TECHNICAL QUARTERLY

"AN EXCHANGE OF IDEAS"

TQ 10-1, October 1995 *EDITOR: Kathleen M. Jones*

"KNOW YOUR VITAL SIGNS" CAMPAIGN KICKS OFF SUCCESSFULLY

by **Bernie R. Fette**
Media Relations Coordinator
Texas Transportation Institute
Texas A&M University System

BACKGROUND

In the wake of a recent study showing that Texas motorists have a limited understanding of several traffic signs, signals, and lane markings, the Texas Department of Transportation (TxDOT) is working to increase understanding of some traffic control devices as it makes changes to others.

The actions are part of the implementation plan for Research Study 0-1261, ***Motorist Understanding of Traffic Control Devices***, sponsored by TxDOT and conducted over the past four years by the Texas Transportation Institute (TTI). The study evaluated the effectiveness of 52 traffic control devices through surveys and focus groups involving more than 2,400 Texas drivers.

The study's objectives were to select devices with the potential for driver misunderstanding, to measure understanding using a representative survey sample, to evaluate understanding as a function of demographics, and to recommend changes to improve understanding. TxDOT initiated the study to ensure that the state's transportation network improves and evolves along with the society it serves.

"We're always working to improve what we have," says Lewis Rhodes, the study's Project Director at TxDOT. "We're continuously trying to make things more helpful to the driver."

Lewis Rhodes, P.E., (left) and Carlos Lopez, P.E., of TxDOT's Traffic Operations Division host the 3 July 1995 "Know Your Vital Signs" news conference at the Austin District Sign Shop.

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The *Technical Quarterly* is dedicated to the free flow of ideas and information within the transportation community.

TTI Associate Research Engineer Gene Hawkins and Research Scientist Katie Womack shared responsibility for the study as coprincipal investigators.

"Through this research, we intended to utilize scientific methods to evaluate devices which could or should be improved from the perspective of driver understanding," Hawkins said. "By implementing the findings of the research, we hope to improve the overall effectiveness of the transportation system, thereby enhancing safety and ease of travel."

Potential explanations cited in the study for confusion over some traffic control devices included the increasing age of the driving population (it's been 20 years or more since most drivers had any formal driver instruction), the increasing complexity of driving in urban areas, the increased proportion of non-English-speaking drivers in Texas, and nonuniform and/or nonstandard design or application of devices.

ACTIONS TAKEN

In response to the study's findings, TxDOT has implemented the following changes: the optional "protected left on green" sign was replaced with a "protected left on green arrow" sign and the "limited sight distance" sign was deleted in Revision 5 of the ***1980 Texas Manual on Uniform Traffic Control Devices*** (MUTCD); uneven pavement construction signs will change from symbol signs to word message signs when Part VI of the national MUTCD is adopted by Texas (by January 1996).

Additionally, the following changes were recommended in July 1994 through a memorandum distributed to each TxDOT district by the Traffic Operations Division:

- the grooved pavement sign should replace the rough road sign
- the reduced speed ahead sign should replace the speed zone ahead sign
- curve and turn signs should have advisory speed plaques
- the divided highway ends symbol sign should be used at the end of a divided highway and followed by a two-way traffic symbol sign
- when double solid lane lines are used, the do not cross double white line sign should be used.

One of the more visible efforts to improve driver understanding was initiated on 3 July 1995 in Austin, when TxDOT officials held a news conference to launch a statewide public education campaign entitled "Know Your Vital Signs." The "Vital Signs" campaign, inspired in part by the results of Research Report 1261-4, is a joint effort of five state agencies and 3M Corporation, and each of the organizations plays a distinct role in the campaign.

- TxDOT — the department's Public Information Office will direct the campaign and ensure statewide implementation through public information officers located in each of TxDOT's 25 district offices.
- The Texas Department of Public Safety — the DPS will include some of the issues addressed in the campaign in the next issue of the ***Texas Driver's Handbook.***
- The Texas Education Agency — the TEA will update its curriculum of driver education classes to help ensure that all students develop a clearer understanding of traffic control devices at a young age.
- The Texas Department of Health — the TDH will incorporate "Vital Signs" elements into its program aimed at senior drivers, to educate that group on the many changes in traffic signs, signals, and lane markings over the years.
- TTI — the Institute's Center for Information and Technology Exchange developed the overall campaign and produced a 30-second public service announcement for television, as well as a poster and brochure for distribution throughout the state. The brochure focused primarily on sign shapes and colors, one of the fundamental areas of confusion identified through the study.
- 3M Corporation — 3M, which manufactures the reflective sheeting used on many traffic signs, underwrote the cost of the poster and brochure and also donated 160 duplicates of the video PSA for distribution to television stations throughout Texas.

The "Vital Signs" campaign and other outcomes of Study 0-1261 represent one of the more sweeping research implementation efforts in recent memory. As TxDOT Engineer of Traffic Carlos Lopez noted at the 3 July news conference, the activities are consistent with TxDOT's mission. "This research," Lopez said, "represents TxDOT's commitment to the continuous improvement of our state's transportation system and to the safety of everyone traveling on that system."

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This meeting will feature all nine new Research Management Committees (RMCs) at one conference. The RMC titles are:

- Management and Policy
- Multimodal Transportation
- Traffic Operations
- Roadway Planning and Design
- Structures
- Pavements
- Materials
- Construction and Maintenance
- ROW, Hydraulics, and Environmental Conservation

TXDOT STARTS GEOPAK IMPLEMENTATION

Excerpted by **Kathleen M. Jones**
Information Specialist II
Research and Technology Transfer
Texas Department of Transportation
from ***TxDOT Implementation Evaluation for GEOPAK***

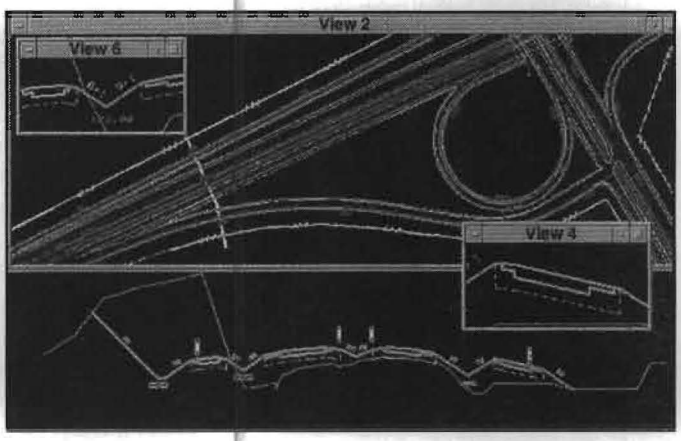
WHAT IS GEOPAK?

GEOPAK is a suite of powerful, flexible civil engineering design programs (Fig. 1). GEOPAK was the only off-the-shelf software that, at the time of the evaluation, offered a comprehensive, integrated roadway design system that ran on every current or proposed engineering graphics platform at the Texas Department of Transportation (TxDOT). Using MicroStation's easy-to-use, familiar graphical interface, GEOPAK operates on DOS-, Windows-, and Windows-NT-based personal computers, as well as Hewlett Packard Series 700, Sun SPARC, Silicon Graphics, and Intergraph Clipper workstations. Recently, the Federal Highway Administration (FHWA) selected GEOPAK as its primary roadway design tool. A number of other state DOTs are using GEOPAK, also. TxDOT's Alternate Roadway Design System evaluation team recommended a phased implementation to this software. The Senior Management Team has approved the recommendation.

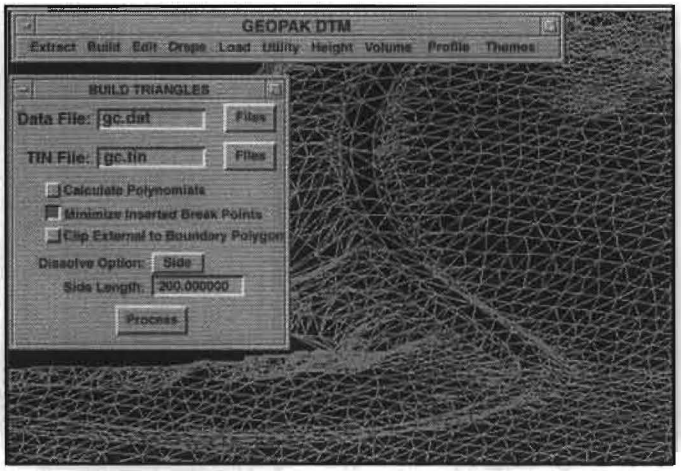
WHY CHANGE NOW?

