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16. Abstract
Accelerated Pavement Testing has become an important part of pavement research and validation of pavement and materials design concepts worldwide. In 1990, the Texas Department of Transportation undertook the design and construction of the Texas Mobile Load Simulator (TxMLS). TxMLS has the capability of applying a large number of uniform load applications to a pavement section, either normal field sections, or specially constructed test sections. In 2000, TxDOT elected to develop a permanent test site for the TxMLS to be designated the Texas Accelerated Pavement Test Center (TxAPT). This report outlines the first year of operation of the TxAPT Center.

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First-Year Annual Operating Report for 2002

W. Ronald Hudson
Ron White

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Research Project: 5-1924-01
Research Project Title: *Implementation of a Fixed Site for the TxMLS-Extension*

This research was conducted for the Texas Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration by the Center for Transportation Research, Bureau of Engineering Research, The University of Texas at Austin.

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and his support staff for all their hard work involved in accomplishing the first year of setting up the Texas Accelerated Pavement Test Center.

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Executive Summary

Accelerated Pavement Testing has become an important part of pavement research and validation of pavement and materials design concepts worldwide. In 1990, the Texas Department of Transportation (TxDOT) undertook the design and construction of the Texas Mobile Load Simulator (TxMLS). The TxMLS has the capability of applying a large number of uniform load applications to a pavement section, either normal field sections or specially constructed test sections.

The TxMLS device is capable of applying several hundred thousand-load applications per week with loads ranging from 10,000 lbs up to 48,000 lbs on a set of tandem axles. From 1991 to 1999, the TxMLS was used to evaluate existing in-service pavements in Victoria and, more importantly, four major test sections near Jacksboro, Texas. In 1999, a complete renovation of the TxMLS was undertaken, since it had fulfilled its original design life on field test sections. This renovation was undertaken to address several observed problems and improve the performance and reliability of the MLS device. Some of the major improvements include:

- New axle bogies
- New drive chain mechanism
- Reposition (lower) the two drive motors on separate support cradles
- Rebuild the load rails
- Redesign the load wheels and associated bearings
- Install new strain gauge system for monitoring tire loads
- Hydraulic system to set axle loads

The new hydraulic system allows operators to apply more uniform loads and set the loads more quickly than before. The heavy drive motors have been moved to separated cradles that position them closer to the ground.

In 2000, TxDOT elected to develop a permanent test site for the TxMLS to be designated the Texas Accelerated Pavement Test Center (TxAPT). Proposals were requested from several universities within the State. After review and resubmission of proposals on three separate rounds of consideration, a proposal submitted by the Center for Transportation Research at The University of Texas at Austin was selected for funding. It was determined that the fixed site

location for the TxMLS would be at the University of Texas' J. J. Pickle Research Campus (PRC) located in northwest Austin. A description of the location and the related facilities are included in Appendix A.

In addition to setting up the fixed TxAPT Center, it was also decided to maintain the mobile capability of the MLS. Therefore, all support equipment for mobile operations, including generators, fuel tanks, repair trailers, mobile instrumentation, weather stations, etc., would be maintained in working order for the foreseeable future.

First-Year Annual Operating Report for 2002

1. Creation of the TxAPT Center

Upon acceptance of the proposal from the Center for Transportation Research (CTR), funding was provided by the Texas Department of Transportation (TxDOT) from several sources within its research program in order to commence operation of the Texas Accelerated Pavement Test Center (TxAPT) in mid-January 2002. Many groups within TxDOT are involved in the operation of TxAPT. However, it was ultimately decided that during its first year of operation, the Center director would report to Dr. Mike Murphy, a representative of the Pavement and Materials Section within the Construction Division, and Dr. German Claros was selected as the Project Director, representing the TxDOT Research and Technology (RTI) Section that was providing the operating funds for the TxAPT Center. The TxAPT Center is being developed under Implementation Project 5-1924-01, titled "Implementation of a Fixed Site for the TxMLS". Funding for the TxAPT Center is provided on a fiscal year basis, and effective September 1, 2002, funding was provided as an extension under the same project number and title.

Additional funding was to be provided under Project #0-9900, however that funding would commence during calendar year 2003 (Fiscal Year 2003-2004).

This first formative year of the TxAPT Center has included interaction with many individuals from TxDOT, and provided information and coordination with the TxAPT staff. Key individuals include:

- Dr. Dar-Hao Chen, CST, TxDOT
- Mr. Mike Finger, CST, TxDOT
- Ms. Caroline Herrera, CST, TxDOT
- Mr. Paul Krugler, Director, RTI, TxDOT
- Mr. John Bilyeu, CST, TxDOT
- Mr. Cy Helms, CST, TxDOT
- Mr. Thomas Bohuslav, Director, Construction Division, TxDOT
- Mr. Greg Cleveland, CST, TxDOT

- Mr. Mark McDaniel, CST, TxDOT
- Mr. Steven Smith, BRG, TxDOT
- Mr. Andrew Wimsatt, TxDOT, Fort Worth
- Dr. Mike Murphy, CST, TxDOT

In addition to the names specifically mentioned above, numerous other people contributed to the initiation of the TxAPT Center. We regret if any names have been inadvertently omitted.

2. TxAPT Center Staff

Originally, CTR proposed Dr. W. R. Hudson to work half-time as director of the TxAPT Center. Dr. Hudson prepared the original proposals and modifications in concurrence with the TxDOT team, which made the initial selection. The original proposal and its revisions carefully specified and documented the need for a full-time research engineer to work on the development of the TxAPT Center and, subsequently, to work with and support individual projects to be carried out at the TxAPT Center by other research agencies. In this regard, it should be remembered that the TxAPT Center is set up as a completely open shop and that each project after the Pilot Study will be carried out by an appropriate research agency selected and funded by the TxDOT Research Management Committee (RMC-1) upon the recommendation of the Pavement TAP. It was also carefully documented and approved that a full-time administrative associate was needed to carry out the administrative work and database-related activities for the TxAPT Center. The breadth and detail of the technical and administrative activities required in developing and operating the TxAPT Center are such that it is imperative to retain the full-time services of a qualified administrative associate.

Additional staff recommended for the TxAPT Center would be occasional special services from research professors at The University of Texas at Austin (UT/Austin), such as Dr. Jorge Prozzi, Dr. Zhanmin Zhang, and graduate students to be supported when and if their contributions would add directly to the success of the TxAPT Center.

In April 2002, Dr. Hudson, along with CTR Director Dr. Machemehl and Executive Director/CTR Mr. Rob Harrison, interviewed a number of applicants for the position of full-time research engineer. While several qualified applicants were interviewed, we felt

especially fortunate to have the opportunity to interview and subsequently hire, Mr. Ron White, who holds a Master's Degree in Pavement Engineering at UT. Mr. White has more than 10 years of experience in pavement-related research, instrumentation, engineering and technology. His thesis involved accelerated testing of a concrete pavement slab at the J. J. Pickle Research Campus (PRC) under the direction of Dr. Hudson.

For administrative activities, we were equally fortunate to attract, Ms. Sharon Campos, who had previously served as administrative associate in the Superpave Project for the Strategic Highway Research Program (SHRP), and for the Superpave Center at UT/Austin.

In addition to the permanent staff and the faculty and graduate students discussed above, the TxAPT Center has access to permanent staff at CTR for advice on computers, data processing, data handling, Web sites, etc. Particularly valuable in this regard is Dr. Tom Rioux, who has worked with us on website related data activities at no cost to this project.

The TxAPT Center has also provided 2-4 members of the Mobile Load Simulator (MLS) operating crew during 2002. At the beginning of Fiscal Year 2002, we provided 4 members; currently, at the end of the year we are providing two members of the MLS operating staff, who are in the process of rehabilitating the device.

3. Operating Advisory Group

In our initial proposal to TxDOT, we strongly recommended the appointment of the Operating Advisory Group (OAG) for the TxAPT Center. This recommendation was approved and the OAG was set up in January 2002. The members of the OAG are as follows:

- Virgil Anderson, Consultant
- German Claros, RTI, TxDOT/Austin
- James Freeman, TxDOT
- John Harvey, University of California/Davis
- Ronald Hudson, Director, TxAPT, CTR, UT/Austin
- Paul Krugler, Director, Research & Technology Implementation Office, TxDOT

- Dallas Little, TEEX, Texas A&M University
- Carl Monismith, University of California/Berkeley
- Mike Murphy, CST/M&P, TxDOT/Austin
- Soheil Nazarian, Professor, University of Texas/El Paso
- Tom Scullion, Research Associate, TTI/Texas A&M
- Ken Stokoe, Professor, UT/Austin
- Ron White, Research Engineer, TxAPT, UT/Austin
- Tom White, Professor, Mississippi State University
- Andrew Wimsatt, TxDOT/Ft. Worth

Members of the OAG were selected to represent (1) key pavement interests within TxDOT, (2) representatives of at least two other universities in Texas that have significant pavement research programs, and (3) at least three outside members who could bring to our activities knowledge of work at other accelerated pavement test facilities. During 2003, the OAG was co-chaired by Dr. W. R. Hudson, director of the TxAPT Center and Dr. Mike Murphy, coordinator of the TxMLS program, CST/M&P/TxDOT. During 2002, the OAG met twice to review our program and make suggestions about its direction. Their counsel has been invaluable in the development of the TxAPT Center, and the minutes from the two OAG meetings are reproduced in Appendix B and Appendix C, attached hereto.

4. Open Shop Operation of TxAPT Center

In its initial presentation of proposals to develop the TxAPT Center, the Center for Transportation Research strongly recommended and proposed that an "open shop" operation be developed at the TxAPT Center. This means that CTR does not intend to try to dominate or carry out all, or even a majority, of the research to be done at the TxAPT Center. Rather, it is our intention to operate the TxAPT Center in cooperation with TxDOT, and after its initial formulation and pilot testing, to recommend research topics and projects to the Pavement TAP and RMC-1 for funding and issuance of request for proposals (RFPs). These RFPs will be distributed to all research agencies that work for TxDOT and selection of winning agencies will be done in accordance with normal TxDOT/RTI procedures.

It was determined that an initial Pilot Study should be carried out to test the operation of the renovated MLS and to finalize the details of the permanent facility. It was recommended that Dr. Hudson serve as the research supervisor for this Pilot Study. However, in order to maintain a completely open and unbiased shop, neither Dr. Hudson nor key members of the TxAPT Center staff will submit proposals to carry out individual research projects within the TxAPT Center, unless they are specifically requested to do so by TxDOT and RMC-1 for special technical reasons. The TxAPT Center will work closely with research representatives on the OAG, which include Drs. Tom Scullion/TTI, Dallas Little/TTI, and Soheil Nazarian/UT El Paso, to ensure that they and all other university researchers have full opportunities to carry out research work at the TxAPT Center.

There had been some speculation that it might be desirable to phase in part-time staff in setting up the TxAPT Center, because no active research would be carried out during the first year. In fact, that has not the case, as has been proven beyond doubt during the past year. The numerous activities of moving the MLS to Austin, setting up a temporary facility, designing and constructing the initial permanent facility, working with the OAG, and holding more than fifty individual meetings with various groups and subgroups of TxDOT have absorbed all of the available time and energy of the TxAPT Center's permanent staff. In addition, we have undertaken the development of a basic library of work done by other accelerated pavement test centers, reviewing available instrumentation, coordinating with other universities, such as the University of Houston (Dr. Richard Liu), UT El Paso (Dr. Soheil Nazarian), and numerous other activities necessary for start-up.

While some have the impression that the permanent facility could be constructed and testing could begin within a 6-month period, that is not realistic. The redesign and final renovation of the MLS equipment itself was still underway as of December 31, 2002. Significant progress has been made and it is anticipated that the equipment will be turned on in a February 2003 timeframe. In addition, it has been essential that all of the administrative activities associated with site selection, approval, construction plans and drawings, and approval through UT and TxDOT channels be carried out. Planning, design, and construction of a typical highway facility takes from 3-7 years from inception to completion. While the construction of the TxAPT embankment and test pavement is a small project, it nevertheless has all the elements of a highway construction project.

Furthermore, it requires intensive review and coordination with a wide variety of groups at TxDOT and UT. We have worked diligently to coordinate all of these activities and expect that bids for construction will go out in February 2003. While we can all wish that things would move faster, we believe that the process has moved with reasonable speed. In November 2002, correspondence to the director of the TxAPT Center and TxDOT RTI Director Mr. Paul Krugler, TxDOT Director/Construction Division Mr. Thomas Bohuslav, and under whose aegis the MLS has operated, outlined that he hoped and felt that initial testing could be carried out in late spring 2003. We believe this predicted timeframe will be fulfilled and have worked diligently toward that end.

