clarify effective flange width procedures.
- Check direct joint shear capacity of dry joints
- Promote the use of strut-and-tie modeling as a good tool for heavy end diaphragm and deviator design
- Disseminate the fact that segmental bridges are very stiff and behave quite predictably under live loads
- Understand that external tendon fatigue should not be a problem because the stress increases under live load are very small
- Predict and control thermal gradient deformation of match castings

EDITOR'S NOTE

Instrumentation of Segmental Box Girder Bridges and Multipiece Winged Boxes (CTR 0-1234) is a fine example of a truly cooperative research project. By use of solid advance planning, the researchers were able to gather extremely valuable field data during construction without hindering the construction operation. The contractors were very interested in the outcome and helpful. The TxDOT Technical Panel, chaired by Pat Bachman, P.E., worked very closely with the researchers and the contractors in all phases of the study. (The research community awarded Mr. Bachman the M. D. Shelby Award for excellent technical assistance this year for his efforts on Study 0-1234.) Although the project was long and complex, it proceeded smoothly because of the mutual respect and diligence shown by all parties.

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2. Roberts, Carin L., John E. Breen And Patrick M. Bachman. "Instrumenting the 'Y'," ***Civil Engineering*** 62(November 1992): 48-51.
3. Fleming, J. E. "FRAME2D," program for Basic, 1985.

NEW TXDOT TEMPORARY SEDIMENT CONTROL FENCES SPECS SUMMARIZED

by **John A. Teamah,**
Engineering Assistant III
Materials and Tests Division
Texas Department of Transportation

BACKGROUND

On Septtember 9, 1992, the EPA issued rules (40 CFR 122) to establish the general permit requirements for storm water discharges at construction sites. The regulations required that each construction project clearing land area larger than five acres should administer a "Storm Water Pollution Prevention Plan" (SW3P) to manage storm water runoff. These regulations affect essentially all Texas Department of Transportation (TxDOT) construction projects.

To comply with the new rules, TX DOT developed a specification for "Temporary Sediment Control Fence" that could be incorporated into the SW3Ps of TxDOT's construction projects. Temporary sediment control fences (silt fences) are erosion control devices consisting of geotextile fabrics placed vertically on supports. The geotextile fabrics intercept and detain water-borne sediment while allowing percolation of water. Silt fences are used for the purpose of decreasing the velocity of runoff flows so that sedimentation can take place.

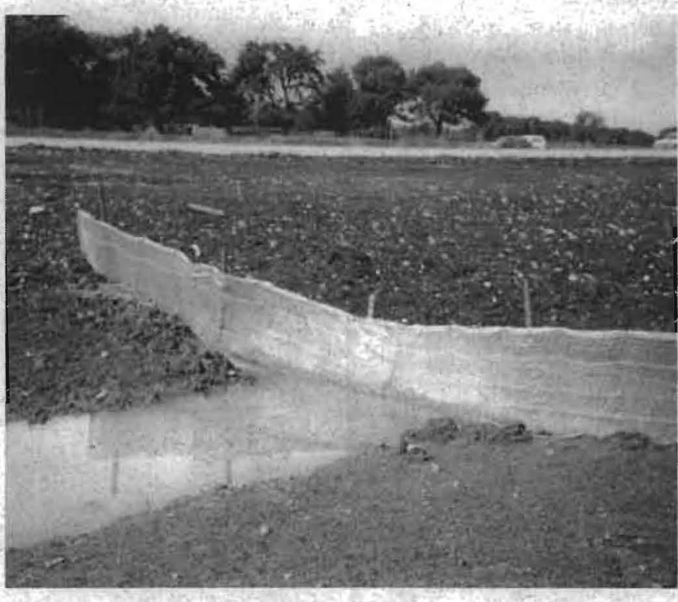

FIGURE 1: Woven fabric 0.70-inch rainfall.