Why should TxDOT switch from its current, proven RDS and IGrds roadway design system? This design system, while it has served very well, is aging. The addition of new features to RDS/IGrds has become difficult and costly or, occasionally, impossible, hampering TxDOT's ability to develop fully automated plan preparation. Also, every TxDOT enhancement to RDS/IGrds takes it further away from the AASHTO original, making it more difficult for TxDOT to take advantage of enhancements added by AASHTO. The last time TxDOT upgraded to a new version of AASHTO RDS, it took about 30 FTE-months of work to port TxDOT enhancements to the underlying AASHTO code. In 1993, the Information Systems Division (ISD) began looking for ways to upgrade TxDOT's roadway design software to current technology standards.

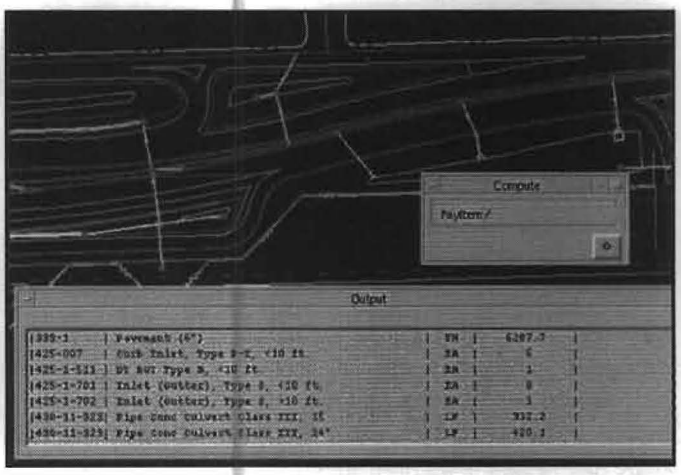
Rendered proposed model



No template proposed sections



Full-functioned digital terrain modeling



Automated plan quantities

FIG. 1: Four examples of GEOPAK features.

The other driving factor is federal metrication mandates. Metrication would require major modification of the aging software, and ISD personnel viewed the situation as an opportunity to retool roadway design automation.

EVALUATION HIGHLIGHTS

Since all PS&E projects let after 30 September 1996 have to be in metric units, ISD had to begin software evaluation immediately. Six districts (Beaumont, Brownwood, San Antonio, Abilene, Austin, and Houston) joined the Design Division (DES) and ISD in the evaluation. At the start of the evaluation in July 1993, GEOPAK was the only off-the-shelf system that satisfied all the essentials needs of TxDOT's design staff. Therefore, it was the only package evaluated.

The evaluation team developed fourteen criteria categories, placing emphasis on evaluating GEOPAK's ability to perform functions according to TxDOT's design standards. The categories are:

- General Specifications
- Digital Terrain Modeling
- Original Cross Sections
- General Coordinate Geometry
- Horizontal Alignment
- Vertical Alignment
- Superelevation
- Design Cross Sections
- Earthwork
- Right-of-Way
- Quantities
- Reports
- Visualization/Modeling Tools
- Development Language

Benefits

Throughout the evaluation process, the evaluation team found that GEOPAK offered not only a timely solution to the metrication of the PS&E process, but also provided many useful features not available in the current TxDOT roadway design system.

TABLE 1: Estimated time savings are greatest in the areas of cross section creation and contour generation.

ESTIMATED REAL-TIME BENEFITS	
Process	**Time Savings**
Cross section creation	8 hours saved on original 24 hours saved for additional sections
Contour generation	8 hours
Utility location on cross sections	1 hour per utility
Earthwork quantity calculations	1 hour per roadway
Pay item quantity calculations	2 hours per sheet

The evaluation team confirmed that GEOPAK provides an integrated design solution from survey to construction. The growing complexities of today's projects require a roadway design software package offering these extensive capabilities and resource-saving features.

The current system uses multiple computer applications in the design process. GEOPAK incorporates many of these design processes in one package. Performing engineering design processes within a single package ensures consistency of work and compatibility of different design efforts. It also simplifies training. These advantages save the department valuable resources, including time and personnel dedicated to developing and supporting a variety of engineering applications.

GEOPAK's plan production tools and plan sheet layout capabilities fit with TxDOT's effort of standardization through the Automated Plan Preparation System (APPS). Additionally, GEOPAK is written in MicroStation Development Language (MDL). Applications running directly through MicroStation will be familiar to users, thereby, simplifying the transition to new software. A subset of GEOPAK also operates within Power Draft, an enhanced subset of MicroStation. Power Draft is significantly less expensive than MicroStation. Using this combination of software leads to a potential cost saving of $1000 per copy.

GEOPAK provides direct translation from a two-dimensional (2-D) design environment to three-dimensional (3-D) models diminishing the need for advanced 3-D MicroStation training. Dynamic, on-screen design provides immediate interpretation of plan view geometrics, aiding an engineer in making quicker and better design choices through instant visualization.

The evaluation team estimated benefits measured as real time saved during plan sheet production (Table 1). They concluded that designers experienced in the use of GEOPAK would realize a 30 to 35 percent reduction in project time on rural jobs and a 25 to 30 percent savings on urban jobs.

POTENTIAL ENHANCEMENTS

GEOPAK is developed and maintained by Beiswenger, Hoch and Associates, Inc. (BH&A), a consulting engineering firm in North Miami Beach, Florida. BH&A's staff have degrees in computer science, engineering and land surveying. The BH&A design staff uses the GEOPAK software to produce their own plans. Throughout the evaluation, the GEOPAK development and support staff provided excellent support for the TxDOT effort and responded promptly to support calls. Additionally, they proved their willingness and ability to provide customizations to match TxDOT specific needs.

Currently, the GEOPAK Suite includes GEOPAK Road, GEOPAK Site and GEOPAK Survey. Refinements to GEOPAK Survey will provide a complete Survey Data Management System (SDMS) interface and functionality comparable to Computer Aided Integrated Civil Engineering and Surveying (CAiCE). Once GEOPAK is implemented, the goal will be to limit use of CAiCE to the number of copies TxDOT has already purchased, and GEOPAK Survey will become the primary survey package.

TxDOT and BH&A are discussing integration of the Texas Hydraulic System (THYSYS) into GEOPAK. If this effort is successful, TxDOT will consider sharing other programs. Sharing these programs may result in a significant reduction in TxDOT's annual GEOPAK license fee.

BH&A is developing a bridge design module that will include all aspects of RDS bridge geometry, providing a link to integrate TxDOT's structural design and analysis programs. Separate modeling software will not be necessary because GEOPAK can create a 3-D bridge model as a by-product of bridge design.

Another area under development is construction supervision. A link to MicroStation Field will provide a pen-based solution enabling personnel to use electronic field books to record and manage construction activities.

Under BH&A's standard license agreement for GEOPAK, all future subsystems will be provided to TxDOT at no additional cost.

TRAINING

A team of instructors from BH&A and ISD will conduct initial training classes. Thirty-three GEOPAK classes are scheduled over the next four years. These classes will gradually phase out a similar number of RDS/IGrds classes currently being taught.

TxDOT and BH&A are jointly producing a customized self-paced training video. Using this video as a substitute for instructor-led classes can save TxDOT substantial amounts of money in travel expenses and instructor time.

RECOMMENDATIONS

The evaluation team recommended implementing GEOPAK, phasing it in over four or more years. They also recommended that RDS and IGrds be licensed and used as long as necessary, but that ISD should evaluate the RDS/IGrds agreement yearly to determine whether or not the licensing can be reduced or discontinued. During the implementation period, ISD should continue to evaluate and implement new GEOPAK releases, to customize it as required for TxDOT standards, to add user-requested enhancements, and to provide technical support.

The evaluation team created a plan outlining training and equipment requirements, as well as a timeline, to migrate from the existing system to a full statewide implementation of GEOPAK (Table 2). The Senior Management Team has approved this plan and the pilot study recommendations.

CONCLUSION

The Senior Management Team has approved the recommendation to migrate from RDS and IGrds soft-

TABLE 2: Summary of the Alternate Roadway Design Pilot Study's migration plan.

SUMMARY Recommended four-year statewide implementation plan for GEOPAK
Fiscal Year 1995
◊ **Continue to license RDS/IGrds** ◊ **Continue to lease CAiCE** ◊ **License 35 additional copies of GEOPAK** ◊ **ISD will develop training programs, continue user support** ◊ **Begin coordination with vendor to integrate THYSYS** ◊ **Surplus money will be dedicated to training and licenses**
Fiscal Year 1996
◊ Continue to license RDS/IGrds ◊ Continue to lease CAiCE ◊ Complete training material; begin training program ◊ Replace existing IGrds classes with GEOPAK classes ◊ Continue joint venture project with vendor ◊ Evaluate integration of other TxDOT software with vendor ◊ License up to 175 additional copies of GEOPAK
Fiscal Year 1997
◊ **Continue leasing RDS/IGrds** ◊ **Purchase copies of CAiCE** ◊ **Continue GEOPAK training** ◊ **Continue joint venture with vendor** ◊ **License up to 275 additional copies of GEOPAK**
Fiscal Year 1998
◊ License RDS only ◊ Continue GEOPAK training ◊ Procure corporate license for GEOPAK (up to 2000 copies)

ware to GEOPAK for roadway design. Implementation of GEOPAK realizes a number of direct and indirect benefits to TxDOT. Examples of these benefits are:

- Significant time reduction in plan preparation
- Less staff needed to support development and maintenance of RDS/IGrds
- Integration of multiple design systems on multiple platforms
- Implementation of 3-D design concepts and technology

RAP RESEARCH PACKAGE HELPS TXDOT RECYCLE RESOURCES

Reprinted from
Texas Transportation Institute's
Researcher, Summer 1995 Issue

TxDOT has been studying ways to use RAP economically and effectively.