5. Contents of this Report

Since this is an annual operating report for the TxAPT Center, after presenting the background above, we will then present a more or less chronological history of the activities carried out in the development and operation of the TxAPTC. We will limit ourselves in individual discussions to elements key to the operating activities. Not documented will be the many daily discussions among TxAPT staff, individual meetings with representatives of TxDOT, discussion of individual elements of the proposed test facilities and hundreds of other details that have been pursued. On a daily basis, the TxAPT Center staff discusses specific elements of its operation. We answer scores of emails and provide administrative answers to contractual questions through the CTR project administration staff.

As of this writing (March 1, 2003), TxAPT met many times with Dr. Virgil Anderson who, although he has billed only 2 days as a paid consultant, has contributed many additional free hours of advice on variability within accelerated pavement test sections and how this can be utilized to gain maximum amounts of information from each individual test. Dr. Randy Machemehl, Mr. Rob Harrison, Nancy Armstrong, and the CTR staff have contributed extensive time and effort to the success of the TxAPT Center. These are required and normal activities for the development of a new center of this magnitude and we thank them for their contributions and want to acknowledge how valuable they have been in the work to date.

The CTR research administration, and the TxAPT Center staff are fully committed to the successful development of an accelerated pavement test center for TxDOT and to

working with all researchers and appropriate groups within TxDOT to fulfill this goal and obtain maximum benefit for the citizens of the State of Texas.

6. Temporary Site for MLS

On May 8, 2002, TxDOT's Dr. Claros and Mr. Holms, and TxAPT's Dr. Hudson and Mr. White visited the MLS rehabilitation site in Livingston, Texas, with representatives of TxDOT. We had an opportunity to see the on-site renovations of the device, and to discuss the progress with the MLS operating crew. At that time, it appeared that the support from the contractor (RGB) for the redesign and modifications was not proceeding very rapidly. Upon our return to Austin, we discussed the possibility of moving the device to Austin with Dr. Mike Murphy, so the entire crew and RGB could work under closer supervision by TxDOT. Although the contract did not provide for CTR to develop a temporary location for the MLS, our staff worked with the Physical Plant Facilities group at PRC and the Ferguson Research Laboratory, and located a site that could be cleared and paved for continued rehabilitation of the MLS 2002.

In July 2002, the temporary site was paved with TxDOT project funds, and the MLS was moved to the temporary site at PRC on August 13.

The process of selecting the temporary site took into consideration the size of the MLS, as well as the space required by the associated equipment. A "Shakedown" test will be conducted at the temporary site and some of the support equipment, including the generators, control trailer, and supply trailer must be set up within 200 ft of the MLS.

Permission was obtained to temporarily locate the TxDOT MLS on property controlled by Ferguson Labs at PRC. This property, which is located north and east of the construction bullpen access gate, and west of Neils Thompson Drive (Figure 1), is currently used by Ferguson Labs to store surplus materials and items awaiting disposal. CTR rearranged and removed these materials to make room for the MLS and related equipment. This work was carried out under the guidance of a Ferguson Labs representative.

In addition to the site cleanup, a section of the site was overlaid with asphalt. This improvement will allow a "Shakedown" test to be performed after the MLS is fully assembled. The proposed construction included installing an asphalt overlay extending from the north side of the construction bullpen gate to the gore point where the spur road

and Neils Thompson Drive meet, plus a segment from Neils Thompson Drive to the bullpen gate. This work included the following (Figure 1):

1. Clean existing surface of loose stones and remove vegetation from the area to be paved.
2. Roll the prepared surface, as needed, to recompact loose material.
3. Apply a prime/tack coat and level up, as needed, to cover exposed base material and produce a consistent pitch (cross slope). The final cross slope will not exceed 1% nor vary by more than 10% over the length of the section.
4. Apply a tack coat to the resulting surface and lay 1.5 inches of asphalt over the entire section with tapers as shown for transitions to existing surfaces.
5. Remove and dispose of all waste material and excavated material and clean up the site.

Type D asphalt with a maximum aggregate size of 3/8″ was laid. The final asphalt thickness varies along the length of the site as shown in Section A-A and Section B-B, (Figure 2) from 1.5″ up to a maximum thickness of 5-6″. This design reduced the variable cross slope over the length of the site.

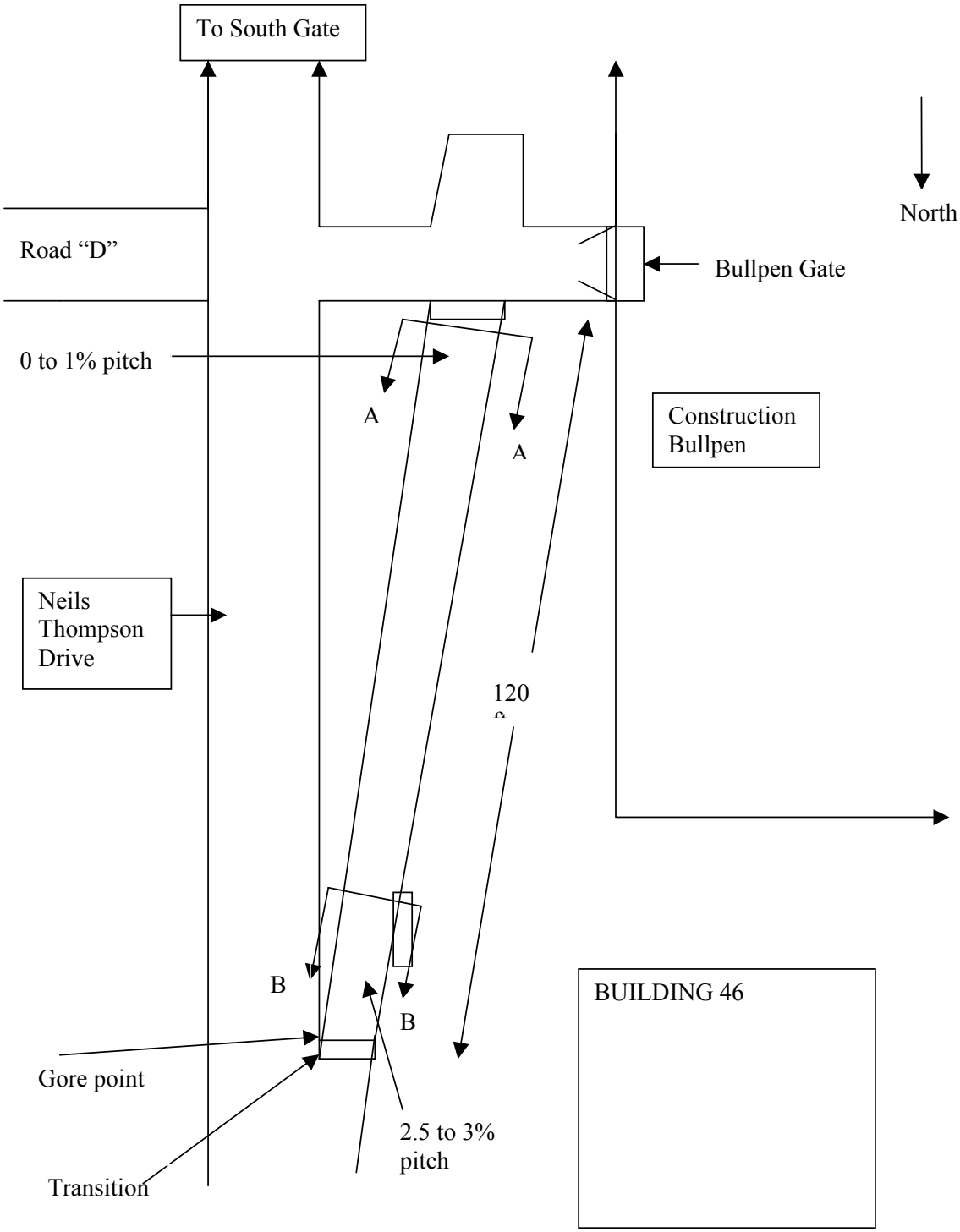
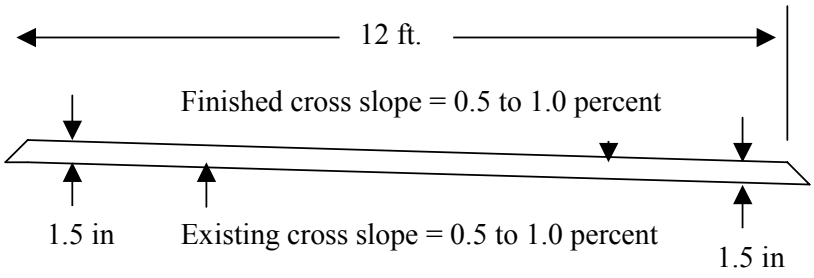
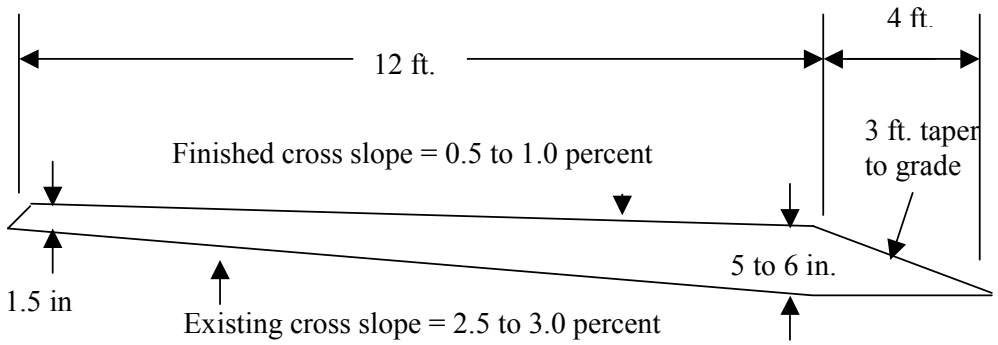


Figure 1. Temporary site work diagram



Section A-A. Transverse profile of ACC overlay.



Section B-B. Transverse profile of ACC overlay.

Figure 2. Transverse profiles of MLS sections

After moving the MLS to the TxAPT embankment, provisions will be made to repair any damage done by the MLS to the temporary site, in order to return the site to an acceptable condition.

7. Equipment Storage

TxDOT has provided a list of support and data collection equipment assigned to the TxMLS branch. Some of this equipment was moved to the temporary site during the completion of the system assembly and shakedown, and is shown on the temporary site layout diagram (Figure 3). Other equipment did not need to be on site and was stored by TxDOT, pending the completion of the TxAPT embankment. A few items were stored

locally, as this equipment was used fairly frequently. The storage location of the MLS support equipment is shown below.

Support Equipment	Storage Location*
• Crew trailer for MLS operation	On site
• Wells Cargo Repair Trailer	On site
• 1-1/2 ton utility truck	On site
• 400 kW generator	On site
• 100 kW generator	On site
• Lincoln welder on trailer	On site
• Portable welder	On site
• Portable air compressor	On site
• 4 Transporter dollies	PRC
• Grove TMF 25 ton crane	PRC
• 12,000 Gal. Fuel Trailer	TxDOT
• IH truck. Used to move the MLS short distances	TxDOT
• Core rig trailer	TxDOT
• Data collection Equipment	TxDOT
• Dynatest FWD (1)	TxDOT
• Portable seismic pavement analyzer {PSPA} (1)	TxDOT
• Transverse/longitudinal profile beam (1)	TxDOT
• Dynamic Cone Pentrometer (1)	TxDOT
• Multi-Depth Deflectometer (1)	TxDOT
• Automatic Crack Monitoring system (1)	TxDOT
• Load cell weigh-in-motion system (1)	TxDOT
• Weather station (1)	TxDOT

