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VISUALIZING THE TRANSPORTATION ENVIRONMENT: NEW TECHNOLOGIES CREATE LIFE-LIKE IMAGES

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INTRODUCTION

"Visualization" has become the term for an umbrella of technologies and methods that work together to visually communicate a past, existing, or future condition. In the project production process, the transportation industry has traditionally employed 2-dimensional graphic tools — plan drawings and profiles — to visually represent a 3-dimensional world. But now, computer-generated still and animated digital imagery on a 3-dimensional palette offers much more accuracy and reality, providing DOTs with better tools for project planning, public information/education, operations, and right-of-way litigation [Ref. 1].

PROBLEM

Adverse public reaction sometimes slows or even stops expansion or alteration of the transportation system. Sometimes citizens just cannot get an accurate "vision" of the end product, and they do not always understand the potential benefits of highway projects. Instead, they perceive a threat to the economic well-being of their business, or they worry about the property value of their homes.

Visualization — letting the public see what the designers envision.

In fact, as the sophistication of design communication tools has grown to include video imaging, animation and computer simulation, some private interest groups have successfully used these 3-dimensional advanced visualization methods in court, winning awards on the basis of "visual" damages at the sites in question. Without using similar methods, it is sometimes difficult for the state to win support for a transportation construction project. Also, to encourage community involvement, transportation agencies must be able to develop a view of the future — an accurate and realistic image of what the area will look like after a project is completed.

SOLUTION

The good news is that the state is now using some of these advanced visualization tools in effectively communicating the complicated details of proposed transportation projects to both a concerned public and to juries in litigation proceedings. The Texas Department of Transportation (TxDOT) is leading

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the "Transportation Visualization" movement as one of the only transportation agencies that has actually produced and used animation as part of a project development process [Ref. 1]. Also, visualization tools have played an important role in actual right-of-way and condemnation cases involving the state and TxDOT.

Digital Images: Project Planning and Community Involvement

"Static and dynamic digital composites are two of the most effective communication tools that are also now relatively cost-effective," says Terry Larsen, a visualization specialist at Texas Transportation Institute (TTI). In both techniques, a base image (usually a photograph or video) of the geographic location is acquired and scanned into the computer, and a 3-dimensional computer model of the proposed new transportation elements, such as a bridge or new driving lanes, is generated. The key difference between the two techniques is the addition of motion with a dynamic base image. For instance, if stationary video footage of a freeway with moving cars is shown with a synthetic overlay of a new overpass, the audience gets a more "real-time" effect.

TxDOT's El Paso District has successfully used digital imaging as part of a comprehensive visual analysis project to set goals for right-of-way beautification on Interstate 10. Citizens have characterized the view from IH-10 as barren, dirty, and monotonous — a dismal impression created by unattractive riprap and the lack of vegetation (Fig. 1). "The department is broadening its traditional role as caretaker and constructor of the roadways to include development and enhancement of the public right-of-way," says Mary May, District Engineer in El Paso. "We're hoping to set a pattern where communities pull together in the continuous development of this aesthetic infrastructure."

With this goal in mind, TxDOT contracted with TTI researchers in the Environmental Management Program to initially identify the best enhancement strategies and get a community effort off the ground. The researchers used digital composites to illustrate how thematic murals, painted bridges, and landscape elements would brighten up the IH-10 corridor (Fig. 2).

First, live action videotape and photographs recorded conditions along the interstate from a number of specific vantage points. Next, researchers used Intergraph's MicroStation software to build a 3-D CADD model of the bridges and retaining walls. Renderman by Pixar created the proposed murals. The main work of the project consisted of overlaying the appropriate views of these computer-modeled improvements onto still images, then digitally adjusting them so that the resulting composite would have that

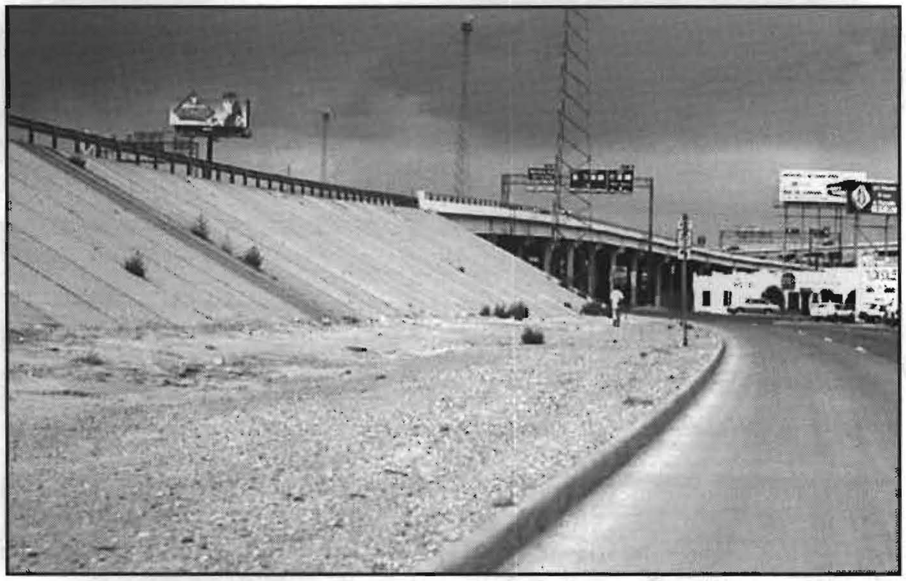

FIG. 1: A "before" photograph from one of the specific vantage points along IH-10 characterized by citizens as barren and monotonous.

FIG. 2: The "after" shot shows the public how the designers envision the enhancement to communicate aesthetic issues of color, scale, and mass.

"real" quality. Using Adobe Photoshop, the addition of shade, shadow, and material color allowed the proposed improvements to blend into the existing image.

These images enabled the designers to communicate aesthetic issues of color, scale, mass, and views to the public in an easily understood format. According to Larsen, the TTI principal investigator of the project, "this increased accuracy of communication enables the public and designers to 'work from the same page,' and produces more effective interaction and decision-making."

Animation: Supporting Right-of-Way and the Attorney General's Staff

In the case of O'Kelley vs. the state of Texas, TTI produced an animated video for the Attorney General's Office. This video helped to save the state of Texas $125,000. The animation demonstrated that proposed freeway changes would not impair visibility of the O'Kelley property from the freeway, the main lanes, the frontage road, or the direct connectors. Unlike video overlays, computer animation is a completely synthetic image based on a mathematical description of all components in the scene [Ref. 3].

Although animation projects are more costly in both dollars and time, these images offer many advantages not available with still or dynamic digital composites. "With animation we can create a section of highway that looks exactly like the finished product," says Larsen, the O'Kelley animation creator, "and we can also look at that product and its surrounding environment from a variety of different camera angles and viewpoints, some of which may not even exist yet in the real world."