INTRODUCTION

Although Texas has used reclaimed asphalt pavement (RAP) since the 1930's, legislative and public demands for agencies to recycle waste material have fueled the initiative to find new and innovative recycling methods for milled asphalt material. In response, TTI, in cooperation with the Texas Department of Transportation and the Federal Highway Administration (FHWA), set out, in two related studies, to identify and evaluate economical and effective uses for RAP in routine maintenance (0-1272) and then to monitor performance of several experimental test sections throughout Texas (0-187-24).

WHAT IS RAP?

RAP is produced when asphalt pavement is removed to correct surface irregularities, to maintain curblines, or to remove a poor quality layer. Following removal, the asphalt material is salvaged and stockpiled. In the past, Texas used only a small portion of the RAP before the leftovers went to the contractor that removed it. However, over the past four years, legislative activity regarding the state's use of RAP prompted a change in this approach.

RAPPING IN THE HOUSE

Texas legislation passed in 1991 (Article 6673i and 66741-2) required quite an aggressive RAP program, calling for TxDOT to retain title to all RAP removed from the state highway system, to maximize its use, to keep an inventory, and to give an annual report on the use of RAP to a legislative audit committee. This bill led TxDOT to give the districts primary responsibility for maximizing the use of RAP.

In May of 1995, however, the Texas legislature passed Senate Bill 688, which basically repealed the previous requirements concerning RAP. The new bill does still require the state to determine the most cost-effective and environmentally sensitive manner to use RAP, in effect, challenging TxDOT and other government entities to continue recycling RAP in the construction and maintenance of public facilities.

THE RAP STUDY RESULTS

Beginning in 1990, TTI researchers Cindy Estakhri and Joe Button reviewed RAP literature, interviewed other state DOTs, and distributed a questionnaire on the use of RAP to the 24 TxDOT districts. Survey response was excellent. Results showed that more than 80 percent of the millings used in Texas are of reusable quality; and in FY 92, only a year after the initial legislation passed, the department was already reusing 60 percent of its RAP.

"We found that the most common maintenance uses for RAP were with driveways, mailbox turnouts, and shoulder repairs," says Estakhri. District maintenance personnel also reported improvements in RAP quality if it was blended with emulsions and with other maintenance mixtures.

To validate survey findings, researchers also analyzed various RAP maintenance mixes in twelve different field projects. The field experiments were designed to find the most effective handling and mixing

procedures for RAP. How does RAP perform when cold-mixed with a recycling agent and when blended with different conventional maintenance mixes? How does it perform as a base material? While the initial 0-1272 findings were relatively positive, TTI continued monitoring the test sites over a period of two years under a follow-up study (0-187-24).

"Most of the field experiments performed well, and much better than anticipated from the onset." says Estakhri. After two years of close examination, the most successful sections contain a cold-mix of RAP with a recycling agent (AES-300RP) or a blend of RAP with another maintenance mixture. RAP was also successful when used as a stabilized base and/or when blended with existing base materials.

RAP'S FUTURE

TxDOT Director of Field Operations Bob Templeton says that the department will continue to benefit from TTI's findings and use as much of the reclaimed asphalt pavement as possible. "We try to reuse all of the stockpiled RAP by putting it back into the projects it comes from. If not, we will continue to find other maintenance uses for it, such as driveways, mailbox turnouts, and other low-volume paved areas." Where research is concerned, Templeton says no changes are expected. "It always behooves us to find new recycling methods."

wRAPping up the Studies

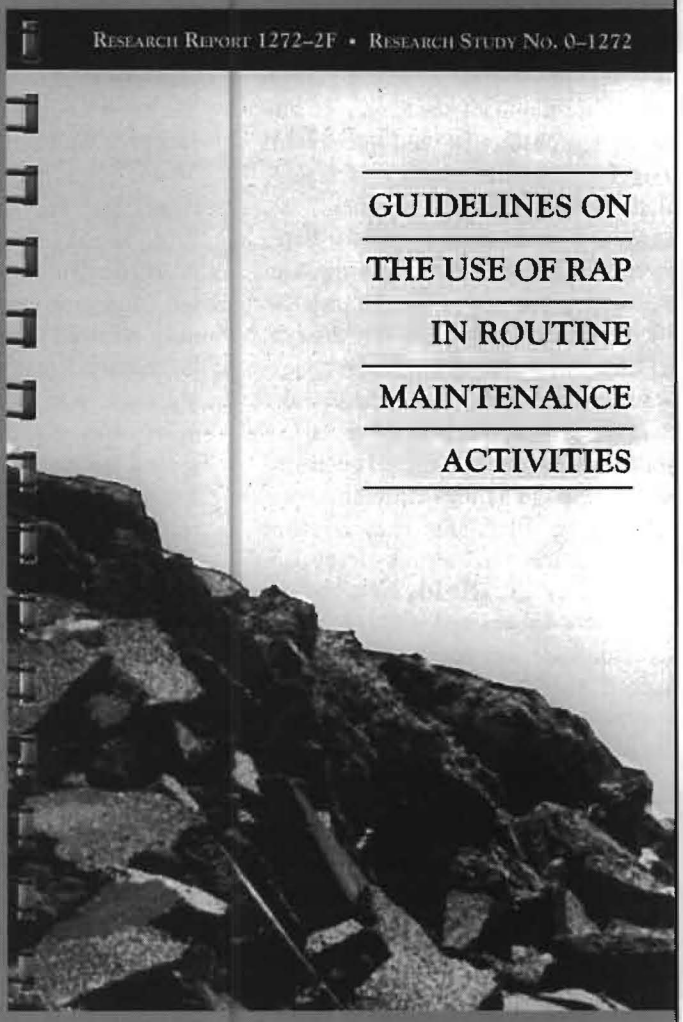
As environmental legislation and budget constraints continue to challenge the country, implementation of the findings from these RAP studies has national significance. The results are now being used to develop two videos — one aimed at maintenance crews, explaining proper methods for working with RAP, and the other for engineers, documenting RAP's various uses and economical advantages over conventional techniques.

In addition, a field manual entitled ***Guidelines on the Use of RAP in Routine Maintenance Activities*** has been published and distributed. According to TxDOT's Research and Technology Transfer Office, users have found the pocket-size, reader-friendly format very appealing.

TxDOT Director of Materials and Testing Katherine Hargett says she likes the idea of a manual to further educate department personnel. "I think the manual is an excellent tool when implementation does not require a new or revised specification or test method, and the information to be supplied is more than can fit the supplemental research report format."

According to TTI head of the Materials and Pavements Joe Button, "We will continue to look for more opportunities to create these types of implementation tools, so that, as with these RAP studies, TxDOT can maximize its use of our research findings."

For copies of the manual or videos, contact Dana Herring, Research Librarian, at (512) 465-7944.



BRIDGE PAINT IS FARSIGHTED INSPECTION TOOL

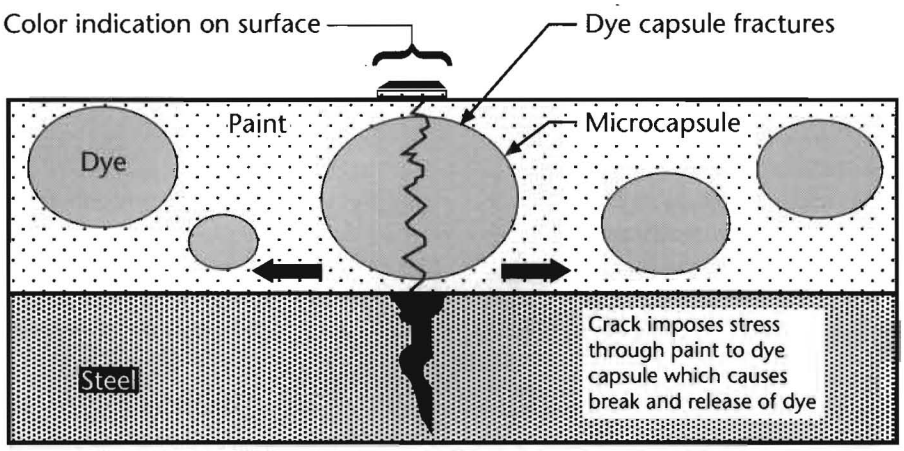
by **David Herman**
Reprinted by permission of ASCE
from ***Emerging Technology***
2(June/July 1995): 6

A new type of paint for bridges may give inspectors an easy way to spot the tiny cracks caused by loading stresses yet avoid getting up close and personal with their subjects.