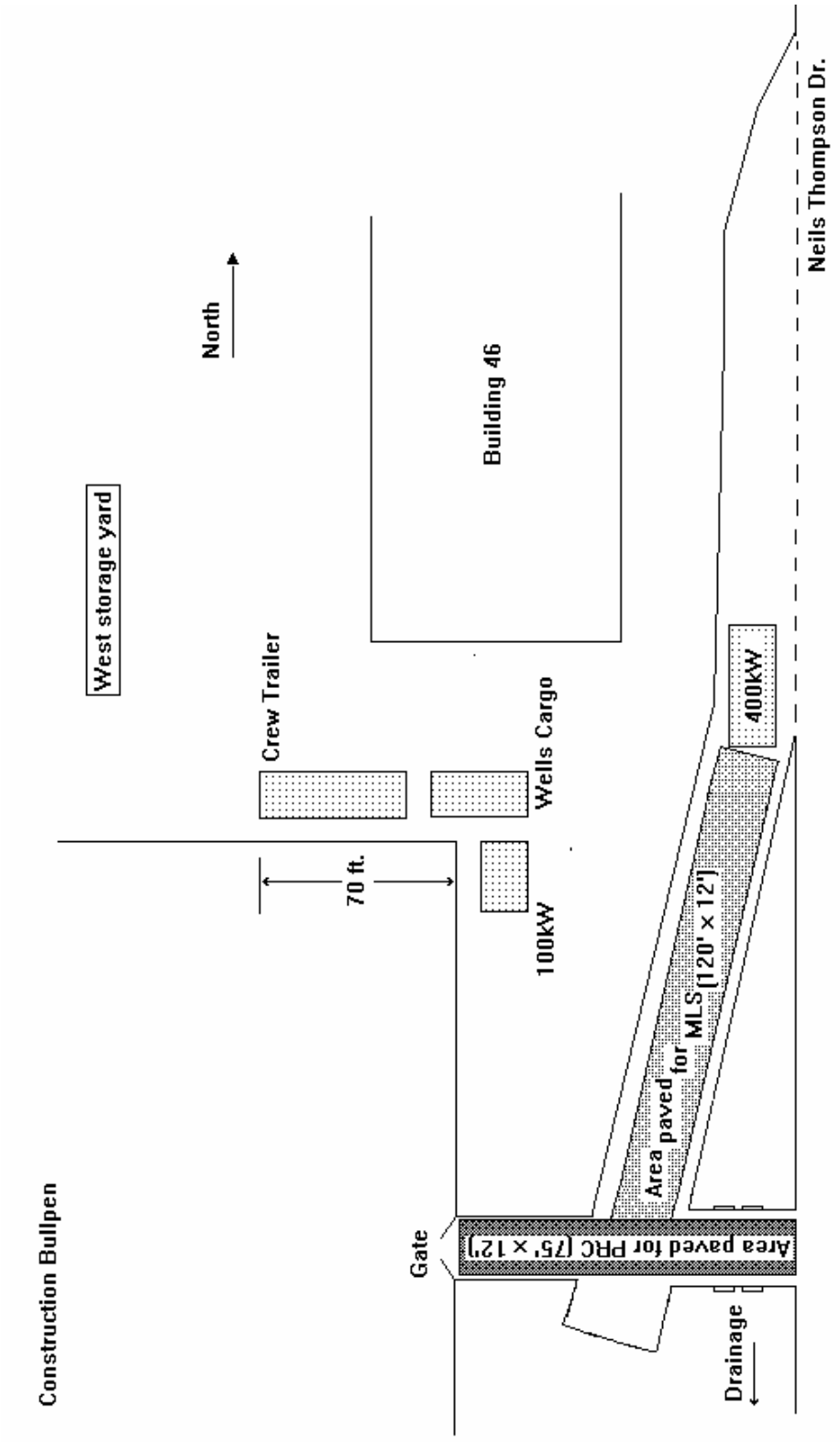


Figure 3. Temporary site layout

Since the relocation of the MLS to PRC, good progress has been made with the renovations. TxDOT has renegotiated its arrangements with the RGB Company and a representative is on-site supervising the renovation work. Additional modifications have also been made. The power rails have been lowered to provide more direct contact, and the drive shafts have been modified to account for projections previously not covered.

8. Design of the Permanent MLS Test Embankment

In its original proposal, TxAPT presented up to five possible locations for the permanent APT facility at PRC. Next was the task of selecting one of these locations for actual construction. This activity involved extensive discussions with representatives of Physical Plant at UT/Austin. While the contract for TxAPT calls for a 5-year facility, we desire to provide a facility that could be used for a longer period if TxDOT deemed it appropriate. The UT Physical Plant has a long-term plan for all UT land and it was necessary to carefully coordinate to obtain a facility that was both satisfactory for our use, but would not necessitate moving the facility prematurely should TxDOT desire to continue its operation.

It was also necessary to have appropriate, but not be excessively steep drainage, because an embankment with a relatively flat configuration to minimize the effect of surface slope on the pavement test results was needed. It was also necessary to drill boreholes at the various sites to ensure that bedrock did not occur too close to the surface, and thus cause interference with the pavement test results and the evaluation of the materials properties using Falling Weight Deflectometer (FWD), which is sensitive to bedrock depth.

Ultimately, two sites were selected for final consideration. Initially, the team felt that a site just south of Road "D" on the south end of PRC would be most appropriate. An alternate site was selected north of Road "D" and just east of Neils Thompson Drive. After additional testing of bedrock and coring to a depth of 20′ it was determined that the secondary site was preferable to the initial site. It met fully the characteristics desired for the construction and, more importantly, it showed no bedrock to a depth of 20′.

This site was presented to TxDOT and three to four meetings were held with various representatives. Initially, some of the representatives felt that the site was too narrow and there was great discussion of the possibility of including two subgrades into the initial

construction. After significant discussions and recommendations, and detailed discussions with the TxDOT Materials and Test Group, a construction plan was finally approved for an embankment 75′ wide and 350′ long at the secondary site, as shown in Figure 4**.** It was determined that if, and when, a second subgrade was desired, it could be added to the east side of the initial embankment construction. This might necessitate excavation of the back slope and the importation of some materials; however, there was strong consensus opinion and also support by the OAG to settle for a single subgrade in the initial construction. Cost was also a factor in the considerations.

The clay at the current site is a dark gray heavy clay with a liquid limit in the range of 55 and a plasticity index in the range of 35. This clay provides a medium-strength subgrade characteristic of much of Texas that can be constructed with a selected water content and density to provide the strength desired for much of the testing for the first 5 years of the TxAPT Center's operation. It was also decided during the many meetings discussing the construction of the embankment to include a 1.5% grade transversely from the embankment centerline and longitudinally sloping down toward the south with a grade 1.5% (Figure 5**)**. This allowed the embankment height to be minimized, as well as the construction cost to be minimized.

At first it was expected that significant additional heavy gray clay would have to be borrowed off-site to construct the embankment. However, arrangements have been made with the PRC Physical Plant to borrow sufficient gray clay adjacent to the current site and replace it with fill brought in from a materials supplier. This not only ensures uniformity in our embankment, but also minimizes costs because early indications suggest that select borrow will be cheaper than trying to locate, purchase, and process a select clay with the needed characteristics. This is due to an economy of scale because no one processes select clay, but many sources provide a higher-quality select borrow at low costs.

As soon as the project was approved, TxAPT began the detailed search for an exact site at PRC. This required specific negotiations with the land use committee of the UT System Board of Regents. CTR and TxAPT also did coring and surveyed the choice locations. This process took approximately six months and resulted in a favorable permanent site location.

Beginning in June 2002, the TxAPT staff, led by Mr. Ron White, began preparing the plans and specifications for the embankment. These initials draft plans were presented to TxDOT for review. They were reviewed by the TxDOT Construction Division under the leadership of Mr. Thomas Bohuslav with the idea of possibly obtaining an existing TxDOT contractor to carry out the construction. After reviewing the legal aspects, Mr. Bohuslav notified all parties that it would be impossible for TxDOT to supervise the construction of this facility because it was not on a normal TxDOT right-of-way. The preliminary plans were reviewed, with comments provided by Mr. Mark McDaniel, Ms. Caroline Herrera, and others in the Materials and Test Division.

After the final site was selected, TxAPT and UT staff undertook detailed coring and materials investigations. Numerous meetings were held with the sponsors to consider initial designs and layouts for the test pads. After several reviews, a final finished layout of 75' x 350' was solicited as the proper size by consensus with the sponsors. TxAPT did numerous initial trial layouts and after approval, turned the final sketches over to UT Physical Plant to begin final design, plans and specification preparation.

In November 2002, work began to select a consultant to take the preliminary plans and specifications and turn them into contractual documents that could be awarded as a contract by UT. Smith-Western Engineering Company was selected for this purpose because it is familiar with relatively small-sized projects, and has worked with TxDOT representatives on many such projects at small airports around the state. It has provided preliminary recommendations and information to the staff, and expects to provide the final contract documents for review in February 2003. A meeting is planned at that time with all interested TxDOT representatives and UT Physical Plant personnel so everyone can provide input into the final design details of the facility. This is important because the facility will be used for the next 5 years for major pavement research that is important to TxDOT.

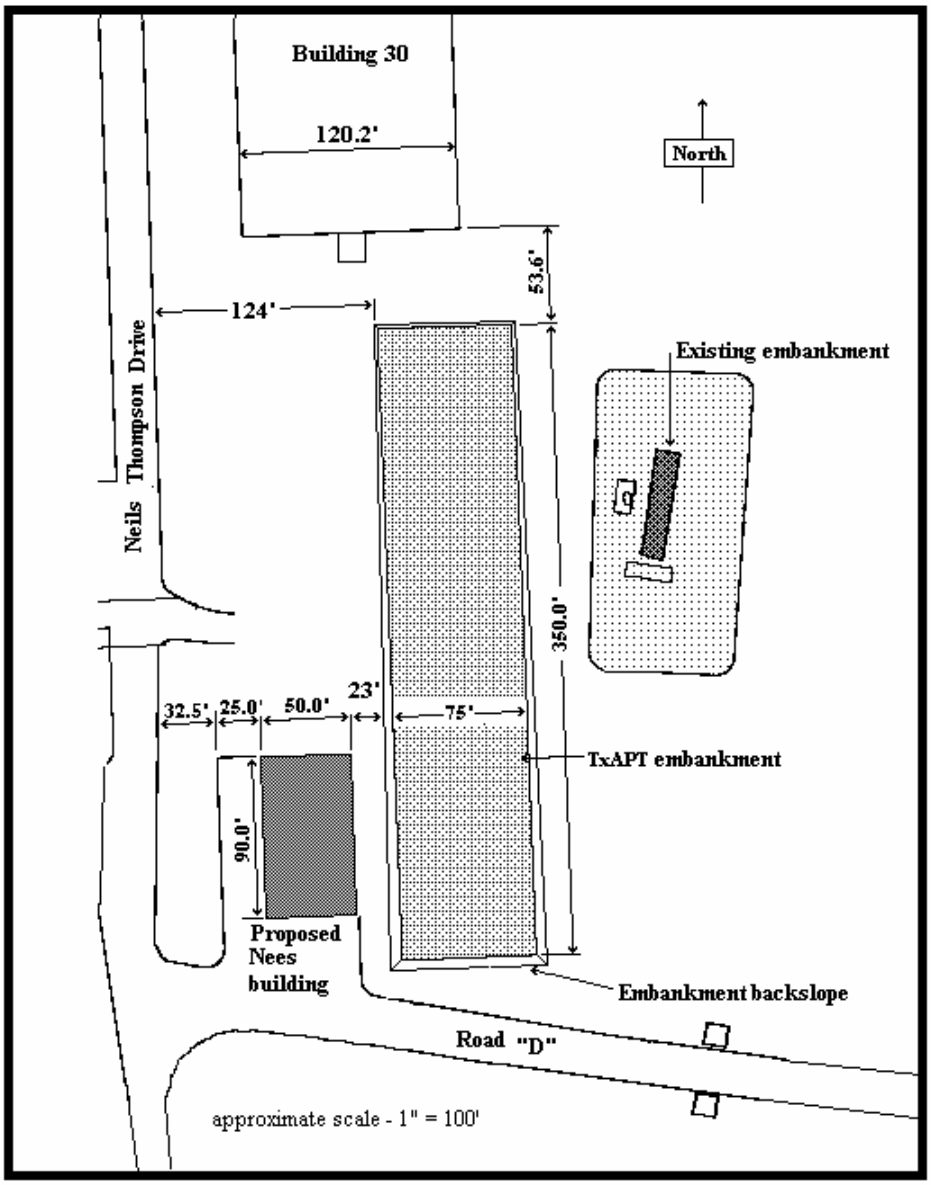
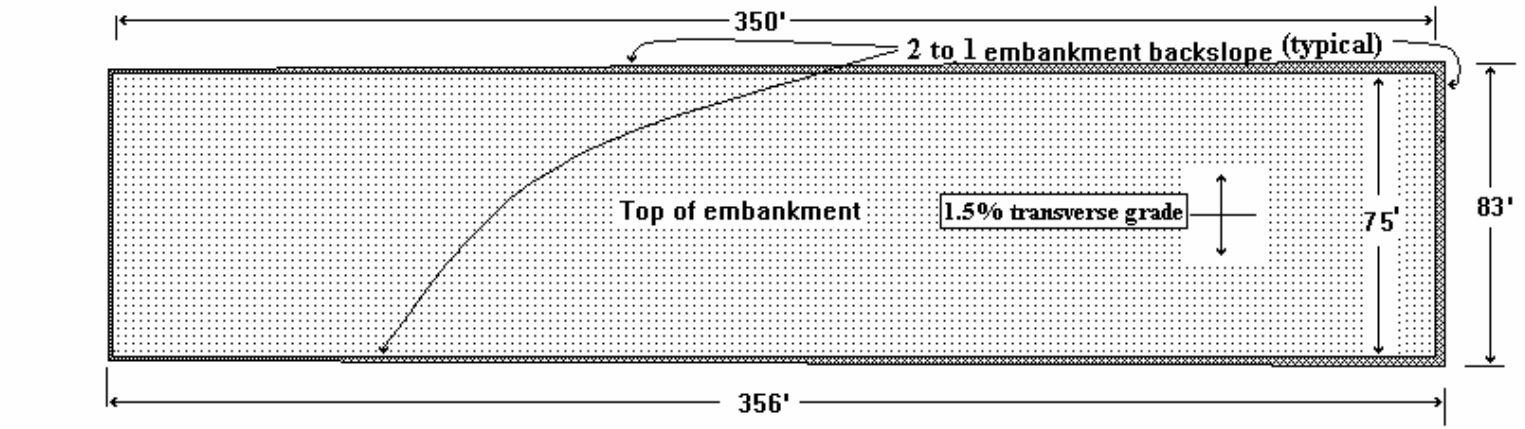
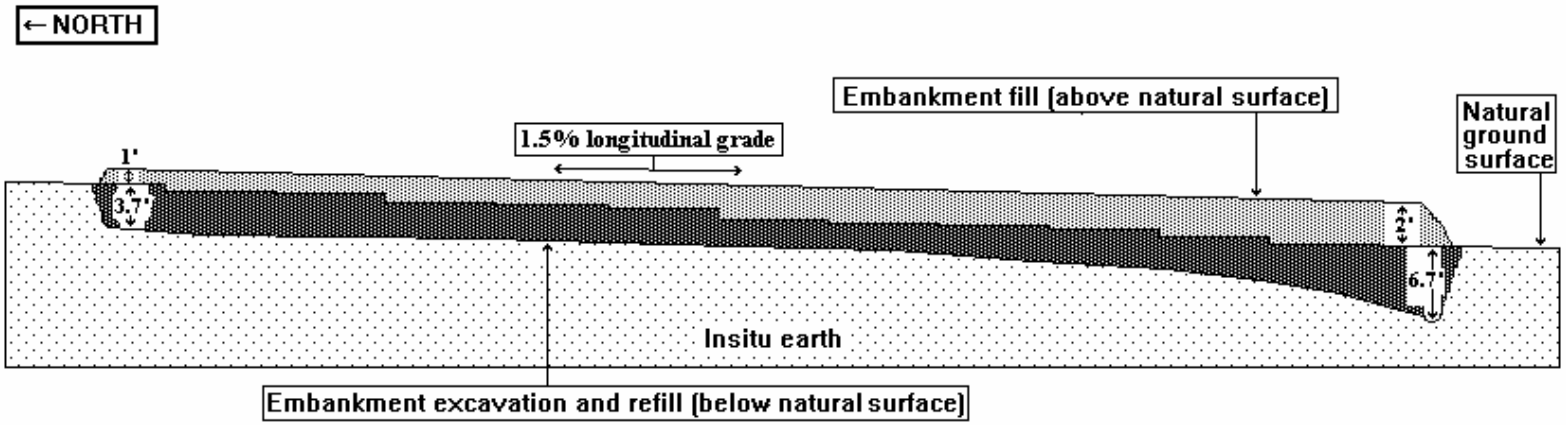