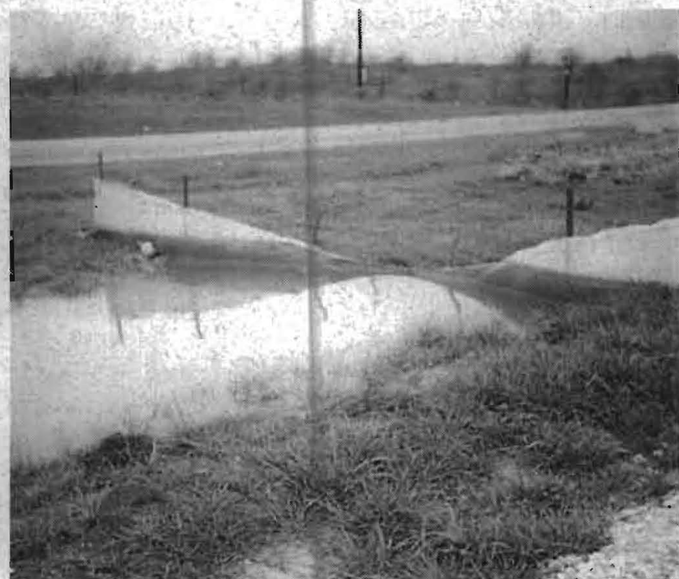

FIGURE 2: Nonwoven fabric after 1.54-inch rainfall.

The specification described three types of temporary sediment control fences:

1. Type 1 was a self-supporting fence using a woven geotextile fabric.
2. Type 2 was a net-reinforced fence using a nonwoven geotextile fabric.
3. Type 3 was a triangular filter dike using nonwoven geotextile fabric.

The initial specifications for the nonwoven geotextile fabric were modifications of existing specifications for filter fabric. Filter fabric is designed to allow water to flow through, but to retain soil particles.

THE PROBLEM

One early field problem was difficulty with some fabrics to meet equally the requirements of retaining maximum amounts of sediment while providing high flow rate efficiency (no in-service clogging). The clogging phenomenon was noted almost exclusively in fences using nonwoven geotextile fabric. Field reports indicated that sometimes storm water runoff overtopped or flattened the fence by the hydrostatic head developed against the clogged nonwoven geotextile fabric. The overtopped fence then resuspended silt previously caught behind the fence, thus increasing the amount of sediment carried off-site. Field personnel reported that the clogging of nonwoven silt fences resulted in their replacement after virtually every rainfall event.

WHY

The differences in the manufacturing processes of woven and nonwoven geotextiles influence the pore geometry of the fabric and, hence, the hydraulic characteristics such as apparent opening size (AOS), permitivity and permeability, and clogging and blinding resistance.

The woven geotextiles are manufactured on conventional textile weaving machinery into a wide variety of fabric weaves. The woven geotextiles have regular openings which allow water flow across their manufactured plane.

Unlike the conventional weaving techniques, nonwoven geotextiles are produced by extruding melted polymers through dies or spinnerets. The bonding processes of the filaments produced take several types of treatments which include chemical (synthetic resin), thermal (heat bonded), and mechanical (needle punched) bonding. The nonwoven geotextiles have random distribution of openings or lack distinct and measurable openings. This requires water to take a tortuous path in the plane of the fabric in order to travel from one side of the fabric to the other.

In essence, these two types of geotextile fabrics function differently in their mechanism of water transmission and one would expect them to function differently in erosion control devices.

FIELD INVESTIGATION

An in-field test section study was conducted to determine the effectiveness of woven and nonwoven geotextiles in silt fence applications. During the test section study, Type 2 silt fence designs using woven and nonwoven geotextiles were deployed at selected locations; photographs were taken before and after rainfall for evaluation; and discussions were held with various field personnel. Early experience with wind damage failures of Type 1 designs and installation and maintenance difficulties with Type 3 designs precluded evaluation of these fences and resulted in a recommendation to eliminate their use.

Three construction projects in the Austin District of the TxDOT were selected for deploying silt fences. These projects were located in areas with an annual rainfall of 32 inches and in both environmentally sensitive and non-environmentally sensitive areas. The trial placements were designed to determine which fabric material, woven or nonwoven, would achieve the following results during a rainfall:

1. reduce in-flow velocities without water ponded behind the fence;
2. trap water-borne sediment from storm water runoff; and
3. require less maintenance and show overall cost effectiveness.

The silt fences were mainly deployed within the confines of a ditch at recently disturbed areas and slopes with low-level channel flows.

FINDINGS

The findings of this study indicate that the woven geotextiles were effective in trapping water-borne sediment, while allowing percolation of water. These deployments required little maintenance during the first test sections. The woven geotextiles could be broomed and put in service without replacement after a rainfall. This type of maintenance can increase the useful life of woven geotextile silt fence to perhaps five months or more through multiple rainfall events.