The formulation known as Smart Paint — developed by the Center for Advanced Technology of Large Structural Systems (ATLSS), Bethlehem, PA — combines conventional bridge-maintenance coatings and microencapsulated, oil-soluble dye. When bridge steel cracks, the fragile capsules adjacent to the fault rupture, leaving a highly visible pattern along the length of the damage. The paint, which has proved successful thus far in the laboratory, is scheduled for field tests this summer.

With Smart Paint, cracks little more than [25.4 mm] 1 in. long "can be seen by the eye [4.6–9.1 mm] 15–30 feet away," says Bill Michalerya, ATLSS industry liaison for technology transfer. With cracks so visible, investigators do not have to be within a few feet of the structure to locate damage as they do with visual inspection, ultrasonic transmission and other primary crack-detection techniques. Scaffolds and safety equipment associated with close inspections are not required following use of the new paint, so traffic around or below the bridge is not disrupted.

After Smart Paint is applied, fatigue cracks can be revealed at any time, making the coating a year-round, in situ diagnostic tool; other methods generally permit only periodic monitoring by transportation departments. Inspectors looking for telltale signs of stress on a Smart Paint-coated structure can "detect cracks more easily and sooner than with the naked eye [searching on ordinary] painted steel," says Michalerya.



Fragile, dye-filled microcapsules, which are the essential element of Smart Paint, rupture when cracks form in bridge steel under the coating.

Current research on Smart Paint has been limited to lab tests on small samples and full-scale, [900-mm] 36-in. steel bridge girders. Within those tests, two different Smart Paint formulations have been developed. A nitrocellulose-layer-based paint, which is currently available, can only be used for structural testing in laboratory situations, where weatherability is not a factor. The other, an epoxy-based protective coating designed for field use, should be tested for overall survivability this summer on several bridges in Pennsylvania, according to Michalerya.

Once field tests are complete, ATLSS will market the paint through Competitive Technologies, Inc., a for-profit spin-off company of the research center and Lehigh University. Michalerya expects Smart Paint to be "somewhat more expensive" than conventional maintenance coatings, because "it's paint plus microcapsules with dye plus know-how. Then again ... it would probably be used primarily on specific locations with fatigue detail problems," which could amount to just the 10–15 percent of a bridge's surface prone to fatigue cracks.

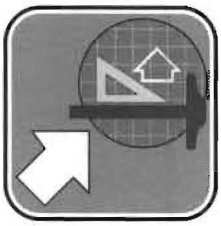
The major savings of Smart Paint application, he says, "will come with early recognition of cracks and avoiding shutdown because of bridge failure."

For further information, contact Bill Michalerya, industry liaison for technology transfer, Center for Advanced Technology of Large Structural Systems, Lehigh University, Bethlehem, PA 18015; (610) 758-5483.

METRIC WORKSHOP QUESTIONS

The Texas Department of Transportation (TxDOT) hosted a series of metrication workshops in April and June mainly for staff level design and construction personnel. This article synopsizes questions raised before and during these workshops.

PLAN PREPARATION/REVIEW



***Q** Will TxDOT consider placing a stamp on plan sheets to indicate whether a project is in metric or English units?*

A TxDOT considered placing a stamp on projects that are in metric units and decided that it is not warranted. This decision was based on two issues: 1) If a stamp is omitted, then TxDOT would be subject to claims; and 2) The required units will be clearly stated on the proposal. By stating the applicable Specification Book and metric stationing and units of measure throughout, the plans should provide sufficient indication as to whether a project is metric .

***Q** Will TxDOT metric plan sheet cells include a bar scale to help determine whether a plan sheet has been reduced?*

A Yes. The Information Systems Division will include a bar scale on the plan sheets.

***Q** How will bridge widening details be handled?*

A The bridge layout should show the metric width of the completed bridge. The layout will show the width of the existing structure in metric dimension to the nearest millimeter (obtained by measurement or by multiplying the English plan dimension by the appropriate factor). The widening width can be obtained from this dimension. Usually no other dimension of an existing structure is needed.

Occasionally there is a need to include an as-built plan sheet from the existing structure. In these cases, converting the drawing to metric is not necessary, since the sheet is for reference of field conditions only. The as-built plan sheet is not used to build the widening and should be so noted.

Bridge details will show all dimensions in metric. Dimensions for new bridges will relate to the station line rather than to any part of an existing structure.

***Q** Will English-dimensioned inlets and manholes be usable within metric standards?*

A Inlet and manhole standards will be new sheets with metric dimensions, some dimensions "hard" and some "soft." **Do not** use or convert English-dimensioned sheets. Since TxDOT standards for inlets and manholes specify custom, cast-in-place concrete dimensions, reinforcing steel and fabricated grates will be "hard" metric. Manufactured manhole rings and covers will be "soft" metric dimensions. Referenced pipe sizes will be "soft" according to international Standards Organization guidelines (pipe sizes will not change physically).

***Q** Will there be a "soft" conversion for precast box culverts and pipe culverts?*

A As stated in the metrication guide, the metric products will have tolerances that allow for an English equivalent.

***Q** How will the conversion to metric affect:*

- ***Permits for proposed pipelines/utilities, etc.?***

A TxDOT requires metric units for dimensions that reference the location and area of the utilities. While the layout of the utility must be shown using metric units, the utility companies may use English units to identify their hardware on projects they pay for directly.

- ***What about the relocation of existing pipelines or utilities within or crossing highway rights-of-way when the relocations are due to highway improvements?***

A If the utility owners or their contractors perform the relocation work, they may work in English units as long as they reference the location to our facility in metric units. If, however, the utility owners wish to include their relocation work in a TxDOT contract, their plans must be in metric units to be compatible with the PS&E.

***Q** Will signal hardware (e.g., poles, mast arms, signal lenses) be "hard" or "soft" converted?*

A The signal hardware has been semisoft converted — meaning that, while the metric dimensions may be slightly different than current English dimensions, the tolerances are such that the hardware that met TxDOT current standards will meet TxDOT metric standards.

TRAINING AND COORDINATION WITH OTHER AGENCIES

***Q** Has TxDOT established a panel to work with local municipalities to ensure compatibility of plats, development plans, utility plans, and training?*

Continued on page 12

SHRP CORNER

AUTOMATED CRACK SEALER HAS POTENTIAL TO REDUCE DANGER AND CUT COSTS

by **Ken Boehme**
Senior Field Engineer
Construction and Maintenance Division
Texas Department of Transportation

BACKGROUND

The nation's highway system is aging, while the volume of traffic that it supports continues to increase. Numerous factors, such as stricter environmental regulations, contribute to the rise in costs for road maintenance. Road maintenance technology, however, has remained virtually stagnant for many years. 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.

Automation of road maintenance operations has a tremendous potential to improve this situation. Highway crack sealing is especially well suited for automation since it is such a widespread, costly, and labor-intensive operation. Labor turnover and training are increasing problems for crack-sealing crews, and as traffic volumes increase, crack-sealing operations become increasingly disruptive to the traveling public. Automation of crack-sealing operations can reduce labor costs, improve work quality, provide better records, and reduce worker exposure to roadway hazards. User costs can be reduced as well by minimizing interference between maintenance crews and traffic and by enabling maintenance operations to be performed during off-peak periods at night.

A joint research project sponsored by the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA) is developing an automated crack sealer (ACS). The ACS is a unique system that has the potential to reduce costs, reduce material waste, and greatly reduce the hazards currently associated with crack sealing. The system will clean, seal, and squeegee a pavement crack — an operation that usually requires a crew of three to five persons. Researchers expect that the automated system will require only one person to operate it. This study is being performed by the Center for Transportation Research, The University of Texas at Austin, Construction Automation Laboratory. Dr. Carl Haas is the principal investigator.

DESIGN AND OPERATION

The ACS (Figs. 1&2) consists of a train that includes a towing truck, conventional crack sealant smelter and pump trailer, and an XY plotter table trailer. A computer, a video camera, a generator, an air compressor, and two line conditioners complete the automated crack-sealing ensemble. The sealant smelter and pump trailer were loaned to the project by Crafco, Inc. of Chandler, Arizona. TxDOT is providing a pickup truck for towing the equipment.