For example, let us say the state is proposing to build a new overpass and widen the feeder road. The adjoining property owners are claiming that the view of and from their businesses will be negatively affected. Animation can overcome real-world physical limitations by allowing a 3-dimensional dynamic perspective of what the property would look like from a car driving on the yet nonexistent overpass, from a specific point on the property, or even from an aerial viewpoint. This kind of flexibility can be important in a right-of-way case where millions of dollars are riding on a jury's subjective judgment of how something is going to look and how that will affect the surrounding property when completed [Ref. 2]. According to Larsen, if a project is judged from only one viewpoint, sometimes that viewpoint can mislead because it doesn't consider that fourth dimension — motion.

So what goes into producing animation for transportation projects? The entire product development process is relatively time-consuming and involves three separate phases: image/data acquisition and input, image processing, and post production and output. Each phase relies on different types of hardware and software.

Three modules in "fourth dimension" software — modeling, rendering, and animation — are necessary for this type of visualization (Fig. 3). An important time-saver in the first production step is the modeling of a base image in a true 3-dimensional (x, y, z) environment. When animators have to create a 3-dimensional model from a 2-dimensional plan drawing, the entire production time can increase by as much as a third. All the major CADD programs now have 3-dimensional modeling environments, with Intergraph's MicroStation the most widely used in transportation [Ref. 1].

Rendering the model gives the image its color, shading, and light. The sophistication of these effects will determine how real the sequence looks. Depending on the software, several different types of rendering techniques are available, each providing a successively higher level of detail. With wire mesh shading, the simplest method, all elements of the image are transparent, and the edges of masses are delineated with lines and the curved surfaces by a polygon

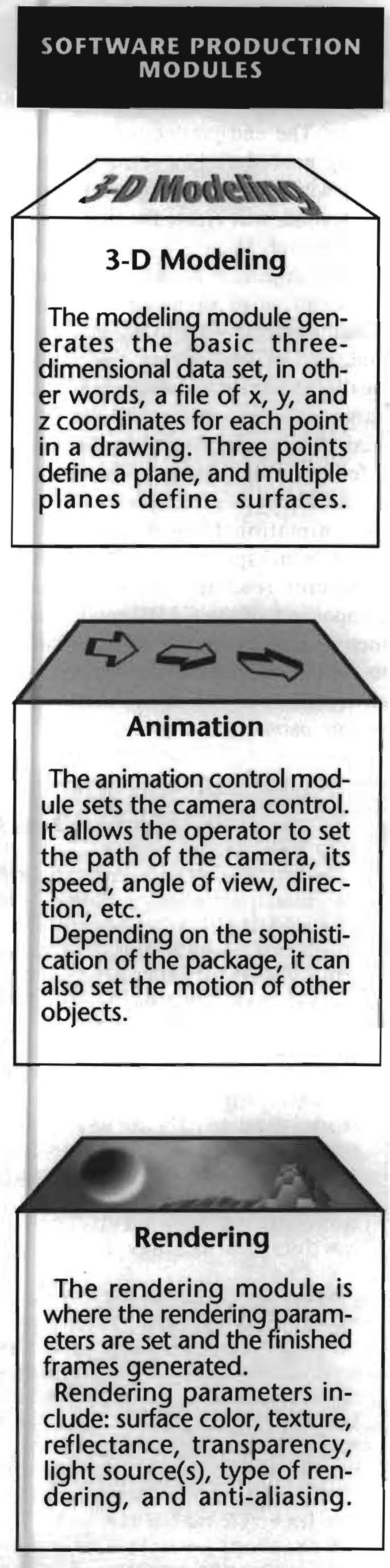

FIG. 3: Components of 4-D software.

mesh. Phong shading, the most realistic type, smoothes all edges and varies a colored surface by computing the color for each pixel in the image. The end product of any rendering procedure is a set of images that, when viewed at thirty frames per second, will create the illusion of motion [Ref. 1].

The animation module deals with a second level of motion — that which controls speed, angle, direction, etc., of any moving object. Basically, the software places a virtual camera in an animated car and records the view from the vehicle as it follows the geometry of the model, so the audience actually experiences the animation from a "realistic" driver's perspective. Making the computer read the mathematical components of the CADD model and then programming the "camera car" to follow the geometry of the visual environment is one of the more important parts of the whole process.

CONCLUSION

The decision to animate or to use any other 3-D visualization technology for a highway construction project should carefully consider several factors. What is the cost of the visualization services in relation to the sensitivity and complexity of the project? Does the agency's project environment allow for production time of 3-D visualization? Is the general public heavily involved in a very complex project?

If there is a large amount of money riding on the success of a transportation project or right-of-way case, or even if there is more than one potential use for the 3-D product, then the long-term benefits of the investment often far outweigh the short-term costs of production. For example, if a plaintiff is asking for $25 million and the state is offering $12 million, the animation would cost only about 1 percent of the difference between those two numbers. "The term 'expensive' is relative," says Larsen, "but when you're working with millions, or when you're concerned with obtaining public support for a project, an investment in transportation visualization is definitely worth it."

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2. "Animation: It's Not Just for Entertainment Anymore!" Texas Transportation Researcher. Texas Transportation Institute, The Texas A&M University System. Spring 1993. Pp. 8-9.

3. Terry R. Larsen. Interview. March 31, 1995.

VISUALIZATION IN TRANSPORTATION IS ON THE RISE

An upcoming report for NCHRP Project 20-5, Topic 25-091, "Applications of 3-D and 4-D Modeling for Transportation Systems," will present results of a survey used to determine the current use of visualization technology in transportation practice. The survey addressed a variety of questions about knowledge and awareness of visualization tools, target audiences, the visualization production environment, acquisition of visualization products, agency perceptions of cost-effectiveness and public acceptance of visualization tools. A review of the results and follow-up interviews indicate that as we move into the twenty-first century, visualization will become an integral part of transportation practice.

Twenty-nine state DOTs, one Canadian province, two consulting firms, and five universities responded to the survey, giving a final total of thirty-six usable responses. All indicated that they have adopted a computer-based drafting and design environment. Although Texas was the only state transportation agency that had actually produced and used animation as part of a project development process, 59 percent of the respondents indicated that they were currently developing some type of animated material, and 91 percent were in the process of evaluating hardware and software for producing 3-D visualization materials.