The nonwoven geotextile fabrics, on the other hand, collected a myriad of silt and clay which readily clogged the openings of the fabric, creating dams. The field reports indicate that many times the storm water runoff overtopped or flattened the fence, resuspending silt previously caught behind the fence and carrying most of it off-site. The nonwoven geotextile fabric could not be cleaned for subsequent use by brooming. These geotextile fabrics had to be replaced frequently at an estimated cost of \$3.50 per square yard almost equivalent to a new installation .

Cost analysis of Type 2 silt fences constructed of woven and nonwoven geotextile fabrics indicates that the unit cost of both materials varies slightly, but the overall maintenance cost of the nonwoven geotextile fabric is twice that of woven geotextile fabric. This is simply because woven geotextile fabrics require only minor maintenance such as brooming off silt to allow passage of water without frequent replacement.

Based on the study, recommendations were made to change the construction specification for "Temporary Sediment Control Fence" and the materials specification for "Temporary Sediment Control Fence Fabric." The TxDOT Specification Committee approved these changes which are currently in use. The following outlines the changes in the silt fence specification:

1. All temporary sediment control fences should be net reinforced with vertical supports.
2. All net reinforcement should be galvanized welded wire mesh of at least 12.5-gauge wire with maximum openings of 8 square inches (2-inch x 4-inch openings). The use of poultry wire as a net reinforcement is not allowed.
3. Only woven geotextile fabric is acceptable material for temporary sediment control fence.
4. Fastening of the woven geotextile fabric to the top strand of reinforcement should be done at a maximum spacing of 15 inches.

SUMMARY

In using temporary sediment control fences, one must recognize the limitation of the devices. Temporary sediment control fences cannot be expected to function adequately in live streams or areas of high velocity of flow exceeding approximately 40 gallons per square foot per minute. In extreme conditions, other erosion control devices and structures must be considered.

However, the changes made to TxDOT specifications will make temporary sediment control fences a cost-effective, functioning, and essential part of erosion control plans for construction projects.

Copies of the revised specifications for construction and for woven geotextile fabric are available. *For more information, contact John A. Teamah, TxDOT, Materials and Tests Division, 3800 Jackson, Austin, TX 78701, (512) 465-7986, fax (512) 465-7999.*

ERRATA

In *TQ8-2,* "The Benefits of U. S./Mexican Intermodalism," the editor mistakenly labeled Figure 7 as "Union Pacific's intermodal facility near Laredo." The caption should read, "Southern Pacific's intermodal facility near Oakland, California." The error was not the author's, and the editor apologizes for any confusion or problems she may have caused.

COMPUTER TIP

• **Delete temporary** computer files promptly. Keeping them on the hard drive eats useful space and requires research and time to delete them months later.

Source: Cesar Gomes, 1545 Welch St., N. Vancouver, British Columbia, Canada, as seen in Communication Briefings 12(July 1993): 1.

CAN COMPUTER-DISPATCHED TECHNOLOGY IMPROVE THE DISPATCHING OF SHARED-RIDE VEHICLES?

The Intelligent Vehicle-Highway Systems (IVHS) technologies use computers and other advanced technologies to further more efficient use of roadways. IVHS technologies include such things as electronic payment media, automatic vehicle locator systems, and intelligent data bases, all related to highways and roadways. A key part of advanced public transportation systems (APTSs) and the APTS program of the Federal Transit Administration is the mobility management approach to service delivery, a mechanism for integrating and coordinating transportation services offered by many providers involving all modes of transportation.

The main objective of ***Assessment of Computer-Dispatched Technology in the Paratransit Industry*** is to ascertain whether computer-dispatched technology is or will become capable of improving the efficiency of dispatching shared-ride vehicles on a real-time basis. The investigators are trying to fully understand the current operating capabilities of computer-dispatched systems and to examine their economic benefits and costs . The investigators attempt to determine the suitability of computer-dispatched technology for applications that include user interface and information.

Future technological directions for computer dispatching of vehicles are part of the research effort. The study examines computerized dispatch and capabilities enjoyed by taxicab companies and computerized capabilities of paratransit operations. Site visits and telephone interviews were used to collect information.

Computer-dispatched systems are expensive, with a cost of about $1 million for a taxi company with 300 cabs. Nationwide, about 30 cab companies have invested about $30 million in the past 7 years for computer-dispatching systems. The current savings of travel time for the passengers is estimated to be $44 million, which results entirely from private investment. It is estimated that public investment could yield similar savings. The operating capabilities of computer-dispatched technology are impressive. For example, passengers can call a taxi company and within 30 to 45 sec a taxi will be dispatched to them.