The operation of the ACS includes several different steps. First, a computer-imaging system views cracks on the roadway. The system operator identifies the crack location by tracing a line over the crack image on a monitor with a light-pen or a mouse. The computer processes this information and feeds it to a motor controller that commands an XY plotter table to follow the pave-

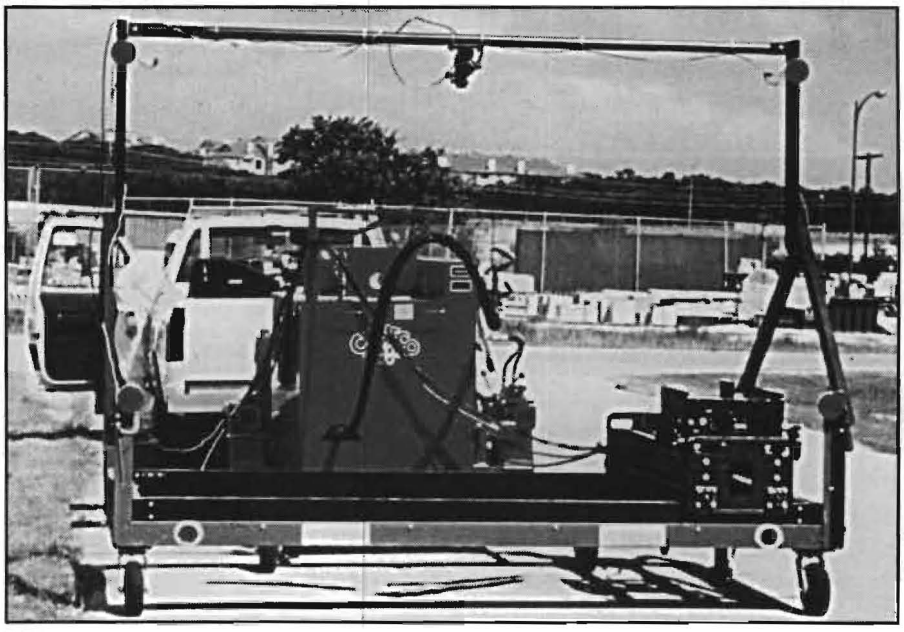


FIG. 1: Prototype automated crack sealer, XY plotter table trailer in foreground.

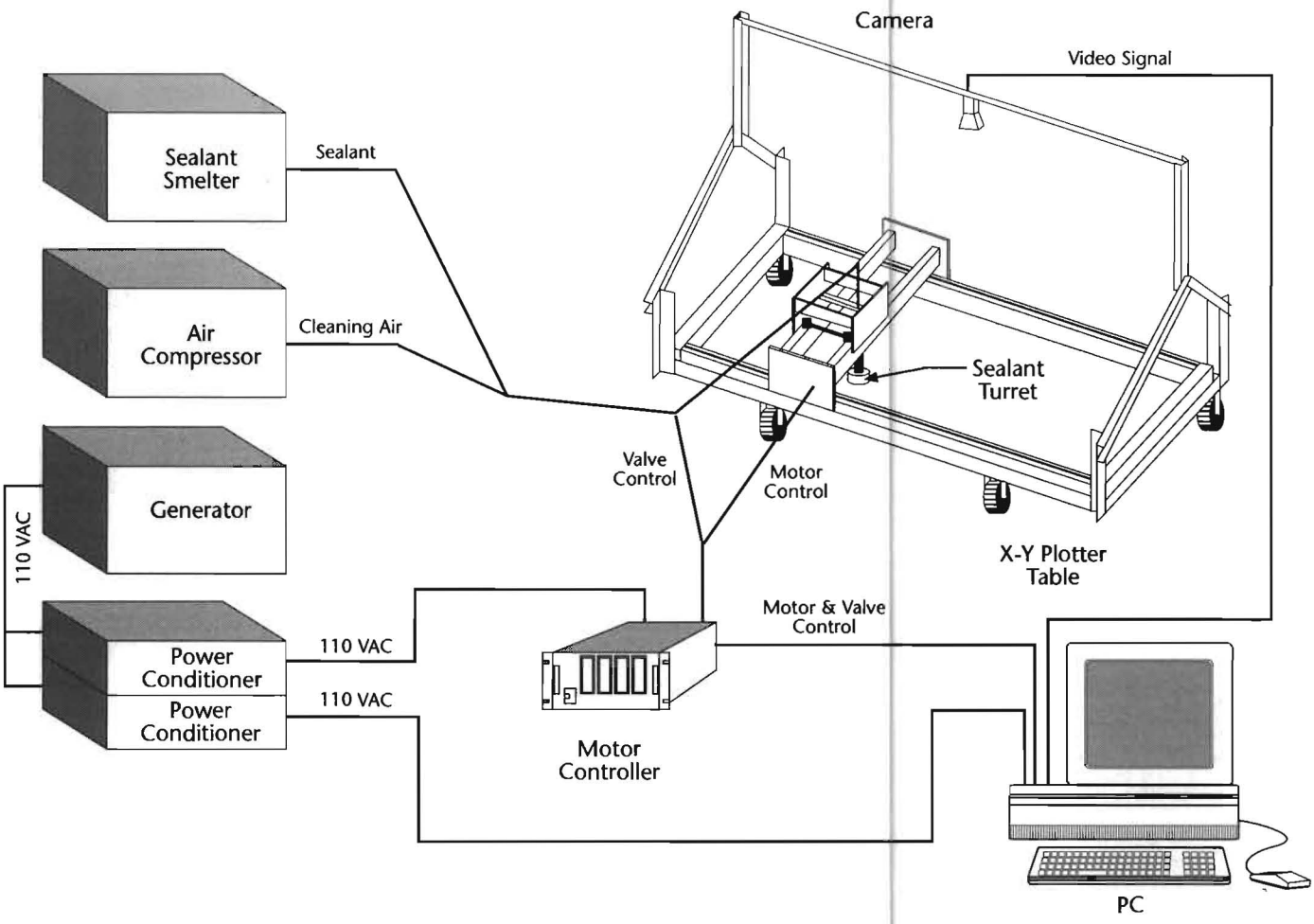


FIG. 2: Schematic of automated crack sealer system configuration.

ment crack and to operate the cleaning air and sealant valves. A motorized turret on the sealant nozzle rotates and directs the cleaning air nozzle and a follow-behind squeegee. Once the XY plotter table seals all cracks within its limits, the operator moves the entire equipment train to the next crack location and repeats the process.

AUTOMATION DETAILS

A standard PC controls the entire ACS system. Control boards for a video camera and a motor controller have been added to the PC, and special software was developed to integrate all hardware component controls in a single Windows application.

To capture and process video images of the pavement cracks, researchers added a commercial image-capture board to the PC. A DT3852 board, manufactured by Data Translation, captures a 640x480 monochrome image and allows the user to access the image data in a buffer to process it. A commercial security camera obtains the video image.

The core computer program used to drive the ACS is the example program that came with the Data Translation DT3852 video board. Researchers modified this source code to integrate a line drawn in the image, to process the data, and to send commands to the motor controller via its own software driver. The final program is a user friendly Windows program executed from the main window.

The XY plotter table employs an Aerotech Unidex 500 motor controller that allows simultaneous control of multiple axes and digital input/output (used for valve control). The researchers selected this particular motor controller because of programming ease and system reliability.

To operate the crack-sealing software, simply double-click on the cf3-demo icon in the applications window. Once the program is running, display live video by entering the appropriate command from the program menu. The operator performs this step while slowly driving the equipment train on the roadway looking for cracks. Once the operator locates a crack, he/she stops and obtains a still image by entering another command from the menu. The user now identifies crack locations by drawing lines over the crack images on the monitor with a light-pen or a mouse.

The user initializes the motor controller by entering a menu com-

mand. This command resets the controller and homes the axes. Entering another command from the menu causes the sealant turret to follow the cracks on the pavement, to operate the compressed air valve to clean the crack, and to operate the sealant valve to seal the crack.

First Demonstration

A successful demonstration of a first-generation laboratory model of the ACS was conducted at The University of Texas Pickle Research Center on June 16, 1995. This demonstration enabled the project to proceed into its final phase. The research team expects to complete a road-worthy prototype by the end of August 1996 that will be capable of performing crack-sealing operations at conventional crew speeds or better.

The final phase of the project includes procuring a road-worthy XY plotter table trailer, developing software to improve speed and accuracy of the operation, performing field trials, making necessary mechanical modifications to enhance overall efficiency and operation, and training TxDOT personnel in the operation of the automated crack sealer. Once this project is completed, this device will be turned over to TxDOT. The research team anticipates that this particular piece of automated maintenance equipment should be commercially available in the not-too-distant future.

SUMMARY

Automation of crack-sealing operations has many potential benefits. First, crack sealing is a widespread and common operation. If TxDOT achieves even modest savings in crack sealing, the total savings would be substantial. The proposed ACS should eliminate a major portion of the labor costs associated with crack sealing. The ACS has the potential to achieve improved quality over conventional methods of crack sealing and, in turn, reduce the need for additional crack sealing over time. The ACS would reduce the exposure of maintenance workers to injury and accident. The ACS will be able to record data concerning the location and linear feet of cracks sealed, as well as other useful information. Finally, the experience gained from implementing this technology will provide valuable guidance in future efforts to implement advanced technologies in road maintenance and construction.

