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16. Abstract

This report presents the first phase of a test plan for the use of the Texas Mobile Load Simulator (TxMLS). It was developed through an iterative process of consultation between TxDOT's Pavement Division and its researchers. The scope of this phase was limited to tests conducted in Victoria, Texas (Yoakum District).

The guidelines for the selection of test sites and for testing operations at field locations that were developed under Project 1978 formed the basis of this Test Plan. The tasks and responsibilities of the research team from the respective universities have been incorporated in the report, together with the anticipated outputs from Phase 1. A research management structure was developed to ensure the necessary integration of these activities. This structure was augmented by the development of a testing and measurement protocol.

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TEXAS MOBILE LOAD SIMULATOR TEST PLAN

by

Frederick Hugo

Research Report 1978-1

Research Project 7-1978
Texas Mobile Load Simulator Implementation Assistance

conducted for the

Texas Department of Transportation

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

February 1996

IMPLEMENTATION STATEMENT

The objective of this study is to provide the Texas Department of Transportation (TxDOT) assistance in the use of the Texas Mobile Load Simulator. Meeting this objective entails an ongoing, interactive relationship with both the manufacturer, VMW Industries, and the end-users, represented by TxDOT and its researchers. In this process, appropriate applications of the machine were developed, together with guidelines for the selection of test sites and testing operations at field locations. With the advent of the test program, this information was incorporated into the test plan, which was implemented as a modification to Project 1924. As a result, the system is now being implemented.

Prepared in cooperation with the Texas Department of Transportation.

ACKNOWLEDGMENT

The author acknowledges the support and expert assistance provided by the TxDOT MLS Team, as well as that provided by the researchers from the respective universities involved in this effort.

DISCLAIMERS

Frederick Hugo, P.E.
Research Supervisor

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SUMMARY

This report presents the first phase of a test plan for the use of the Texas Mobile Load Simulator (TxMLS). It was developed through an iterative process of consultation between TxDOT's Pavement Division and its researchers. The scope of this first phase was limited to tests conducted in Victoria, Texas (Yoakum District).

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TEXAS MOBILE LOAD SIMULATOR (MLS) TEST PLAN

1.0 INTRODUCTION

Among all accelerated pavement testing devices, the Texas Mobile Load Simulator (MLS) has the ability to test the widest range of variables within a pavement system (Ref 1). Indeed, a problem is not to fall into the trap of making the scope of testing with the prototype MLS *too wide.*

In developing the predecessors of the MLS, it was found necessary to conduct exploratory testing on a limited scale so as to establish the specific operational characteristics of the devices (Refs 2, 3). This also provided sufficient data to guide further application of the respective devices. A similar process is being followed with the MLS to establish a better understanding of its unexplored capability.

While accelerated pavement testing (APT) is not complex, there are a significant number of steps that need to be attended to during the test process. These need to be carefully managed to ensure that optimal results are obtained. A system for achieving this will be established during initial tests that are to be conducted — as Phase 1 — on virgin pavements that were specifically constructed for this purpose on a frontage road adjacent to US 59 in Victoria, Texas, in the Yoakum District. The sections have both thick and thin asphalt, as well as jointed concrete pavements.

Once these tests have been completed and the test system established, the MLS will be moved to the Lufkin District, where trial sections have been constructed and studied over an extended period of time (under regular traffic) to provide insight into appropriate and economically viable rehabilitation options at a future date (Ref 4). The site also offers the opportunity for conducting some unique experiments as Phase 2, since it will enable performance under regular traffic loading to be correlated with performance under accelerated axle loading. These experiments will provide data valuable for the validation of certain research findings that are still subject to widely differing viewpoints.

It is expected that these tests will extend over the next 12-18 months. Afterwards, it should be possible to expand the test program to another part of the state, as Phase 3, to study the impact of other variables. The test plan will initially consider only the Phase 1 tests sections in Victoria. It will, in due course, be updated to give details of the next test phase in the Lufkin District.

2.0 OVERALL OBJECTIVES OF THE STUDY

The Executive Management Committee of TxDOT, headed by Mr. Robert Cuellar, has outlined four primary objectives for the MLS test program. These were used as the basis for setting the objectives of the initial study. In addition, secondary objectives were formulated to focus on specific issues. A number of related objectives pertaining to the MLS were also included. Accordingly, the following objectives were formulated:

1. Investigate load damage equivalency

2. Determine remaining life and its impact on rehabilitation guidelines
    2.1. Investigate remaining life prediction
    2.2. Compare viable rehabilitation options
3. Investigate new pavement materials (e.g., use the MLS as a validation tool for Superpave)
4. Truck component—pavement interaction
    4.1. Determine operational limitations of the MLS
    4.2. Study pavement response under controlled, multiple axles

It should be noted that other fields of activity in pavement engineering, which have also advanced extensively, will also be addressed by the program. Two specific examples are the establishment of the Superpave System for Asphalt Binders and Hot Mix, and the Long-Term Pavement Performance System for studying the in-service behavior of pavements. This should assist in obtaining the most cost-beneficial use of the respective entities, and ensure greater understanding of the pavement system.

3.0 OBJECTIVES OF PHASE 1 OF THE STUDY

In Phase 1 of the study the objectives will be to:

1. determine the pavement loading characteristics of the MLS;
2. study the ability of NDTs to monitor pavement damage during trafficking;
3. evaluate the measured pavement response and performance against the predicted values;
4. compare the moduli obtained from different sources, such as lab, MDD, strain gauge, and SASW.

3.1 Expected Outputs from Phase 1

More specifically, the tests in Phase 1 will address a number variables and characteristics that are expected to produce the following outputs:[1]

- Variability in the MLS's axle loading characteristics along the test section. (MF, BS, FH, & EF)
- The influence of load variation along the length of the test section. (D-HC, JW, Y-HC, RH, CP & EF)

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[1] The initials in parenthesis note persons who are expected to be involved with the respective topics. The underlined initials are the lead person(s). This should be read together with the management organigram that is discussed under Section 7.3.

- The influence of load variation in the two wheel tracks. (D-HC, JW, Y-HC, RH, CP & EF)
- The comparative behavior of the different WIM devices. (MF, FH & BS)
- Stiffness reduction in terms of load applications and crack development. (KS, JL, SN, & Y-HC)
- Predicted vs. measured response in terms of strains, deflection and pressure. (D-HC, JW, Y-HC, RH, CP, EF & TS)
- Predicted vs. measured cracking and rutting distress in terms of axle load applications. (D-HC, Y-HC, JW, FH & EF)
- Predicted versus measured permanent deformation of the respective layers in terms of load applications. (D-HC, JW, Y-HC, TS & EF)
- Performance in terms of predicted versus actual distress. (D-HC, JW, Y-HC, & EF)
- Change in longitudinal smoothness in terms of axle load applications. (Y-HC & TD)
- Joint faulting (variation in load transfer) in terms of load applications. (MF, Y-HC & JW)
- Predicted versus actual remaining life. (D-HC, Y-HC, JW & EF)
- Stress dependency of pavement layers. (TS & JW)
- Change in surface friction in terms of axle load applications. (MF)
- The influence of the environment on pavement response with time. (RH, CP & MM)
- The effectiveness of retrofitting strain gauges. (RH & CP)

4.0 PAVEMENT STRUCTURE AND SITE LAYOUT

Figure 1a and 1b detail the pavement sections and layout of the instrumentation located in Victoria. Apart from the pretrial test section, six further test sections are feasible on the constructed test pavements. These have been designated F_1-F_4 (asphalt) and R_1-R_2 (jointed concrete). The two asphalt pavement section F_1 and F_3 have been instrumented.

The pretesting trials were performed on a section whose pavement is similar to the pavement of test section F1. Two weigh-in-motion scales, one a French CAPTELS and the other a German PAT, were installed. In addition, a number of piezo-electric WIM cables were installed. There are one #1 grade and four #2 grade piezo-electric cables. These will all be used to gather WIM data for calibrating the MLS bogies and to perform comparative testing.

Three holes were drilled into the pavement as part of our cross-hole shear testing; a multi-depth deflectometer was installed to explore the collection of deflection data. The results of the initial commissioning test were reported by Ken Fults of TxDOT at a workshop held during the TRB meeting in January 1995.