Figure 4. TxAPT PRC site layout, Option 1



Plan view of TxAPT embankment.



Profile of TxAPT embankment showing cut and fill.

Figure 5. Embankment

9. Five-Year Strategic Plan for the TxAPT Center

In August 2002, the TxAPT Center staff prepared a draft 5-Year Strategic Plan for consideration by TxDOT and the OAG. That document describes a plan for work to be completed by the TxAPT Center and its partners under the direction of TxDOT. TxDOT funds this work on an annual basis, as previously discussed.

The program is organized to allow for leveraging of TxDOT resources and research results to shop results and assistance from other APT sources, where available. The long-term vision is to improve TxDOT pavement technology so TxDOT can more efficiently complete its mission and meet the needs of the public.

The Strategic Plan outlines the general background goals of the TxAPT Center and provides a description of potential work that it can carry out. This document will be updated at regular intervals as new information becomes available.

While TxAPT Center staff will outline various research topics that we feel are appropriate and high priority, it is clearly understood that all funding and research decisions are currently to be made by RMC-1 and the ROC of TxDOT, with technical input and recommendations from TxAPT Center staff and through the TxDOT Pavement TAP.

The Strategic Plan attempts to outline general plans and goals for the TxAPT Center. Previously, the MLS was used to do performance prediction testing for various pavement sections. It is possible that the equipment can be used more effectively for individual pavement section validation, specific investigations, and ultimate proof testing.

The work described in the TxAPT Center's Strategic Plan is designed to assist TxDOT in meeting the following needs:

- provide TxDOT with an ongoing and improving technical resource for testing pavements,
- address immediate TxDOT needs regarding to pavement technology policy decisions and new solutions to immediate problems,
- continue to develop new technology that has the potential for large payoffs in the long-term, and
- facilitate implementation of new pavement technology and aid in the evaluation of existing technology.

All work performed to address the immediate needs of TxDOT is intended to also provide information and technology to complete long-term research goals that will have large payoffs for TxDOT in the future. Two key principles in the TxAPT Center's mission are to avoid duplicating work done by other researchers, and to incorporate useful results, methods, and knowledge from outside TxDOT wherever possible.

Research services outlined in this Strategic Plan include:

- Assisting RMC-1 in the development of a program for pavement research, involving APT.
- Building and maintaining a pavement APT research database.
- Providing pavement technology advice to TxDOT, as requested.
- Special forensic investigations of pavement performance, as requested.
- Implementation projects for technologies under evaluation by TxDOT.

10. Pilot Study for TxAPT

At the RMC-1 meeting in November 2001, funds were set aside for the initial Pilot Study to be carried out at TxAPT to proof test or shakedown the system. It was determined that this initial study would deal with the damage to thin load-zoned roads by heavy trucks with overload permits, which are currently allowed by law. Funding was deferred until January 2003, to be carried into 2004. A detailed problem statement was prepared in August 2002 and an RFP was issued as Project #0-4574-1, titled "Determine the Impact of HB 2060 Permits on Texas Load Zone Roads." Mr. John Bilyeu was selected as the TxDOT Project Director, and the draft proposal was submitted in December 2002. That proposal is still under review. It was decided, however, that the construction of the initial test pavement surfaces, a thin base of approximately 6″ and a thin surface of approximately 2″ would be constructed as part of the initial construction procedures. This will save the time and energy associated with preparing a second set of construction plans and obtaining a second contractor. Final pavement details will be reviewed as part of the construction plans and specifications in the February 2003 meeting outlined above.

11. Fall Meeting of the Operating Advisory Group

Administrative procedures of TxDOT call for problem statements to be submitted for funding, and accepted and prioritized in the fall of each year. To comply with these dates, TxDOT requested that the OAG and the TxAPT Center review possible high-priority projects and submit them to the Pavement TAP for review. The OAG met at CTR on October 17, 2002, and reviewed a variety of topics. The minutes of those discussions are presented in Appendix C.

The results of that meeting were presented to the Pavement TAP for its review and prioritization prior to the meeting of RMC-1 on November 6, 2002. Based on those recommendations and the support of the Pavement TAP, a number of projects were included in the priority list for which proposals were requested. Some of the possible projects that were discussed include:

- Incorporating the validation of the AASHTO 2002 Design Guide into APT results when possible.
- Evaluation of new high-performance flexible bases in Texas.
- Impact of new truck tire load enforcement legislation on Texas highways.
- Impact of new truck tire load enforcement legislation on regular versus high-performance bases.
- Evaluate/validate the laboratory work of the rut resistance of fatigue resistant AC mixes.

It should also be kept in mind, as was pointed out to the Pavement TAP and RMC-1, that the TxAPT Center can be used in several ways. The first plan was to use it for direct research to tackle problems and find direct solutions. Secondly, it can be used as a tool to validate results of research carried out under previous projects. Finally, it can be used as a validation tool for new materials, or as a part of a research project to provide performance information as input into an ongoing research effort that involves laboratory and field-testing, as well as accelerated performance testing. All of these concepts were presented to the Pavement TAP and in a separate formal presentation to the RMC-1 by Drs. Claros and Hudson to bring them up to date on the status of TxAPT. The chairman of the RMC-1 serves as a member of the

OAG. Prior to September, that member was Mr. Carl Utley; however, the Chairman of the RMC-1 changed in September 2002, and Mr. Jim Freeman became a member of the TxAPT OAG.

12. Instrumentation and Data Collection Equipment

As previously outlined, TxAPT is a cooperative effort with TxDOT. Currently, the MLS equipment itself is to be operated under the direction of TxDOT. Mr. Mike Finger is the coordinator of field operations for MLS. TxDOT will also provide basic instrumentation and data collection equipment as part of the operation of the TxAPT Center because it already owns or has purchased much of the equipment needed for permanent installation and evaluation of test pavements. TxDOT also has existing interagency agreements with several universities to obtain the expertise and technical support needed to install these instruments. In November 2002, Dr. Dar-Hao Chen was selected to become the APT systems manager and supervise the MLS operations for TxDOT. Dr. Chen had previously been charged with analysis and instrumentation, but currently supervises both the instrumentation and analysis side along with the operations of the equipment itself.

Many meetings have been held during 2002-2003 to discuss aspects of instrumentation, ranging from moisture, temperature measurements, multi-depth deflectometers, weight (load) monitoring, weather stations, etc. Most recently, a number of meetings were held to consider the installation of moisture devices in the embankment. Two meetings were held with Dr. Richard Liu of the University of Houston, who is manufacturing moisture-measuring devices. In January 2003, a final recommendation for installation of moisture sensors in the embankment was presented as part of the design and construction documents and TxDOT will make the final decisions. Dr. Liu was asked to furnish this instrumentation under an ongoing TxDOT contract. Temperature devices, like the "iButton," will also be installed, which has the capability of recording temperature for remote readings. Some thermocouples may be installed as part of the weather station. These decisions will be made in a January/February 2003 time frame. It is critical that all installed instrumentation be coordinated with the existing TxDOT instrument reading equipment and with current TxDOT procedures, as well as the construction processes to be carried out by the contractor for the TxAPT Center through UT.

Dr. Liu is also building profile-measuring equipment for measuring the transverse and longitudinal profiles over the tested section under the MLS. That equipment is to be installed on the MLS in February 2003. This equipment is being developed under the management of Mr. John Bilyeu. Crack observation equipment will also be installed. The TxAPT Center staff has reviewed the crack detection cameras, and there is currently concern that the sensitivity of the cameras will not permit the detection of hairline cracks. This will have to be tested and provisions made as needed. It is anticipated that visual condition surveys will be conducted in tandem with the crack detection cameras.

13. Weather Station

TxDOT currently has a weather station capable of measuring rainfall, wind, humidity, barometric pressure, velocity, direction, and thermocouples. We have requested that TxDOT move this equipment to the temporary site for testing and comparisons. It is currently considering this request. The operation and provision of this equipment and data will be under TxDOT supervision.

14. Data Analysis and Review

During the past year, the TxAPT Center has carried out a variety of data analysis and review in preparation for its operation and the creation of the TxAPT database. A number of meetings have been held with TxDOT staff, particularly Dr. Mike Murphy, Dr. Dar-Hao Chen, and Mr. John Bilyeu. Meetings were also held with Dr. Fred Hugo, who had been in charge of creating a Web site database. We obtained a copy of that Web site information from Dr. Hugo. We also thoroughly reviewed Dr. Hugo's files CTR. Dr. Hugo took most of the files back to South Africa; however, Dr. Hudson and Mr. White reviewed those remaining.

We met with Dr. Ken Stokoe and Dr. Soheil Nazarian to understand better the availability and storage source of SASW and SPA data. In these many meetings, it was determined that the primary source of data from past MLS tests is from Jacksboro, Texas. Mr. John Bilyeu is considered to have the definitive primary data from the four Jacksboro test sections. We are coordinating with him and will obtain the data for installation into the permanent database. This may be done under a separate project with Dr. Murphy. Dr. Soheil Nazarian has the data from dynamic testing, such as SASW and SPA. That data is not in summary form and is somewhat complex in its characteristics. Mr. Ron White visited El Paso

to go over the availability and details of that data with Dr. Nazarian's staff. Some of that data was obtained in disk form, and at the appropriate time, we will work with Dr. Nazarian to transfer the data to a permanent database.

