MDOT
Michigan Department of Transportation

RESEARCH PROGRAM STRATEGIC DIRECTION

TO SUPPORT AND IMPROVE

THE TRANSPORTATION PROGRAM OBJECTIVES

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October 2000

MDOT RESEARCH PROGRAM STRATEGIC DIRECTION

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INTRODUCTION

This report is a brief overview of the Research Programs for FY 95 through FY 99. A new strategic direction for the Research Program is outlined. This strategic direction aligns research program with Michigan Department of Transportation's (MDOT) Business Plan. Input from the universities and MDOT Regions and Divisions of the bureau of Highways in Lansing was collected to outline the strategic direction, vision, goals and measurable outcomes of the research program.

The proposed five-year research plan in the areas of Bridges and Structures, Pavements and materials and Traffic and safety were developed by the experts in these areas. Thanks are due to Roger Till, Dave Smiley, and Dr. Dale Lighthizer for this effort.

MDOT's SPR Part II Program shows about nineteen projects per year and Technical Assistance program shows about sixty-four project per year. Centers of Excellence at the Michigan State University and the University of Michigan have been active since 1995. Center of Excellence at the Michigan Technological University is active since FY 99.

During 1999, the peer review of the research program was completed. We are continuing dialogue with the universities to improve the research program, through team meetings and re-engineering of the process. Key issues such as 1) Call for Research, 2) administering research contracts, 3) long-term commitments, 4) implementation/benefits of research, and 5) financial management, will be addressed.

MDOT Research Program Strategic Direction

Mission	**Utilize research to continuously seek ways to improve the quality of transportation services.**			
Vision	**Conduct applied research and implement findings to support and improve the transportation program objectives**			
	Customers Become Customer Driven	**Products and Services** Deliver Products/Services to Meet our Customers' Most Important Needs		**Human Resources** Promote Employee Excellence	**Organization** Support a Flexible and Responsive Organization
Goals	**Improve Safety, Traffic Movement & Capacity of Infrastructure**	**Improve Design, Construction & Maintenance Methods**	**Improve Material Uses and Quality**	**Provide Training, Education, and Process Improvement**	**Develop Effective Research Partnerships**
Measurable Outcomes	1. Reduced crash rates 2. Reduced injury and fatality rates 3. Reduced congestion/ increased capacity 4. Reduced travel time 5. Reduced tort litigation 6. Reduced operational impacts on facilities 7. Reduced user costs 8. Maximize cost effectiveness* 9. Implementation of research findings	1. Performance of the fix compared to expected design life 2. Reduced reactive maintenance 3. Improve process to deliver projects (i.e., cycle time) 4. Initiates contractor innovation 5. Documented performance 6. Validation by peer review 7. Reduced user costs 8. Improve work zone safety 9. Maximize cost effectiveness* 10. Implementation of research findings	• Long term performance improvements 2. Improved constructability 3. Reduce construction time 4. Validation by peer review 5. Maximized cost effectiveness* 6. Implementation of research findings	• Maintain core competencies 2. Develop transportation professionals 3. Provide technical assistance 4. Reduce cycle time 5. Performance of solution 6. Improve motorist safety 7. Customer satisfaction 8. Number of problems solved 9. Maximize cost effectiveness* 10. Technology transfer	1. Develop University Research Centers 2. Involve regions and industry to identify research needs 3. Strive for consensus 4. Encourage public and private research efforts 5. Customer feedback

*Cost Benefit Measures:

1. System condition
- Life cycle cost
- Achievement of expected life
- Available funding levels

Approved by the Engineering Operations Committee (EOC) on November 9, 1999

PROPOSAL FIVE-YEAR RESEARCH PLAN
FY 2000-2005

BRIDGES AND STRUCTURES

The following research focus areas would be beneficial to the department.

Bridge Decks

1. Causes and cures for bridge barrier cracking.
2. Methods to eliminate or improve joints bridge joints.
3. Stainless steel reinforcement - allowable lap lengths, development lengths, and concrete cover
4. Causes and cures for bridge deck corner cracking on skewed structures.
5. Methods to increase life of bridge decks from 30 years to 75 years.
6. Determine the criteria for and benefits of a penetrating sealant for bridge decks.

Concrete

1. High performance concrete including, but not limited to high durability, early strength gain, low permeability, and low shrinkage.
2. Concrete performance specification - specifying allowable shrinkage and permeability.
3. Develop non-destructive test methods for prestressed and reinforced concrete structures.
4. Determine the criteria for and benefits of a penetrating sealant for piers.

Prestressed Concrete

1. Post tensioned spliced prestressed concrete beams.
2. Affect of small size aggregate gradation on strength and durability of prestressed concrete beams.
3. Forecast and resolve deterioration problems with the ends of prestressed beams.
4. Develop repair method for box beams with corroded prestressing steel.

Steel

1. Develop better fatigue resistant details of steel structures and identify existing details that may develop fatigue problems and develop appropriate retrofits.
2. Develop coating systems for steel bridges that are more environmentally and worker friendly.
3. Affect of multiple heat straightening on strength and toughness of steel beams bridges impacted by high loads.

Materials

1. Determine the cost effectiveness of fiber reinforced composites for use in highway structures.
2. Affect of using 100 mm by 200 mm concrete cylinders for acceptance testing instead of 150 mm by 300 mm for prestressed and plain concrete.
3. Use of neoprene capping for compression testing for accepting prestressed concrete beams.

Design

1. Determine the impact of the AASHTO LRFD bridge code and transition the department into the use of the AASHTO LRFD design code.
2. Update the department's highway safety devices to NCHRP 350.
3. Develop rapid repair and replacement construction procedures that have less impact on the traveling public.
4. Investigate the viability of high performance materials to be used in bridges and highway structures for more efficient designs.
5. Develop a slope paving method that is durable and easy to maintain.
6. Develop bridge inspection and evaluation techniques to better scope bridge rehabilitation projects.
7. Creation of a demonstration funding pool. This general fund would allow qualifying projects to fund cost of experimental projects.

Loading

1. Investigation of current bridge loading versus design loading. Is MS23 loading adequate?
2. Determine the actual response of bridges to load for better capacity rating.
3. Investigate load distribution of heavy trucks on steel and concrete bridges.

PROPOSED FIVE-YEAR RESEARCH PLAN
FY 2000-2005

PAVEMENTS AND MATERIALS

General Goals

1. Develop practical solutions to everyday problems.
2. Find conclusions that are not just a confirmation of generally accepted knowledge.
3. Avoid repeating studies where only the effects of isolated variables are evaluated - concentrate on a holistic approach.
4. Expand the researcher's role beyond their individual field of expertise.
5. Enhance MDOT's use of technology in problem solving.

Study Objectives

1. Increase pavement performance
2. Reduce costs
3. Identify design, construction and maintenance practices that significantly enhance performance or reduce costs.
4. Assure benefit/cost relationships are improving and not sacrificed.

Study Time Frame

1. Short Term (<3 years) - Projects that support (foundation) other needs
2. Long Term (3 to 5 years) - Projects are independent or dependent on preceding results

Research Focus Areas

1. **Performance Specifications**

   Objective: Develop specifications for materials based on their influence on pavement performance

   Need Areas:

   - Measures to assure material and construction quality are sufficient to meet or exceed the pavement's desired service life
     - Appropriate tests with threshold values
     - Acceptance/rejection criteria
   - Identify root causes for (material) deterioration
   - Develop models to predict likely performance
   - Investigate causes for distress initiation
     - load
     - material property
     - environment
   - Isolate effects from construction quality
   - Adjusted payments for pay items dependent on test results

2. **Capital Preventative Maintenance Program**

Objective: Support continued development and execution of a cost effective PM strategy for the state trunkline network

Needs Area:

- Determine optimal time to apply PM treatments
  - definition for "optimal time"
  - initial application and subsequent frequency
  - assess "life extension" gains on pavement's rate of deterioration
- Effects PM treatments have on pavement service life
  - maximize "life extension" gains
  - differentiate effects of application rate and work quality
  - rate benefits of a PM treatment on varying pavement condition
  - cumulative benefits of the same or different PM treatments
- Value of specific crack treatments on "life extension" gains
- Assess benefits of using enhanced materials for PM treatments
- Methods for longitudinal joint rehabilitation (concrete pavement)
- Re-develop the precast option for full-depth concrete repairs
- Assist Maintenance Division in development of MMS

3. **Adoption of a Mechanistic Design Procedure**

Objective: Prepare for decision to adopt the mechanistic-based 2002 AASHTO Design Guide

Needs Area:

- Assess advantages and disadvantages of mechanistic design methodology versus MDOT's current procedure
- Identify and implement needed changes for a effective transition
  - education and training
  - program software development (MichPave, MichBack, Illi-slab)
  - material characterization

4. **Material Performance**

Objective: Base material specifications on their contribution to pavement performance - material economics

Need Areas - Concrete Mixtures:

- High performance concrete (P1-modified)
  - Utilize properties that assure long term service life with minimal maintenance
- Compatibility of admixtures
- Desirability and amounts of cement additions > GGBFS
- Consistency (variability) in batching > cause for non-uniform condition?