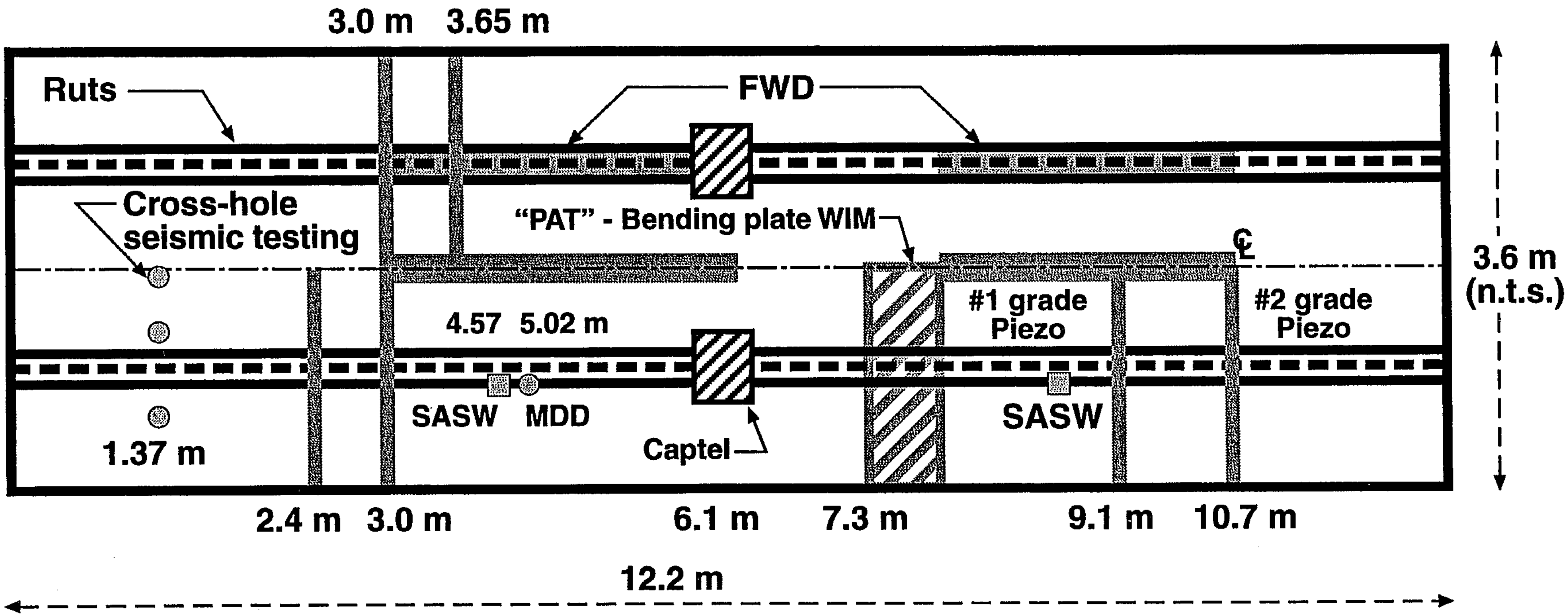


Figure 1a. Plan view of pretrial test section showing layout of test points

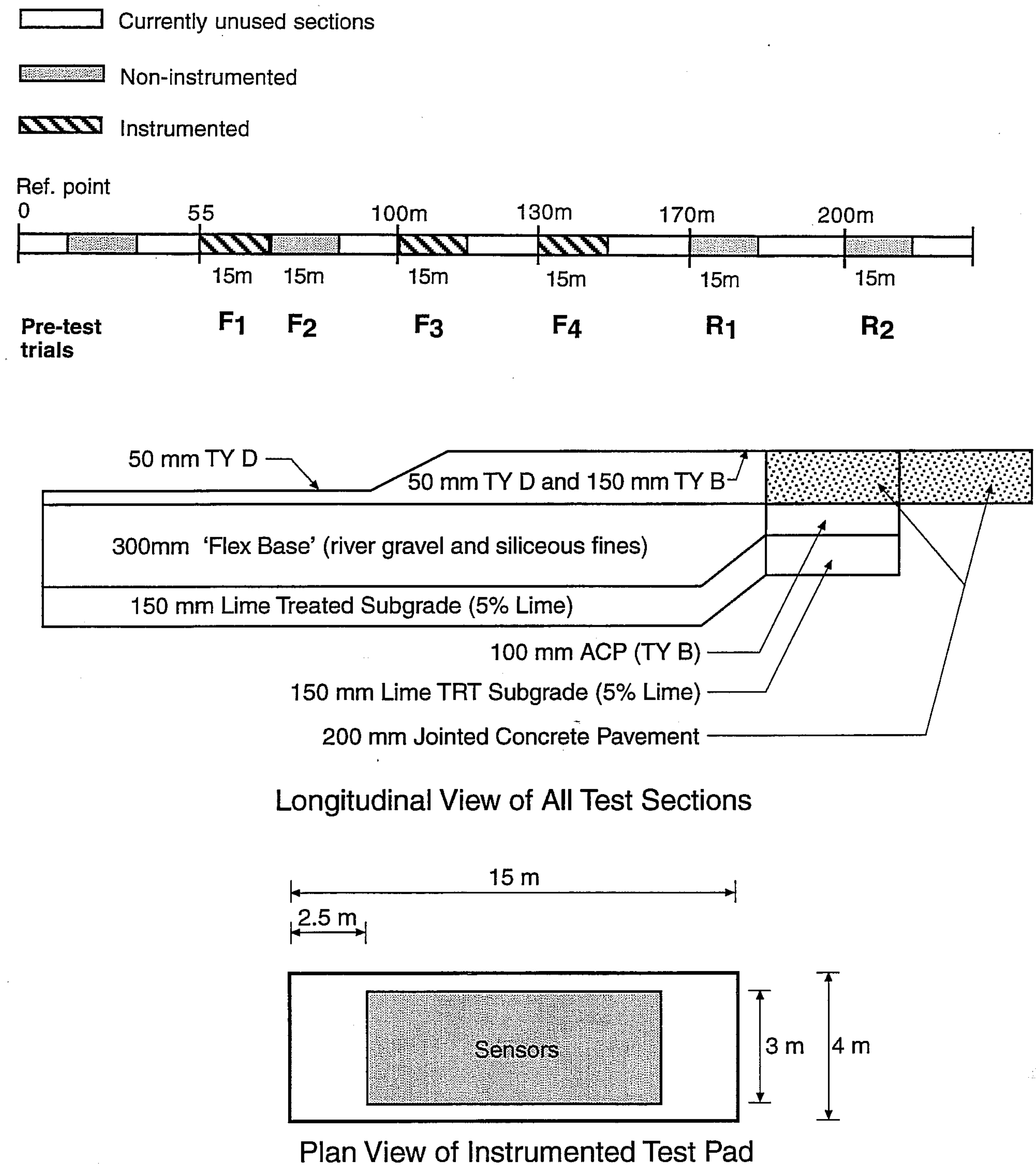


Figure 1b. Layout of instrumented flexible and rigid test sections at Victoria

5.0 SITE PREPARATION

The following tasks have to be undertaken in order to prepare the new test site:

1. A grid shall be painted over the proposed MLS test pad for the next MLS test site. The grid is shown in Figure 2a as a 12 m x 4 m outline that is subdivided into eight 3 m x 1.5 m sectors and eight 3m x 0.5 m sectors. This grid is important in that all measurements will be referenced to it. A thin white line will be adequate. Careful navigation will be required when positioning the machine to ensure that the wheel tracks of the MLS coincide with existing subsurface strain gauges. (The accuracy with which the MLS can be placed on a existing instrumented section needs to be ascertained in order to complete this task successfully.) (D-HC and MF)
2. A permanent reference base, in the form of two aluminum rails, must be installed on the pavement surface along the length of the test section. These will be utilized both as a guide rail for the profilometer and as a reference beacon for it (see Figures 2a and 3). Their altitudes should be determined relative to a fixed non-variable benchmark that is to be installed at least 4 m away from the machines jacks and preferably 10 m in the case of asphalt pavement and 20 m in the case of concrete pavement. It is to be anchored at a depth that is stable (at least 4 meters).
3. A thermocouple string must be installed to give representative layer temperature measurements. In general, asphalt layer temperatures are recorded at the top, middle, and bottom of the layer. This may be modified for a thin layer, such as encountered on site 1 (75 mm). Temperature measurements in the base are less critical but a measurement at mid-depth would be helpful. Access needs to be provided so that the temperature can be read while FWD testing is going on. (MF)
4. Three 1 m deep by 37 mm diameter access holes must be drilled at the locations shown in Figure 2, approximately 100 mm from the transverse profile line for cross-hole shear testing. The holes must be lined and capped. (JR & TS)