In consideration of the development of the permanent database, we became aware that TxDOT, under the leadership of Dr. Mike Murphy has funded a project with CTR to evaluate the Web site created by Dr. Hugo. That project is underway and at present Dr. Tom Rioux is evaluating the data in the current database. Because this project was already underway, we have suspended additional review of past data and will take full advantage rather than duplicate the efforts of Dr. Rioux's project.

15. Analysis of Jacksboro Variability

One of our goals in data analysis has been to determine the variability of data as it exists in the prior tests. One advantage of the MLS is that it applies full-axle loads, rather than single-wheel loads, such as those applied by the Heavy Vehicle Simulator (HVS) and the ALF manufactured in Australia.

Dr. Virgil Anderson, our statistical consultant, has suggested that it may be possible for us to gain additional information from our tests owing to the fact that we are, in fact, loading two wheel paths, as opposed to one, and are obtaining twice as much information as obtained by other accelerated pavement loaders. In order to evaluate this, Dr. Jorge Prozzi, as part of a summer employment contract, and later through a donated labor agreement, has worked with Dr. Anderson to evaluate that data.

This data is contained in a database at TxDOTs Bull Creek campus. A copy of that database on a CD was sent to the TxAPT Center for storage and possible analysis. This database consists primarily of processed data, typically in Excel format.

The original ("raw") data is also available at TxDOT in a number of 3.5-inch floppy disks. It is recommended that personnel of the TxAPT Center obtain these disks and create backups for future uploading into the permanent MLS database.

Of the four sections tested, the data corresponding to sections 281S1 and 281N1 is the most complete. For this reason, these data were used to carry out a preliminary analysis to examine the data's variability.

Dr. Anderson performed analysis of variance on the data of the two above-mentioned sections. The objective of the analysis was to determine any significant differences between the mean rut depths under different conditions. These conditions are:

- MLS section numbers 281S1 and 281N1, represented by variable SEC = 1 and SEC = 2, respectively.
- Left and right wheel path of the MLS axle, represented by variable PAT = 1 and PAT = 2, respectively.
- Number of axle-load repetitions applied to the test section, represented by the variable REP = 4 to 11 for axle-load repetitions 20k, 40k, 80k, 150k, 300k, 450k, 600k, and 750k, respectively.
- Longitudinal position, represented by variable POS = 1 to 9 for longitudinal positions 0.0, 1.5, 3.3, 4.5, 6.0, 7.5, 9.0, 10.5, and 12.0 meters, respectively.

The analysis of variance also enables the error term for the rut depth to be estimated. Table 1 shows the results of the analysis of variance.

Table 1. Analysis of variance

SOURCE	DF	SS	MS	F-stats	P-value
SEC	1	1552.59	1552.59	1007.84	0.0000
PAT	1	148.049	148.049	96.10	0.0000
REP	7	1281.70	183.100	118.86	0.0000
POS	8	109.448	13.6810	8.88	0.0000
SEC*PAT	1	68.4743	68.4743	44.45	0.0000
SEC*REP	7	393.441	56.2059	36.49	0.0000
SEC*POS	8	87.6606	10.9576	7.11	0.0000
PAT*REP	7	93.3020	13.3289	8.65	0.0000
PAT*POS	8	56.5825	7.07281	4.59	0.0000
S*P*R*P	239	368.182	1.54051		
TOTAL	287	4159.43			

It can be seen that the individual effects and the cross-product terms are all very significant but there is no interest in the cross terms for the current analysis. From Table 1, the estimate of the error variance is $\hat{\varepsilon}^2 = 1.54$.

Tables 2 through 5 show the results of the analyses to determine whether there are significant differences between the levels considered for the variables SEC, PAT, RES and POS, respectively.

Table 2. Comparison of mean rut depth by section only (SEC)

SECTION	MEAN RUT DEPTH	GROUPS
2	6.2683	I
1	1.6247	.. I
All means are significantly different from one another.		
Critical t-value		1.970
Rejection level		5%
Critical value for comparison		0.2882
Standard error for comparison		0.1463
Error term used: SEC*PAT*REP*POS (1.54)		239 df

Table 2 shows that the average rut depth for SEC = 1 is 1.62 mm, while the average rut depth for SEC = 2 is 6.27 mm. At a five percent level, this difference is significant; hence, the sections belong to different groups. This result was, as expected, due to the differences in the pavement structures tested.

Table 3. Comparison of mean rut depth by wheel path only (PAT)

WHEEL PATH	MEAN RUT DEPTH	GROUPS
2	4.6635	I
1	3.2295	.. I
All means are significantly different from one another.		
Critical t-value		1.970
Rejection level		5%
Critical value for comparison		0.2882
Standard error for comparison		0.1463
Error term used: SEC*PAT*REP*POS		239 df

Table 3 shows the comparison on the left and right wheel path across test sections. The results indicate that the mean rut depth of PAT = 2 is significantly larger that the rut depth for PAT = 1. This result is somewhat unexpected, as it indicates that there is a systematic difference between the right and left wheel path across sections. Unfortunately, at this time we cannot consider the reason for this because the wheel loads (right and left) were not monitored continuously during the test. The continuous monitoring and recording of individual wheel loads would enhance the analysis of the results.

It should be kept in mind, however, that this preliminary conclusion is based on the analysis of the results of two sections only, but the trend was consistent with the other two sections.

Table 4. Comparison of mean rut depth by repetitions only (REP)

REPETITIONS	MEAN RUT DEPTH	GROUPS
11	6.9564	I
10	6.5147	I
9	5.7219	.. I
8	4.4714	 I
7	2.7686	 I
6	2.0122	 I
5	1.6900	 I
4	1.4367	 I
There are 5 groups in which the means are not significantly different from one another.		
Critical t-value		1.970
Rejection level		5%
Critical value for comparison		0.5763
Standard error for comparison		0.2925
Error term used: SEC*PAT*REP*POS		239 df

The results of the analysis of the variation of average rut dept with axle-load repetitions are given in Table 4. As expected, the average rut depth increases as the number of load repetitions increase.

Table 5 shows the results of the analysis of the variability of the mean rut depth with longitudinal position. If the MLS axle loads were uniformly applied along the test section, no significant difference would be expected. However, this is not the case because five heterogeneous groups could be identified (see Table 5, column GROUPS).

The most interesting finding is that while P0S = 8 (10.5 m) shows the largest rut depth, the adjacent point, POS = 9 (12.0 m), shows the smallest rut depth. As before, and without the knowledge of the applied load, it can only be hypothesized that the dynamics of those MLS axles were playing a significant role in these results.

Table 5. Comparison of mean rut depth by longitudinal position only (POS)

POSITION	MEAN RUT DEPTH	GROUPS
8	5.1422	I
4	4.4350	.. I
6	4.1725	.. I I
1	4.1338	.. I I I
3	3.8447	.. I I I
7	3.7897	.. .. I I
2	3.6847	.. .. I I
5	3.5572	 I
9	2.7587	 I
There are 5 groups in which the means are not significantly different from one another.		
Critical t-value		1.970
Rejection level		5%
Critical value for comparison		0.6113
Standard error for comparison		0.3103
Error term used: SEC*PAT*REP*POS		239 df

16. Summary of Analyses

It should be remembered that most accelerated pavement tests apply load only on a single wheel or on one pair of duals. The results shown in Table 3 suggest that there may be significant differences between the wheel paths and this can double or triple the amount of information produced by the MLS, which is good news indeed.

17. Analysis of Deflections Versus Subgrade Strengths

Dr. Prozzi also carried out a layered analysis to determine the effective deflections that would be observed under various test pavements for various subgrade properties. This was important in selecting the subgrade to be included in the permanent test embankment. The analysis determined that the deflections under the 4' of gray clay were likely to be under 1.0 mm, which is in the desired range for a medium-quality subgrade.

18. Meeting with John Harvey, Director of Accelerated Pavement Testing, University of California

Dr. John Harvey has been involved in the development and use of two accelerated pavement test machines for Caltrans for several years. He and his predecessors have developed a wealth of information on how to carry out accelerated pavement testing in a complex cooperative environment. Dr. Harvey met with us at the TxAPT Center on July 15-17, 2002. Also attending that meeting were Dr. German Claros and Dr. Mike Murphy, as well as several other TxDOT representatives. Dr. Harvey provided us with reports based on his experience and history on operating the HVS in California. He shared with us the many problems he had observed. Many of his ideas have been implemented into the thinking and development of our Strategic Plan and other documentation.

Significantly, Dr. Harvey continually emphasized how important it was to prepare a detailed test plan for each test to be carried out. During their early years of operation, Caltrans found that because there were so many people involved in various aspects of the testing, there were misunderstandings and, in some cases, sponsors and representatives interrupted the testing without the knowledge of the research team. He strongly recommended that all persons involved in a particular test, including the sponsors, funding agency, operating crew, instrumentation crew, etc., should meet and agree on a detailed test schedule and test plan. This includes the loads to be applied, the schedule for stopping the loading to undertake measurements, types of measurements and when they should be made and who makes them, how the data is collected, and who processes the data and checks the accuracy, as well as many other details.

Dr. Harvey recommends that this detailed test plan, including detailed assignments be reviewed and signed by key leaders of each group associated with the test. By signing the test plan, everyone validates that they are aware of the details and their responsibility and

involvement. Perhaps more importantly, they also acknowledge that they individually do not have the authority to stop the testing or interfere with the test plan without approval of the other team members. The signed and approved test plan is turned over to a person designated as the "Test Master." Anyone who wishes to modify the test plan or interrupt the procedures can do so only with the approval of the Test Master. During an individual test, the Test Master is on call 24 hours a day, 7 days a week to provide necessary support and control for the test group.

The on-site testing personnel, even though they may work for a different agency, or temporarily be assigned to the project, are assigned under the leadership of the Test Master for the duration of that particular test.

Dr. Harvey reemphasized the importance of this approach and the TxAPT Center staff strongly recommends that it be adopted during the Pilot Study.

19. Literature Review and Documents Obtained

During the past year and a half, we have obtained a wide variety of documents from many sources, particularly the National Cooperative Highway Research Program (NCHRP) and Caltrans. Our staff has reviewed these documents for application and background to our ongoing activities. Ms. Campos has set up an electronic database for literature applicable to accelerated pavement testing, which is available for anyone to use (see Appendix D). The CTR library is also available and many of the documents can be found there. No attempt has been made to assemble a massive library, because many of the documents are available electronically from other sources. However, key documents, particularly draft documents from the California Test Facility and its operating documents, are available in hard copy.

20. Regular Coordination

During the past year, regular and continuous coordination has been maintained with many elements of TxDOT as outlined herein. In particular, we have communicated by phone and e-mail with TxDOT Project Director Dr. Claros, on a weekly and in many cases, daily basis. Any time a critical element arises, we have held a personal meeting with Dr. Claros and others. In many of these meetings, Dr. Murphy, or representatives of the Materials and Pavement Group have also participated. We have held many other individual meetings with members of the MLS operating crew, both at the site and their offices. We have coordinated

with Dr. Dar-Hao Chen, Mr. Mike Finger, Mr. Cy Helms, Mr. John Bilyeu, and others as necessary.

21. Summary

The calendar year 2002 has been an interesting and productive year for the TxAPT Center. We did not accomplish all of the goals the staff set for itself at the beginning of the year, however we made good progress. The progress in rehabilitating the MLS has been slower than expected. The amount of administrative support and energy required to obtain the final site at the PRC was unpredictably slow on the part of UT. Nevertheless, we have been successful in making progress on both of these fronts. We were successful in hiring an outstanding staff and by working through many of the problems during the past year, we have gained invaluable experience that will help us move forward in a concerted, productive way in the future. Our OAG has been very effective in its support and advice. Our interaction with the Pavement TAP and RMC-1 has been productive and provided insight into the pavement research needs of TxDOT.

At this writing, we are awaiting final approval of our ongoing operating project (Project 0-9900, titled "Operation of TxAPT Center"). We have interacted with TxDOT several times since this project proposal was first submitted in June 2002. We expect that it will be signed in early 2003 to provide the additional funding needed to carry the TxAPT Center through the project year ending August 31, 2003. At the current time, we are still on track to meet the deadline of "beginning testing at TxAPT Center in late spring 2003," which was laid out in correspondence by Mr. Thomas Bohuslav. Although there will undoubtedly be surprises ahead as the renovated MLS is debugged, and there will be issues arising during the construction phase, we believe that the late spring schedule can be fulfilled. And the initial "pilot" or "debugging" section will be run on the new facility with the MLS.