- Develop acceptance specification for permeability
- Develop a fast-set concrete for patching with a relative long service life
- Importance of (compressive) strength in obtaining long term service life

Need Areas - Bituminous Mixtures:

- Customize the SuperPave methodology for Michigan's conditions
  - binder selection > need (value) for polymer enhancement
  - utilization of RAP
  - acceptance test for moisture sensitivity
  - roller compaction > proper amount of effort??
  - aggregate specifications > what are the must haves and the desirables??
- Performance testing
  - utilization of MDOT's APT
  - correlation of design input values with actual field results
- Quantify variation between gyratory compactor and field core densities
- Acceptance specification for segregation
  - continue field studies to assess relationship in preventing long-term performance
  - investigate use of thermal imaging for identification

Need Areas - Aggregates

Objective: Better qualify the contribution aggregate has on long term performance of concrete and bituminous mixtures

General:

- Conduct a value analysis of (perceived) quality versus cost
- Specification for large (4AA) coarse aggregate in pavement concrete
- Additional measures (spec. development) for quantifying aggregate quality

Specific:

- Validate value of 3/8 x ½ particle in bituminous mixtures
- Confirm post-construction chemical reactions with blast furnace slag in concrete
- Importance of "clean" washed aggregate > p-200 spec. issue
- AWI requirements for carbonate aggregate
- Crushed carbonate fines as sand fraction in concrete mixtures
- Aggregate shape requirements in bituminous mixtures
- Long-term water absorption of coarse aggregate in concrete pavement
- Justify tolerances for grading bands for acceptance/rejection

5. **Pavement Management System (PMS)**

Objective: Support the continuing development of the engineering component of MDOT's PMS with emphasis on distress identification, deterioration modeling, forensic studies, and cause/effect relationships

Need Areas:

- Update distress point allocation for various distress types
- Determine cause & effect relationships for distress types
- Document reasons for past performance (successful & unsuccessful) of primary preservation treatments
- Assist in making condition rating methods "non-technical" as a planning tool
- Improve "feedback" process
  - accuracy of design service lives
  - integrate results of material performance studies > i.e.: EUAC analysis
- Develop a RSL measure for RQI

6. **Warranty Support**

Objective: Validate threshold (performance) criteria for a defined warranty period and desired service life

Need Areas:

- Quantify performance relationship between early (<5 yrs) and later (>20 yrs) periods of a pavement
- Establish (new) threshold measures at 5 yrs. for rigid and flexible pavements that represent a high probability of long term performance
- Develop procedures for conducting forensic investigations to determine if poor workmanship or improper material usage during construction caused thresholds to be exceeded

7. **Pavement Structure Analysis**

Objective: Improve understanding of how pavement structures perform

Needs Area:

- Estimate *value* of design and maintenance factors on eventual performance
  - How to best spend a given dollar budget per lane/mile of pavement
  - Benefit/cost of total reconstruction versus major rehabilitation
  - Quantify "success" factors that assure a very long service life
- Isolate and eliminate "root" causes for distress initiation
  - Where? > i.e.: part of structure
  - Why? > i.e.: material usage
  - How? > i.e.: environment/load
- Quantify significance of *heavy* trucks causing fatigue cracking
- Isolate affects of construction factors on achieving long term performance
  - Curing concrete pavement
  - Concrete placement temperatures vs. weather > "construction curling"
  - Broken stone from excessive rolling bituminous mixtures
- Alternative selection between major rehabilitation or continued PM
- Improve processing procedures for RQI

- Quantify benefits to using subgrade reinforcement methods in lieu of traditional R&R
- Determine benefit/cost of crack relief layers for bituminous overlays of rigid or composite pavements

10. **Material Research Projects (Proposed by MTU)**

Aggregate -

- Assessment of the Alkali Reactivity Potential of Michigan's Natural Sands When Used in Portland Cement Concrete (PCC)
- Characterization and Cataloging of Non-Gravel Aggregate Sources Used for Transportation Construction in Michigan
- Comparison of Resilient Modulus Testing for Unbounded Materials With Resonant Column and Torsional Shear Testing
- Confinement and Size Effects in Fracture Characteristics of Aggregates
- Investigation of Strength versus Freeze-Thaw Durability Relationship in PCC

Construction -

- Comparison of MDOT Schedules as a Result of Special Provision for Progress Schedule, FUSP102G
- Work Item Production Rates for MDOT Projects

Hot Mix Asphalt -

- Development of an Effective Angularity Test for Fine Aggregate for Use in Hot Mix Asphalt
- Development and Implementation of Asphalt Binder Characterization and Hot Mix Asphalt Design Certification Classes

Portland Cement Concrete -

- Portland Cement Characteristics and Variability - Medium
- Preliminary Investigations of the Role of Bacteria in Concrete - Medium

PROPOSED FIVE-YEAR RESEARCH PLAN
FY 2000-2005

TRAFFIC AND SAFETY

Future Research

It is expected that in the Traffic Operations and safety Center future research needs will be:

- Impacts of operational changes
- Impacts of legislated operational changes
- Evaluation of new tools and methodologies
- Improvement of predictive models

Research in these areas will impact the identification of potential projects, early preliminary engineering, and operations of facilities.

In addition to the Research Center of Excellence projects, Traffic and Safety has conducted a study of pavement marking materials and their performance (An Evaluation of Pavement marking Materials). This study has provided information necessary to develop performance based contracts. It is anticipated that additional pavement marking research will be conducted to examine additional materials, their application methods, and how they perform.

Year 1 - 2000

- 70 mph speed study
- 60 mph speed study
- Evaluate pavement marking materials/methods\
- Evaluate operational changes
- Evaluate system performance in key safety areas

Year 2 - 2001

- 60 mph speed study
- Evaluate pavement marking materials/methods
- Evaluate operational changes
- Evaluate system performance in key safety areas

Year 3 - 2002

- 60 mph speed study
- Evaluate pavement marking materials/methods
- Evaluate operational changes
- Evaluate system performance in key safety areas

Year 4 - 2003

- Develop new predictive models
- Evaluate pavement marking materials/methods
- Evaluate operational changes
- Evaluate system performance in key safety areas

Year 5 - 2004

- Evaluate pavement marking materials/methods
- Evaluate operational changes
- Evaluate system performance in key safety areas

RESEARCH ACCOMPLISHMENTS - LAST FIVE YEARS

BRIDGES AND STRUCTURES

1. *US-131 S-Curve Bridge in Grand Rapids Saved* - Through alert monitoring and expedited contracting the closing of the S-Curve bridge in Grand Rapids was prevented. During our routine monitoring of the bridge, abnormalities were noticed in bridge's elevations. Upon further investigation, it was decided to underpin the affected areas using an expedited contract. Subsequent monitoring to-date has indicated little additional movement after the underpinning was completed.

2. *Cantilever Sign Support Retrofit Program Implemented* - Procedures were developed to find and repair cracks in these sign supports to safely keep them in service. This program effectively adds life to these structures, saving thousands of dollars in replacement costs.

3. *Post Installed Anchors* - In the past year, the Structural Research Unit completed a report on design procedures for post installed concrete anchors. These procedures have provided mush needed guidance for MDOT, local government and consultant bridge designers.

4. *Prestressed Concrete Beams* - As a result of deteriorated prestressed I-beam ends, the Structural Research unit established a standard repair procedure. This procedure will allow the department to salvage existing beams that are only deteriorating at the ends, therefore, eliminating the need for a costly total superstructure replacement.

5. *Pin and Hanger Assemblies* - The Structural Research Unit completed a study of Michigan's pin and hanger bridges, giving condition ratings, studying the fatigue characteristics, assessing the condition of Michigan's population of this detail, and showing problems that should be watched for such as beam ends in contact and link plate movement. Recommendations were given to the Design and Maintenance Divisions.

6. *Fatigue of Steel Beam Bridges* - The Structural Research Unit assisted the Maintenance Division with several advanced bridge inspection, including inspecting, giving recommendations, and developing details for steel beams having fatigue cracks. By addressing these problems now, the life of these bridges are increased savings thousands of dollars in replacement costs.