The report (DOT-T-92-23) is available through the Technology Sharing Program, U.S. Department of Transportation, Washington, D.C.20590. The report was prepared by John R. Stone, Gorman Gilbert, and Anna Nalevanko, University of North Carolina, Institute for Transportation Research and Education,1100 Navaho Drive, Raleigh, North Carolina 27609, (919) 878-8080. The study was prepared for the Federal Transit Administration's Office of Technical Assistance and Safety.

DISEASE-CARRYING TICKS

Lyme disease, transmitted by tick bites, is a growing threat in the Texas outdoors, especially in the eastern half of the state. The Lone Star tick (brown with a white spot on the back) is the suspected vector in many human cases.

If you're going to be in tall grass or wooded areas, the Texas Department of Health (TDH) recommends wearing long pants and long sleeves. Tuck pant legs into your boots or socks, and put insect repellent containing "DEET" or "permethrin" on clothing and footwear (not on skin). After being outdoors, wash all clothing worn and inspect your body for ticks. Remove them with tweezers, grasping as close to the head as possible and tugging gently but firmly until the tick lets go. The less time it remains attached, the less likely it is to transmit Lyme disease.

If you suffer the flu-like symptoms of Lyme disease, and you suspect a tick bite, get medical attention as soon as possible. For more information, call the TDH Lyme Disease Information Helpline at (512) 458-7228.

Source: ***Texas Safe Talk*** 3(July 1993): 1.

STRESS REDUCER

• **Return potentially** unpleasant and frustrating phone calls first thing in the morning. By getting these calls out of the way, you won't dread making them throughout the day and you'll find your workday to be more productive and pleasant.

Source: Nancy Abrams, 429 S. Sierra #123, Solana Beach, CA 92075, as seen in Communication Briefings 12(July 1993): 1.

The mentioning of brand names is strictly for informational purposes and does not imply endorsement or advertisement of a particular product by the Texas Department of Transportation.

ENGINEERS AND COMPUTERS: REDEFINING THE POSSIBLE

by **Douglas Wolford**
Director of External Affairs
National Academy of Engineering

"Start by doing what's necessary," said St. Francis of Assisi, "then do what's possible — and suddenly you are doing the impossible."

For centuries engineers longed to slice through the complex, repetitive calculations that tethered their creative energies. The computer answered that need, for at its most basic it is a number cruncher par excellence. Yet, unexpectedly, computers opened up new territory well beyond the desert of mathematical drudgery: a realm of creative productivity once considered an engineers pipe dream.

A National Academy of Engineering (NAE) symposium, "Computing: The Transformation of Engineering," chaired by former National Science Foundation director Erich Bloch, took a look at the computer both as the engineer's apprentice and as a revolutionary new window on the world. Held in conjunction with the NAE's 28th annual meeting, the symposium convened some of the country's top computer engineers to describe and demonstrate the frontier technologies now finding application in the United States and abroad.

A SEPARATE REALITY

"The best thing about computer design," said Stephen Jacobsen of the University of Utah, "is that engineers can make their mistakes before they count." In partnership with the "thinking machine," engineers now can imagine, test, and refine concepts on their desks rather than in the field, where missteps can be costly.

Still, Jacobsen pointed out, "machines don't have the wisdom, creativity, or style of their creators."

The computer's catalog of marvels can beguile the unwary. Computer users, drawn into a world of

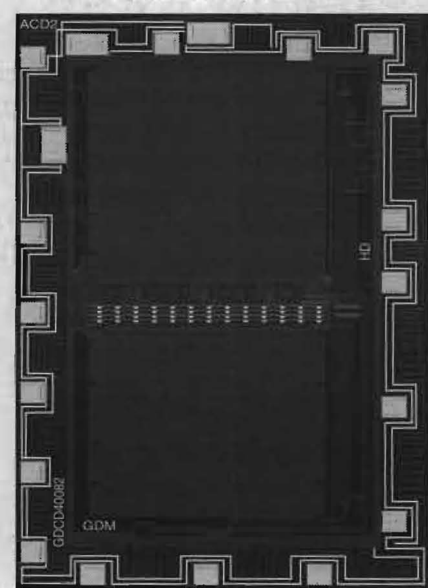

FIG. 1: Computer-generated diagram of an erasable programmable read-only memory chip (EPROM).

their own making, must retain a healthy skepticism. The tidy precision of the computed, *ideal* world offers easy refuge from the messy, *real* world it mimics, tempting engineers to "over-design," to make endless refinements that are more novel than necessary. As F. Gordon Willis of Ford Motor Company put it, "After all, a car is an emotional device — and you can only digitize so much of it before people stop liking it."