METRIC WORKSHOP QUESTIONS

continued from page 9

A No. TxDOT has sent letters to both the utility companies and to the local governments in Texas advising them of the federal mandate for projects to be in metric units by September 30, 1996. Since, in the past, TxDOT districts have done most of the plan development for local government projects, TxDOT determined that extensive coordination was not necessary.

TxDOT has coordinated its internal training efforts with the Texas A&M Engineering Extension (TEEX) Local Technical Assistance Program, so that the local governments and industry could make use of the training and material, if they desire. Metric design training is currently available for TxDOT personnel. TxDOT is just beginning to develop a course for construction inspectors. TEEX can use the materials for this course if it chooses to offer this course, also. For assistance and information on the training available, please call (409) 845-4457 or FAX (409) 845-5726.

Q ***Will there be an effort to develop uniform standards internationally (i.e., Mexico, Canada. Europe, Japan) in the transportation design arena, that will allow us to exchange information particularly with Mexico on projects that affect both of our communities?***

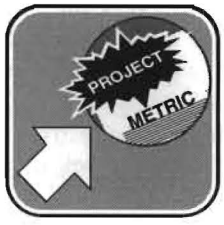
A The U.S. Department of Commerce, charged with coordination of our nation's metrication efforts, is investigating how government could get involved in the establishment of national and international standards. Such standardization has not been done in the past, but the Department of Commerce recognizes the need for it.

We suggest that you both encourage our neighbors to become active in the establishment of our standards and, also, coordinate with the responsible division office if you are aware of any standards we should adopt that our neighbors are using. Please contact Rich Rogers at (512) 465-3690 if you need any assistance.

Q ***What about right-of-way and easement deed records for filing at county courthouses?***

A Filing should not be a problem, as the metric system is a legal system of measurement in the state of Texas. If problems do arise, please bring them to the attention of Jack Housworth, R.P.L.S., Chair of the Standing Committee on Surveying, at (512) 328-2258 or fax (512) 327-3425.

ADVERTISING PROJECTS



Q ***Should special advance notification in advertising include that project is metric?***

A The Design Division maintains a list of the metric projects to be let that is sorted by month and district.

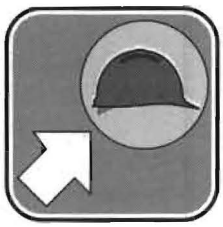
Q ***Will TxDOT hold informational prebid meetings (not necessarily mandatory) on metric projects?***

A A memo will be sent the districts suggesting that prebid meetings be considered, with attendance optional, for all metric unit projects to be let in FY 96.

Q ***Contractors and suppliers expressed interest in seeing a METRIC flag on advertisements and on the quantity summary sheets. Will they be flagged?***

A "Metric" will be imprinted on the proposal cover sheet, and the metric bid units will be indicated in both the informational and bidding proposal. TxDOT does not believe a "metric flag" is necessary, since dimensions and quantities provided in the plans and proposal will be metric.

CONSTRUCTION



Q ***Is October 1995 still the goal for letting the first metric projects?***

A Yes. TxDOT has six projects scheduled for letting in the month of October 1995.

Q ***Should partnering of metric projects be encouraged?***

A Contractors are free to request partnering on **any** project. Currently, a prepartnering questionnaire is sent to participants when a project is identified for partnering. If the partnering participants express interest in metric-related problems, they will be included in the partnering agenda.

Q ***What provision will be made for the substitution of English (foot-pound) reinforcing bar sizes if metric reinforcing bar sizes are not available?***

A Two of our approved suppliers have indicated that they will have metric rebar available by October 1995. In the event there are delays in making the metric rebar available, projects that specify metric rebar may need to be pulled from letting.

Q ***Will TxDOT consider providing an incentive for contractors to provide metric products on English projects?***

A While TxDOT does want to encourage the use of metric products on English projects, an incentive program for using metric products is not feasible due to the complexity of administering it.

Q ***Do you think that there will be initial delays in construction until everyone gets completely familiar with the systems?***

A No. The contractors we have talked to who have experience working with the metric system say it is no problem as long as you force yourself to work in metric and do not try to convert back to the English system.

Q ***Will call outs for premanufactured items (rebar, pipe, etc.) be converted to metric? How will TxDOT handle these items in bid documents and specifications?***

A All manufactured items will be called out in metric designations both on plans and in specifications. Whether the item has a "soft" conversion or "hard" designation will depend on the particular product and industry. Some examples are:

- Reinforcing steel — *Soft**
- Bolts — *Soft**
- Pipe — Soft
- Structural steel shapes — Soft
- Structural steel plates — Hard
- Welded Wire Fabric — Soft (spacing) / Hard (wire size)
- Prestressed beams — Soft

**Changed from hard after June 1995.*

Q ***What will TxDOT's policy be on providing survey or staking data to contractors on a diskette? What format will or could the information be provided in (RDS, GEOPAK, CAiCE, etc.)? If TxDOT moves to GEOPAK, will contractors have to buy GEOPAK or could data be provided in a format usable by multiple software?***

A We can format GEOPAK out put to match the current RDS output we now provide the contractors.

The Information Systems Division currently supports Survey Data Management Software (SDMS). SDMS is an AASHTO software that is available for use in all districts except for the Bryan, Childress, Laredo, Odessa, and Waco Districts. We plan to have SDMS available and implemented in these areas this summer and fall. We will have a supersite license for SDMS by the end of the summer enabling us to distribute this software to contractors and surveyors statewide for use on TxDOT projects only. This software runs on DOS-type data collectors. Contractors might need GEOPAK or CAiCE software for construction staking and/or surveying stakeout, depending on their contract with the district. This need will depend on whether the contractors are doing design and construction or only construction and on how much control the districts have over specific projects.

Q ***What units will TxDOT require for concrete batch tickets during the transition period?***

A For English unit projects — TxDOT will accept, through a no-cost change order, metric concrete designs and batch tickets at any time.

For metric (SI) unit projects — TxDOT will accept only metric concrete designs and batch tickets, unless the contractor can demonstrate to TxDOT's satisfaction that this requirement is not reasonable and can have a change order processed and approved prior to delivery of the concrete. Note that the quantities

and units on the batch tickets do not have to be preprinted, but that the contractor is responsible for their accuracy, in units specified under the contract.

Q ***Since torque standards for metric structural bolts have yet to be identified, what should we do in the interim?***

A We will continue to use English standards and dimensions for structural bolts until standards for installation of metric structural bolts have been developed.

Q ***Will TxDOT require traffic control signs for both construction zones and normal traffic signs to be metric (i.e., 45 mph vs. km/h)? Will speed limits and other things such as mile readings be converted to kilometers/hour and kilometers?***

A No. TxDOT does not want to take any steps to convert sign legends to metric until the Federal Highway Administration fosters national policy requiring the change, combined with a national public awareness effort. However, show dimensions for items like sign faces and letter height in metric on the plans.

CONTROLLING THE FUTURE

The time was ripe — the fifteenth and sixteenth centuries. All over western Europe the arts flourished; the Renaissance was in full bloom; people were challenging theories and systematically investigating the world around them. The world suddenly seemed more prone to except traditional thought than to accept it. In Italy, Galileo sought to understand physical realities and was the first to rationally investigate the behavior of materials under loads. From those first footsteps of Galileo, countless others have worked to develop a more complete engineering theory. Modern engineers benefit from the work of those pioneers and continue to push and prod the boundaries of knowledge.

Lack of scientific theory does not necessarily mean lack of genius. Some of the most influential ideas ever conceived, like the concept of "zero," were done so with no scientific basis. Before the development of modern engineering theory, people had been erecting structures successfully for centuries. Early builders relied heavily, if not solely, on precedents and an empirical knowledge of their building materials. Yet some of those structures have outlasted many of their more modern counterparts. Their longevity, alone, is a testament to the ingenuity of ancient builders and an incentive for engineers to take notice.

Modern engineers definitely can benefit from studying the work of their pre-Renaissance predecessors. Through the awareness of the construction methods of early builders, all engineers are able to take advantage of centuries of experience. Familiarity with the successes and failures of past projects could prevent similar disasters in the future. In this age of computer-aided design, perhaps a gentle reminder is needed stressing simple engineering fundamentals and a stout understanding of building materials. The modern designer or builder should not discount the influence of observation and common sense on successful design.

Upcoming issues of *Technical Quarterly* will present details of a number of structures, all built before the advent of modern engineering theory. This series will not be limited to structures as traditionally defined. Articles may consider any construction with peculiar inventiveness or particular relevance. Prospective topics range from seventh century Chinese bridges to ancient concrete to the mechanics of composite bows. The applicability of each topic will be left to the reader; hopefully, all can benefit from each presentation. After all, in the words of Confucius, "If you wish to control the future, study the past."