However, the research noted a much broader and diverse use of visualization in the private and education sectors. A complete evolution and embracing of visualization in the transportation community will have to be preceded by development of the applications to a point of proven cost-effectiveness and by a major change in the way DOTs approach construction project design. According to Terry Larsen, the TTI researcher heading up the project, "as soon as transportation construction documents are routinely generated in a 3-dimensional CADD environment, rather than on the currently prevailing 2-dimensional production systems, the use of animation and other 3-dimensional dynamic images will broaden and become more cost-effective." Figure 1 illustrates the dramatic increase in the variety of graphic products that can come from moving to a 3-dimensional data set. The NCHRP project report covering this survey is also designed to be an excellent overview of "everything you always wanted to know about visualization technology in transportation, but were afraid to ask." *For more information on visualization services or NCHRP Project 20-5, Topic 25-091, contact Terry Larsen at (409) 847-8996.*

	Cartography	Advanced Planning	Right-of-Way	Design	Construction	Maintenance and Operations
PRODUCTS AVAILABLE FROM 3-D DATABASE	◊ Digital Terrain Models • Traditional Topographic Maps	◊ Animated Sequences ◊ Still Renderings ◊ Wire Frame Perspectives • Traditional Design Schematics (2-D Plan/Profile Sheets) • Aerial Photograph Overlays	◊ 3-D Images To & From Sites ◊ Still Renderings ◊ Wire Frame Perspectives ◊ Integrated Illustrative Plans • Traditional Design Schematics (2-D Plan/Profile Sheets) • Aerial Photograph Overlays • Traditional ROW Maps	◊ 3-D Images To & From Sites ◊ Still Renderings ◊ Wire Frame Perspectives ◊ 3-D Alignment Studies ◊ Animated Sequences (Drive-Throughs) ◊ Construction Sequencing Studies • Traditional Design Schematics (2-D Plan/Profile Sheets) • Aerial Photograph Overlays • Detailed Schematic Plans	◊ 3-D Images To & From Sites ◊ Construction Sequencing Studies ◊ Wire Frame Perspectives ◊ Animated Sequences (Drive-Throughs) • Traditional Design Schematics (2-D Plan/Profile Sheets) • Alignment Data Sheets • Aerial Photograph Overlays • Detailed Schematic Plans	◊ Still Renderings ◊ Wire Frame Perspectives ◊ Construction Sequencing Studies ◊ Animated Sequences (Drive-Throughs) • Traditional Design Schematics (2-D Plan/Profile Sheets) • Alignment Data Sheets • Detailed Schematic Plans • Aerial Photograph Overlays
PRODUCTS AVAILABLE FROM 2-D DATABASE	• Traditional Topographic Maps	• Traditional Design Schematics (2-D Plan/Profile Sheets) • Aerial Photograph Overlays	• Traditional Design Schematics (2-D Plan/Profile Sheets) • Traditional ROW Maps • Aerial Photograph Overlays	• Traditional Design Schematics (2-D Plan/Profile Sheets) • Alignment Data Sheets • Detailed Schematic Plans • Aerial Photograph Overlays	• Traditional Design Schematics (2-D Plan/Profile Sheets) • Alignment Data Sheets • Detailed and Schematic Plans • Aerial Photograph Overlays	• Traditional Design Schematics (2-D Plan/Profile Sheets) • Alignment Data Sheets • Detailed Schematic Plans • Aerial Photograph Overlays

FIG. 1: Comparing products available from 2-D and 3-D databases.

TXDOT'S RESEARCH RESTRUCTURED

by **Tom Yarbrough**
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WHAT'S HAPPENED

The way TxDOT pursues research has changed. On May 8, 1995, TxDOT Executive Director Bill Burnett formally announced revisions to TxDOT's research program. These changes are based on the Continuous Improvement Team for Research's recommendations. Beginning work in late 1993, the CI team reviewed the existing program extensively. The recommendations of the CI Team, with some modification by the Senior Management Team, became effective on June 1, 1995. This article will highlight the changes and their intended effect on TxDOT's research program.

ADMINISTRATIVE STRUCTURE

The most obvious change is the administrative structure of the research program. Under the "old" structure, five area advisory committees functioned under the direction of the Research and Development (R&D) Committee. The area committees made recommendations to the R&D Committee concerning selection of new projects, as well as modifications and continuations of ongoing projects. The R&D Committee made the final selection.

The new program empowers nine Research Management Committees (RMCs) with the authority to administer the program within their respective study areas, including choosing what problems to study and approving modifications and continuations for ongoing projects. Table 1 lists the nine RMCs and their chairs.

The R&D Committee has been eliminated, replaced by the Research Oversight Committee (ROC). The role of the ROC is to prioritize funding among the nine RMCs, establish and implement TxDOT's *Long-Range Plan for Research*, and oversee diversification within the research program. Bob Templeton, Assistant Executive Director for Field Operations, chairs the ROC

TABLE 1: Titles and chairpersons of the Research Management Committees.

RMC #	RMC TITLE	NAME	DST/DIV
RMC I	Management and Policy	Bob Cuellar	SMT
RMC II	Multimodal Transportation	Tom Word	CRP
RMCIII	ROW, Hydraulics, and Environmental Conservation	Jay Nelson	PAR
RMC IV	Roadway Planning and Design	Billy Parks	AMA
RMC V	Structures	James Huffman	DAL
RMC VI	Pavements	Walter Crook	BMT
RMC VII	Materials	Maribel Chavez	ABL
RMC VIII	Construction and Maintenance	Gene Adams	ATL
RMC IX	Traffic Operations	John Kelly	SAT

with Tom Griebel, Assistant Executive Director of Multimodal Transportation, serving as vice-chair. The nine RMC chairs compose the remaining membership of the ROC.

Moving decision-making authority downward to the RMC level speeds up actions and improves decision quality. The RMCs are already well acquainted with the needs and projects in their part of the long-range plan and will not need to be briefed like the old R&D Committee. Expanding the committee study areas from five (under the "old" structure) to nine will allow the RMCs to focus research efforts properly. This tighter focus should help to get research findings into the field faster, as well, since the findings should be more tailored to existing needs or projected trends.

LONG-RANGE PLANNING

In order to plan, execute, and implement research in a logical and efficient manner, TxDOT is developing a long-range plan for research. The planning effort began over one year ago, under the guidance of the "old" area advisory committees. Long-range planning subcommittees addressed assigned topic areas and developed a total of twelve long-range plans. These twelve plans are reassigned to the RMCs to review, to further develop and enhance, and to prioritize goals and objectives. The twelve plans have been melded into a single plan for departmental use.

The Research and Technology Transfer Office anticipates that the RMCs will convene Technical Advisory Panels (TAPs) to continue work on the long-range plan topics. TAP membership will consist of TxDOT personnel with expertise in specific topic areas, FHWA personnel, university professors and researchers, and industry representatives.

The long-range plan serves two primary purposes: as a tool for TxDOT planning, execution and implementation of research and as a resource management tool for the state-supported universities that conduct TxDOT research, providing guidance for planning in terms of staff and facilities.

RTT recently distributed a draft version of the long-range research plan throughout TxDOT and the universities as part of the call for FY 1997 research problem statements. The CI Team envisions that the majority of research problem statements generated over the coming years will spring from the long-range plan.

PROJECT DIRECTOR AND PROJECT MENTOR

The project director (PD) is the person assigned from within TxDOT who is responsible for overseeing the technical aspects of a research project. The CI Team recognized the importance of the PD's role as crucial to the success of the research project and its subsequent implementation. Under the revised research structure, the PD's role remains essentially the same, but a project mentor (PM) role has been created to augment that of the PD.

The project mentor is an RMC member assigned to an individual research project. Every research project will have both a PD and a PM. The PM serves as a direct link between the RMC and the PD. The PD will coordinate his/her activities with the PM, and the PM will assist the PD in keeping the research project in line with the desires of the RMC, coordinate project implementation plan development, and offer guidance and advice as a mentor to the PD.