Appendix A
Background of the TxAPT Center Site

A number of site characteristics, active research operations and physical facilities at Pickle Research Campus (PRC) would make it an excellent site for the proposed activity. Located at PRC is a very unique National Science Foundation (NSF) research activity directed by Dr. Ken Stokoe, a senior CTR researcher. This activity entitled "Large Scale Mobile Shaker and Associated Instrumentation for Dynamic Field Studies of Geotechnical and Structural Systems," is the only such activity funded by NSF in the United States. It is planned as a 14-year research effort, which is funded at approximately $3 million for the first four years. Among many other elements related to the TxAPT research effort, this activity has Rolling Dynamic Deflectometer (RDD) and Stationary Dynamic Deflectometer (SDD) hardware and instrumentation. Dr. Stokoe has used these devices in conjunction with the Texas MLS device and has offered all of his equipment, instrumentation, and experience to the CTR TxAPT team.

The Ferguson Structural Engineering Laboratory, located within walking distance of the proposed TxAPT test site, has an active machine shop. TxAPT repairs requiring welding or machining of certain parts could be accomplished within that facility. Also nearby is the Center for Electro-Mechanics, which has extensive machine shop capabilities and could be called upon to provide supplemental TxAPT support. Dr. David Fowler, a CTR researcher and Director of the International Center for Aggregates Research, operates his Materials Research Center in Building 18B within walking distance of the proposed site. Testing equipment and facilities for a broad range of pavement materials characterization and evaluation are available in Building 18B. The Center for Research in Water Resources has extensive office and laboratory space about one-half mile east of the proposed TxAPT operations site. The Center for Transportation Research has on-going relationships with all of these centers and activities and can easily foster support activities ranging from MLS repairs to office space. Additionally, the Pickle Commons Building is available for large or small group meetings and presentations, with virtually any desired type of catered meal service. Through recent administrative changes, the College of Engineering has operational control of the Pickle Campus. As an element of the College, the Center for Transportation Research has full access to and use of Pickle Campus assets.

Access to the PRC by highway is excellent and ample free parking is available for visitors. The University operates a shuttle bus service from PRC to the Main campus and headways are 30 minutes for an approximately 30 minute one-way trip. Rail transportation of the large MLS device to PRC is very feasible since the Union Pacific main track traverses the PRC and the track is adjacent to the likely MLS sites. Access to PRC by visitors based outside Austin is easily provided by the new Bergstrom International Airport.

A map depicting two possible locations for the TxAPT facility is shown in Figure A1.

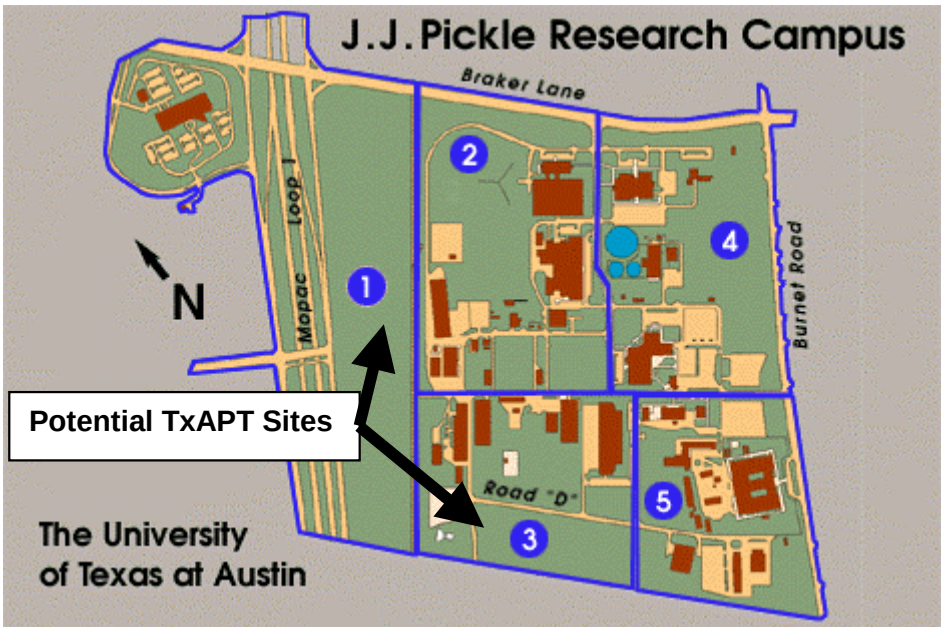


Figure A1. Site Map of Pickle Research Campus and Potential TxAPT Sites in sectors 1 and 3

Appendix B
TxAPT Operating Advisory Group Meeting Notes
April 25, 2002

As recorded by Ron White and Sharon Campos

April 25, 2002

Attendees:

Committee:

Virgil Anderson, Consultant
German Claros, RTI, TxDOT/Austin
Ken Fults, CST/M&P, TxDOT/Austin
Ronald Hudson, Director, TxAPT, CTR, UT/Austin
Paul Krugler, Director, Research & Technology Implementation Office, TxDOT
Dallas Little, Senior Research Fellow, TTI/Texas A&M
Carl Monismith, Professor, University of California at Berkeley
Mike Murphy, CST/M&P, TxDOT/Austin
Soheil Nazarian, Professor, University of Texas/El Paso
Tom Scullion, Research Associate, TTI/Texas A&M
Ken Stokoe, Professor, UT/Austin
Carl Utley, Engineer, TxDOT/Lubbock
Tom White, Professor, Mississippi State University
Andrew Wimsatt, TxDOT/Ft. Worth

Additional Participants:

Sharon Campos, UT/Austin
Dar-Hao Chen, CST/M&P, TxDOT/Austin
Greg Cleveland, CST/M&P, TxDOT/Austin
Cy Helms, CST/M&P, TxDOT/Austin
Randy Machemehl, Director, CTR, UT/Austin
Jorge Prozzi, Professor, UT/Austin
Jeff Seiders, CST/M&P, TxDOT/Austin
Ronald White, Research Engineer, TxAPT, UT/Austin

Introduction

8:30 to 8:40 a.m. – Introductory comments by Randy Machemehl, Director of CTR, and Ronald Hudson, Director of TxAPT. Ronald Hudson made reference to the Operating Advisory Group (OAG) in attendance and how he hoped the day would produce useful dialogue and provide good direction for development of the TxAPT. The agenda was finalized with one addition to the 11:00 a.m. session, Where Do We Go From Here? Debugging of equipment and the pilot study would be included in the session.

Morning Session - The purpose of the morning session was to bring everyone up to date on the background and status of accelerated pavement testing in Texas, California, and Indiana.

8:40 to 9:00 a.m.- Mike Murphy gave a thorough presentation about the historical development and current status of the Texas Mobile Load Simulator (TxMLS), and the planned improvements currently underway on the TxMLS.

The design improvements and retrofits being carried out by RGB from Houston, Texas includes a new bogie carriage design, electric motor mount, chain drive, load wheels, load beam, and load setting method. The State is confident the design improvements will make the TxMLS more reliable with less down time. It is predicted the refurbished unit will be able to operate at speeds up to 25 mph instead of the 8 to 9 mph before renovations. It will also be able to apply a 25 percent overload application (42 kips per bogie).

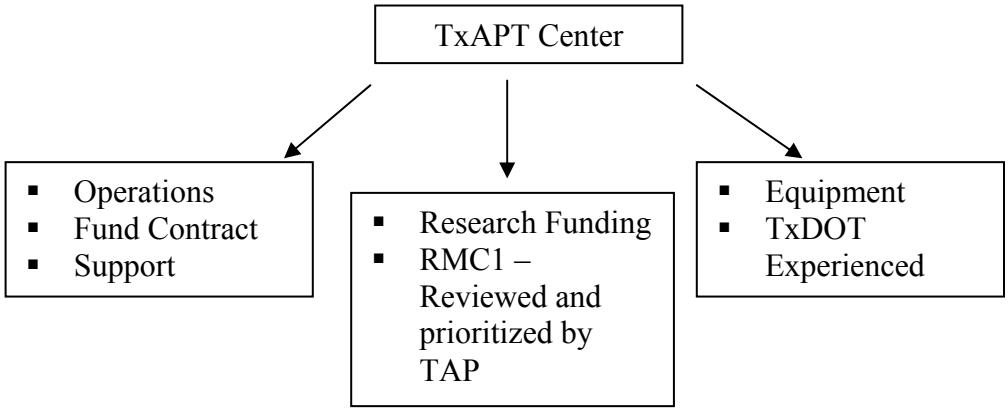
Overall TxAPT Center objectives include:

- Providing a fixed test site to address statewide pavement issues instead of district level pavement issues.
- Increasing safety of APT operations by removing it from traveled roads.
- Reducing impact on traffic operations.
- Providing improved control of test section construction.
- Providing enhanced logistics so that service and repair of the device is timelier.
- Reducing cost of APT operations.
- Enhancing site security.
- Improving access for TxDOT and University researchers.

9:00 to 9:10 a.m.- Ronald Hudson gave a brief overview of the proposed administration of TxAPT.

TxAPT Will:
Be Practical and Usable, with Visible Results
Allow Internet Data Access/Exchange
Provide Validation of What Others View

He described an administration consisting of three main components where one component consists of operations support provided by UT/CTR, the second consisting of research funding provided by TxDOT via RMC1 with research project priorities reviewed by TAP-RMS, and the third consisting of the equipment itself (MLS) provided by TxDOT and operated by a team consisting of TxDOT and CTR employees.



9:10 to 9:25 a.m.– A discussion led by German Claros and Carl Utley of TxDOT described the funding plans for the TxAPT. Some of the points included:

- Operations funding planned at $500-600k per year.
- Maintenance funding provided by the TxDOT Materials and Pavement Section. It was noted that CTR should be equipped to provide some level of maintenance funding to take care of minor maintenance issues.
- Construction funds for test pads and other special equipment funded by research projects.
- Carl Utley confirmed the overall commitment and support of the TxAPT by the RMC committee.
- TxDOT feels the TxAPT will be an essential tool for validating pavement design issues that come from TxDOT research.

9:25 to 9:40 a.m.– Andrew Wimsatt gave a presentation describing a pavement research study where the TxMLS was used in the Ft. Worth District to evaluate two pavement rehabilitation techniques (Remix vs. Dustrol – two different pavement milling/overlay techniques).

9:40 to 10:00 a.m.– Group discussion and questions.

Q. When will debugging of MLS take place?
A. Mike Murphy: The debugging of the TxMLS would take place between late July and August, 2002.

10:00 to 10:15 a.m.– break.

10:15 to 10:35 a.m.– Dar-Hao Chen of TxDOT gave a presentation of MLS data analysis. He described two data collection efforts, one at Victoria and the other at Jacksboro.

Dar-Hao described some of the instruments and techniques used to collect pavement performance data including the falling weight deflectometer (FWD), multi-depth deflectometer (MDD), and map cracking procedures.

It was asked if TxAPT could be used to validate whether the Hamburg is useful, and the reply was probably.

10:35 – 11:00 a.m. – A discussion of background experience and issues was discussed with a number of questions and answers:

Q. Carl Utley: What type of materials tests was carried out?
A. SASW, pavement cores, Triaxial testing.

Mike Murphy: The device will be capable of varying the speed of loading, loading wander, and the amount of load but that varying these parameters would complicate the data analysis.

Carl Monismith: There should be reflection-cracking results.

Q. Tom White asked if the pavement temperature controlled during testing with the MLS.
A. Testing with the MLS was conducted regardless of temperature, although during the Jacksboro test, testing was delayed so that pavement loading could be carried out under similar temperature conditions. It was pointed out that pavement temperature generally ran about 97° due to the shade provided by the MLS.

Q. Where did cracking start?
A. Results from the testing would not allow the determination of where (at what depth?) the cracking started.

Q. German Claros: Were the MLS results compared to distress models?
A. Cracking no; rutting yes.

Q. Does the MLS produce the same type of fatigue cracks as generated by regular traffic?
A. It was stated that there are no good fatigue prediction models.
A. Carl Monismith: Feels there are good fatigue prediction models.

11:00 to 11:15 a.m.– Ronald Hudson gave a presentation to answer the question "Where do we go from here?" He mentioned four key components:

1. Estimating future pavement performance based on TxAPT data.
2. Limitations in error estimation. Keeping the tests simple and evaluate only one factor at time to ensure meaningful research results.
3. Concentrate on research with a good probability of high payoff.
4. Debugging the TxAPT in Livingston, Texas or at the Pickle Research Campus (PRC) and blend the shakedown operation with the production of meaningful research results.