7. *Procedure for Evaluation of Bridge Decks Product and/or Deliverables (Contract Project)* - A practical procedure for evaluation of concrete bridge decks and a procedure for prediction of remaining deck life.

8. *Non-Metallic Reinforcement of Concrete Bridge Decks Product and/or Deliverables (Contract Project)* - Develop and implement materials selection criteria, design procedures, and construction techniques for the reinforcement of bridge decks in Michigan with non-corroding and durable polymeric composite systems (materials reviewed are carbon, aramid, and glass fibers).

9. *Performance Evaluation of Isotropic Bridge Decks* - Structural Research Unit helped develop details and design guidance, and monitored the performance of detail which reduces the reinforcement in bridge decks by approximately 50 percent.

10. *Special Provisions* - Develop special provisions for stainless steel and stainless clad reinforcement for bridge decks.

RESEARCH ACCOMPLISHMENTS - LAST FIVE YEARS

PAVEMENTS AND MATERIALS

1. *Michigan's Rapid Travel Profilometer (RTP)* - In the early 1960's, Michigan began a study to evaluate a new concept for measuring ride quality. The General Motors Corporation had developed a new device, known as travel profilometer, for measuring the pavement longitudinal profile for which roughness value could be derived. Since that time, the Research laboratory's ISS Unit has continued to improve upon those early concepts by keeping the vehicle's sensors and onboard instrumentation *state of the art*. Over the last 30 years ... constructed and serviced several generations of RTP vehicles.

   In conjunction with advancing RTP development, the laboratory developed in the unique ride quality index for Michigan's roads, known as the Michigan Ride Quality Index (RQI). The pavement's longitudinal profile is a series of varying wavelength ch... then correlated their responses into an RQI. An RQI value is determined annual trunkline network.

   There are obvious benefits that result from measuring pavement ride quality. M... level of ride quality reduces pavement damage from heavy loads, reduces damage vehicles and the products they carry, and most importantly provides a pleasurable destination. The monetary dividends derived from measuring ride quality are dif... quantify, but can be accredited in the usage of the information, where it helps project fix selections in the department's construction program. Selecting the right time can achieve substantial returns to the department and can easily com... cost of profile collection and processing. For example, the average $45,000 pe... cost to measure the profile and process an RQI value. The 1998 preventive maintenance program will include approximately 1250 lane miles of fix improvements at an estimated $54.7 million.

2. *Michigan's Lightweight Inertial Surface Analyzer (LISA)* - If a pavement has excellent ride quality, it should originate when the pavement ... constructed or if it does not, it must be achieved from a relative expensive fu... early in its service life after the ride degrades to an unacceptable level. M... department recognized this premise and instituted a ride quality specification surfaces to assure excellent initial ride quality. After implementation, it so that initial ride quality must be measured as it is perceived by the user with .. Can collect a true profile in a manner where it can be processed into an RQI value.

   The traditional instrument used by contractors to measure pavement surface prof... profilograph, which is known as a *rolling straightedge*. The profilograph is adequately measuring the complete variance in wavelength bands that motorists f... objectionable. A new instrument based upon the principles of the department's R.. To measure new surfaces in a timely manner. The Research laboratory's Instrumentation Unit recognized this need and began design and construction of the Lightweight Inertial Surface analyzer (LISA). LISA is based on the same principles of a rapid travel prof... utilizes a laser sensor to sense the profile, an on board accelerometer to negat... and a computer for data storage. The process outputs include a printed longit... an RQI value and comparable profilograph index (inch/mile).

   After a decade of continued refinements, contractor's have begun to purchase the.. Vehicles in lieu of using profilographs because it provides them an immediate p... profile, which is used to make an accurate surface corrections if grinding is n... project specifications. The data can help contractors evaluate their paving techniques and mix designs. These efforts have enhanced pavement performance and extended longer time period before surface overlays are needed.

   The costs and benefits of LISA development can best be equated to department ex... correct inadequate ride. In the 1998 preventive maintenance program, 114 miles ... bituminous overlays

are estimated to cost $8.81 million, which averages $76,700 total development costs for the LISA equate to between one and two miles of thickness overlay cost.

3. *Michigan's Rut Measurement Vehicle (RMV)* - The presence of pavement rutting appears obvious to most observers when a depression wheelpath is evident. Rutting occurs when vehicle loading displaces or consolidates bituminous surface material. The amount and severity of rutting needs to be q.... establish an effective and timely remedial program to correct it. Manual method straightedge extended across the wheelpath and a measurement ruler to find the ... been used historically. This method works for very short road segments, but is any large network of roadways. A better method was needed.

   In 1993, EOC approved a work plan for the development of the department's RMV as proposed by the Research Laboratory's Instrumentation Unit. T... eleven laser sensors attached to a beam Straightedge on the front bumper of a .... vertical distance to the pavement surface, onboard accelerometers to negate movement, and a computer to store collected data. The vehicle is operational ... to accurately measure pavement surface rutting.

   The costs and benefits of RMV development can best be equated to department exp... correct rutting. The proper fixes to eradicate rutting are dependent on the ca... rutting. Typically, if minor in depth or caused by bituminous consolidation, a ... applied in the wheelpath to fill the depression and a subsequent application is the entire lane width, which also covers surface distress features. In the 199... maintenance program, 221 miles of microsurfacing are scheduled at an estimated ... million for an average cost of $51,000 per mile. When the RMV was proposed in ... estimated to cost about $100,000. The actual annual operational cost, including ... (three year life), one FTE operator, and miscellaneous service costs equate to ... two miles of microsurfacing treatments.

RESEARCH ACCOMPLISHMENTS - LAST FIVE YEARS

TRAFFIC AND SAFETY

The MDOT/MSU Research Center of Excellence has delivered the following projects from 1995 to present:

1. An Operational Comparison of the Single Point Urban Interchange to the Standard Design of a Michigan Urban Dia. Interchange - Z1
2. 2-Lane, 2-Way Horizontal Curve Accident Red. Prob. Model - Z2
3. Safety Effects of Signalized Intersections - Z4
4. Congestion Analysis of Southfield Freeway - Z3
5. Evaluation of Experimental Signing in Construction Zones - Z5
6. Assessment of the Effectiveness of the ATMS deployment in Alleviating Congestion in SE Michigan - Z6
7. Raising the Speed Limit from 65 MPH to 70 MPH - Z7
8. Evaluation of Passing Relief Lanes Signing/Marking Options - Z9
9. Logo Signing Evaluation - Z8
10. Cont. of Raising the Speed Limit on Freeways in Michigan - Z10
11. Work Zone Speed Study - Z11
12. Grand River Pedestrian Study - Z12
13. Highway Rest Area Characteristics and Fatigue Related Truck Crashes - Z13
14. Evaluation of MMUTCD No Passing Zone Marking Criteria - Not Executed
15. Work Zone Speed Study Part II - Z-14
16. Work Zone Delay Model - Z15

The 70 MPH speed study has proven to be a particular success. The entire project was delivered early to meet the needs of the state legislature. There continues to be interest by the public and the press in the project.

The single point urban interchange study has provided valuable insight in to some of the issues relating to the costs and practicality of using this design in Michigan.

UNIVERSITY RESEARCH CONTRIBUTIONS AND BENEFITS

Michigan State University

Traffic Operations and Safety Research Center

- Performed an evaluation of the Adaptive Traffic Signal System in Oakland County, in cooperation with FHWA, the Oakland County Road Commission and MDOT. The results of the evaluation were used to obtain additional federal funds to expand the program. The evaluation of the expanded program is currently being conducted.

- Conducted an evaluation of the impact of raising speeds on the rural freeway system to 70 MPH. This study generated the data to assist MDOT to establish its position on the expansion of the pilot program and to address the issues raised in the legislation proposing to raise speed limits on other roads.

- Conducted an evaluation of the LOGO signing pilot project as required by the legislature. The results were used by the legislature in supporting the proposal to expand the system to include additional interchanges.

- Conducted a study of the impact of portable changeable message signs used to inform weekend traffic about delays on the freeway system carrying traffic between downstate Michigan and the northern recreation areas. The information from this analysis will be used to determine whether the program should be expanded next year.

- Evaluated the SCANDI freeway management system. Results of the research found an increased capacity due to ramp metering. A videotape was made of the results and distributed across the nation by the Federal Highway Administration.