The revised program places more emphasis on making sure results are used. PDs will promote and monitor the use of study findings for three years after the study ends.

RESEARCH MANAGEMENT COMMITTEE MEETINGS

Formerly, each research area advisory committee held meetings twice a year. With the new research structure, RTT will make a major change in meeting format. All RMC members will attend a single meeting, held twice year. The first meeting will be held December 5–7, 1995, in Austin. The meeting will consist of an opening executive session, followed by individual breakout sessions for each of the nine RMCs to conduct committee business and hear progress reports, followed by another executive session. The meetings will be held in the spring and fall of each year, and the location of the meeting will vary. RTT plans to hold RMC meetings near universities that participate in the TxDOT research program, and to offer tours of university facilities to increase RMC member knowledge of university research capabilities, while allowing researchers to interact with RMC members on a more personal basis.

CONCLUSION

Transportation experts recognize TxDOT's transportation research program as one of the best the world. The revised program will improve TxDOT's already world-class reputation through streamlined, coordinated planning and research and through increased and faster application of research results. Many of the CI team's recommendations will mean a substantial commitment from those involved in the program, but the ultimate payoff will be a more efficient, safe, responsive, and cost-effective transportation system for the state of Texas.

TRANSGUIDE OFFERS TECHNOLOGY TOUR

by **Betty Taylor**
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INTRODUCTION

Technology drives into action this summer when TxDOT's newest advanced traffic management system opens along San Antonio freeways. TransGuide, or Transportation Guidance System, will warn drivers ahead of time of incidents and accidents along the freeway and provide alternate routes. Through the use of computers, fiber optics, overhead variable message signs, lane control signals and cameras, the system detects changes in traffic patterns and makes changes to all affected signs and lane control signals in the area within a two-minute-and-15-second time frame (Fig. 1). Main objectives of the system include reducing congestion and enhancing emergency response time to incidents along the highway. Participants in the TransGuide operations center include TxDOT, City of San Antonio Police and Fire dispatch, and VIA Metropolitan Transit Authority bus dispatch.

TransGuide is part of ITS, or Intelligent Transportation Systems, a nationwide effort to better manage traffic along the nation's existing freeways. Currently, TransGuide is one of the fastest, most accurate, and technologically advanced systems in the nation. San Antonio District Director of Transportation Operations Patrick L. Irwin, P.E., and Traffic Management Engineer Patrick F. McGowan, P.E., consulted over 150 engineers and scientists before designing this fully redundant, reliable and accurate system. TransGuide relies on non-vendor-specific equipment for easy expandability in the future. In addition, over 34,000 (eventually 128,000) traffic solution scenarios entered into the mainframe (DEC) VAX 810 FT computer account for the system's speed and accuracy. The communications system includes innovative designs that allow for cost savings, flexibility and efficiency.

FIG. 1: A variable message sign, part of the TransGuide System, warns motorists of changing freeway conditions. (Credit: Kemp Davis Photography)

The Operations Center

The TransGuide operations center (Fig. 2), located in the IH 10/ IH 410 interchange in San Antonio, houses the San Antonio District Transportation Operations offices; offices of VIA Metropolitan Transit Authority, City of San Antonio traffic operations (police/fire/EMS/9-1-1 dispatch), and two research agencies on the third floor; and the computer and operations rooms. This includes a backup emergency management center, the alternate Public Safety Answering Point dispatch center.

The operations room houses 18 workstations and will initially operate from 5 A.M. to 8 P.M. weekdays and during special events on weekends. Other agencies will also operate workstations that will be utilized for research and development. An 80-cube video wall (Fig. 3) in the operations room provides operators with detailed highway, video, and weather maps.

FIG. 2: San Antonio District's TransGuide operations center. (Credit: Bill Frost, SAT, TxDOT)

FIG. 3: View of the video wall in the operations room. Inset shows close-up of workstation screen. (Credit: Kemp Davis Photography)

Construction of the project began in 1993 with AlliedSignal Technical Services Corporation as the primary contractor. Main subcontractors include H. B. Zachry, AT&T, and Browning Construction. The $32 million Phase I of the system includes 41 km (26 miles) of freeway (sections of US 90, IH 10, US 281, IH 35, IH 37 and Loop 410) mainly in the downtown San Antonio area (Fig. 4). Eventually, TransGuide will include 308 km (191 miles) of freeway in Bexar County at a cost of $151 million. The system is 80 percent federally funded and 20 percent state funded.

Phase I begins with over 800 inductive loop detectors placed at a maximum of one-half-mile spacing. The detectors measure groups of vehicles' speed, volume, and occupancy. The local control unit (LCU) keeps a moving average of these rates and sends the information back to the TransGuide operations center approximately every 20 seconds. The LCU will also perform diagnostic monitoring of each individual detector to test for nonactivity and maximum presence conditions. Results of this diagnostic monitoring will be sent to the TransGuide mainframe. Connection to the mainframe will be made via an RS-232 link to the digital communication network.

NETWORK MANAGEMENT

The Network Management System gathers status information from the field equipment via remote units installed in the fiber hub cabinets. The remote units monitor alarm points, and transmit the status to the operations center via digital loop carriers. The remote units will provide a visual indication of alarm points in the fiber hub cabinets (Fig. 5). The Network Management System will gather discrete status information from communications equipment in the operations center using the central units.

When an incident registers in the TransGuide operations room, the system automatically generates an alarm on the floor manager's work station (Management Control Unit) and changes the color of the roadway on the associated map display system screen (Fig. 6). If the alarm is designated as an incident, it is assigned to an operator, and the affected cameras are turned on to identify the type of incident. The floor manager can remotely control pan, tilt, zoom and focus of any of the 52 high-resolution cameras in Phase I. The half-inch frame interline transfer (FIT) CCD color video cameras are installed atop camera poles. Operators in the TransGuide center also can remotely control the cameras after an incident is assigned to them. The cameras incorporate 750 lines of horizontal resolution, six shutter speeds and a 48:1 zoom capability. Field of view at one-half mile is 20 feet vertical by 30 feet horizontal. After the incident is identified, the operator answers three questions in a point and click setup:

- What type of incident is it?
- What lane(s) are affected?
- Does demand exceed capacity?

Based on the answers to these three questions and several other variables, the computer can automatically change affected variable message signs (VMS) and lane control signals (LCS) in the area within a 15-second time frame. When the type of incident is identified, police and fire operators in the operations center can immediately dispatch the appropriate help needed (including EMS and 9-1-1) to the scene of the incident. VIA bus dispatch operators in the center will also be able to reroute buses and keep them on schedule when an incident occurs.

Phase I includes 50 fiber optic variable message signs. The larger of these signs are placed on overhead sign bridges and offer three lines of text. Each character is formed by 35 luminous dots in a matrix of five columns by seven rows. The luminous dot consists of the ends of fiber optic bundles. An electromagnetically controlled shutter mechanism opens and closes in front of the fiber optic bundles to allow light passage from the luminous dots. Smaller two-line VMSs are stationed at entrance ramps to the freeways within the project limits. Preprogrammed messages have already been entered into the mainframe that will warn drivers ahead of time of major and minor accidents, debris on the road, water on the road, evacuation routes, and other incidents along the freeway. Operators will still have the flexibility to enter a message manually if needed.