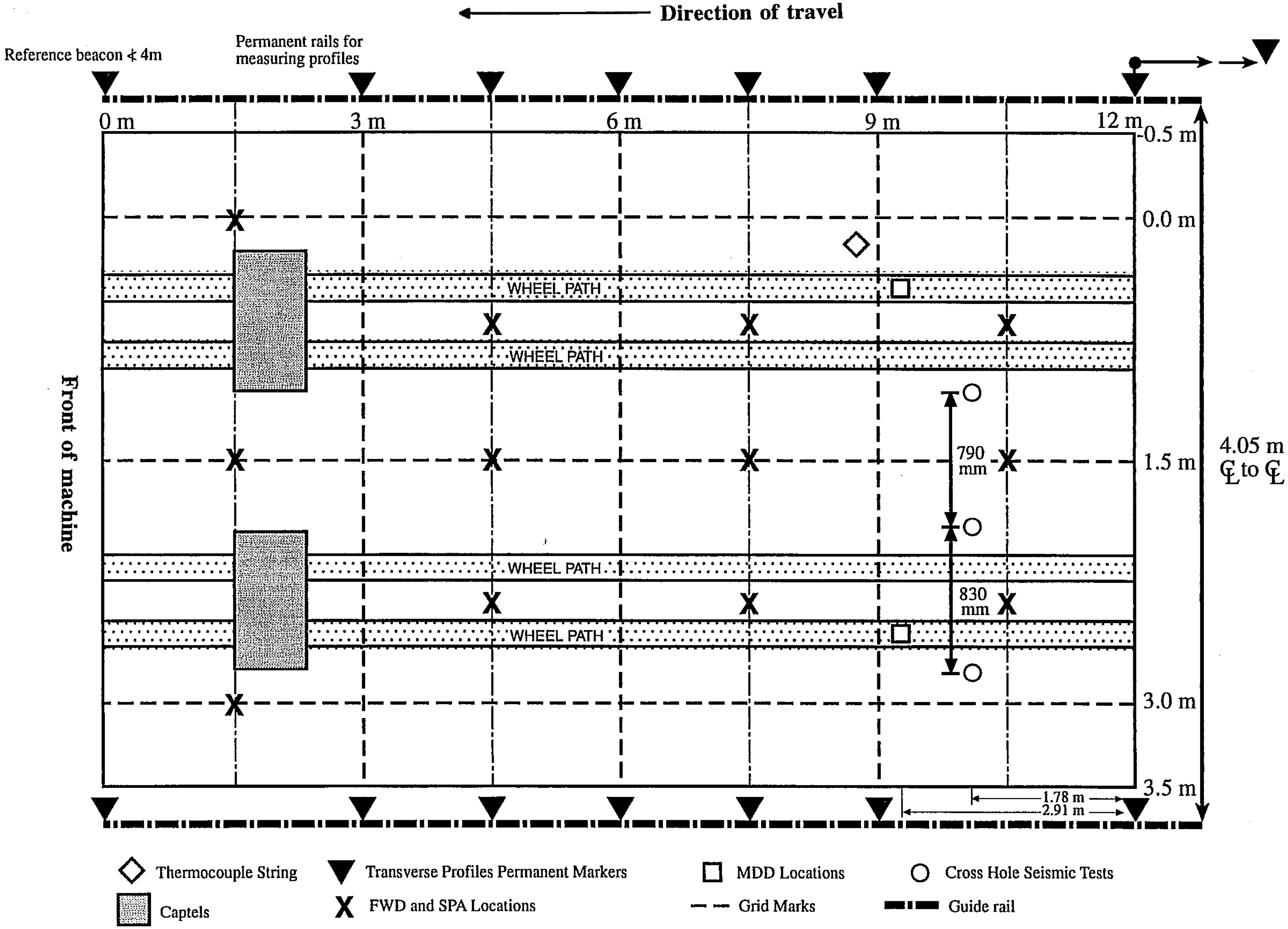


Figure 2a. MLS test setup for Test 1 in Victoria

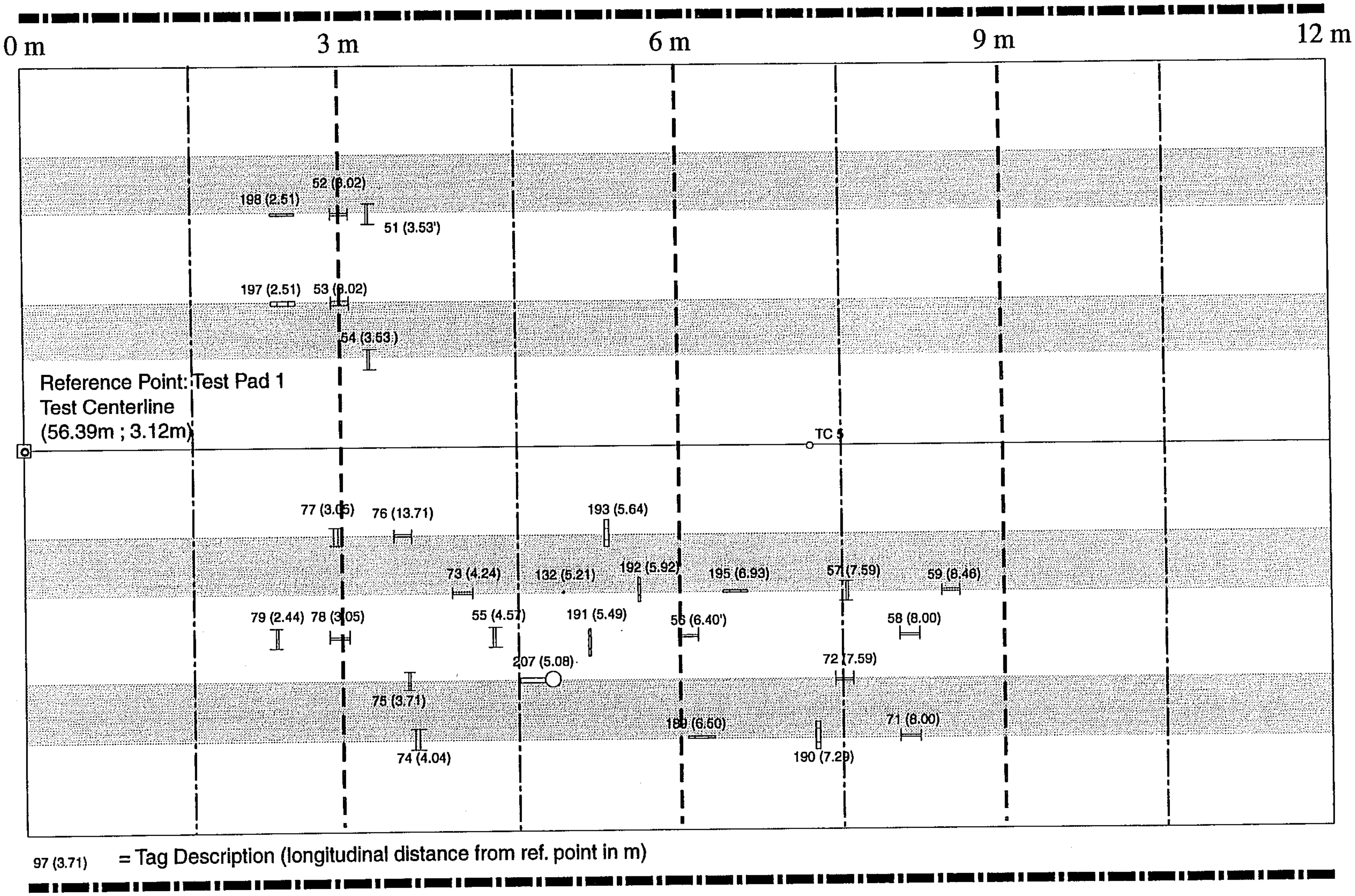


Figure 2b. Example of strain gauge in Test pad 1, top of base (sensors numbers and positions)

6.0 TESTING AND MEASUREMENT PROTOCOL

The following testing and measurement protocol has been drafted for the initial stages of the project. These will be reviewed from time to time and adapted as necessary. All of the raw data and processed results will be sent to D-HC. It should also be noted that unless otherwise prescribed in this section or otherwise instructed by the Project Director, all tests will be conducted after the following load applications have been completed:

Testing Intervals Relative to Trafficking
0
2,500
5,000
10,000
20,000
40,000
80,000
160,000
320,000
640,000
1,280,000
2,560,000

6.1 Falling Weight Deflectometer

Four load levels (standard set-up) are to be used, corresponding to approximately 27, 40, 49, and 62 kN. One set of drops are to be performed at each location shown in Figure 2. Only peak load and deflections are to be recorded. Full wave shape at the single FWD test point are to be recorded. Thermocouple temperatures are to be entered with the time of each FWD data set, noted as comment.

Prior to starting the test sequence, FWD tests are to be conducted at 1m intervals in each wheel path to identify any weak spots in the section. The FWD test pattern may be modified, based on these initial findings. (Responsibility for coordinating the FWD data collection rests with MF; responsibility for processing the standard FWD deflections rests with D-HC and TS.) Moduli will be backcalculated and forwarded to D-HC.

6.2 Ground-Penetrating Radar

Once the test location is accurately defined, ground-penetrating radar (GPR) runs should be made in each wheel path to determine if there are any anomalies in the asphalt, and to determine the uniformity of the base layer. (TS will collect and process all GPR data.)

6.3 Seismic Testing

1. Seismic pavement analyzer (SPA) tests should be undertaken at the same location as the FWD tests at selected intervals. Temperature data should also be taken for each SPA test. Additional manual SASW tests are also to be conducted at selected intervals. (KS will be responsible for coordinating SASW tests. TxDOT should collect the SPA data following training from SN; SN will process the data.) The resulting layer moduli will be forwarded to D-HC.
2. Cross-hole testing will be performed with and without wheel loads straddled across the holes (KS will be responsible for all testing and processing). Readings are to be taken only at selected intervals. The calculating layer moduli will be forwarded to D-HC.
3. Rolling dynamic deflectometer tests will be performed prior to MLS testing to determine uniformity of the test section (Dynamic deflection data will processed by KS).

6.4 MultiDepth Deflectometer

1. Two multidepth deflectometers (MDDs) should be installed at the locations shown in the layout of the test section in Figure 2. They should be in the outer wheel paths at 100 mm offset from the transverse profile line. (JR and TS)
2. At the beginning of the test and at the predefined stopping intervals, no load MDD output voltage should be recorded. The MDD will be used to identify the accumulation of rutting in each layer, to check the uniformity of load on each MLS axle set, and to assist in backcalculating layer moduli with depth. The results of these analyses will be forwarded to D-HC. The transient deflections under load should also be recorded for one complete cycle of the MLS (deflections under each wheel). (During the first test, JR and MF will be responsible for MDD data collection.)

6.5 Strain Gauge and Pressure Cell Readings

The strain gauges were instrumented in the flexible section: two in the thick section and one in the thin section. The overall layouts and longitudinal positions are recorded as shown in Figure 2b. Full waveshape data should be collected for one complete loop of the MLS (all wheels). Gauges that need to be monitored should be defined (D-HC).