11:15 to 11:40 a.m.– Carl Monismith provided the California experience and perspective with accelerated pavement testing. He made the following observations:

- California looked to experts in South Africa for their expertise in APT.
- They bought two Heavy Vehicle Simulators (HVS) for $1.8 million.
- A pilot study was carried out with lab work being done in California and fieldwork carried out in South Africa.
- The South Africans provided extensive technological support to get the California program started. The cooperation and support of SA personnel was outstanding.
- The SA research group CSIR and the American company, Dynatest, worked in partnership with California to produce a successful APT program in California.
- A committee oversees the program in California.
- Three considerations for analytical developments at TxAPT:
  - Lab Testing
  - Validation of Field Evaluation
  - Good analytical group at TxDOT and UT

- It is critical to pick and choose a research project carefully because of the expense of testing.
- Laboratory testing must be carried out in conjunction with APT to get the desired results.
- Operating costs for the HVS are approximately $100,000 per month per unit. This does not include laboratory-testing costs.
- Each test takes approximately three months per test section. Fatigue testing takes longer than rut testing.
- Lab testing includes flexural strength, flexural fatigue, shrinking, and durability.

Carl stated that, to be successful, an APT program must have:

- Planned data analysis
- Materials laboratory testing
- Planning/Research
- Implementation – put the results of testing into practice

The areas of expertise currently engaged in PRC Projects are:

- Construction
- Traffic Materials
- Geotechnical
- Statistics Performance Modeling
- Systems Analysis
- Information Management
- Mechanics
- Planning

In summary, Carl Monismith stated it is important to control pavement temperature. MDD is best for measuring pavement deflection. Thermocouples are installed in the pavement to monitor temperature gradient and moisture sensors are installed in the base and sub-base to monitor moisture content.

The two HVS devices are operated seven days a week, twenty-two hours per day. Each unit was recently refurbished costing $400k per unit.

Q. How many people operate the station per shift?
A. Two people at a minimum.

Q. How much load does the HVS apply to the pavement?
A. Rut testing is carried out with a 9-10k load; fatigue testing is carried out with a 22.5k load.

11:40 a.m. to noon - Tom White described the APT system he developed and supervised at Purdue University. Some operational features of the APT system included:

- The system applied a constant load.

- The load is applied at a constant speed.
- The pavement temperature can be controlled.
- The system can apply load in either one or both directions.
- The wheel path of the load can be varied to introduce wander.
- The system can apply a load every 15 seconds.
- The system was run approximately 20 hours a day and could operate unattended.

Tom estimates the cost of one test to be $7,000 per data point. The cost of the unit itself was $140,000.

The ability to control the temperature was very important as most of the tests conducted were carried out at a pavement temperature of 50° C.

The types of testing carried out at this facility included:

- Relative tests
- Response tests (i.e., response of the pavement with one wheel passage with measurements taken at the beginning, middle, and end of the loading cycle)
- Performance tests (i.e., predict rutting)

From an operations perspective, Tom had difficulty with local pavement contractors, who in the wintertime would shut down their operations and not be available to construct test sections. This caused some significant delays in his research program.

Laboratory testing needed careful monitoring to know who had test samples, where testing was done, and where were test samples stored. Also standard operating procedures had to be developed to ensure consistent and unbiased monitoring of the test sections.

Tom concluded his presentation with what he felt was the most important aspect of a successful APT program:

- A clear and open line of communications is needed to prevent mistakes and misunderstandings, etc.
- Don't let issues go unresolved.

Some questions and answers followed Tom's presentation:

Q. Are you still working on this project?
A. Yes, under Project NCHRP-14.

Q. How do you build such small sections?
A. You have to work closely with the contractor. Generally they were able to achieve the desired gradation but he found that AC content varied more than desired. They used a batch plant instead of a drum plant.

Q. In your opinion, what are the effects of bedrock?
A. Our test pit is 6′ deep, and we have the ability to vary the moisture content. I feel that 5′ of moist clay is ample to mitigate the effects of bedrock.

LUNCH

Afternoon Session - The purpose of the afternoon session was to start and open discussion of the potential benefits and limitation of accelerated pavement testing; what can be accomplished at TxAPT and how to integrate nationwide with other test centers and data.

1:00-1:15 p.m. - Virgil Anderson gave a presentation on statistics and how sampling is relevant to APT.

1:15-1:25 p.m. - Kenneth Stokoe gave a presentation about a super accelerated pavement-testing device he is working on under a National Science Foundation grant. It is expected there will be some overlap with this NSF project and the TxAPT. This synergy should benefit both projects.

1:25-2:30 p.m. – There was a discussion about setup and operational problems that could be encountered with the TxAPT.

Andrew Wimsatt: What is the status of the TxAPT operators? Will the operators be TxDOT or CTR employees? He also mentioned that when he was working with the MLS in Jacksboro, operator moral was low. The operators told him that management (and researchers) did not listen to the operators. They cite an example of a researcher that wanted to run the MLS on wet pavement, against the advice of the operators.

Ronald Hudson: There will be eight operators, four will be TxDOT employees and four will be CTR employees. It is handled this way for funding purposes only. The crew chief will supervise the operators and will be a TxDOT employee. CTR will oversee the operations and coordination of the Texas Accelerated Pavement Test (TxAPT) Center at the Pickle Research Campus and will be the liaison between the equipment, its operators, and the researchers.

Q. Who will pay for minor repairs?
A. Depending on the cost of the repairs/maintenance, it is hoped that CTR will have a budget for buying minor parts to keep the TxAPT operational day to day.

Carl Monismith: TxAPT must have well defined plans to ensure full use of a system that has a finite life. Projects must be selected carefully with an eye on the end result. It is important to maintain open lines of communication (this same comment was made earlier by Tom White). The operational limitations of the device must also be determined and well as the research limitations.

Ken Fults: Everyone who measures stress, does so with different protocol. He would like to see a standard protocol established for measuring and monitoring distresses. It would be beneficial if this protocol were compatible with protocols used by other APT facilities.

Ron White: The same could be said for the format of the database where TxAPT results would be stored. If there could be some standard data format defined, then results from other

APT facilities could more easily be retrieved and evaluated by Texas researchers, as could TxAPT results by others.

Carl Monismith – CALTRANS marks cracks with pavement chalk to make them visible then photographs the pavement. The chalk lines are then digitized to provide a measure of crack density.

German Claros – TxDOT uses a line scan camera to record pavement cracking.

A report is available that gives an international survey of APT systems worldwide. This report should provide useful background information on similar facilities around the world.

Q. Will the TxAPT be able to address/control pavement temperature?
A. There are not any defined plans, nor is there a budget allotted to address the issue of controlling pavement temperature. At some point in the future, this issue should be re-addressed.

It was noted that laboratory testing would be required to characterize material properties and that a reference library of material properties should be established for research purposes.

Q. Dallas Little: How do you could change subgrades?
A. You shouldn't need to change subgrades, at least early on in the program. Everything that happens does so in the 1st foot or so.

Q. Andrew Wimsatt: What is TxDOTs commitment to the TxAPT program?
A. Ken Fults: TxDOTs commitment and support comes from the highest levels in the department.

Carl Monismith: CALTRANS APT program started in 1994, with an original 5-year commitment. However, CALTRANS now commits about $5million annually to the APT program.

The issue of how the TxAPT would be moved from pad to pad was raised. An idea was mentioned of placing tracks under each of the four supports to move the system longitudinally or laterally.

2:30-2:45 p.m. - Afternoon Break

2:45-2:50 p.m. - Mike Murphy provided information about a TxDOT brainstorming session last October, 2001, where "high payoff" tests and a five year plan were discussed. In the past the MLS was used for a comparative study carried out at the district level. In the future, statewide issues should be addressed for a bigger payoff with a higher profile.

It was mentioned that temperature control is important for pavement rutting tests because it is best to run these tests at elevated (if not constant) temperatures.

Carl Monismith: California's first priority for the APT was to evaluate/validate the States pavement design procedure. The test pavements in California was built using CALTRANS equipment. They also put overlays on asphalt rubber and pavement.

Tom White: Their early emphasis was on rut testing. The emphasis was on a rutting compared to our farm to market roads.

Ken Fults: TxDOT would like to use the device to help develop performance-based specifications.

Ronald Hudson: Are there was any corollary tests that could be conducted simultaneously with the pavement studies? Mike Murphy: Skid resistance testing.

Carl Monismith: Using the MLS to compare material types was one of the important aspects.

Tom White: If you have a good model, then it will have graphs in it that represent aggregate gradation. The effect is a natural effect and you can extrapolate the results a lot quicker.

Carl Utley: With NAFTA, the additional traffic is tearing up the roadways. Discussions then ensued regarding the HB2060.

Ronald Hudson: What about putting pavement paint down to test sections using MLS? Tom White: The paint is like a thick polymer material, and would definitely affect the results.

Carl Monismith: After the MLS is up and running, we need to consider installing an instrument that records the pressure distribution of tires. Tom White: Need to take individual tire tread and consider the length of the tread as well.

The issue of whether to install weak or strong subgrade material was raised.
German Claros: The site where the test pads will be installed should be excavated to bedrock and backfilled with a uniform subgrade material. The subgrade should tend to be weaker because stronger subgrades will require greater applications. Carl Monismith: CALTRANS has tested on weak subgrades.

Tom Scullion: Suggested using 2 subgrades. Said we have to get the site prepared. Also suggested stockpiling 2 embankments and use soil to build different subgrades at different times.

Ronald Hudson: In terms of the farm to market road, the subgrade is a problem, but the highway subgrade is OK.

Regarding environmental control (i.e., pavement temperature) the TxAPT will only attempt to monitor conditions as they exist during the testing. At some point in the future, it could be possible to develop some means for controlling the environmental conditions.

4:00-4:30 p.m. The Path Forward

Schedule next OAG meeting (perhaps some time in September or early October) after the device has been moved to PRC. Everyone is asked to email his or her schedule for this time frame to Sharon Campos at scampos@mail.utexas.edu.

Appendix C
TxAPT Operating Advisory Group Meeting Notes
October 17, 2002

Recorded by TxAPT Staff
October 17, 2002

Attendees:

Committee:

Virgil Anderson, Consultant
German Claros, RTI, TxDOT/Austin
Ronald Hudson, Director, TxAPT, CTR, UT/Austin
Paul Krugler, Director, Research & Technology Implementation Office, TxDOT
Mike Murphy, CST/M&P, TxDOT/Austin
Soheil Nazarian, Professor, University of Texas/El Paso
Tom Scullion, Research Associate, TTI/Texas A&M
Ken Stokoe, Professor, UT/Austin
Ron White, Research Engineer, TxAPT, UT/Austin
Tom White, Professor, Mississippi State University
Andrew Wimsatt, TxDOT/Ft. Worth

Additional Participants:

John Bilyeu, TxDOT/Austin
Sharon Campos, UT/Austin
Dar-Hao Chen, CST/M&P, TxDOT/Austin
Cy Helms, CST/M&P, TxDOT/Austin
Randy Machemehl, Director, CTR, UT/Austin
Mark McDaniel, TxDOT/Austin
Jorge Prozzi, Professor, UT/Austin
Yetkin Yildirim, UT/Austin

Introduction/Welcome

8:30 to 8:40 a.m.– Introductory comments by Randy Machemehl, Director of CTR, and Ronald Hudson, Director of TxAPT.

8:45 to 9:15 a.m. Review Status of MLS - Mike Murphy provided a brief update on the status of the MLS retrofit.

Andrew Wimsatt will be consulted regarding typical construction of farm to market roads.

Discussion:

TxAPT research recommendations from TAP:

1. Validation of mix design of rut resistant and fatigue resistant pavement structures.

2. Impact on the highways of Legislative changes in truck tire load.

Mike Murphy mentioned that an effort could be made to work with trucking companies to investigate their direction on future tire designs so that TxDOT can stay current on how new and innovative truck tire design could impact pavement performance in Texas.

Paul Krugler – Place emphasis on "High Payoff" research topics so that we can justify the monies spent. Our efforts MUST make a difference (i.e., save taxpayers money) in TxDOT operations. Need to look at each research topic and how well suited each is to TxAPT.

Tom White suggested TxDOT perform a formal cost/benefit analysis on research funded by TxDOT. The impact put forward can affect hundreds of millions of dollars.

It is important to get early results to maximize the number of sections that can be tested:

1. Perform pavement studies that test weak pavement structures to get early failure.
2. Perform analysis to evaluate NDT methods we could use to reliably anticipate and predict pavement failure so that testing can be terminated prior to pavement failure.
3. Make pavement structure weaker with lower modulus materials or thinner sections then use laboratory testing to extend results to stronger/thicker pavements.

Tom White indicated that thinner pavements will fail sooner but researchers will see greater variability in the results. Thicker pavements will have less variability but they will require more load applications before failure is reached.