In addition, overhead lane control signals will indicate closed lanes with red "Xs" and open lanes with green arrows. The LCS are fiber optic type dot indicators on a flat black, nonreflective, rectangular face. The signal will be clearly visible and legible for one-quarter mile under normal atmosphere conditions. The color of each indicator will be obtained by the use of color filters at the lamp end of the fiber optic bundles. If motorists need to use caution in a lane that is open, a yellow down arrow will be displayed. Merging traffic will follow yellow diagonal arrows (Fig. 6).

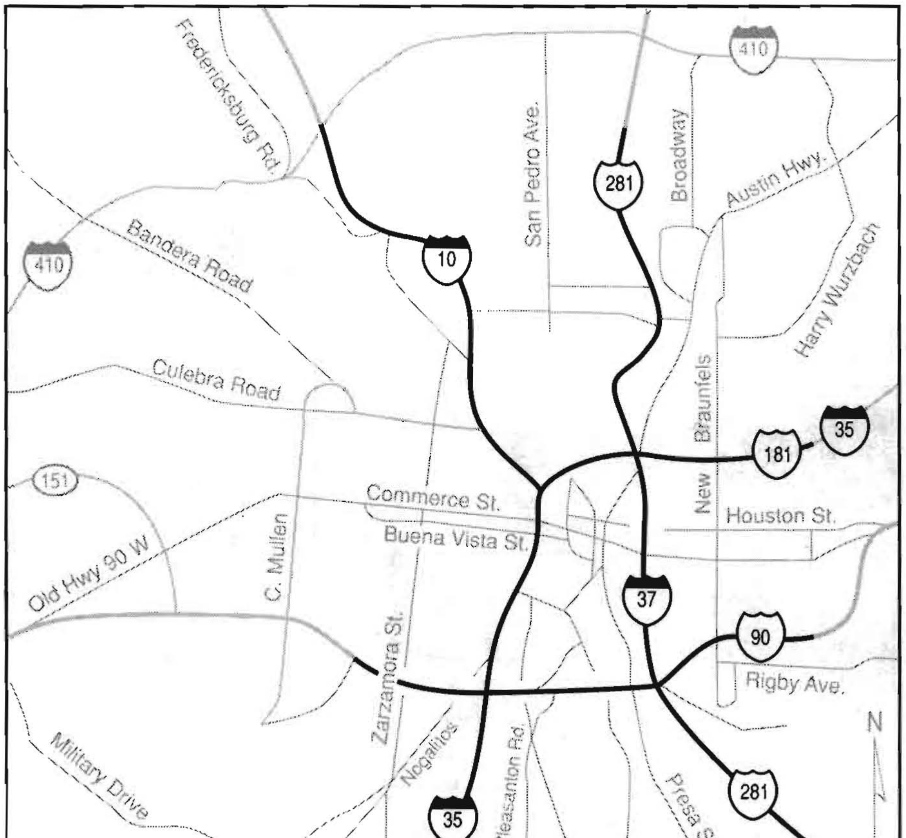

FIG. 4: Map of San Antonio with TransGuide System shown in solid black lines. (Graphic: Mike Gray, CTR)

SYSTEM COMMUNICATIONS

The digital communication network transports video, data, and voice information from field equipment to the operations center. The network employs SONET standard communication protocols transmit-

FIG. 5: Working on a fiber hub cabinet. (Credit: Kemp Davis Photography)

FIG. 6: An incident management team in action at a TransGuide opertaions control workstation. (Credit: Kemp Davis Photography)

Again, the redundancy ensures that if a piece of equipment is destroyed or damaged in the field, the system will automatically reroute itself and continue operating.

"The most important special feature of TransGuide is the mainframe software system," states San Antonio District's Pat McGowan. The software supporting this system is an integration of tailored commercial-off-the-shelf (COTS) products and custom code developed exclusively for the TransGuide system. Both the COTS and custom-developed software will work together to minimize risk and maintenance costs. The system is designed to be compliant with the current POSIX and OSF standards.

ted over a fully redundant, single-mode, fiber optic system. Equipment within the communication network digitizes the video, data, and voice signals before transmission to provide the quality, reliability, compatibility, and expandability required for the current and future systems.

Equipment used in the network includes data service units, digital loop carriers, DS-3 video codecs, OC-3 digital multiplexers, a DS-3 digital matrix switch, a DS-1 digital matrix switch, a communication system switch, and a network management system. At the field equipment level, the data service unit converts RS-232 variable message signs and lane control signals to a DS-0A digital format and interfaces to the digital loop carriers. These signals are massaged and filtered in various ways before being distributed to the TransGuide mainframe (Fig. 7).

The mainframe computer has two fully duplicated sets of components, called zones, which ensure that there is no single point of failure: a single hardware error or fault in either zone cannot disable the entire system. These two zones are linked by high-speed parallel data paths. Each zone contains its own backplane to link its central processing unit, system I/O and memory modules. This redundancy ensures that even the backplane is not a single point of failure.

This central processor is served and supported by two primary dedicated communication networks, including a dual rail Ethernet local area network, which is used to connect the mainframe to devices and displays within the operations center.

FUTURE APPLICATIONS

The TransGuide system has laid the basic groundwork for other ITS technologies. These include advanced traveler information systems (ATIS), automated collision notification, collision avoidance, international border electronic clearance, in-vehicle computers and regional operations.

Some of these technologies are

FIG. 7: Lane control signals. The left-hand one is a diagonal yellow, warning motorist to merge with the right lane. The down arrow in the right-hand lane is green, showing the lane is open and traffic is running normally. (Credit: Kemp Davis Photography)

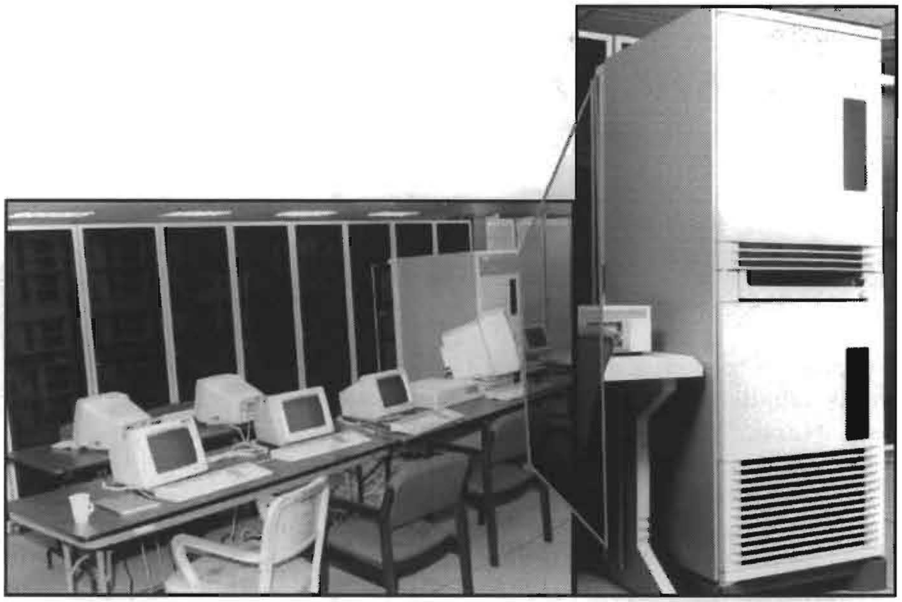

FIG. 8: The TransGuide computer room. Inset: the brains of the operation — a DEC VAX 810 FT mainframe. (Credits: Kemp Davis Photography and Bill Frost, SAT, TxDOT)