Editor's Note

I encourage readers to submit articles, outlines for articles or topics of interest for this series.

CHINA'S ZHAOZHOU BRIDGE

by **Jeff Schmitz**
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Master's Degree Program
The University of Texas at Austin

BACKGROUND

Arch bridges have graced the world's rivers and streams for centuries. Both Roman and ancient Chinese builders spanned countless waterways with stone arches, many of which still stand. Arches transmit all loads axially through a series of stones called voussoirs. Stone's major strength is compressive and, for most practical purposes, may be considered infinite. As long as the arch's line of thrust lies within the voussoirs, collapse will not occur [1].

The earliest arch builders relied solely on semicircular arches, which exert little horizontal thrust on piers and abutments. Controlled thrust is especially crucial during the construction of multispan bridges. Excessive horizontal thrust from one arch span may cause one of its supports to shift, especially if an opposing thrust from an adjacent arch can

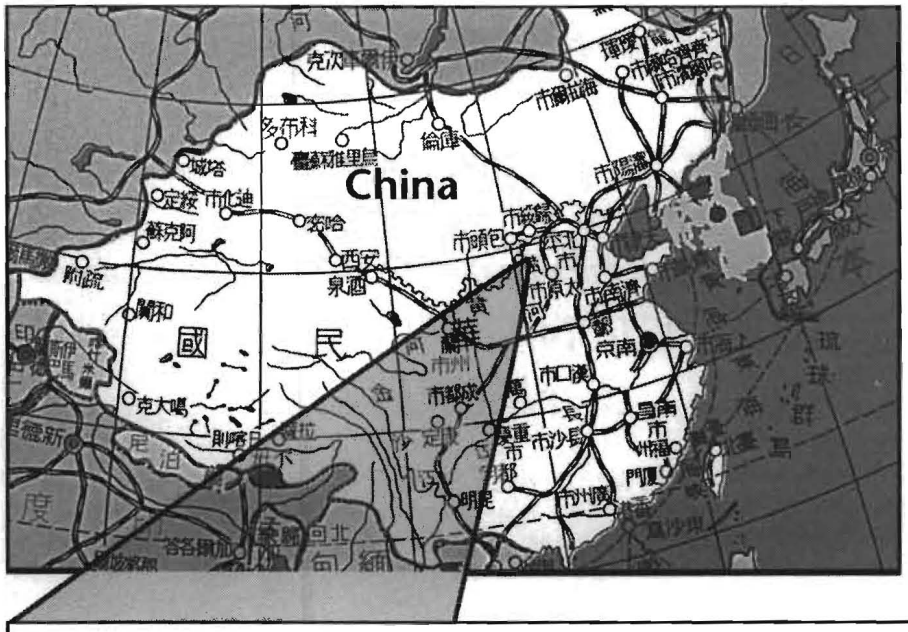
not counter it. With the semicircle's advantages of little horizontal thrust, though, come practical limitations; every semicircle rises half its span. Therefore, as bridge lengths increase, two options became available to arch builders. They could either use multiple spans of shallow arches that hamper boat traffic to provide gentle approaches for road traffic or else use spans of deeper arches with steep, difficult roadway approaches to provide clearance for boat traffic. For the ancient Chinese, who relied heavily on both road and river traffic for transportation and commerce, this was a serious dilemma.

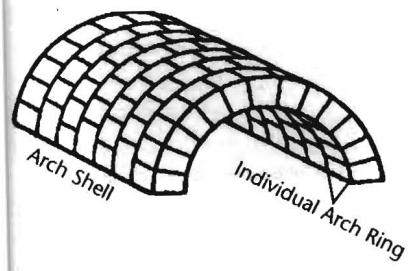
INNOVATION IN STONE

Around 610 A.D., Chinese builder Li Chun devised an alternative to semicircular arches. His bridge spanning the Chiao Shui River in China's Hebei province was the first documented segmental arch ever constructed. It is still carrying traffic after 1400 years. The bridge's shape — a segment of a circle rather than a semicircle — provides a clearance of 7.2 m (23.7 feet) above the chord line of its 37.5 m (123-foot) span. The clearance sufficiently permits boat traffic to pass beneath unimpeded, while accommodating road traffic with gentle approaches.

Chun's bridge, most commonly known as the Zhaozhou Bridge, consists of the following components as shown in Figure 1: a thin (1.03 m [3.4 foot] deep) arch shell, masonry sidewalls, deck slabs, foundations, and rubble fill. Iron, dove-tailed cramps join adjacent voussoirs in the arch shell, helping to prevent sliding between stones. The spandrels, the area between the arch shell and the deck, are pierced by four secondary arches, also segmental. The pierced spandrels, along with the rubble fill, both economized materials and significantly decreased the dead load on the arch shell. During severe flooding, the spandrel voids also provide a release for floodwater, decreasing the current's lateral thrust on the bridge.

The arch shell consists of a series of 28 parallel, but separate, arch rings, each with 43 wedge-shaped voussoirs. To prevent separation of the parallel arch rings, Li Chun used not only numerous iron cramps, but also 9 steel rods that extend the width of the bridge, through every arch ring. In addition, the arch rings camber inward, so that the width of the arch shell is greater at the springing than at the crown. Each of these features helps the separate arch rings to act as a unit — the cohesive arch shell.





In a masonry arch, voussoirs form individual arch rings and parallel rings form the arch shell. The rings camber inward at the crown.

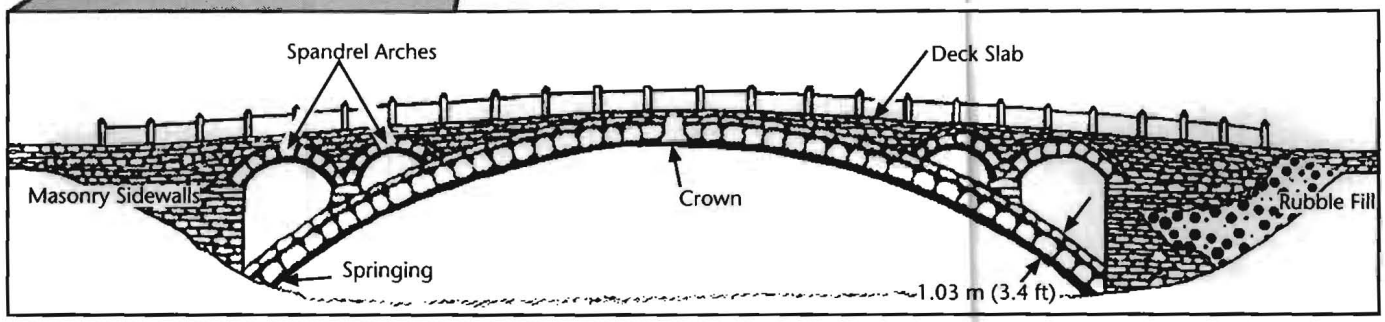


FIG. 1: Schematic of the Zhoazhou Bridge built around 600 A.D.

Analysis has shown that a concentrated gravity load at the arch's quarter-span point would shift the thrust line to the edge of the arch shell [2]. In such a case, though, masonry arches are able to redistribute thrust, preventing immediate collapse [2]. As the thrust line approaches the boundary of the arch shell, the joint between adjacent voussoirs opens. The opened joint effectively behaves as a hinge, redistributing the thrust line if additional load is applied. Three such hinges can safely develop in an arch; if a fourth hinge develops, the arch becomes unstable and collapses [3]. The thin voussoirs of the Zhaozhou Bridge, then, contribute to the arch's flexibility, while preventing collapse.

THE "WHY" AND "HOW" OF CONSTRUCTION

The Sui Dynasty, in power at the time of the Zhaozhou Bridge's construction, recognized the role of transportation in establishing a powerful empire. A well-developed road and canal system not only provided domestic military access to the Chinese Empire, but also encouraged commerce, thus contributing to economic success. The Sui emperors supported the development of public works, including a grand canal for irrigation and transportation, improvements to the Great Wall, and construction and maintenance of roads and bridges [4]. The Zhaozhou Bridge was one of the improvements made during Sui rule.

A crew of local residents, probably forced into service by their emperor, provided the labor necessary for the bridge's construction. Labor, of course, was manual and limited by physical restrictions. To transport the limestone masonry from its quarry to the bridge's location more than 30 km (18.6 miles) away, workers spread a layer of water on the ground, allowed it to freeze, and slid the materials over the iced surface. As a result, the construction schedule was sporadic, depending on weather and the availability of materials.