9:45 a.m. – Summary of TAP Meeting - German Claros presented and led a discussion regarding TxAPT research ideas voted on by the TAP committee during their meeting on September 27. The two research topics receiving the most TAP votes were:

1. Determine the impact of new truck tire load enforcement legislation; combine with evaluation of high performance bases.
2. Determine the fatigue resistance of rut resistant mixes.

Two other studies were also discussed:

3. Evaluate high performance flexible bases (excluding tire load enforcement legislation.
4. Evaluate the development of reflection cracking

The TAP recommended items 1 and 2 to the RMC. Item 3 was also considered by TAP to separate the evaluation of base material from the tire load study. Item 4 was discussed briefly then dismissed by the TAP due to perceived problems related to constructability and environmental control issues.

The pros and cons of each proposed APT study under review by the TAP were discussed.

Topic 1. Impact of new truck tire loads + high performance base evaluation:

Pros

a. Marries tire load issue with high performance bases.
b. Potentially a high degree of interest on this issue by the legislature.

Cons

a. New tires may not be available.
b. New tires may not be installable on existing bogie rims.
c. Industry may be in transition.
d. A study (research project 4361) is currently underway to perform analytical study of tire loads. It might be best if this project were substantially complete before proceeding with MLS validation.

Topic 2. Determine fatigue resistance of rut resistance ACC mixes:

Q. Pros
A. Rutting could be the better test since fatigue is much more dependant on aging.
A. Aging could be a problem that is modeled with stiffer AC mixes.

Q. Cons

a. No environmental control.
b. No aging of asphalt is done.
c. Related analytical research projects should reach some level of completion prior to validation with the MLS.

Topic 3. Evaluation of high performance bases:

Q. Pros
a. There is less impact on MLS test results from changes in the environment.
b. The number of variables (testing factorial) in an APT study could be reduced with lab tests.

Q. Cons
a. Changes in moisture content can impact results.

Topic 4. Evaluate the development of reflection cracking:

Q. Pros

Q. Cons
a. Difficult to construct – test section more suited to test in-service pavements.
b. Environmental control is important for this study.

LUNCH

1:00 p.m. Discuss and Rank Priorities - Mike Murphy led the group in a discussion of other MLS research priorities. He took notes during the discussion and will provide a summary of the discussion, which we will forward to the OAG with these minutes.

Mike Murphy led the discussion of priority research issues that could be addressed with the MLS:

1. Evaluate and quantify damage due to heavy trucks.
2. Evaluate and compare rehabilitation strategies of in-service roads.
3. Evaluate new and innovative paving materials.
4. Evaluate new truck technologies.

Use of MLS to evaluate in-service pavement is not now a priority, however, the MLS will maintain its mobile capabilities.

Other considerations regarding the types of research done on the facility:

1. TxDOT is just completing the rehabilitation of the MLS. Significant improvements have been made to the design of the MLS. Never the less, the performance and serviceability of the rehabilitated MLS are unknown. The types and complexity of future research projects performed with the MLS will depend to some extent on the expected number of applications the MLS can apply in a month. Future research performed with the MLS must take into consideration the performance of the MLS.

2. The environment will be a chief concern when selecting projects for the MLS. Ideally, most testing would be done at a fixed temperature with fixed moisture conditions. Significant changes in either of these variables during the coarse of a testing sequence could jeopardize the collection of meaningful data.

3. If the MLS can complete a test series rapidly, then the effects of environmental variables could be minimized. If the test sequence extends into two or more seasons, then the effects of changes in temperature and moisture conditions or test results could become significant and would have to be considered in the data analysis. It was suggested that we consult with the Turner Fairbanks ALF facility for information on how they handle changing environment at the FHWA APT site.

4. The TxAPT facility will be used to validate the results of related TxDOT Pavement Research (i.e., Evaluation of High Performance Bases). The results of the studies to be validated should be substantially completed before a corresponding validation test is considered with the MLS.

The following contractor names were mentioned as possible bidders on the TxAPT site work:

- Austin Bridge and Road
- Dunnick
- Zachary

It was also suggested we contact the Paving Association, and the Texas Hot Mix Association for ideas, comments and possible support.

Construction supervision by qualified inspectors will be important to ensure the TxAPT facility is constructed according to specifications. CTR will work with TxDOT to locate candidates for this job. Someone mentioned there are many TxDOT and private sector retirees that could be hired for this purpose as consultants. Possible contacts would be Terry Jackson and Bill Garbade.

2:45 p.m. – Review of Subgrade and Site Plans - Ron White presented plans and led a discussion about development of site plans and subgrade preparation.
German Claros felt an analysis of the anticipated deflections should be performed to make sure the planed subgrade would satisfy the objectives of the TxAPT (weak structure to help ensure early failure).
Paul Krugler wanted us to consider the possibility of excavating the tan clay to a uniform depth over the entire test pad embankment, and then place the tan clay to a constant depth so that its properties will be uniform throughout the test section embankment.

3:45 p.m. – Discuss Pilot Study Details and Funding - German Claros led the group discussion regarding the Pilot Study. The request for proposals is out and CTR will be submitting a response in the next few weeks to describe how this first project could be carried out.

The purpose of the pilot project is as follows:

1. Identify the impact of House Bill 2060 permits on Texas load zone roads.
2. Evaluate the operating characteristics of the refurbished MLS.
3. Develop standard operating procedures for the MLS/data collection.
4. Establish "Test Plan" development guidelines, and protocols.
5. Determine the operational reliability of the MLS
6. Finalize data handling and data QA/QC procedures

It was discussed that the pavement should mimic Texas farm-to-market roads structural capacities and construction procedures unless it is determine that such a design would compromise the results of the data (i.e., unpredictable pavement behavior due to uncharacteristic loading rates).

4:30 p.m. – Closure and Planning the Path Forward. It was agreed that the next OAG meeting should be held in approximately 6 months after the shakedown test of the MLS.

Follow-up Items:

1. Contact Andrew Wimsatt about farm-to-market construction.

2. Locate 1987 report done for Attorney General's office on Test Track done at PRC.
3. Contact Texas Hot Mix Association regarding "friendly contractors".
4. Ron White will send soil samples to Soheil Nazarian at UTEP

Appendix D
TxAPT Literature Search
NOTE: This is an ongoing literature search on APT and MLS and is updated periodically.

*Ordered by TxAPT	Title	Authors	Pub. Date	Report No.	Publisher
	Accelerated Load Testing of Pavements: HVS-NORDIC Tests in Sweden 1999	Wiman, Leif G.	2001	VTI Rapport 477A-2001	Swedish National Road
*	Accelerated Pavement Performance Testing of Ultra-Thin Fiber Reinforced Concrete Overlay, Recycled Concrete Aggregate, and Patching Materials	Kuo, Shiou-San; Armaghani, Jamshid; Scherling, Dave			TRB (submitted to A2B09)
*	Accelerated Pavement Testing in Australia and Europe: the OECD FORCE Conference	Sharp, K.G.	1991	ARR 214	
*	Accelerated Pavement Testing of Drained and Undrained Pavements under Saturated Base Conditions	Bejarano, Manuel; Harvey, John	2002		submitted to A2B09
	Accelerated Pavement Testing of Rutting Performance of Two Caltrans Overlay Strategies	Harvey, J; Popescu, L	2000	TRB1716; ISBN 0309066956	TRB
*	Accelerated Pavement Testing; Data Guidelines	Saeed, Athar; Hall, Jim	2002	NCHRP	ERES
	Accelerated Testing for Studying Pavement Design and Performance (FY 99)	Malhjem, Hani; Sheffield, Frederick	2000	FHWA-KS-99-7	KS DOT
*	An Investigation into the Effects of Artificial Aging on Rutting Performance of a Thick Asphalt Base Using the Model Mobile Load Simulator (MMLS)	Hugo, Fred; Reck, Nicholas	1993	CTR1934-1	CTR
*	Annual Operating Report for the Texas Accelerated Pavement Test Center (TxAPT)	Hudson, W.R.; White, Ronald; Rioux, T.W.	2003	CTR9900-R2	CTR
	Answers on a Fast Track: Accelerated Pavement Testing in the United States	Monismith, CL; Nokes, WA; Coetzee, NF	1996	TR News 184	TRB
*	Application of Full-Scale Accelerated Pavement Testing	Metcalf, JB	1996	NCHRP Synthesis of Highway Practice 235	TRB
***Ordered by TxAPT**	**Title**	**Authors**	**Pub. Date**	**Report No.**	**Publisher**
	APT Symposium - The First Review and Discussion of Accelerated Pavement Testing Findings in Texas MS-6709		1997		UT Austin
*	Automatic Crack Monitoring System	Liu, Richard; Chen, Xiemin; Wu, Min	2001	3997-1	UH

*	Caltrans Accelerated Pavement Test Program-Test Results: 1994-1997	Harvey, John; Hoover, T; Coetzee, N; Nokes, W; Rust, F	1998		AAPT
*	Caltrans Reports	Monismith, C; Harvey, J			Caltrans
*	Construction and Comparison of Louisiana's Conventional and Alternative Base Courses Under Accelerated Loading	Metcalf, JB; Romanoschi, S.; Li, Yongqi; Rasoulian, M; Roberts, F.	2001	347	FHWA
*	Data Handling Procedures for TxAPT Center	Rioux, T.W.; Hudson, W.R.; White, R.P.	2003	CTR1924-P4	CTR
*	Detailed Workplan for TxAPT Site Preparation	Hudson, W.R.; White, Ronald	2002	CTR1924-P2	CTR
*	Development of a Methodology to Determine the Appropriate Minimum Testing Frequencies for the Construction and Maintenance of Highway Infrastructure	Zhang, Zhanmin; Fowler, David; Hudson, W.R.; Ceballos, Ricardo	2001	CTR1781-1	CTR
*	Draft Manuals and Procedures for MLS Data Collection and Equipment Operation Including Plans for MLS Shakedown Test	Hudson, W.R.; White, Ronald	2003	CTR1924-R1	CTR
*	Draft Technical Memorandum MLS Project IAC00-0256	Kistner, JC	2002		Kistner, JC
	Establishing the California Department of Transportation Accelerated Pavement Testing Program	Nokes, WA; Stolarski, PJ; Monismith, CL; Harvey, JT; Coetzee, N; Rust, FC	1996	TRR 1540	TRB
*	Establishment of Reliable Methodologies to Determine In-Situ Moisture Content of Base and Subgrade Soils	Liu, Richard; Chen, X;He, R;Ma, W; Wu, H.	1998	3935-S	TxDOT/U of H
*	Evaluation and Improvement of Seismic Pavement Analyzer	Yuan, D; Nazarian, Soheil	1998	2936-1F	UTEP
***Ordered by TxAPT**	**Title**	**Authors**	**Pub. Date**	**Report No.**	**Publisher**
*	Evaluation of An Accelerated Pavement Testing Facility and Development of its Load Equivalence Factors	Chen, Jian-Shiuh; Lin, Kuei-Yi	2002		ASTM
	Evaluation, Design, and Implementation of an Automated Process-Control and Data-Acquisition System for the Texas Mobile Load Simulator (TxMLS)	Collier, Dennis S.	1996	CTR 2912-S	CTR
	Executive Summary Report on the Production of the Prototype Texas Mobile Load Simulator		1996	CTR 1978-2F	CTR
	Experimental Design, Planning, and Analysis of Pavement Test Sections for the Texas Mobile Load Simulator		1995	CTR2921-1F	CTR

*	First-Year Annual Operating Report for 2002	Hudson, W.R.	2003	CTR1924-R2	CTR
*	Five-Year Strategic Plan for the Texas Accelerated Pavement Test Center	Hudson, W.R.	2002	CTR1924-P1	CTR
	Full-Scale/Accelerated Pavement Testing for the Texas State Department of Highways and Public Transportation	Hugo, F; McCullough, BF, van der Walt, B	1991	TRR 1293	TRB
*	Full-Scale/Accelerated Pavement Testing: Current Status and Future Directions	Coetzee, NF; Nokes, W; Monismith, C; Metcalf, J; Mahaoney, J	2000		TRB
*	HVS Test Plan for Goal 7 Dowel Bar Retrofit Rehabilitation of Rigid Pavements	Monismith, C; Harvey, J	2001		Caltrans
*	In Situ Determination of Elastic Moduli of Pavement Systems by Spectral-Analysis-of-Surface-Waves Method, Practical Aspects	Nazarian, Soheil; Stokoe, Ken	1985	CTR 368-1F	CTR
*	In Situ Determination of Elastic Moduli of Pavement Systems by Spectral-Analysis-of-Surface-Waves Method, Theoretical Aspects	Nazarian, Soheil; Stokoe, Ken	1986	CTR 437-2	CTR
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