already in the planning stages. The San Antonio District has initiated a program termed the "Media Distribution Plan" which will involve the transfer of real-time traffic information from TransGuide to the local media for dissemination to the traveling public. An advisory panel of local media representatives meet on a regular basis to discuss the best possible way to distribute this information As a result, TxDOT is purchasing a low-power television station and TransGuide traffic information will be broadcast over the entire metropolitan area. Receiving the data requires a low-cost antenna. Participants have the opportunity to receive TransGuide traffic video, graphical maps, scenario data, lane closure data, and other traveler information. Other users of the system will consist of large business employers, trucking companies, overnight freight companies, EMS vehicles that will display accident video in the response unit, hospital emergency rooms, and bus companies. Also, the information will be displayed in information kiosks located within the metropolitan area.

Also in the planning stages is an automated collision notification program along the IH 35 corridor between San Antonio and Laredo. This program involves the placement of cameras along the corridor at a spacing of approximately 8 km (five miles) to identify the numbers of vehicles and injuries involved in incidents along the corridor. The TransGuide operations center would be notified of an accident within seconds and surveillance cameras would automatically fix on the accident. Police, fire, and EMS personnel stationed within the center would immediately dispatch emergency services.

Another program being considered is the international border electronic clearance system. The program would facilitate the movement of legal, commercial and private traffic at highway crossings along the Texas/Mexico border. It involves video pattern recognition, traffic control, and verification of control compliance to identify and separate high- and low-risk vehicles for subsequent inspection or facilitation of border crossing.

Finally, TransGuide is serving as a regional traffic center for most of South Texas, helping to manage traffic in the Laredo, Pharr, and Corpus Christi Districts.

All of these systems will help TransGuide achieve its goals to:

- Manage traffic
- Reduce congestion
- Improve the environment by reducing vehicle emissions
- Increase emergency response time
- Increase safety
- Save money by reducing personal and business delay costs
- Reduce secondary accidents

Most importantly, TransGuide has the capability to save lives. These factors and more are the driving forces that will help TxDOT grow with the Intelligent Transportation System and the technical industry. TransGuide is technology in motion — technology that can help make highways safer for all of us.

For more information, contact TransGuide Public Information Officer Betty Taylor at (210) 731-5223. Also, San Antonio District has produced two videotapes, one for technical audiences and one for the general public, about the TransGuide system. These tapes are available on loan from the Research and Technology Transfer Library. Call Dana Herring at (512) 465-7644.

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TXDOT SHRP ASPHALT PRODUCTS EVALUATION

by **Darren Hazlett**
Supervising Chemical Engineer
Materials and Tests Division
Texas Department of Transportation

The Texas Department of Transportation has a Technical Working Group (TWG) that evaluates the SHRP asphalt products for implementation. This group is responsible for review of all asphalt-related products, which primarily revolve around SUPERPAVE specifications and tests for bituminous mixtures and binders.

WHO IS ON THIS TWG?

The TWG consists of the following people:

- Darren Hazlett — Materials and Tests Division
- Ken Fults — Design Division
- Steve Smith — Odessa District
- Steve Ekstrom — Paris District
- Janan Sahtout — Corpus Christi District
- Wayne Leake — Tyler District
- Victor Piñon — San Angelo District
- Bruce Knipp — Amarillo District
- David Head — El Paso District
- Chris Pankey — Research and Technology Transfer Office
- Jim Cravens — Federal Highway Administration

WHAT IS THE TWG DOING?

The Asphalt Product TWG has targeted the SUPERPAVE performance-graded (PG) binder specification and supporting tests as the first group of the asphalt products ready for evaluation. Equipment is available to perform the binder tests and support the binder specification. TxDOT has one set of this equipment in the Materials and Tests Division and has been evaluating the asphalts supplied under the current viscosity specification.

The SHRP PG grading of binders takes more time than TxDOT's current viscosity-graded specifications. Therefore, we (the TWG) are investigating other methods of quality control for HMAC binders besides batch testing and approval at the source.

Since there is no commercially available equipment to perform the SUPERPAVE mixture tests, the TWG members cannot make a decision regarding the mixture tests and specifications at this time. We anticipate conducting a full evaluation once equipment is available.

ACTIVITIES THIS CONSTRUCTION SEASON

This construction season, we will gather field data to support future decisions regarding quality control and assurance of asphalt binders. We have written a special specification to obtain field samples of binders. We want some districts to use this specification in a few construction projects this construction season, generally one project in three to eight districts.

THE SPECIAL SPECIFICATION

When using the special specification, districts will still specify asphalt material grades under current specifications. PG grades should not be specified in the projects — special field samples will be obtained and tested according to the SHRP protocols, and the binders will be graded by the PG system. This procedure will give us information about what PG grades TxDOT is actually using now, since we can grade all asphalts under the PG system. The information gathered will also tell us about the variability in the test pro-

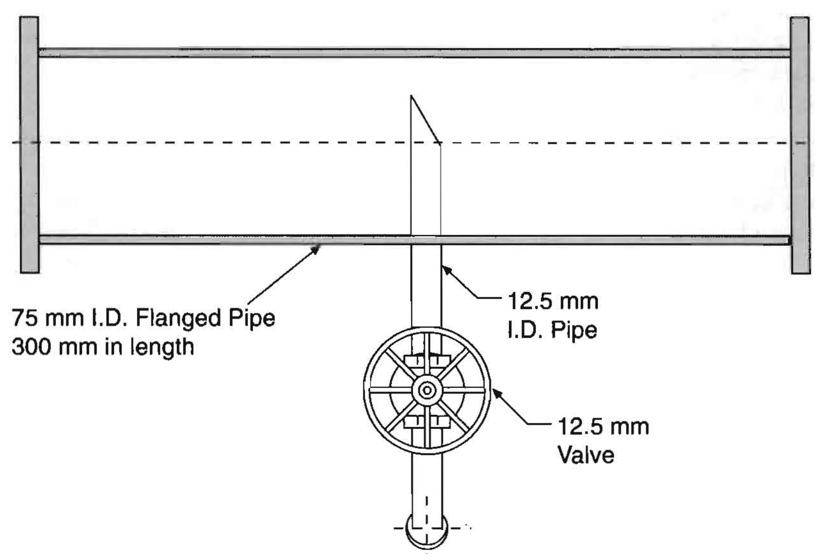

FIG. 1: Asphalt tank sampling port.