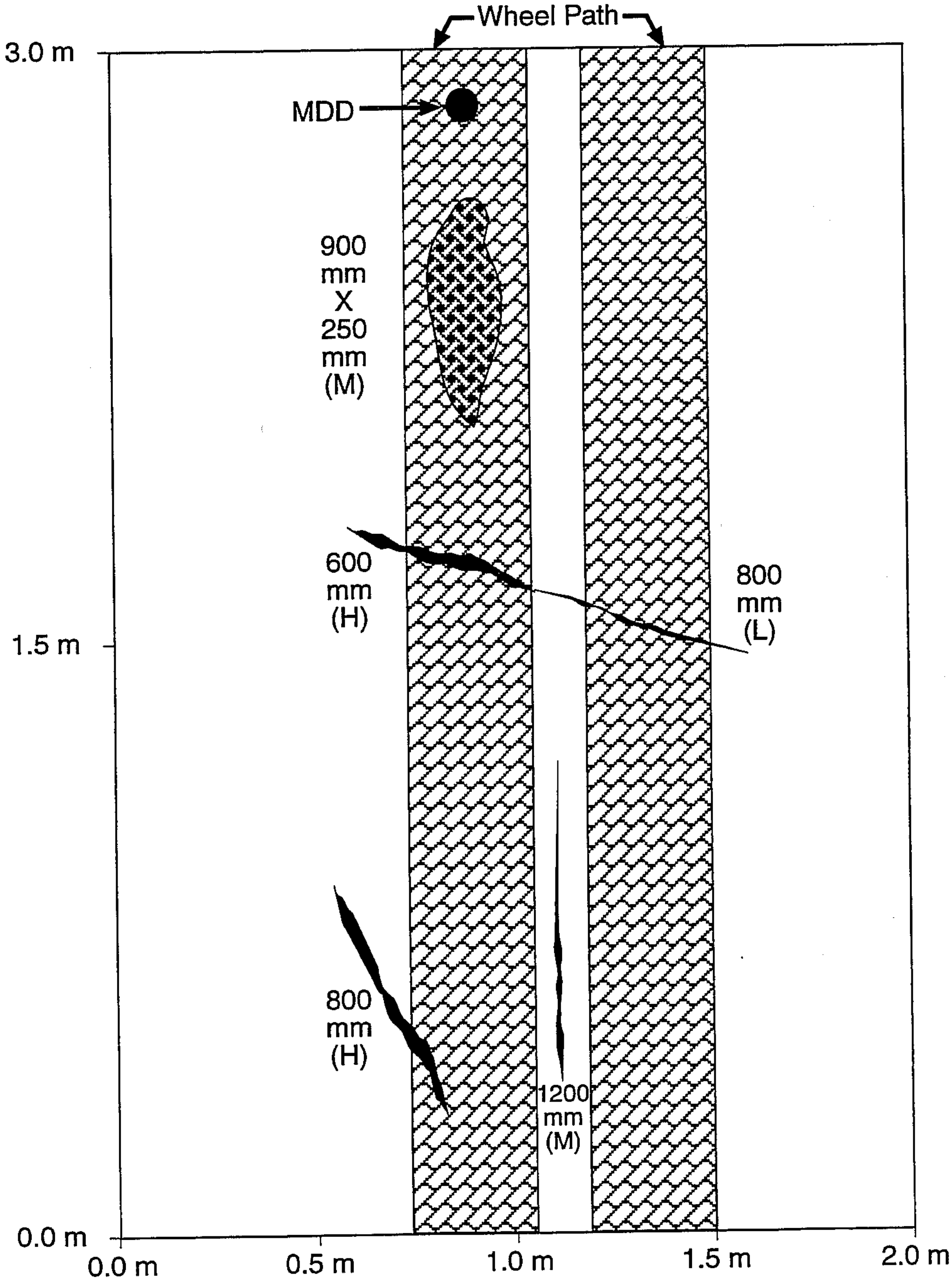
Once in operation, it is anticipated that these data will be collected prior to stopping the machine for the crack and NDT testing. (MF, D-HC, and TS will be responsible for all data collection and processing.)

6.6 Visual Inspection

All cracks are to be mapped manually. Maps should show the length and width of each crack in each sub sector (3m x 1.5m) of the section. The lengths are to be measured with a rolling wheel or tape measure accurate to the nearest 25 mm. Crack widths are to be classified (feeler gauges help here) as follows:

1. Hairline (visible but no measurable width)
2. Slight (less than 1 mm wide)
3. Moderate (less that 2.5 mm wide)
4. Severe (greater than 2.5 mm wide)

For alligator cracking, the cracks within the cracked area should be mapped and the length and width of the cracked area recorded. In addition, the average crack width within the area should be used to define the severity level. Each of the subboxes should be sketched and the different cracks color coded to show different severities. The time, date, and surface temperature should be entered on each crack map. A typical crack map is shown in Figure 3. Once underway, it would be best to prepare the crack maps during the cooler part of the day (night or early morning), if possible, as some cracks can disappear under traffic. Once the crack mapping is completed, the cracks should be chalked and photographed. (MF will be responsible for all visual crack maps with training by FH.)



MLS Test #: V/F 1
Block: 1.1
Reps: 50,000

Date: 10/28/95
Time: 08:50
Surface Temp.: 10°C

Figure 3. Example of a typical pavement surveillance block

6.7 Transverse Profiles

Measurements are to be made across the full width of the MLS, i.e., on either side of the center line, straddling the wheel paths (see Figure 4). The measurements are to be made at 3m centers across the center of each of the subsectors at the prescribed axle-related intervals (FH and MF). The measurements should be made in a self-checking manner by closing each traverse on a fixed benchmark on the guide rails. (MF will be responsible for collecting the Transverse Profile date, training will be provided by FH.) The analysis results will be forwarded to D-HC.

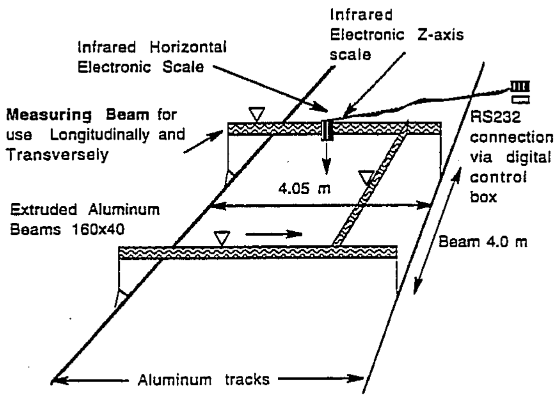


Figure 4. Schematic of profilometer

6.8 Longitudinal Profiles

Measurements are to be made along the length of the left and right outer wheel paths of the MLS, i.e., on either side of the center line as well as along the center line. Reading are to be taken only at selected intervals. The measurements should be made in a self-checking manner by closing each traverse on a fixed benchmark on the guide rails. The riding quality must be calculated using the reduced level at 150 mm intervals. (MF will be responsible for collecting the Longitudinal Profile date, training will be provided by FH.)

6.9 Communications

At the beginning of each MLS test, a schedule of when the anticipated data collection times are likely to occur should be established (MF). This schedule should be distributed to the contact person at each university. In addition, a bulletin of activities shall be issued daily to the office of the Project Manager for distribution to all concerned (MF, FH, TS, SN).

7.0 EXPERIMENTAL PLAN

The experimental plan is an important facet of the project, one that requires the support and cooperative effort of all task team members. The controlling guidelines and related factors used in the development of the experimental plan are described below.

7.1 Controlling Guidelines

Features of the full-scale MLS testing are expected to be similar in many respects to those found with roll-over testing on the instrumented sections and tests conducted with the MMLS. The experimental procedures for these earlier tests should therefore provide a sound basis for the development of the test procedures for the full-scale MLS test program and the analysis of its results (Refs 5–10). Apart from this, the following guidelines have been taken into account:

- Some duplicate testing is needed to establish variability.
- Some triplication is desirable at a future date for the same reason.
- The number of variables during a single test needs to be minimized.
- The number of goals achieved simultaneously needs to be optimized.

Comparative tests should also be used for achieving other goals simultaneously.

7.2 Testing Program at Victoria

The testing program at Victoria will follow the proposed test scenarios shown in Table 1. This should be read with Figure 5(a), which depicts pavement test scenarios under accelerated traffic in terms of environmental impact. In short, it depicts how the pavement's performance may be affected by allowing the environment to age the asphalt to different degrees, prior to APT. It also indicates in detail that the number of accelerated load repetitions that can be attained at any particular point in time, when taken through phases A, B, & C, varies depending upon the nature of the pavement construction and the effect of environment. As shown, it is not known, prior to testing, whether the intrinsic pavement life is extended or shortened by such aging.

Figure 5b shows similar information in a format previously used (Ref 5). It illustrates how the remaining life is affected by both traffic and the environment, and how the latter could reduce the intrinsic pavement life. It also shows how the limiting strain values in an asphalt pavement are influenced by the environmental and traffic history of such a pavement. It can be seen that this could necessitate the use of shift factors less than 1 when comparing accelerated traffic with normal traffic. Likewise laboratory performance may require shift factors greater than 1. We have previously discussed in detail both the effect of time on the strain levels and the remaining life at any point in time (Ref 5).