Nevertheless, it is easy to be seduced by the charms of "virtual reality" (VR). Anyone who has seen the movies "Terminator II" or "The Lawnmower Man" knows a thing or two about computer visualization, which includes VR — a type of computer simulation that allows the user to interact with an environment that seems almost real.

For engineers like James Clark of Silicon Graphics Inc., VR systems are much more than the ultimate video game. Look at a "traditional" blueprint or pen-and-ink sketch. The design seems desiccated, inert, unworthy: like a butterfly under glass. In virtual reality, the same design comes alive. Freed from the plane of the paper, it responds as its creator's thoughts progress. Suddenly the computers vision redefines the possible. Now what can be imagined can be attained — almost instantly.

SEEING THE HIDDEN

Petroleum engineers are using computers to sleuth for oil hidden thousands of feet beneath the earth's surface. "Contrary to the popular image," said Richard Ewing of Texas A&M University, "crude does not pool in giant underground cisterns, waiting for someone to build a filling station and siphon it up." Instead, engineers use a variety of computer techniques — including "seismic prospecting," a blending of acoustics with computers — to determine the geology of oil-bearing rock. Such simulations suggest drilling sites where the chances of finding and recovering oil are greatest.

"Designer" materials, too, are taking shape on the computer screen, according to Siegfried Hecker of Los Alamos National Laboratory.

Materials engineers and scientists, whose work is often done within the minute confines of the molecule, need computers to visualize the microscopic features that, multiplied by thousands of millions of atoms, determine the properties of steel, plastic, or concrete.

The insights gleaned at the molecular level can be scaled up to approximate and "fine tune" the finished product. Parts for the space shuttle, for example, were first modeled on the computer to help guarantee their resistance to meteorite impact.

ARTFUL DODGES

Computers give engineers an artful dodge around the dreary practicality of the real world and the freedom to dream the world as it could be. They can dare designs and test techniques that would otherwise be unthinkable in terms of cost, complexity, safety, or time.

In the automobile industry, engineers can design, style, assemble, and even crash-test cars — all on the screen. According to Ford's Willis, a new engine from concept to prototype once took Ford engineers a full year to design and build. Now it can be done in five weeks.

Computers have made inroads in civil engineering by beginning to integrate research, design, construction, operation, and maintenance. These functions once were performed piecemeal.

Later, in the early days of computing, they became "islands of automation within an uncoordinated process," according to Lehigh University engineer John Wilson. Coordination of these functions not only streamlines the process, it alters the way of thinking about the process and provides insights for future improvements.

Perhaps most amazing, the computer now takes part in its own evolution. The first integrated circuit "chips" — the computer's brain — were painstakingly drafted by hand. Later versions were drawn by computer, though still designed entirely by humans. Today, through electronic design automation, or EDA, computers can design computers.

Custom-made chips for specific applications can be designed and tested quickly with these software programs. Businesses, under pressure to respond instantly to market needs, use EDA to reduce their lead-times and envision more complex chips. By the end of this century, asserted Alain Hanover of Viewlogic Systems Inc., EDA will help engineers pack 20 million to 50 million transistors onto a single chip.

Computers may have begun their partnership with engineers by churning through the dirty work — doing a numbing round of calculations with precision and speed. But the real business of the engineer is not arithmetic. It is to see the world not as it is, but as it might be. Only the computer has so advanced the quest for that ideal. And in the process, has changed our view of what is possible.

FIGURE 2: The computer allows the engineer to visualize data three dimensionally.

Source: National Research Council's ***NewsReport*** 43(Winter 1993): 18-20. Reprinted by permission.

TRB IDEA PROGRAM UP AND RUNNING

Major leaps in scientific and technical progress are based on highly innovative thinking — that is, outside the mainstream of scientific thought.

SHRP's IDEA (Ideas Deserving Exploratory Analysis) program offered support for innovative, high-risk projects that would solve a problem within the scope of SHRP's research objectives. The program provided funding for about a year of research designed to prove the feasibility of the project. In cases where the concept proved feasible and showed potential for producing a tangible, cost-effective product, further funding was available for developing and field testing prototypes.