- Conducted a four-year evaluation of the different materials used for marking pavement lane lines. The study found that the much less expensive water-based paints performed as well as the more costly material, but also found that none of the paint material in use at that time (1997) resulted in levels of retro-reflectivity which will satisfy anticipated national standards.

- Compared the performance of a single-point interchange to that of the design traditionally used by MDOT. It was found that the single-point is generally much more expensive to construct (an additional $5 to 8 million), and does not provide additional capacity in most potential application. However there were applications found where this design would be an attractive alternative.

- Conducted an evaluation of speed management in work zones. The results showed that speeds in work zones are a function of the conditions in the zone rather than the speed limits that are imposed. Thus, the current MDOT policy of setting work zone speed limits based on work zone activity level (and exposure of workers) was validated.

  It was also determined that the control of speeds in work zones is best accomplished through use of police presence. Other control measures are far less likely to have positive effects. This basically supports a policy of using additional police presence in work zones if lower speeds are important.

- Evaluated the model that MDOT currently uses for estimating work zone delay costs. The results showed that it would be appropriate for use when relative comparisons of construction/rehabilitation alternatives were important, but absolute values of model estimates of queuing and delays were not comparable to those observed in the field.

- Investigated congestion along Southfield Freeway (M-39). The study analyzed high risk locations, congestion patterns, and perceptions of travelers. The recommendations from this study assisted MDOT toward identification of strategies for alleviation of traffic congestion along M-39.

- Analyzed pedestrian crossing patterns and preferences in order to assess pedestrian crossing options, explain pedestrian behaviors and attitudes, and assess quality of service provided to pedestrians. The results from the evaluation will be used for proper selection and deployment of pedestrian treatments in future rehabilitation projects.

Pavement Research Center of Excellence

- Development of a test method and a computer program for detecting segregation in asphalt mixes during the paving operation.

- Assessment of the pavement damage contributed by various degree of asphalt mix segregation.

- Developing a CD-ROM-based pavement distress-training manual.

- Developed a manual for the preservation of flexible, rigid and composite pavements.

- Modified the MDOT pavement management process for distress.

- Established the design characteristics of MDOT's SuperPave mixes.

- Developed the Michigan Flexible Pavement Design System (MFPDS) software for analysis and design of flexible pavements. This Windows-based software will become the cornerstone of MDOT's future mechanistic design process for flexible pavements. The software contains modules for AASHTO design, analysis, backcalculation, and mechanistic design. Fatigue and rut depth models based on Michigan data were developed and implemented in the software. An implementation plan for the new design process has been developed.

- Validated the MFPDS software system using surface deflections and horizontal strains within the AC layer measured in the field under FWD and truck loading. The study demonstrated that the MFPDS system provides reasonable predictions of pavement deflections and strains.

- Developed high-early-strength concrete mixtures with reduced cement content which incorporates processed cellulose fibers. These new mixtures are resistant to shrinkage and microcracking and exhibit improved durability characteristics. A field demonstration project, involving early-opening-to-traffic pavement repair was implemented using the new mixtures. This design will replace MDOT's existing fast track high-early-strength mixture design.

- Developed an NDT method to predict concrete strength (Maturity and Equivalent Age Method). This will allow MDOT to predict opening times to traffic based on a 24-hour time-temperature history of the in-situ concrete. MDOT was equipped with 4 maturity meters last spring and has started to develop time-temperature histories for their most popular mixture designs.

- Studied the effects of various factors on transverse cracking in jointed concrete pavements. Three analysis procedures based on the use of falling weight deflectometer (FWD) data were demonstrated. Results were used to develop threshold limits necessary for performing evaluations with these procedures.

- Studies materials related distress (MRD) of pavements to assist identification of the prevalence of MRD in concrete pavements. In the ongoing work, efforts will be made to relate the manifestation of MRD to concrete mixture designs, aggregate types in the PCC mixture and the exposure environment.

- Currently developing a roughness threshold for use in MDOT's preventive maintenance program. The threshold is aimed at retarding pavement deterioration caused by dynamic loading.

- Currently determining the characteristics of MDOT's existing and new SuperPave AC mixes under repeated cyclic loading. The results will be used by MDOT in the structural design of pavements.

- Currently determining the causes of premature cracking of AC mixes overlaying rubblized concrete pavements. We plan to develop new guidelines on the use of rubblized concrete bases in rehabilitating Michigan roads.

- Assisted various regions and TSCs to evaluate pavement conditions and select rehabilitation alternatives.

- Arranged van tours where MDOT and PRCE personnel toured various pavement sections and discussed their conditions and performance. The accelerated pavement testing facilities at Purdue University was visited during one tour.

- Conducted training seminars (short courses) for the design of asphalt, concrete and composite pavements.

Michigan Transit Center

While the Michigan Transit Center is headquartered at Michigan State University, most of the projects are subcontracted to other universities. The benefit of the only project performed by MSU is outlined below. It is presumed that other universities will report the benefits of the work they did.

- Evaluated the cost-effectiveness and appropriateness of new technology applications to local transit operations. The results will be used by MDOT in making funding decisions for local agencies.

Structures Research

The work reported below were performed on projects outside of the MDOT centers.

- Investigated the durability of fiber reinforced polymer (FRP) wraps for rehabilitating corrosion damaged bridge columns. This technology was implemented in the field on a trial basis and has the potential to drastically reduce chipping and patching repair of corroded bridge columns in the long term.

- Selected corrosion-resistant FRP reinforcing bars for corrosion-free and durable reinforced concrete bridge decks. Experimentally verified the durability of the FRP bars. Developed relevant design methodologies. Field implementation in Michigan is planned relevant design methodologies.

UNIVERSITY RESEARCH CONTRIBUTIONS AND BENEFITS

University of Michigan

Synthesis of MDOT Bridge Engineering Practice

The project objective was the development of a synthesis of bridge engineering as practiced by the Michigan DOT. It covers the areas of planning, design, construction, maintenance, materials, and research. In particular, the synthesis is intended to serve as a reference document, and to provide support for the introduction of PONTIS and future development of a new generation of comprehensive Bridge Management Systems (BMS). The documented information is based on MDOT and AASHTO publications, interviews with MDOT staff, and research results. The statistical data is presented in graphs and tables, based on the Michigan Bridge Management Database.

Field Tests of Bridges

A considerable effort is focused on the development of an efficient system for highway load effects control. The study involved experimental and analytical components. It includes the development of a weigh-in-motion (WIM) truck weight measurement system, fatigue load spectra measurement system, and failure detection system. The system consists of equipment (data acquisition systems, strain transducers, LVDT's, wireless transmitters, optical deflection measuring device, and other equipment), and analytical procedures (finite element models, development of load spectra, component-specific diagnostic test, prediction of remaining fatigue life). It can be used for monitoring of highway loads and bridge diagnostics. The system provides data on truck parameters (weight, axle loads, speed, lane position, multiple presence) and load effects (girder moments and shears, girder distribution factors, component-specific strain and stress, dynamic stress, and fatigue load spectra). The system evaluates the actual strength (proof load tests) and estimates the remaining life of the bridge. The results were summarized in the Guide for Evaluation of Existing Bridges.

Weigh-In-Motion (WIM) Truck Measurement

The knowledge of truck loads and truck load effects is important for evaluation of exiting bridges and prediction of the remaining life. The truck weight measurement results should be unbiased. It has been observed that drivers of illegally overloaded vehicles avoid highways with truck weigh stations. Instead, they use alternative routes to avoid citation. Yet, truck weigh stations serve as a major data source. In this project, the measurements were taken so that drivers were not aware of the presence of the WIM equipment. A considerable unbiased data base has been developed for various locations in Michigan. Truck loads vary from site-to-site and their actual level can be determined by site-specific measurements. This, combined with proof load testing, can serve as an efficient control measure to monitor highway loads and a tool for component-specific bridge diagnostics (evaluation of site-specific bridge condition). The developed procedures can also be applied in the law enforcement effort.

Verification of Bridge Load Parameters

The MDOT-sponsored research provided a basis for verification of important parameters considered in evaluation of existing bridges. In particular, the field measurements and advanced analysis resulted in establishing realistic dynamic load factors (DLF) and girder distribution factors (GDF). The field measurements confirmed that DLF decreases for heavy trucks, and DLF is considerably less than value specified by the AASHTO code. The measured GDF's are in general less than specified values, however, the conclusions and final report are still in progress. A considerable effort has been focused on the analytical modeling of bridge behavior using finite element method (FEM). Advanced FEM computer procedure has been developed for calculation of strain, stress and deflection in steel girder bridges.