Table 1. Proposed test scenarios, Victoria

		Phase/Load Applications		
Section	Description	A	B	C
PreT	Pretest trials	1,200,000 maxs		
F1[a]	50 mm (2") asphalt	650,000	x-650,000	
F2[c]	50 mm (2") asphalt	650,000	x_f-650,000 [b]	
F3[c]	200 mm (8") asphalt	750,000		
F4	200 mm (8") asphalt	750,000		
R_2	PC (undoweled)	750,000	(x_f-750,000)[d]	

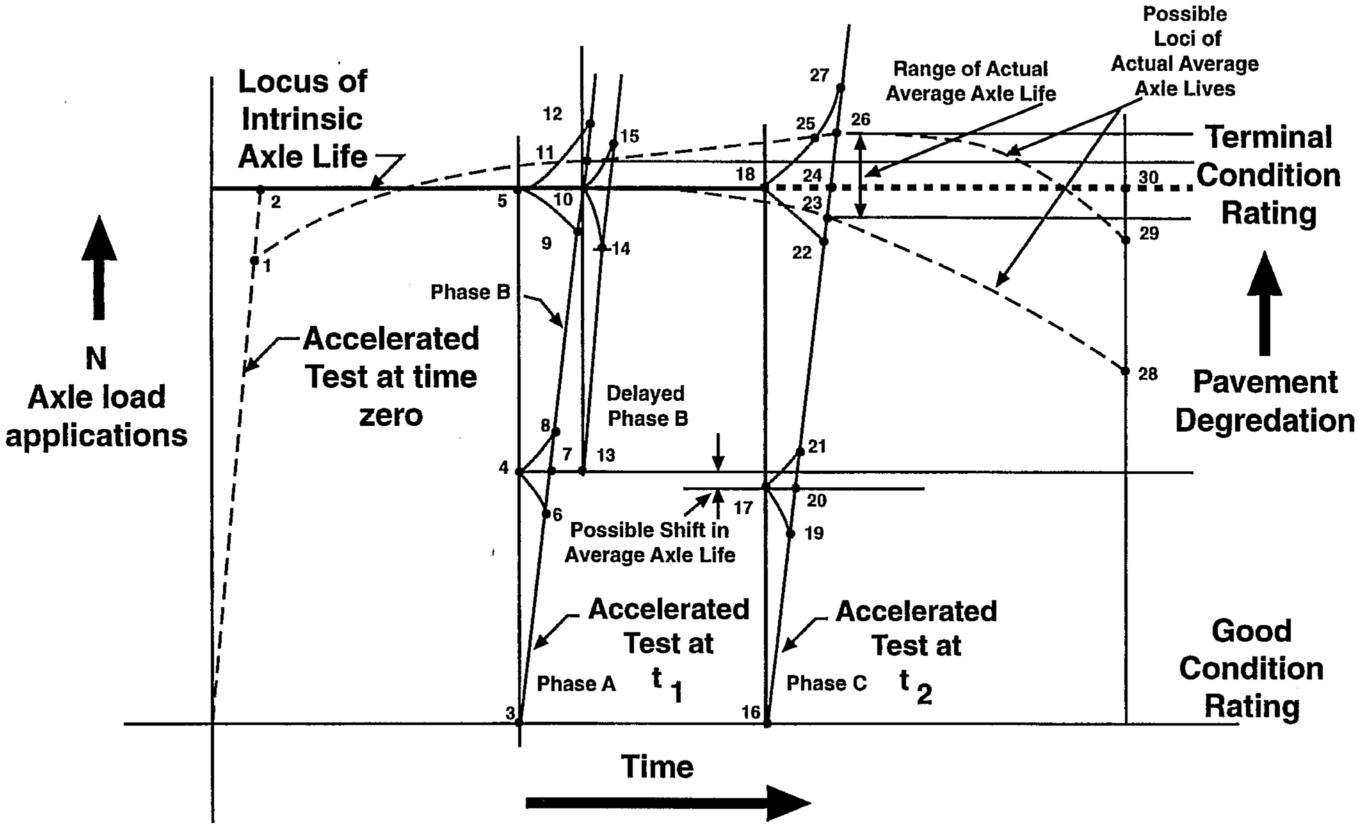
x_f=number of load application required to produce "failure".

[a] Influence of machine determined by moving 2 m longitudinally for application of 5,000 load applications.

[b] x_f= number of load applications required to produce "failure" after returning at some later date.

[c] Retained for future Phase B testing to measure environmental impact.

[d] With artificial application of surface water at $N=2x10^6$.



PAVEMENT PERFORMANCE SCENARIOS

Figure 5a. Schematic outline of pavement scenarios during accelerated testing with no real traffic (rev)

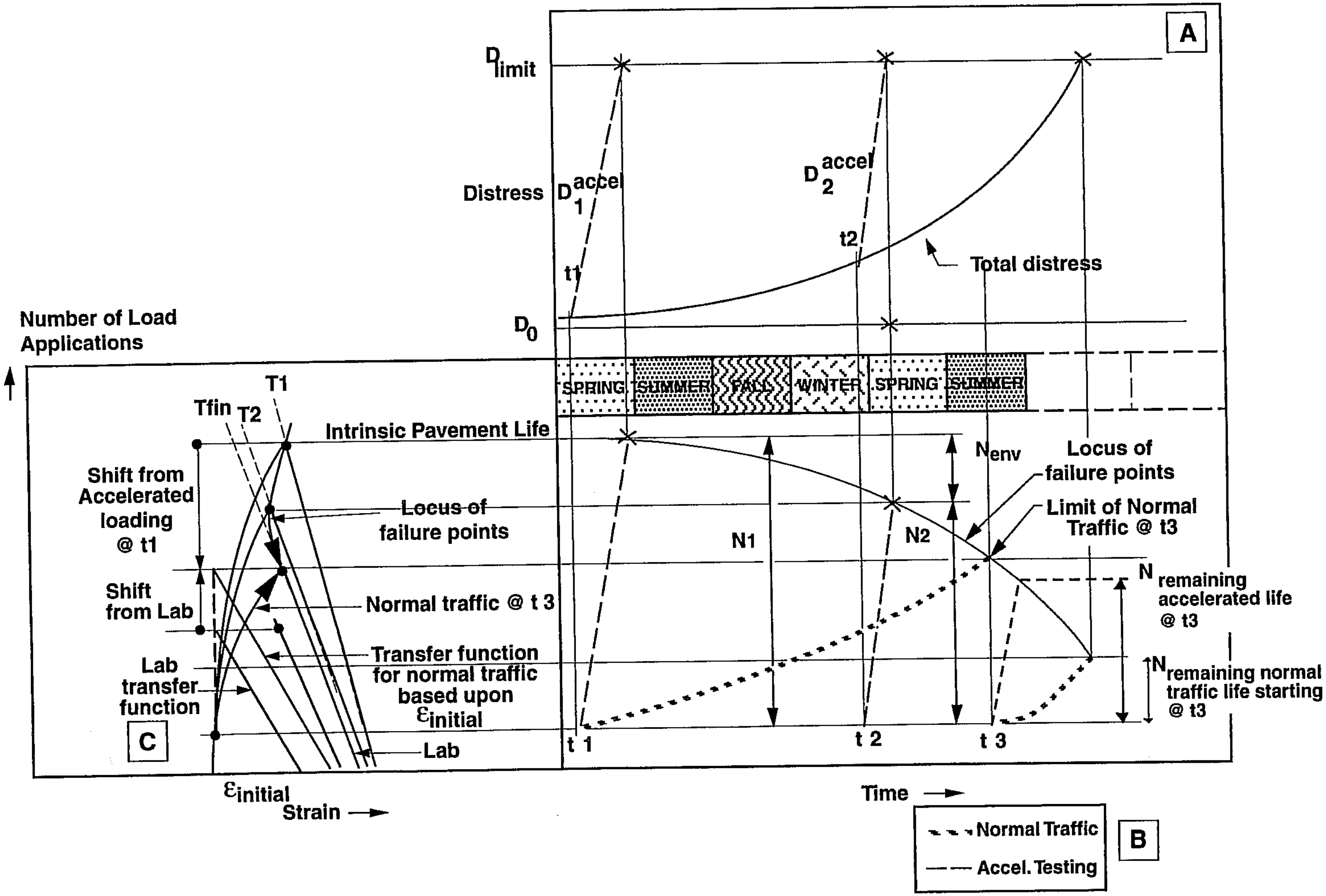


Figure 5b. Conceptual comparison between accelerated pavement testing and normal traffic subject to environmental impact

The following aspects of the experimental plan should be borne in mind:

- A tentative schedule for testing at Victoria is shown in Figure 6(a) and 6(b).
- Sections should be preserved for return at a future date to take into account time effects, whenever possible.
- Some controlled external forces may be needed to accelerate pavement degradation or distress.
- Uniformity of a pavement section will be established by NDT prior to tests.
- Instrumented sections on new construction are to take priority and to be considered for Second Phase testing, sometime in the future.

7.3 Organizational Management Structure

Figure 7 shows the proposed organizational structure, which is in accordance with the research agreement linking the various profiles.