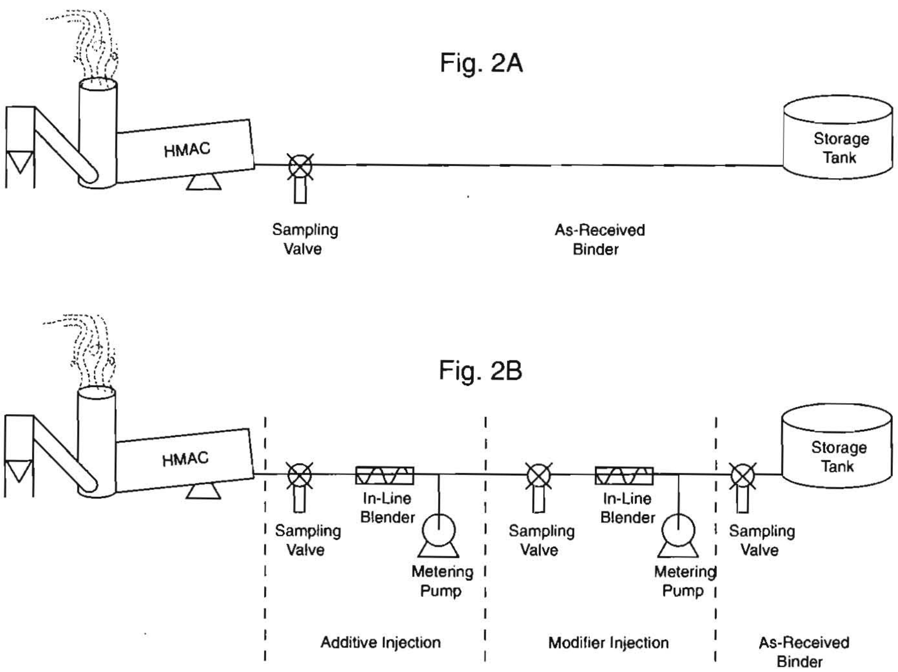

FIG. 2: Two possible situations for the equipment requirements and placements. Figure 2A shows the simplest case, where binder from the storage tank only is used in the HMAC and no additives are injected. Figure 2B shows a more complex case, where a tanked binder has both modifier and additive injection.

cedures and variability in binder supply.

The special specification has been written to fit into a QC/QA HMAC project. It uses the one-per-sublot rate as the rate at which to take binder samples. The Materials and Tests Division will perform SHRP binder testing on these samples.

The specification requires a sampling port in the pipeline for sampling the binder as represented in the storage tank. Also required are a metering pump, in-line blender and sampling port in the pipeline for each additive or modifier to be injected. Furthermore, any antistripping additives must be added downstream from all other materials, i.e., added last.

The sampling port or valve is described in AASHTO T40, Section 9, "Sampling from Pipe Lines During Loading or Unloading," (Fig. 1).

Every time sampling is performed for HMAC sublots, binder samples should be taken at all sampling ports. This method will give TxDOT samples of binders as they progress from the tank to the hot mix unit, the last sample being the actual binder finally incorporated into the mix.

Since sampling will be done for every HMAC sublot at every sampling port, the possibility exists for one project to generate a significant number of samples for analysis. Besides determining the variability of the testing procedures and materials, we will use the data generated to determine an appropriate sampling rate. We hope to learn that sampling can be performed on a greatly reduced scale and still ensure material quality.

INTERESTED?

Several districts have been approached to gauge their interest in incorporating this special specification into a project for this construction season. A few have expressed their interest in participating. The districts approached have generally been those that have a member on the TxDOT SHRP Asphalt Technical Working Group, charged with evaluating the SHRP asphalt products for implementation.

Other interested districts or contractors can contact Darren Hazlett at (512) 465-7352 to check on the status of this program and on their possible inclusion in this data-gathering phase of SHRP binder implementation.

METRIC AWARENESS

Metrication is making great progress in the Texas Department of Transportation. Did you know that in:

- **Right-of-Way**
  - ◊ **Dual Units — You should use dual units (maps/field notes) *ONLY* in items of public interest**
  - ◊ **Utilities - Do our layout in metric. Let the utility company place their utilities in whichever system they choose.**
- **Structures**
  - ◊ **Dimensions — Use meters for layouts and millimeters for bridge details**
  - ◊ **Culverts — Culverts will be sized in 300-millimeter increments. The width range is 900 to 3000, and the height range is 600 to 3000.**
- **Design**
  - ◊ **Plans — Plans will show which spec book (metric or English) applies for bid purposes during the transition.**
  - ◊ **Lane widths — TxDOT has adopted hard conversions for lane widths. In metric design, 3.6-m lanes replace the 12-foot standard and 3.3-m lanes replaces 11-foot ones.**

HOW TO AVOID BRIDGE EXPANSION JOINT RAIL FAILURE

based on
Evaluation of Failure in Bridge Expansion Joint Rails
(CTR 0-1309-1F)

by V. Dolan and Dr. K. Frank
Center for Transportation Research
The University of Texas at Austin

THE PROBLEM

About 10 percent of bridge strip seal expansion joints on Texas Department of Transportation (TxDOT) bridges fail prematurely. Strip seal expansion joint systems are composed of two structural parts: the rail and the concrete deck. Expansion joints can fail in either one of these parts or a combination of both. Not only do joint failures pose a maintenance and durability problem for the structure, but also failed rails can twist up and be a safety hazard to motorists.

Pharr District Office asked Center for Transportation Research (CTR) researchers to evaluate the cause of failure in some bridge joints in McAllen that had been in service only six months. The researchers determined that poor concrete consolidation caused the failure, resulting in unintended loads on the anchorage studs of the rails. This article outlines what they found and what to do to avoid the problem.

AN OVERVIEW OF THE INVESTIGATION

The site

The interchange of US 83 and US 281 at McAllen, Texas, opened in December of 1993. It is composed of four unidirectional ramps. Each ramp contains a mix of simple span AASHTO girders and continuous steel girders. The supporting substructure includes both concrete and steel bent cap systems with concrete piers. Concrete systems are inverted tee bents, hammerhead or tee piers, and concrete beam straddle bents. Decking for all of these structures is 8-inch reinforced concrete with a design strength of 24.8 MPa (3600 psi). Concrete mixes for the decks are standard TxDOT S class with a maximum aggregate size of 38 mm ($1\frac{1}{2}$ inches). All ramps have vertical grade, and most are in horizontal curves with superelevation.