Evaluation of Concrete Bridge Decks

A practical procedure is being developed (in progress) for evaluation of the actual condition of the concrete deck to determine if it should be replaced and if not replaced now, how much remaining life exists. The study is focused on the documentation of various stages of deterioration based on MDOT experience and field inspections. The mechanisms leading to deck failure are analyzed, based on theory and practical observations. The most important parameters which affect the deck performance include material properties (concrete mix), pouring procedures (construction joints), freeze and thaw cycles, axle loads, strain/stress cycles due to truck traffic, and fatigue of concrete. The analysis of such data is used to calibrate the parameters in deterioration model developed for concrete decks.

Proof Load Tests

An efficient approach to verify the load carrying capacity is proof load test. This is particularly important for bridges which are difficult to evaluate by analysis (missing drawings, visible signs of deterioration such as cracking, corrosion and/or spalling concrete). Proof load tests were carried out on about 10 bridges. The selected structures include reinforced concrete T-beam bridges, and steel girder bridges. The span range is between 6m and 30m. All tested bridges are located in Michigan. Bridges were selected for proof load tests because of low rating factor, visible deterioration (corrosion), or lack of documentation. Two structures were repaired and proof load test was used as verification of the repair efficiency. It was difficult to provide a load which is considerably higher than legal Michigan truck load. Therefore, military tanks were used from the National Guard. M-60 or M-1 tank weighs about 60 Tons and the length of tracks is about 4m. The proof load level was determined by considering a load factor and dynamic load factor which results in almost twice the legal load.

Implementation

The results of this research are implemented on a regular basis. The project team works closely with MDOT staff. The research work progress is presented at meetings and reports. In particular, practical needs are discussed to direct the research effort accordingly. The field work is carried out on bridges selected in coordination with MDOT. Some of the most efficient results which have been already implemented include WIM measurements and proof load testing. The developed procedure have been used by MDOT for evaluation of selected partially deteriorated bridges. Further work will be focused on the development of a remote sensing device for

measuring lane-specific truck parameters, the development of practical procedures for active and passive control of truck load effects and continuation of the work on signal processing procedure to improve prediction of life expectancy and reliability of bridges structures based on WIM measurement data.

UNIVERSITY RESEARCH CONTRIBUTIONS AND BENEFITS

Michigan Technological University

MTU contributes to the MDOT research program in a number of ways. The contributions and benefits can be described in terms of the organizational resources provided by the Michigan Tech Transportation Center, as well as specific project outcomes.

The Michigan Tech Transportation Center (TC) provides a central organizational structure for the transportation related research and outreach activities at Michigan Tech. Currently there are four distinct organizational groups within the Michigan Tech TC, as well as a number of direct associations with individual faculty and programs elsewhere at MTU. The four groups integral to the TC include the Local Technical Assistance Program (LTAP), the Transportation Materials Research Center (TMRC), the Technology Development Group (TDG), and the Tribal Technical Assistance Program (TTAP). In addition to these four groups, a number of individual researchers perform transportation related research and outreach activities under the organizational structure of the TC. This includes research performed at MTU as part of the Transit and Traffic & Safety Research Centers at MSU, and individual projects in the areas of construction, water resources, and environmental engineering. Additionally, the Keweenaw Research Center coordinates some transportation-related activities through the TC.

One advantage of this combined organizational structure of the Michigan Tech TC is that it provides the opportunity for a single contract master agreement for all research and contract work performed at MTU for MDOT. This allows projects to be initiated by use of a work authorization rather than individual contracts for each project. It also combines the technical research expertise with strong technology transfer capabilities. The combined size and scope of the programs represented by the TC has also helped to secure internal resources within MTU including new office and laboratory space, new transportation faculty positions, and cost sharing on individual projects. The Transportation Center groups have all recently moved into adjacent facilities on the third floor of Dillman Hall, which facilitates increased interaction between the various transportation programs.

The groups and individuals associated with the Michigan Tech TC represent a wide range of technical talent that has been readily available to MDOT for short-term consultation, as well as longer-term contracted research efforts. Also, as a result of the MDOT sponsored research being performed by the Michigan Tech TC, a number of industry groups have engaged MTU researchers in ongoing technical discussions related to construction material performance Because of it's technical stature and organizational independence, the Michigan Tech TC is able to function as an independent third party between MDOT and industry representatives and associations in the continuing effort to improve the performance of physical facilities.

Specific MDOT sponsored projects conducted in the transportation materials area at MTU over the last several years and their benefits include the following:

In a study of sealant performance, a series of Guidelines for sealing cracks in HMA pavements was developed. This included screening work on new sealants.

As a subcontractor to the PRCE at UM on a project on drainable bases for PCC pavements, resilient modulus testing performed at MTU provided insight on the permanent deformation characteristics of various base courses.

Materials related distress projects have help identify mechanisms of distress on projects on US 23 and US 24. Also as part of these efforts, researchers reviewed and commented on the MDOT maintenance / rehabilitation strategies to treat MRD problems on US 24.

A number of research efforts have focused on developing a scientifically sound approach to looking carefully at durability issues related to slag aggregates. Benefits of this work include a better understanding of the mineral compounds present in slag aggregates and possible dissolution mechanisms in concrete.

Work was performed at MTU in cooperation with the PRCE at MSU, MnDOT, and private industry to refine finite element software for the analysis of PCC pavements. This software will likely serve as a key element in future mechanistic design procedures.

Aggregate performance projects have provided improved ways of characterizing concrete aggregates. These methods include the use of helium and bulk pycnometers to provide a more accurate measurement of absolute specific gravity and porosity. Additionally, methods for characterizing the load rate sensitivity of aggregates were developed and demonstrated for commonly used Michigan aggregates.

UNIVERSITY RESEARCH CONTRIBUTIONS AND BENEFITS

Wayne State University

Contributions to MDOT's Research Effort

This is a multi-phased multi-year research that focuses on establishing the framework for the development of a non-destructive durability test for new concrete bridge decks.

In the research program our goal is to advance the performance concept to a new level by acquiring the performance measure from the constructed structure. More specifically, the contribution of the research to durability assessment of concrete will be twofold. First, a new and rapid permeability measurement procedure specifically at early age concrete is developed. Second, the measurement procedure obtains the permeability of field concrete in comparison to the permeability measured from standard specimens. Permeability measurement procedure is performed indirectly based on the measured ultrasonic pulse velocity (UPV).

Benefits Derived

The primary benefit is its contribution to the advancement of performance-based specification of concrete durability. FHWA indicates that; Performance-Related Specifications (PRS) are part of a process of continuous quality improvement in highway construction. The proper use of PRS will result in more cost-effective construction and durable highway structures.

MICHIGAN STATE UNIVERSITY
PAVEMENT RESEARCH CENTER OF EXCELLENCE
94-1699

Authorization No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
95-1-1	Michigan Pavement Rehabilitation Methods & Selection Process	338,400.00	42,915.79	94,985.10	84,489.28	-0-	-0-	Closed
95-2	Mechanistic Design Implementation Plan for Flexible Pavements and Overlays	80,000.62	18,333.91	37,692.64	12,863.59	-0-	-0-	Closed
95-3	High Early Strength Concrete	96,723.34	30,780.49	63,899.27	-0-	-0-	-0-	Closed
95-5	Test Method to Determine the Existence of Segregation in Bituminous Mixes	90,000.00	29,428.00	45,618.97	11,379.11	-0-	-0-	Closed
96-1	Improvement of MICHPAVE & MICHBACK	125,069.00	-0-	27,943.63	62,586.21	24,210.54		Closed
96-2	Calibration of MICHPAVE's Rut & Fatigue Distress Models. .	116,426.82	-0-	33,458.52	45,811.28	15,718.40		Closed
97-1-1	Factors Affecting Shear Capacity of Transverse Cracks in Jointed Pavement	150,172.39	-0-	27,053.94	54,991.21	28,690.85	17,285.28	Open
97-6-1	Coordination and Management of the PRCE for FY 96/97	16,648.00	-0-	6,709.25	-0-	-0-	-0-	Closed
97-6-2	Appropriations for FY96/97 *Training and Educational Seminars*	59,000	-0-	375.85	-0-	-0-	-0-	Closed
98-1-1	Monitoring Mechanical Properties for Large Stone Concrete Pavement Mixtures	9,200.00	-0-	-0-	7,727.98	-0-	-0-	Closed
98-2-1	Detecting & Quantifying Segregation in Bit Pavements & Relating It's Effects to Conditions	200,328.00	-0-	-0-	63,423.61	54,395.30	24,161.36	Open
98-3-1	A Study in Material-Related Distress (MRD) in Michigan's PCC Pavements	64,808.00	-0-	-0-	59,978.26	-0-	-0-	Closed
98-6-1	Coordination and Management of the PRCE for FY 97/98	18,756.00	-0-	-0-	9,483.70	-0-	-0-	Closed