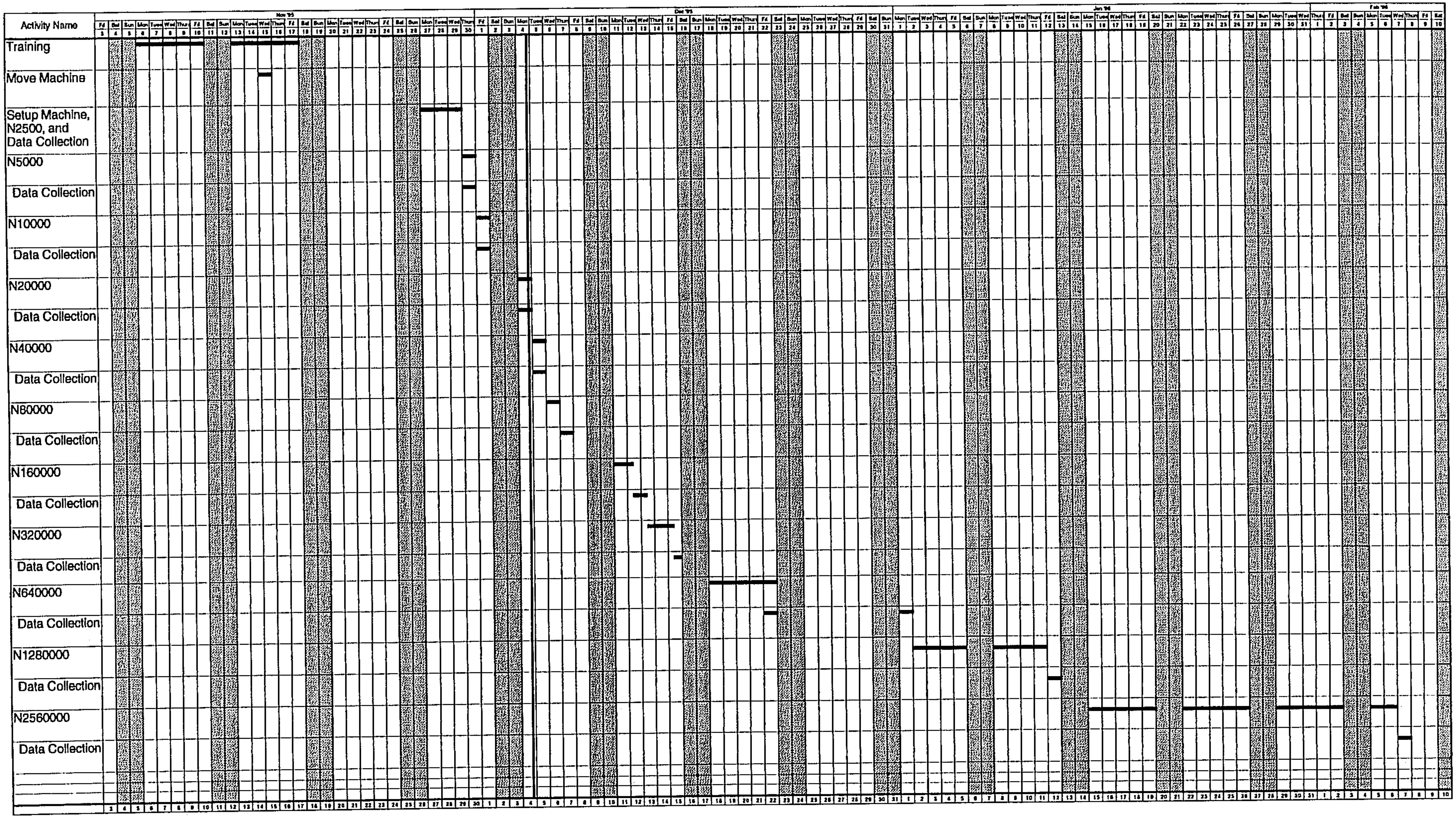


Figure 6a. Provisional schedule for first test at Victoria

STUDY SUPERVISORS: B.F. McCullough, F. Hugo and T. Scullion DATE: November 6, 1995