Expansion joints for the interchange are elastomeric strip seals. Joints consist of rails located on each side of the expansion area. A rubber seal attaches to both rails to prevent drainage at the joint. The rails are steel and are held in place with 152 mm (6 inch) by 13 mm ($\frac{1}{2}$-inch) diameter studs cast in the concrete. No weep holes were present to allow the escape of air or bleed water out of the concrete. Figure 1 shows a cross section of rail and strip seal. Studs are attached alternately to the top and side of the rail at 305 mm (12 inches) on center. Typical spacing of the joints was every three spans in the concrete section (approximately 91.5 m [300 feet] between joints) and at ends of each continuous steel girder unit. The arrangement of expansion joints varied depending on the substructure type. The design used only one expansion joint on inverted tee bents and two units at steel box girder bents (Fig. 2).

Inspectors located distressed joints by either listening for a loud "clanking" noise as traffic passed over the joint or by watching for joint movement under passing traffic. Once all the distressed joints were identified, the contractor removed a 305 mm (1-foot) section of the concrete around the joint with jackhammers.

The researchers observed and recorded the condition of the joints during removal. They slated a section of roadway at Pier 22 along ramp 2 for "careful removal" (the rail and surrounding to be removed intact). This block was shipped to Ferguson Structural Engineering Laboratory at The University of Texas at Austin for full analysis.

The contractor removed exposed joints and replaced them with new joints. The new joints conformed with new TxDOT standards of 16 mm ($\frac{5}{8}$-inch) studs and 13 mm ($\frac{1}{2}$-inch) weep holes drilled along the top of the rail.

Summary of Field Observations

1. Areas of voids between the rail and concrete bridge deck showed a direct correlation to the locations of stud failures.
2. Bending over of studs did not result in fracture in areas near where studs had failed. This simple test indicated that the welds were of reasonable quality and the studs did not contain significant fatigue cracks. (Laboratory analysis bore out this observation.)
3. Congestion of reinforcing steel at the rails aggravated the lack of

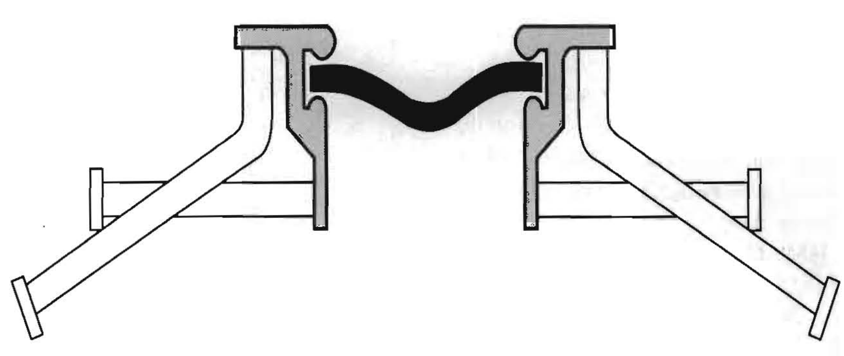

FIG. 1: Typical strip seal expansion joint with seal and anchorages.

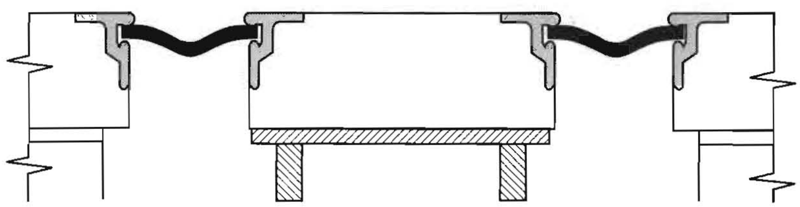

FIG. 2: Arrangement of expansion joints at steel bent caps.

consolidation of the concrete. Voids in the concrete were visually observable at the vertical surface, at the end of the slab, and under the rail.

4. Voids in the concrete and the rails that had fractured studs were at the upper end of the slab in most cases. The tendency of plastic concrete to flow away from the rails probably aggravated poor consolidation of the concrete.

Laboratory Analysis

Researchers widened the sample by testing rails that had failed after six months from two bridges in the Austin District as well as rails from McAllen. They also evaluated a section of rail from another research project. This rail had been subjected to static loading in the laboratory and had performed acceptably. Testing of the rail sections, studs and welds showed no predisposition of the rails to failure. The steel makeup and stud welding appeared to be of uniform consistency and acceptable quality. Although failure of the expansion joints expressed itself in the rails and studs, this is a secondary effect induced by problems with the concrete placement.

An evaluation of the insitu strength of the slab concrete was performed on the roadway section using a Schmidt or rebound hammer. The results averaged a concrete compressive strength of 30.3 MPa (4400 psi.) The Schmidt test may not be as accurate as a core test, but it is sufficient to show that there was not a localized reduction of concrete strength in the roadway section.

CONCLUSIONS AND RECOMMENDATIONS

The joint systems in the McAllen structures failed because of a lack of complete concrete consolidation under the joint rails. Several factors contributed to incomplete consolidation of the concrete including: lack of weep holes, incorrect form placement, and less-than-optimal pouring sequence.

Recommended Procedure

- Use the new TxDOT standard of 16 mm ($\frac{5}{8}$-inch) studs and 13 mm ($\frac{1}{2}$-inch) weep holes drilled along the top of the rail. Weep holes in the top flange of the rail are necessary to allow for excess air and bleed water to escape from underneath the rail. The holes also act as a method of quality assurance. The presence of concrete in these holes after concrete placement indicates the presence of concrete under the rail.
- Use correct form placement at the ends of the slab. Forms must be placed so that concrete can get under the lower lip of the vertical flange. You may need to overfill this region with concrete, vibrate it, and strike it off in order to get enough material under the lip.
- Consider concrete flow problems when you work out the pouring sequence of a slab, especially on sloped bridges. The pouring sequence used on the McAllen bridges was typically downhill, which is not the best concrete practice. This downhill flow of the plastic concrete pulled concrete away from the inside of the joint rails and resulted in detrimental voids. A better pouring sequence would have been to start at the lowest point of the slab and pour to the highest point as required in the TxDOT specifications for concrete placement.
- Use standard rebar spacing. Congestion of the slab reinforcement at the rail makes it difficult to place and consolidate concrete correctly.
- Vibrate the concrete adequately. Proper vibration is the key to good concrete consolidation.

In the rush to get a slab pour started or finished, crews may sometimes accidentally neglect to consolidate the concrete around the ends of the slab at the expansion joints. Bridge inspectors occasionally may need to remind crews that most premature expansion joint rail failures can be avoided by knowing and using good concreting practice. It is cheaper for everyone and safer for the traveling public if the expansion joint rails are installed right to begin with.

For more information, contact Randy Cox, P.E., (CMD) at (512) 416-2189 or Mark Bloschock, P.E., (DES) at (512) 416-2178.

DID YOU KNOW...

The National Pavement Association, along with the Asphalt Institute, the FHWA and AASHTO, is sponsoring the Third annual U.S. Hot Mix Asphalt Conference in Dallas November 29 through December 1. The Harvey Hotel at the Dallas/Fort Worth Airport is the site.

Topics include the impact of metrication, an update on SHRP Superpave, and the latest in asphalt construction techniques.

For more information, contact LaDonna Burton of the National Pavement Association at (301) 731-4748; fax (301) 731-4621.

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