Authorization No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
98-7-1	The Engineering Characteristics of Michigan's Asphalt Mixtures	146,533.00	-0-	-0-	26,637.23	50,232.86		Closed
99-2-1	Development of Roughness Threshold for the Preventative Maintenance of Pavements . . .	217,665	-0-	-0-	-0-	43,883.38	46,352.89	Open
99-3-3	Comparison of Concrete Pavement Performance Utilizing Different Types of Coarse Aggrgate	8,000	-0-	-0-	-0-	-0-	7,835.77	
99-4-3	Identify Causes for Under Performing Rubbilized Concrete Pavement Projects - Phase 1	91,549.79	-0-	-0-	-0-	11,117.03	82,824.68	Closed
99-6-1	Coordination and Management of the PRCE for FY 98/99	18,863.17	-0-	-0-	-0-	3,813.22		Closed
00-1-1	Development of a Computer Program for Dynamic Backcalculation of Flexible-Pavement Layer Moduli	138,939	-0-	-0-	-0-	-0-	-0-	Open
00-2-1	Evaluation of Alignment Tolerances for Dowel Bars and Their Effects on Joint Performance	61,130	-0-	-0-	-0-	-0-	112.50	Open
00-3-1	Identify Causes for Under-Performing Rubblilized Concrete Pavement Projects - Phase 2	162,111.04	-0-	-0-	-0-	-0-	-0-	Open
00-5-1	Feasibility Evaluation for Enhancing Michigan's Procedures for Pavement Design and Selection	5,500	-0-	-0-	-0-	-0-	-0-	Open
00-6-2	Coordination & Management of the PRCE for FY 2000	22,879					7,039.55	Open
	TOTAL EXPENDITURES FOR MSU PRCE BY FY		121,458.19	337,737.17	439,389.46	232,061.58	238,286.52	

MICHIGAN STATE UNIVERSITY
OTHER RESEARCH CONTRACTS

Contract No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
94-0069 Last Amendment Number	Polymers in Bituminous Mixtures (Original contract number 92-1595)	1,173,788.00 Started in FY 91/92	357,644.72	263,405.88	-0-	-0-	-0-	Closed
96-1068	Non-Metallic Reinforcement of Concrete Bridge Deck	262,226.00	-0-	27,813.68	104,251.98	-0-	46,720.18	Open
96-1069	Polymer Composite Jackets for Column Repair	194,981.00	-0-	22,898.07	94,005.15	36,046.50	15,965.06	Open
98-1187	European Demonstration Project on I-75 in Detroit	32,653.00	-0-	-0-	-0-	23,244.97	7,940.08	Closed

UNIVERSITY OF MICHIGAN
PAVEMENT RESEARCH CENTER OF EXCELLENCE
95-0242

Authorization No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
95-4	Distress in JRCP in OGDC	164,000.00	35,045.08	89,604.74	39,350.18	-0-	-0-	Closed
96-6-2	Measuring and Interpreting Road Profiles	27,662.00	1,042.49	26,619.51	-0-	-0-	-0-	Closed
98-4-1	Freeze-Thaw Evaluation of Large Coarse Aggregate Using MDOT"s Confined and Unconfined Methods	179,395.00	-0-	-0-	80,933.02	11,212.23	59,469.21	Open
98-5-1	Concrete Mix Design Manual	8,220.00	-0-	-0-	8,035.24	78.96	-0-	Closed
98-8-1	Transverse Crack Propagation of JPCP as Related to PCC Toughness	244,347.00	-0-	-0-	49,155.27	13,109.33	45,453.48	Open
99-1-1	Verify Loss of Base Contact from PCC Slab Curling on Selected Michigan Routes	55,449.00	-0-	-0-	-0-	-0-	-0-	Closed
99-3-2	Comparison of Concrete Pavement Performance Utilizing Different Types of Coarse Aggregate	7,500	-0-	-0-	-0-	-0-	4,852.38	Open

Authorization No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
00-4-1	Investigation of Early Cracking on Selected JPCP Projects	28,000	-0-	-0-	-0-	-0-	-0-	Open
00-7-1-	Feasibility Evaluation for Enhancing Michigan's Procedures for Pavement Design and Selection	1,500	-0-	-0-	-0-	-0-	-0-	Open
	TOTAL EXPENDITURES FOR UM PRCE BY FY		36,087.57	116,224.25	177,473.71	24,400.52	109,775.07	

UNIVERSITY OF MICHIGAN
OTHER RESEARCH CONTRACTS

Contract No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
93-2274	Methods for Rehabilitating Roadways and Structures Under Heavy Traffic	250,347.00 Started in FY 93/94	45,610.78	74,085.73	-0-	-0-	-0-	Closed
96-1067	Repair and Strengthening of Reinforced and Prestressed Concrete Beams Using CFRP Glued-on Plates	149,670.00	-0-	50,949.93	64,487.57	16,361.63	-0-	Open
97-0245	Development of a Guide for Evaluation of Existing Bridges - Phrase 1	45,040.00	-0-	11,985.19	33,054.81	-0-	-0-	Closed
98-1219	Development of a Guide for the Evaluation of Existing Bridges - Phrase 2	42,230.00	-0-	-0-	-0-	20,132.89	17,936.05	Open
98-1303	Research Study to Determine Procedures for Efficient Evaluation of Bridge Decks	47,880.00	-0-	-0-	-0-	31,124.23	16,755.77	Open
00-0341	Verification of Girder Distribution Factors for Steel Grider Bridges	103,650	-0-	-0-	-0-	-0-	1,257.06	Open

MICHIGAN TECHNOLOGICAL UNIVERSITY
RESEARCH CONTRACTS
96-5434

Authorization No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
97-2	Research of Elastomeric Concrete	57,609.00	-0-	5,691.62	51,917.38	-0-	-0-	Closed
98-MTU-1	Modernization of Illi-Slab Finite Element Analysis Program for Concrete Pavements	40,012.00	-0-	-0-	11,325.07	26,100.93	-0-	Open
98-MTU-2	Evaluation of the Dynamic Fracture Characteristics of Aggregate in PCC Pavements	473,817.00	-0-	-0-	98,951.45	226,363.74	141,139.27	Open
98-MTU-3	Publication of *Research Record* for FY 97/98	44,207.19	-0-	-0-	44,207.19	-0-	-0-	Closed
98-MTU-4	General Field and Laboratory Investigations	7,450.00	-0-	-0-	6,458.57	-0-	-0-	Closed
98-MTU-5	Michigan Concrete Paving Manual - Practices and Materials	90,406.00	-0-	-0-	-0-	65,200.91		Open
99-MTU-1	Publication of the *Research Record* for FY 98/99	43,199.00	-0-	-0-	-0-	21,137.16	-0-	Closed
99-MTU-2	Operation and Management of the Transportation Materials Research Center for FY 98/99	35,920.00	-0-	-0-	-0-	21,834.38		Open
99-MTU-3	A Study of Materials-Related Distress (MRD) in Michigan's PCC Pavements - Phrase 2	257,558.00	-0-	-0-	-0-	12,489.61	143,122.40	Open
99-MTU-4	Evaluation of De-bonding of Multiple Layer Polymer Concrete Bridge Deck Overlay	41,586.00	-0-	-0-	-0-	14,855.93		Open
99-MTU-5	Construction Project Scheduling at MDOT	40,543.00	-0-	-0-	-0-	2,779.16	36,313.23	Open
00-MTU-1	Publication of Reserach Record	43,447	-0-	-0-	-0-	-0-	27,562.80	Closed
00-MTU-2	Operation & Coordination of the TMRC	36,202	-0-	-0-	-0-	-0-	27,996.05	Closed