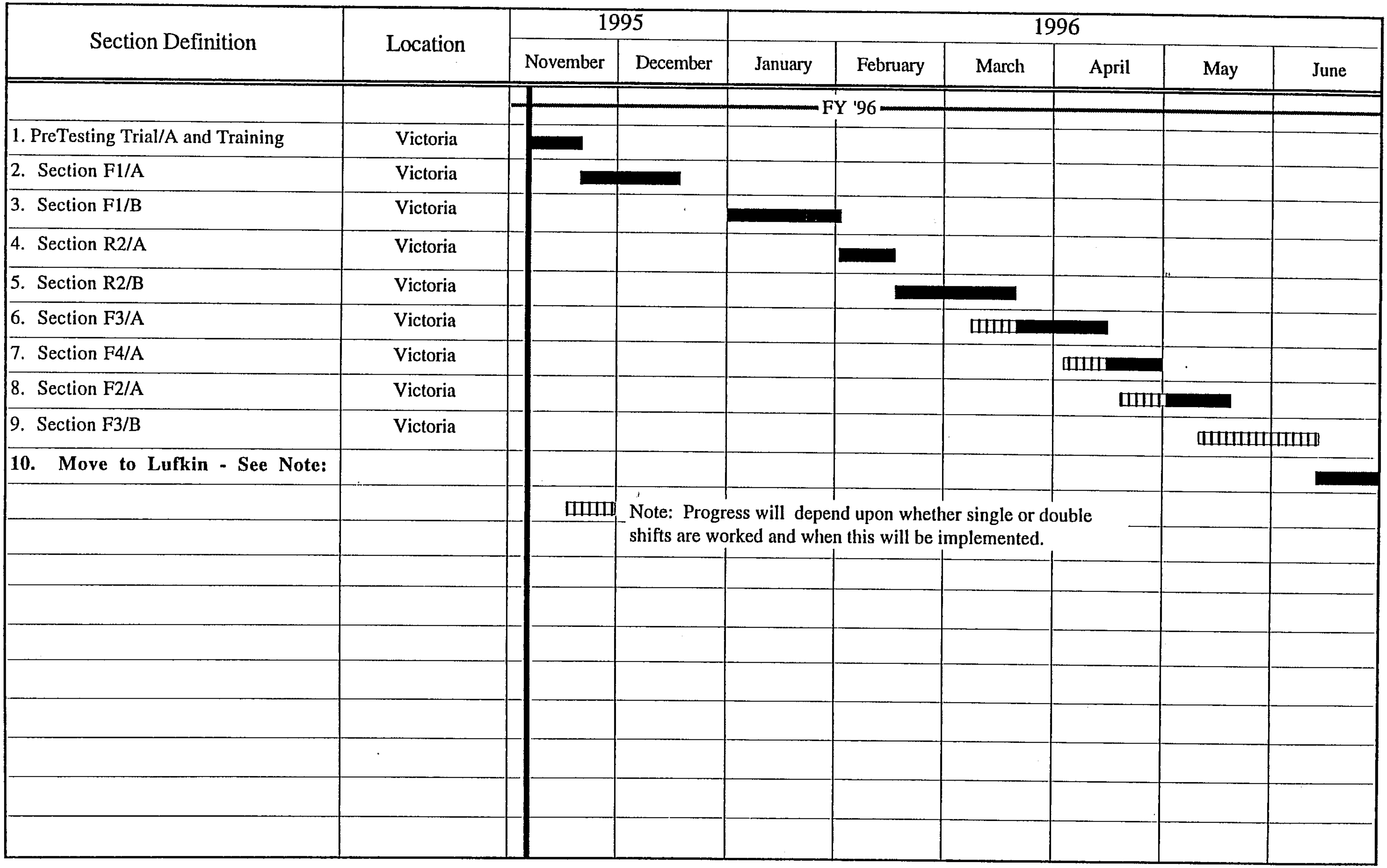


Figure 6b. Proposed test schedule

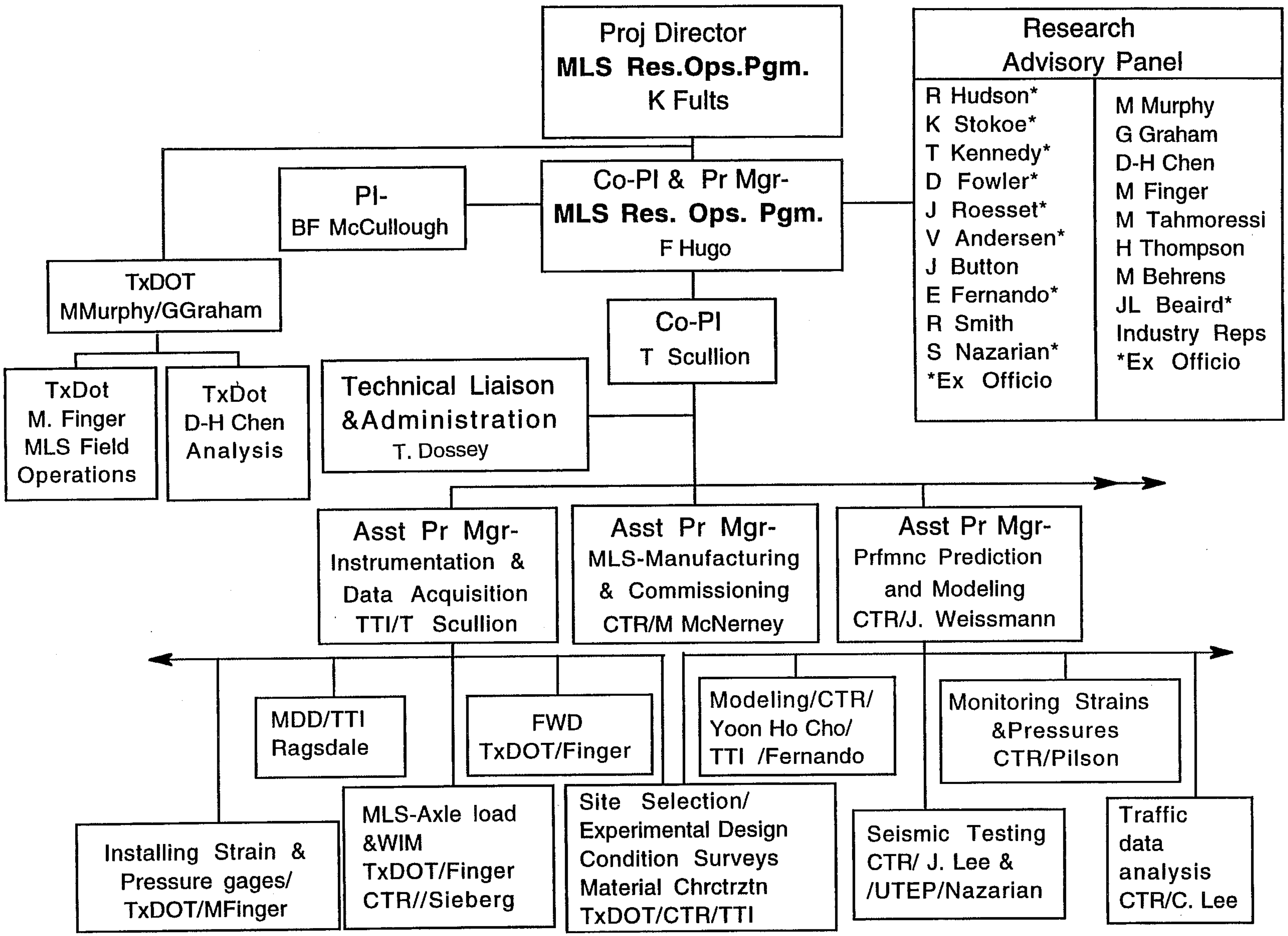


Figure 7. MLS research management structure — October 18, 1995

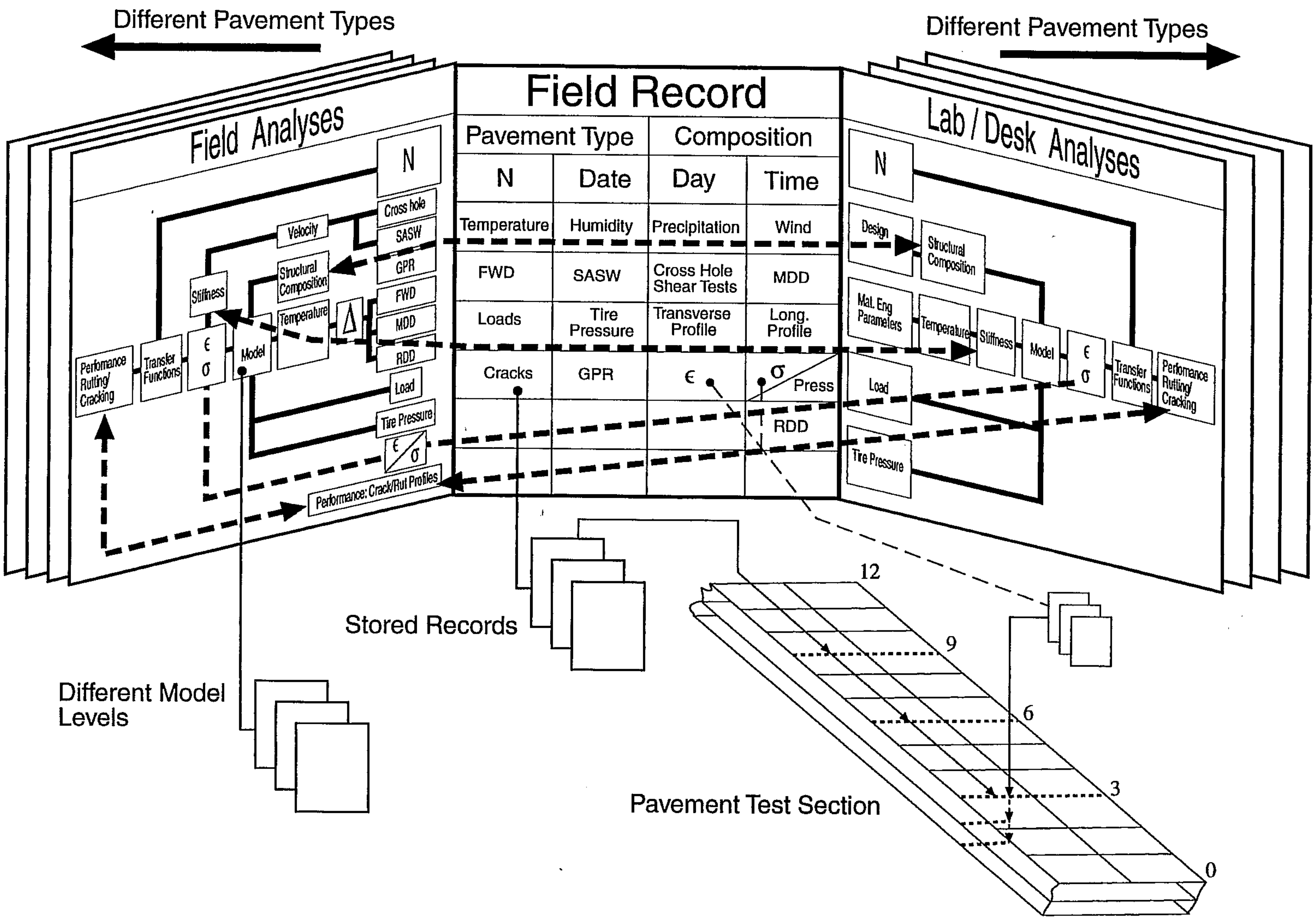


Figure 8. Proposed framework for MLS database

REFERENCES

1. McNerney, Michael T., Frederick Hugo, and B. Frank McCullough, "The Development of an Accelerated Pavement Test Facility for Florida Department of Transportation," Research Report 997-3F, Center for Transportation Research, The University of Texas at Austin, May 1994.
2. Romero, Recaredo, Aurelio Ruiz, and Javier Perez, "First Test on the Centro de Estudios de Carreteras Test Track," Preprint Paper No. 92-0008, Transportation Research Board, Washington, D.C., 1992.
3. "Recent Findings of Heavy Vehicle Simulator Testing," Symposium presented by the National Institute for Transport and Road Research, August 1984.
4. Hoskins, Brock E., B. Frank McCullough, and David Fowler, "Development of a Long-Range Plan for the Rehabilitation of US 59 in the Lufkin District 11," Preliminary Report 987-1, Center for Transportation Research, The University of Texas at Austin, February 1991.
5. Hugo, Frederick, B. Frank McCullough, and Barry van der Walt, "Full-Scale Accelerated Pavement Testing for the Texas State Department of Highways and Public Transportation," Transportation Research Record 1293, Transportation Research Board, Washington, D.C., 1991.
6. Lee, James, Frederick Hugo, and Kenneth H. Stokoe, II, "Using SASW for Monitoring Low-Temperature Asphalt Degradation Under the Model Mobile Load Simulator (MMLS)," Preliminary Research Report 1934-2, Center for Transportation Research, Bureau of Engineering Research, The University of Texas at Austin, November 1993.
7. Hugo, F., "Some Factors Affecting the Design and Use of the Texas Mobile Load Simulator," Vehicle-Road Interaction, ASTM STP 1225, B. T. Kulakowski, Ed., American Society for Testing and Materials, Philadelphia, 1994, pp 67-88.
8. Hugo, F., and N. C. Reck, "An Investigation into the Rutting Performance of a Thick Asphalt Base by Means of Accelerated Testing on Model Scale," Proceedings of the Sixth Conference on Asphalt Pavements for Southern Africa, CAPSA '94, Cape Town, 1994.
9. Smit, André de F., Frederick Hugo, and Martin van de Ven, "MMLS Testing of a Scaled Large Aggregate Base with Binder Variation," *Journal of the South African Institution of Civil Engineers,* Vol. 38, No. 3, Third Quarter, Johannesburg, September 1996.
10. Kim, Seong-Min, Frederick Hugo, Jose M. Roesset, and Thomas D. White, "Dimensional Analysis of the Mobile Load Simulator Action on Pavements," Research Report 2914-1F, Center for Transportation Research, The University of Texas at Austin, March 1995.

APPENDIX:

DETAILS OF ACTIVITIES RELATED TO THE RESPECTIVE TASKS

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The activities of the respective Task Teams will, in general, be as set out below. The institutions involved are as indicated, with the name of the lead institution underlined. It should however be understood that the tests are of an exploratory nature and that adaptations may be necessary.

TASK 1 — FALLING WEIGHT DEFLECTOMETER TESTING: TXDOT, CTR, AND TTI

1.1. Falling Weight Deflectometer (FWD) testing will be used throughout the test program to monitor the structural response of the pavement. This will assist in determining the special variability of the pavement sections.

1.2. Testing will also be performed at selected intervals during trafficking to establish the variation in deflection response and structural integrity.

1.3. We will analyze and evaluate the data, and will assist in synthesizing the findings during the test program.

TASK 2 — GROUND RADAR SURVEYS AND ANALYSES: TTI

2.1. A Ground Penetrating Radar (GPR) survey of the proposed test pavement will be done with a statistical analysis to compare the structural composition of any proposed site to that of the entire section. It is proposed to use both high frequency and low frequency GPR to investigate both near surface and deep pavement conditions.

TASK 3 — SEISMIC TESTING AND ANALYSIS: CTR AND UTEP

3.1. Seismic testing:

3.1.1. SASW testing of the proposed test pavement will be done with statistic analyses to select a representative test section by comparing its structural integrity to that of the entire section.

3.1.2. Testing of the pavement being trafficked should be done as per the experimental design in accordance with procedures developed during the testing of the model pavement (4) and during acceptance testing of the MLS on the first test pavement. This is expected to provide an indication of the change in stiffness of the bound materials. Which, in turn, will serve as a basis for monitoring the life cycle of the respective pavement test sections.