MIGRATION OF THE IDEA

Consistent with the policy of many Chinese rulers throughout history, the Sui emperors kept China closed to foreign influence and infiltration. Other than military invasion or occasional envoys, few travelers or ideas crossed the borders of the Chinese Empire [5]. Therefore, the development of segmental arches (as well as many other technological innovations) remained solely a Chinese endeavor for several centuries after the construction of the Zhaozhou Bridge. Mongols, under the rule of Genghis Khan, seized control of China in the late 13th century and opened trade routes between China and Europe, ushering in *Pax Mongolica.* To capitalize on trade opportunities, Marco Polo and other Western merchants trekked to the East, bringing home exotic goods, accounts of the oriental lifestyle, and knowledge of Chinese technology. It is possible that some of those merchants, having seen China's segmental arches, collaborated with European bridge builders after returning from trade expeditions; segmental arches first appeared in Europe in mid–14th century [6]. *Pax Mongolica* was short-lived (1260 – 1368) but made possible the transfer of ideas, for the first time, between China and the West.

Of course, since the 14th century, countless segmental arch bridges have been built world-wide. The building materials have changed, construction equipment has evolved, but their concept and the form are the same. Li Chun's Zhaozhou Bridge, meanwhile, still functions — a testimony to the will and ingenuity of its builders — after almost 1400 years of service.

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6. Needham, J.

SHRP CORNER

TXDOT EVALUATES FLASHING STOP/ SLOW PADDLE

SHRP developed a flashing stop/ slow paddle to get drivers' attention as they entered a work zone. The device has two high-intensity halogen quartz lamps that drivers can see from as far away as 305 m (1000 feet). If cars don't appear to be slowing, the flagger operates the lights by pressing a button on the pole. The lights flash alternately ten times, then automatically reset. Ten rechargeable D-cell batteries mounted in the handle provide power to the lamps.

The flashing stop/slow paddle face is the same size as the standard paddle: 450 by 450 mm (18 by 18 inches). It is mounted on a 1.75 m (68-inch) staff.

Four Texas Department of Transportation (TxDOT) districts, Beaumont, Bryan, Brownwood, and San Antonio, have been evaluating the flashing stop slow paddle for over a year. In construction and maintenance work zones, flaggers have noticed that drivers seem to respond more quickly to the flashing paddle compared to the standard paddle. Flaggers indicate that the device is easy to use and is fairly durable.

Brownwood district also evaluated the flashing paddle in two school crossing zones in the city of Early (Fig. 1). These school crossing zones had several hazards: high speed, restricted sight distances, and poor roadway alignments. During a one-month evaluation, crossing guards detected little difference in driver reaction to flashing paddles compared to standard hand-held paddles, except in poor light conditions. In poor lighting, such as early morning, driver response dramatically increased.

FIG. 1: Use of flashing stop/slow paddle at school crossing in Early, Texas.

The evaluators noted several improvements they would like made to the device (Table 1).

The current model of flashing stop/slow paddle costs $500 and is available from Graham-Migletz Enterprises, Independence, MO 64050, (816) 254-1788.

For more information on this or other TxDOT work zone safety devices under evaluation, call Lewis Rhodes, Engineer of Policy and Standards, Traffic Operation Division (512) 416-3330.

TABLE 1: Suggested improvements.

PROBLEM	SOLUTION
Staff length makes transport difficult	Make the staff folding or capable of breaking down
Sign face can be scraped during transport or daily use	Make sign face replaceable
Weight makes device fatiguing to operate	Make a stand to hold the device

TYLER EVALUATES PROMISING EROSION CONTROL SYSTEM

by **Chris Pankey**
Engineering Assitant
Research and Technology Transfer Office
Texas Department of Transportation

The Tyler District is evaluating a Tri-Lock Erosion Control System as an experimental feature in construction project #: IR 20-6(69)543 (control section 0495-04-040) in Smith County. This area of the state has highly erodible sandy soil. Slope failures are common. The district needed a durable, low-maintenance way to prevent erosion during and after construction.

The Tri-Lock system is a flexible, permeable erosion control system that allows vegetation to come back (Fig. 1). It consists of interlocking concrete blocks (Fig. 2) on top of a

filter fiber blanket. The concrete compressive strength averages 276 MPa (4,000 psi), and the mass density is approximately 2002 kg/m^3 (125 lb/ft^3).

Tri-Lock is easy to install. Workers clear the ditch or run-off area and inspect for it voids and soft areas. After filling any voids and stabilizing soft spots, they place a geosynthetic filter fiber blanket over the prepared surface. Then they pin the filter blanket to the prepared surface and start installing the interlocking concrete segments. It took a six-person crew one week to install 3261 m^2 (3900 sq yd) using a Gradall, a bulldozer, and a dump truck.

FIG. 1: The Tri-Lock erosion control system in place in Tyler District.

FIG. 2: Close-up of the "lock-and-key" blocks.

FIG. 3: Randall Redmond is the project's evaluator.

Besides ease of installation, another feature Tyler personnel liked was the ability of Tri-Lock to follow changes in terrain. Also, Tri-Lock's key-and-lock system provides a void in which top fill may be placed and/or seeded with grass or other vegetation to restore an embankment to a natural-looking condition. The smooth and even surface provided by the system allows normal maintenance with conventional mowing equipment. Notable advantages of Tri-Lock are:

- no cables or additional anchoring required
- conforms to changes in grade and direction
- is available in mat form for machine installation

Tyler District personnel are pleased with Tri-Lock's performance so far. For more information, contact Randall Redmond, P.E. (Fig. 3), Mineola Area Office, (903) 569-2349. Unedited video footage of the Tyler installation is available on loan from the Research and Technology Transfer Library. Call Dana Herring at (512) 465-7644.

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.

USDOT PARTNERS WITH DOD TO DEVELOP HIGH-SPEED RAIL TECHNOLOGY

The Federal Railroad Administration (FRA) and the Advanced Research Projects Agency (ARPA) of the Department of Defense has announced a joint award of $2.9 million to The University of Texas Center for Electromechanics to develop an advanced locomotive propulsion system which will double the acceleration of next-generation high-speed passenger train locomotives.

Federal Railroad Administrator Jolene M. Molitoris said, "The development of this new technology is a key part of the Clinton Administration's and Transportation Secretary Peña's commitment to develop next-generation high-speed ground transportation systems.

"This is the kind of advanced technology America needs. This project will use the best of high technology — turbine engines and advanced electronics — as well as good old American know-how to deliver fast, high-quality passenger rail service. It will be a quantum leap towards making cost-effective high-speed passenger rail service an affordable reality throughout the United States."

The funding will be used to develop a locomotive propulsion system consisting of a turbine-driven electric generator and a mechanical flywheel system. The propulsion system will help raise average train speeds and significantly shorten trip times on existing railroad lines that have frequent stops and curves where trains must slow down. The ability of the flywheel to "bank" energy will permit the overall locomotive system to provide optimum fuel efficiency and reduce emissions by one fourth.

The system could provide corridors nationwide with fast, quiet and economical high-speed passenger trains able to run on existing tracks without the need for costly electrification infrastructure.

The University of Texas project is under the umbrella of the Southern Coalition for Advanced Transportation, a consortium of more than 40 high technology organizations presently working with ARPA in transportation and defense technology. The federal funding will be equally matched by the Texas project team.

The flywheel will be a large disk constructed of advanced composite materials spinning in a vacuum chamber and connected to an electrical motor/generator. When the locomotive stops or is braking, the motor will use available electricity from the turbine or recovered braking energy to "spin up" the flywheel disk. When acceleration is needed, the flywheel drives the generator to return the "banked" energy, slowing its rotation very rapidly while delivering thousands of extra horsepower to the locomotive motors and doubling the locomotive acceleration.

The main benefit of this flywheel is its ability to store and then to release enormous amounts of energy and the immense power the flywheel can capture and exert. The energy storage feature allows the turbine to operate at near constant power and at peak efficiency.

The development of the flywheel propulsion system will be a true partnership effort. The University of Texas project team combines the research and development resources of the Department of Transportation and the Department of Defense; the Association of American Railroads' experience in railroad testing at the Transportation Technology Center at Pueblo; the Argonne National Laboratory's expertise in safety analysis; the General Motors Electromotive Division's skill in building locomotives; the Allied Signal Companies' command of turbines and generator systems; and the AVCON Corporation's experience with magnetic suspension bearings.

The flywheel technology is also of great interest to electric utility companies and is under consideration by the ARPA for several defense applications. The technology being applied to locomotive propulsion draws on research originally conducted for the U. S. Army Electric Gun program, which utilizes strong electromagnetic forces to propel artillery projectiles.

In November 1994, FRA issued an announcement to seek new technologies for use in high-speed rail systems. The flywheel proposal is one of the first technologies funded by the FRA under this initiative.

Contact: David A. Bolger, (202) 366-0881. Reprinted from the ***Fedworld*** Internet site.

INSIDE TQ

BRIDGES

COMPUTERS

CONSTRUCTION

DESIGN

ENVIRONMENTAL ISSUES

MAINTENANCE

METRICATION

ONGOING RESEARCH

SHRP CORNER

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