Authorization No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
00-MTU-3	Aggregate Absorption as Related to Anti-Icing for Elastomeric Concrete Bridge Decks Overlays	61,370	-0-	-0-	-0-	-0-	41,244.16	Open
00-MTU-4	Analysis of Bituminous Pavement Surface Characteristics and Their Effects on Friction Properties	245,000	-0-	-0-	-0-	-0-	8,568.12	Open
00-MTU-5	Development of Laboratory Performance Test Procedures and Trial Specifications for Hot Mix Asphalt	160,104	-0-	-0-	-0-	-0-	40,575.99	Open
00-MTU-6	Synthesis and Review of Superpave Implementation	38,153	-0-	-0-	-0-	-0-	3,229.91	Open
00-MTU-7	Noise Generated by Vehicle/Road Surface Interactions	15,000	-0-	-0-	-0-	-0-	-0-	Open
00-MTU-8	Feasibility Evaluation for Enhancing Michigan's Procedures for Pavement Design and Selection	1,500	-0-	-0-	-0-	-0-	-0-	Open
	TOTAL EXPENDITURES MTU CONTRACT BY FY		-0-	5,691.62	212,859.66	390,761.82	469,751.93	
MICHIGAN TECHNOLOGICAL UNIVERSITY OTHER RESEARCH CONTRACTS								
Contract No	Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
96-0157	Effectiveness of Materials for Sealing Joints and Cracks	97,868	17,914.43	45,730.10	34,223.47	-0-	-0-	Closed
96-0334	A Research Study to Estimate the Film Thickness in Asphalt Concrete	130,000	26,470.35	51,373.86	51,984.31	-0-	-0-	Closed

VARIOUS UNIVERSITIES RESEARCH CONTRACTS								
Contract No	**University** Title	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
96-1165	**Wayne State University** Evaluation of Concrete Permeability by Ultrasonic Testing Techniques	158,842.00	-0-	43,573.28	48,951.34	40,991.68	121,788.49	Open
97-0562	**Lawrence Technological University** New Approach to Innovative Multi-Span Bridge System	9,030.00	-0-	-0-	9,030.00	-0-	-0-	Closed
MISCELLANEOUS CONSULTANT CONTRACTS								
Contract No	**Consultant Name** Contract Title/Description	Authorized Amount	95/96 Expenditures	96/97 Expenditures	97/98 Expenditures	98/99 Expenditures	99/00 Expenditures	Status
97-0767	**Pavement Management Services Inc** Technical Review and Writing Services/ Review Construction Manual for accuracy, consistency in presentation and technical content; to write and review one section of the manual	40,000.00			26,200.00	13,800.00	-0-	Closed
98-0573	**Vector Construction Inc** Materials Testing/ Services including but not limited to the electrochemical removal of chloride ions from concrete structures in Michigan	42,790.00	-0-	-0-	-0-	36,540.00	6,250	Closed

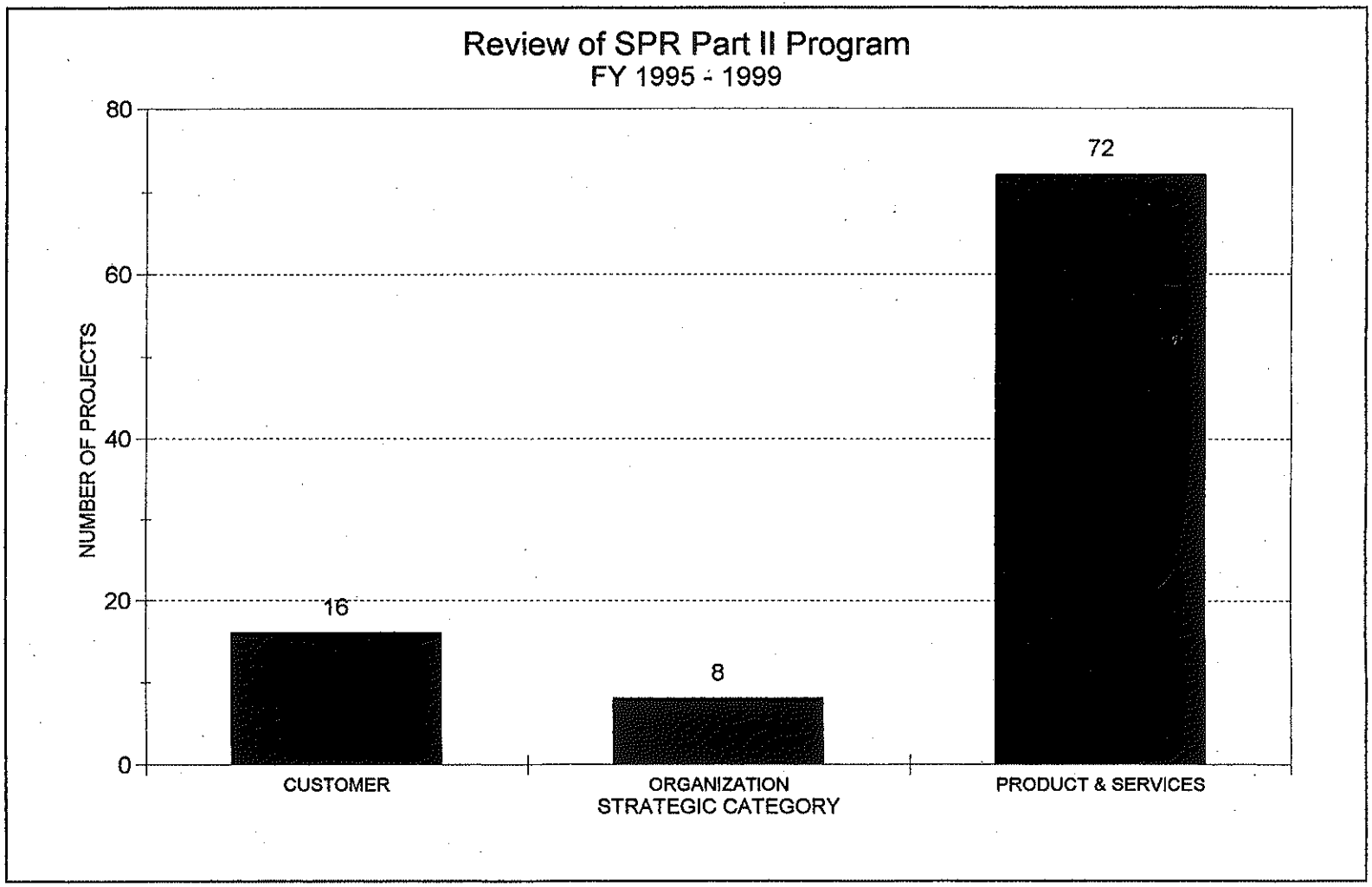
FUNDING FOR RESEARCH CENTERS OF EXCELLENCE FISCAL YEAR 1995-1999					
Center of Excellence	FY 95	FY96	FY97	FY98	FY99
Pavements	250,000	350,000	350,000	350,000	350,000
Traffic/Safety Operations	250,000	250,000	250,000	250,000	250,000
Transportation Materials	-0-	-0-	-0-	-0-	350,000

SPR II PROGRAM REVIEW

BASED ON MDOT RESEARCH

PROGRAM STRATEGIC DIRECTION

FY 1995-1999


Review of SPR Part II Program
FY 1995 - 1999
NUMBER OF PROJECTS
80
60
40
20
0
16
8
72
CUSTOMER
ORGANIZATION
PRODUCT & SERVICES
STRATEGIC CATEGORY