3.1.3. Analyze and evaluate the data and assist with synthesis of the findings during the test program.

3.1.4. Analyze and evaluate the data and assist with synthesis of the findings to assist with the selection of the test section.

3.2. Cross-hole shear testing:

3.2.1. Cross-hole shear tests will be done to establish small strain stiffness of materials of the selected test sections, under various conditions of loading, as per experimental design.

3.2.2. Testing will also be done at selected intervals during trafficking to establish the variation in shear response.

3.3. Heavy-load Defection Proofing with the Rolling Dynamic Deflectometer:

3.3.1. Conduct tests on the pavement section with the Rolling Dynamic Deflectometer (RDD) prior to MLS testing to determine spatial material variability. Full details of the HLDP have been set out in the proposal to TxDOT Project 1422, "Stationary and Continuous Measurements with the Heavy-Load Profiler." Repeat measurements as per the experimental design.

3.3.2. Analyze and evaluate the data and assist with synthesis of the findings to assist with the selection of the test section.

3.3.3. Analyze and evaluate the data and assist with synthesis of the findings during the test program.

TASK 4 — MDD INSTRUMENTATION: TTI

4.1. Install MDD's (to be acquired by TxDOT) in test sections according to the approved experimental plan. In general two per test section.

4.2. Drill and seal three 1m deep 37 mm of holes in each test section for cross hole shear testing.

4.3. Provide technical assistance during the execution of tests including the supply of the data acquisition and signal cleaning up software for the MDD's.

4.4. Assist with collection and synthesis of test data during the test program. Attention will be given to the identification of noise in the data and the minimization thereof.

4.5. Assist with the development of a system to integrate the respective data collection systems.

4.6. Stiffness of the materials will be used as a guide to the structural integrity of the pavement section.

TASK 5 — EXPERIMENTAL DESIGN PLANNING, STATISTICAL EVALUATION OF DATA AND SYNTHESIS OF THE RESULTS: CTR, TTI, AND UTEP

This test will require input from all three institutions. It will rely on sound, statistical evaluation of all the data.

5.1. Assist with the structuring of the experimental plan.

5.2. Evaluate results obtained during experiments with the MLS, assessing variability and its impact or extrapolation of the results.

5.3. Provide on-going advice on the adaptations to the experimental planning considered necessary after statistically evaluating the experimental findings. In particular, guidance will be given on future instrumentation needs including, retrofitting of strain gages and other instrumentation.

5.4. Assist with synthesis of the respective findings in terms of statistical confidence levels pertaining to inter alia:

- loads
- pavements
- spatial variability
- structural composition
- response measurements
- performance measurements
- environmental parameters
- correlation with data obtained by other means (such as SHRP's, LTPP and Superpave) on comparable pavement systems.

5.5. Examine output of instrumentation applied to MLS test sections as well as the loading cycle and use these test results as a measure of variability in the test applications to assist in the understanding of test phenomena and extending test results to full life cycle testing.

5.6. Examine the variability and the trends in the statistical analysis of measured instrument response in conjunction with environmental factors with the MLS as a predictor of remaining life. These measurements and the assessment of whether or not the observed variability is significant with respect to predicted remaining life, will be vital to the extrapolation of the MLS to full pavement design.

TASK 6 — PREDICTING THE PERFORMANCE OF THE MLS TEST SECTIONS: CTR, TXDOT, AND TTI

One critical component of the MLS test program is to validate and improve upon mechanistic design procedures. Models are used in pavement design and in predicting the performance of new materials and treatments. Validated models can, at the very least, act as screens so that full factorials of tests need not be performed. This is a tasks which will develop a framework by which laboratory testing and field performance can be correlated. Needless to say, the validation of models is an important aspect of the accelerated loading program. Some guidelines on the way in which this issue may be approached, have already been published (5). It will be noted that the model MLS (MMLS) has been used successfully to explore the application of the system (4) (6) (7).

Figure 8 schematically shows the relationship between design analysis and diagnostic field analysis. The multi-leveled and multi-dimensional nature of the respective elements is apparent. This schematic will be used to structure the MLS research management data.

The proposed test sites at Lufkin are part of a long-term rehabilitation study (Project 987), for which structural modeling has been done. This will provide the basis for this study. The test sites at Victoria were designed and constructed by TxDOT. They were instrumented during construction and have been used to explore the best means of measuring pavement response with in situ gages under project 2905.

The results of NDT will be used to characterize the pavement materials. Where feasible, this will be augmented by testing of materials recovered from each layer in the pavement using advanced laboratory testing procedures, including those developed by SHRP. The task will entail using the results of material characterization, and undertaking performance prediction in terms of rutting and cracking prior to MLS testing.

The currently used models will be taken as a point of departure. The material characterization and model verification will continue throughout the entire MLS program. Materials from one of the Victoria tests will be returned to TTI's McNew laboratory for characterization. Laboratory protocols will be reviewed and verified for future MLS work. Trial runs will be made of the available life prediction models. Specific attention will be given to the following aspects:

6.1. Assembling the Routine Design Prediction Programs

The documentation of existing implemented routine design procedures will be reviewed in order to determine if the MLS test can be used to validate the reasonableness of each at predicting life under Texas conditions.

6.2. Assembling the Advanced Mechanistic Design Procedures

Available programs that will be considered include the Federal Highways VESYS Program, TTI's FLEXPASS program, SHRP's level 3 SUPERPAVE and the finite element modeling work currently being developed for CTR project 987. Consideration will also be given to other programs that can account for the dynamic interaction between wheel loads and the pavement surface. The documentation and capabilities of selected programs, as well as the definition of the material characterization information needed to make life predictions, will be reported in summary form.

6.3. Trial Run of Software on Material Data Collected at the Victoria MLS Test

Samples taken from the test area will be subjected to a series of standard and advanced material characterization tests as a pilot study. The standard tests will include asphalt content, air void, PI, LL, gradation. The advanced tests will include the following, all of which can be used in models to predict pavement response and life to failure:

- SHRP characterization test on Asphalt cores including shear tests and creep recovery.
- Resilient Modulus of Granular Materials.
- Permanent Deformation Properties of Granular material (Gnu and Alpha test).
- Resilient Modulus of Subgrade Materials.
- Permanent Deformation Properties of Subgrade Materials.
- Texas Triaxial Classification Strength Test

All of these tests will be conducted in TTI's McNew laboratory.

Each of the programs reviewed in tasks 6.1 and 6.2 and found practical to include in the study will be used to predict pavement performance under the MLS taking due cognizance of the findings of Task 5. A comparison will be made of predicted and measured pavement performance. The performance will include time to first cracking, rut depth and overall composite pavement life.

6.4. Recommendations for Future Work

At the completion of Task 6.3 it should be feasible to make recommendations for future studies. Those programs found to be inadequate will be dropped from considerations. For the programs that appeared promising recommendations will be given for future developments in either improved materials testing or computation techniques. The most important aspect of this work will be developing the framework for future efforts under the guidance of the Project Manager and the Project Director.

Dr. Fred Hugo and Dr. José Weissmann of CTR and Mr. Tom Scullion of TTI will be active in this area. This work will require a coordinated effort between CTR, TTI and TxDOT.

TASK 7 — MLS OPERATION: TXDOT

7.1. Operation of the MLS in accordance with the operating instructions, with application of axle loads and acquisition of data as per prescribed experimental design. Due attention shall be given to the following issues or activities:

7.2. Traffic control (where applicable)

7.3. Public awareness

7.4. Site establishment as per guidance manual

7.5. On-going feedback on pavement response and performance as per guidance manual and experimental plan or instruction.

7.6. Movement and re-establishment of MLS setup as per experimental plan or instruction

7.7. Liaison with the Project Manager and/or assistants during the execution of all experiments.

7.8. Co-ordination and control of all site insets and control

7.9. Execution of all maintenance activities as per guide manual.

TASK 8 — ASSISTANCE WITH DATA ACQUISITION: CTR AND TTI

TxDOT will be monitoring a variety of gages and instruments during operation of the MLS. This includes load cells, strain gages, deflection sensors, temperature probes, WIM pads and others. In the preliminary testing each of these sensors will have its own data acquisition system. A common trigger mechanism is being installed in the MLS to facilitate the integration of the respective data files. Initially this will be done manually. However, it is the intent to develop, and upon acceptance, implement an integrated data acquisition system. Issues to be covered include:

a) Documenting data collection requirements for each of the existing gages or instruments (see the reference to this under Task 6).
b) Identifying the capabilities of the current TxDOT data logging system.
c) Developing a data collection and storage plan for review by TxDOT. The plan will identify what other hardware and software is needed for developing an integrated system. It will also include screen layouts, triggering systems, data cleanup, data summarization options, data storage options, output options both tabular and graphical.

TASK 9 — OVERALL MANAGEMENT: CTR AND TTI

The wide scope of the study, as well as the geographic spread of the test sites and the study's respective researchers, will require coordination through an integrated management system. This will be established in accordance with the organigram set out in Figure 7. The Project Manager will be Dr. Fred Hugo, P.E.; he will be assisted by Mr. Tom Scullion and Dr. José Weissmann. Mr. Terry Dossey will assist with technical liaison and administration. On the part of TxDOT, Mr. Ken Fults, P.E., will serve as Project Director. Contact between TxDOT and the research team will be as depicted in the organigram in Figure 7, i.e., Mr. Mike Finger will serve as the contact for Field Operations and Dr. Dar-Hao Chen for Modeling.