The program was popular because it provided a solution to one of the predicaments facing research organizations, especially publicly funded ones: Major leaps in scientific and technical progress usually are based on highly innovative thinking — that is, outside the mainstream of scientific thought — but those responsible for the expenditure of public funds feel they can only support research that is justified by the consensus of experts in that field. By providing support for embryonic innovative ideas, the IDEA program provided a solution to this predicament.

In January, the IDEA program transferred to the Transportation Research Board (TRB). TRB has broadened the program into three areas: NCHRP-IDEA, IVHS-IDEA, and Transit-IDEA.

NCHRP-IDEA

A cooperative program ($1 million/ year) funded by FHWA and the American Association of State Highway and Transportation Officials (AASHTO), the program supports the National Cooperative Highway Research Program. It seeks new technologies, methods, and processes with application to highways and intermodal surface transportation. It includes innovations in pavement materials and improvements in construction quality, maintenance repair and rehabilitation, steel and concrete structures, and highway safety systems. Developing prototypes for and product testing three successful SHRP-IDEA projects are being continued under NCHRP-IDEA:

- Preparing guidelines for applying a sprayed-zinc anode protection system.
- Developing a rapid method of screening for asphalt stripping.
- Testing an optical system to control aggregate gradations in asphalt.

IVHS-IDEA

The program is funded ($1.5 million/year) by FHWA in support of the national intelligent vehicle-highway systems (IVHS) program. The program will investigate the feasibility of new, unproven, and untested concepts and products and examine how advances and methods in other engineering applications might be used for IVHS.

TRANSIT-IDEA

This program ($0.5 million/year) is part of the Transit Cooperative Research Program, which is managed by TRB through a cooperative agreement with the Federal Transit Administration, the National Research Council, and the Transit Development Corporation (a nonprofit educational and research arm of the American Public Transit Association). The program is designed to foster innovative and cost-effective technologies, processes, or procedures that have the potential to significantly improve transit practice. Program announcements (similar to requests for proposals) were released earlier this year. They describe the technology areas in which projects will be considered. For example, the NCHRP-IDEA program is specifically soliciting proposals in:

- Pavement materials, construction, and performance;
- Pavement maintenance, repair, and rehabilitation;
- Materials for highway structures; and
- Highway safety systems.

Accepted proposals are usually funded for one year or less and for a maximum of $100,000. Proposals are accepted at any time (there is no specific proposal deadline). For more information, contact K. T. Thirumalai, IDEA program manager, TRB (telephone 202/334-1402).

Source: ***SHRP FOCUS*** (June 1993): 4.

BRIDGE RUNOFF PROTECTION

Lakes, rivers, and other water frequently suffer contamination that comes from the bridges that cross them. Some threats are the result of lead-based paint removed during bridge maintenance Pollution also stems from winter use of environmentally harmful deicing materials. Even more serious, though, is the everyday washdown of lead from heavy traffic fuel or unpredictable road spills of hazardous materials.

Containment systems of fine mesh can catch removed paint and provide a solution to bridge painting maintenance problems.

Use of environmentally safe deicing materials can clear the threat to water quality — and reduce bridge and vehicle rust — from deicers.

Risks from heavy traffic contamination or hazardous materials spills are harder to handle.

HOW SHREVEPORT DOES IT

The Louisiana Department of Transportation operates one of the best water protection systems in the country. To protect Shreveport's water-supply reservoir, Cross Lake, the city uses a totally enclosed drainage system. This system collects runoff from the bridge over the lake.

The drainage system includes longitudinal prestressed concrete conduit under the bridge median. This enclosed conduit collects bridge runoff and moves it into a holding pond.

Workers check the pond for contamination. If the liquids meet National Pollution Discharge Elimination System permit limits, they are released into a roadside drainage ditch that leads downstream from Cross Lake.

THE BRIDGE

The bridge over Cross Lake is part of an interstate highway loop that gives drivers access to areas in north Shreveport. There wasn't a good way to go around the lake because it extends from the heart of the city to many miles into the countryside. Louisiana DOT engineers knew this meant protection was needed for the city's water supply, says Babak Naghavi at the state's Transportation Research Center.

Engineers from Howard, Needles, Tammen, and Bergendoff proposed the totally enclosed drainage system eventually adopted by the DOT. Construction of the system cost $2 million — 5 percent of total bridge construction costs.

Interstate 220's Cross Lake Bridge is 85 feet wide and 10,230 feet long.

This means there are 20.48 acres of bridge area that normally drain into the lake. With the system, a safety barrier contains spills over the sides. Bridge runoff flows transversely into gutters next to a median barrier and then to inlets located in each span. The inlets lead to a longitudinal conduit under the barrier.

Runoff flows through the conduit via the northern bridge abutment and into the holding pond. The 3.5-foot-high, 3-footwide precast, prestressed concrete conduit has 4-inch-thick walls lined with a PVC T-Lock liner. Engineers based conduit design on 100-year storm runoff — 10 inches in 24 hours.

CHECKING THE RUNOFF

Naghavi and Donna Skipper, in the Civil Engineering Department at the University of Southwestern Louisiana, reported on effectiveness of the system at this year's Transportation Research Board meeting.

The 6-acre holding pond handles runoff from rainstorms of up to 12.44 inches in 24 hours — and still leaves 2 feet of freeboard above a maximum projected runoff volume. A levee, a discharge gate system, and the pond's 3.5-inch-thick concrete liner isolate runoff until it is tested.

Runoff and spill testing begin when pond water levels reach a point allowing for a maximum 24-hour rainfall plus 1 foot of freeboard.

Pond content needs to meet National Pollution Discharge Elimination System permit limits — 100 mg/liter chemical oxygen demand [COD] limits, 15 mg/liter oil and grease limits, and 0.15 mg/liter lead limits. The COD limits include biochemical oxygen demand. COD limits are more meaningful, Naghavi and Skipper report, because of industrial materials that stick to vehicles and find their way into runoff or that are present in accidental spills.

Normally, total suspended solids are included in NPDES permit parameters. But, in this case, pond settling removes such solids.

Once tests show that water content meets permit levels, pond water is discharged into a roadside ditch. This flows to Twelve Mile Bayou.

If contamination *exceeds* permit limits, water is treated on-site or transported elsewhere for treatment.

JOINT SEALING PROBLEMS

[LADOT] engineers report that the primary problem currently faced in the system is joint seal failure. Several PVC expansion joint strips and their neoprene joint sealers degraded after exposure to weather.

An experimental repair system replaced the original sealing system with polymer resin covered with a 25-mil-thick vinyl ester. Inside the joint, the 2.5-inch-wide ethylene vinyl acetate joint material was compressed into a 2-inch-wide expansion joint. Workers bonded the joint material to the edges with high-modulus epoxy gel. This method held on only 50 percent of the joints, and new repair methods are being tried.

Reprinted with permission from ***Better Roads*** 62(MAY 1992): 19.

HOW CONTAMINANT LEVELS AFFECT ROAD USE

How close has the Cross Lake drainage system come to exceeding its permit limits? Maximum tested levels to date are 85 percent of COD, 47 percent of oil and grease, and 93 percent of lead limits.

In other areas' tests, highway runoff levels ranged from 0.1 to 6.3 mg/liter for lead, 1.0 to 27 mg/liter for oil and grease, and 5.0 to 1,058 mg/liter for COD. Some of the lead levels in these tests exceed typical permit levels. But, when a holding pond is used, most lead and other metals will settle. Lead in runoff comes from typical vehicle combustion. In one California study reported by Kerri, Racin, and Howell, the amount of lead in runoff can be linearly related to the volume of traffic during a storm. This means that engineers need to consider lead in runoff when designing roads. As in the case of automobile-caused air pollution, road use restrictions may become necessary to meet permit levels.

Oil and grease levels can be related not only to overall traffic volume, but also to storm intensity. A hard, driving rain after an extended dry period will wash off accumulated oil and grease from the pavement as well as from vehicles.

HELP WANTED

Research Study 0-1305, ***Factors Affecting Design Thickness of Bridge Slabs***, needs more concrete panels to test in punching shear failure. Precast deck panels up to 6 to 7 feet can be used. Call Dr. Richard Klingner at (512) 471-4577 or 4717259.

TQ's paper includes 20% post consumer waste in the total fiber content.

HELP OFFERED

Rebecca Davio is TxDOT's new Recycling Coordinator. She can help districts and divisions coordinate recycling efforts. Call her at (512) 416-2086 and let her know what your plans are for recycling.

INSIDE TQ

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