PROJECT	TYPE	STRATEGIC	YEAR	TITLE
45563	PAV	PS	1998	1997 Superpave Assessment
96513	TS	C	1995	Access Management Program
97613	TS	C	1996	Access Management Program
97713	TS	C	1997	Access Management Program
HPR 2 (173	MAT	PS	1997	Adhesion Criteria
97625	TS	PS	1996	Adoption of Operations of Y Intersections
97522	MAT	PS	1995	Adoption of Rapid Test for Determining Agg Durability in PCC
97622	MAT	PS	1996	Adoption of Rapid Test for Determining Agg Durability in PCC
97548	ENV	PS	1995	Adoption of an Improved Method of Environmental Investigatio
97648	ENV	PS	1996	Adoption of an Improved Method of Environmental Investigatio
97551	TS	C	1995	Alternate Methods to Reduce Deer/Vehicle Accidents
97651	TS	C	1996	Alternate Methods to Reduce Deer/Vehicle Accidents
97523	TS	C	1995	Analysis of Directional and Bi-directional Median Cross-over
97549	TS	C	1995	Assesment and Recommendation Regarding Pedestrian Safety
HPR 2	PAV	PS	1997	Base Funding for the North Central Superpaver Center (NCSC)
97509	BRG	PS	1995	Bridge Engineering - A Synthesis of Planning, Design, Constr
97609	BRG	PS	1996	Bridge Engineering - A Synthesis of Planning, Design, Constr
97709	BRG	PS	1997	Bridge Engineering - A Synthesis of Planning, Design, Constr
45482	BRG	PS	1998	Bridge Engineering - A Synthesis of Planning, Design, Constr
47870	BRG	PS	1999	Bridge Engineering - A Synthesis of Planning, Design, Constr
97657	BRG	PS	1996	Bridge Management System
97757	BRG	PS	1997	Bridge Management System
97658	AD	O	1996	Business Plan Approach
97758	AD	O	1997	Business Plan Approach
97528	ENV	C	1995	Community Options Model for Transportation
97628	ENV	C	1996	Community Options Model for Transportation
97728	ENV	C	1997	Community Options Model for Transportation
45496	ENV	C	1998	Community Options Model for Transportation
47875	ENV	C	1999	Community Options Model for Transportation
48640	PAV	PS	1999	Comparison of Concrete Pavement Performance
CTIPS	AD	O	1996	Comprehensive Trans Info and Planning System
97549	ENV	PS	1995	Cost Effectiveness of Alternate Tech to Remediate Fuel Conta
97649	ENV	PS	1996	Cost Effectiveness of Alternate Tech to Remediate Fuel Conta
50573	PAV	PS	1999	Crash Testing of MI's Type B & Type T Guardrail System
45550	PAV	PS	1998	Detecting & Quantifying Segregation in Bituminous Pavements
47879	PAV	PS	1999	Detecting & Quantifying Segregation in Bituminous Pavements
45553	MAT	PS	1998	Determination of Moisture Contents in Various PCC Pavements
47885	MATL	PS	1999	Determination of Moisture Contents in Various PCC Pavements
97545	TS	PS	1995	Determination of Sight Distance Variances of Diamond Interch
97645	TS	PS	1996	Determination of Sight Distance Variances of Diamond Interch
51037	MAT	PS	1999	Determine Correlation Between MI's AWI & Pvmnt Fri
48642	ENV	PS	1999	Development of Rainfall Intensity
48643	PAV	PS	1999	Development of Roughness Threshold
45565	PAV	PS	1998	Elastomeric Concretes for Surface Patching of Pavements
45560	MAT	PS	1998	Engineering Characteristics of MI Asphalt Mixtures
47888	MATL	PS	1999	Engineering Characteristics of MI Asphalt Mixtures
97529	ENV	C	1995	Eval Effectiveness of Current Noise Attenuation Programs
97504	BRG	PS	1995	Eval of Crashworthines of R4 Bridge Rail Retrofit

PROJECT	TYPE	STRATEGIC	YEAR	TITLE
97763	MAT	O	1997	Evaluation of Concrete Permeability by UT
45481	PAV	PS	1998	Evaluation of Concrete Permeability by UT
47869	PAV	PS	1999	Evaluation of Concrete Permeability by UT
HPR 2 (174	MAT	PS	1997	Evaluation of Crumb Rubber
47889	MAT	PS	1999	Evaluation of Dynamic Fracture Characteristics
97618	TS	PS	1996	Experimental Use of Mobile Systems for Measurement of Signs
97718	TS	PS	1997	Experimental Use of Mobile Systems for Measurement of Signs
45483	TS	PS	1998	Experimental Use of Mobile Systems for Measurement of Signs
47873	TS	PS	1999	Experimental Use of Mobile Systems for Measurement of Signs
45492	TS	PS	1998	Experimental Use of Mobile Systems for Pavemant Marking
97759	TS	PS	1997	Experimental Use of Mobile Systems for Pavement Marking
97550	PAV	PS	1995	FHWA (SHRP) LTPP Support
97650	PAV	PS	1996	FHWA (SHRP) LTPP Support
97750	PAV	PS	1997	FHWA (SHRP) LTPP Support
45488	PAV	PS	1998	FHWA (SHRP) LTPP Support
47878	PAV	O	1999	FHWA (SHRP) LTPP Support
51870		PS	1999	FIXS
51054	BRG	PS	1999	FRP Composite Bridge Decks
HPR 2 (177	BRG	PS	1997	Fatique Test of Bridge Girders
48638	ENV	PS	1999	Feasibility of In-Kind Northern White Cedar Wetlan
97539	TS	C	1995	First Step for Travel Advisory Project
97639	TS	C	1996	First Step for Travel Advisory Project
97739	TS	C	1997	First Step for Travel Advisory Project
45485	TS	C	1998	First Step for Travel Advisory Project
47872	TS	C	1999	First Step for Travel Advisory Project
45549	MAT	PS	1998	Freeze-Thaw Evaluation of Large Coarse Aggregate
47887	MATL	PS	1999	Freeze-Thaw Evaluation of Large Coarse Aggregate
97634	PAV	PS	1996	Highway Construction and Maintenance
97734	PAV	PS	1997	Highway Construction and Maintenance
97534	TS	PS	1995	Highway Construction and Work Zone
45564	PAV	PS	1998	Highway Maintenance Concept Vehicle - Phase II
47896	PAV	PS	1999	Highway Maintenance Concept Vehicle - Phase III
97520	ENV	PS	1995	Highway Run-off Constituents from Urban
97620	ENV	PS	1996	Highway Run-off Constituents from Urban
97720	ENV	PS	1997	Highway Run-off Constituents from Urban
45494	ENV	PS	1998	Highway Run-off Constituents from Urban
47874	ENV	PS	1999	Highway Run-off Constituents from Urban
SPR 3 (060	PAV	PS	1998	Hwy Maint Conc Vehicle (HMCV) - Phase III
97531	BRG	PS	1995	Impact of Scour on Michigan Bridges
97631	BRG	PS	1996	Impact of Scour on Michigan Bridges
97731	BRG	PS	1997	Impact of Scour on Michigan Bridges
45484	BRG	PS	1998	Impact of Scour on Michigan Bridges
51300	BRG	PS	1999	Impact of Scour on Michigan Bridges
97536	PAV	PS	1995	Improved Methods for Rehabilitating Roads and Bridges
97636	PAV	PS	1996	Improved Methods for Rehabilitating Roads and Bridges
97736	PAV	PS	1997	Improved Methods for Rehabilitating Roads and Bridges
97543	TS	C	1995	Incident Detection of Freeway Interchange and Ramp from 696
97643	TS	C	1996	Incident Detection of Freeway Interchange and Ramp from 696

PROJECT	TYPE	STRATEGIC	YEAR	TITLE
97732	PAV	PS	1997	Instrumentation of Comparative Bit Pavement Sections
45531	PAV	PS	1998	Instrumentation of Comparative Bit Pavement Sections
97542	TS	C	1995	Intelligent Vehicle-Highway Systems Center
97742	TS	C	1997	Intelligent Vehicle-Highway Systems Center
45486	TSC	C	1998	Intelligent Vehicle-Highway Systems Center
47892	TS	C	1999	Intelligent Vehicle-Highway Systems Center
97547	PAV	PS	1995	Investigation of Calcium Hydroxide Depletion
97647	PAV	PS	1996	Investigation of Calcium Hydroxide Depletion
97747	PAV	PS	1997	Investigation of Calcium Hydroxide Depletion
48639	ENV	PS	1999	Long Term Affect of Deicing Salt on Wetlands
45497	TS	PS	1998	Michigan Transit Center for Excellence
50127	MAT	PS	1999	Micro-Surface Mix Design - Pooled fund (100% feder
45566*	PAV	PS	1998	Modern. of ILLISLAB Finite Element Analysis Program for Conc
47886	PAV	PS	1999	Modernization of the ILLI-SLAB Finite Element Anly
45567*	MAT	PS	1998	Monitoring Mechanical Properties for Large Stone Concrete Pa
47891	MATL	PS	1999	Monitoring Mechanical Properties for Large Stone Concrete Pa
	AD	O	1998	NCHRP
48790	AD	O	1999	NCHRP
45570	TS	PS	1998	New Technology Hardware Development Project (UPTRAN)
HPR 2 (136	ENV	O	1996	Noise Barriers
HPR 2 (136	ENV	PS	1997	Noise Barriers
45538	BRG	PS	1998	Non-Metallic Reinforcement of Concrete Bridge Decks
47876	BRG	PS	1999	Non-Metallic Reinforcement of Concrete Bridge Decks
SPR 3 (044	PAV	PS	1998	North Centeral Superpave Center
97517	TS	PS	1995	Optimization of Marking Materials
97617	TS	PS	1996	Optimization of Marking Materials
97717	TS	PS	1997	Optimization of Marking Materials
47894	PAV	PS	1999	Pavement
97756	PAV	HR	1997	Pavement Management System
97554	PAV	PS	1995	Pavement Research Center MSU/UM
97654	PAV	PS	1996	Pavement Research Center of Excellence
97754	PAV	PS	1997	Pavement Research Center of Excellence
45491	PAV	PS	1998	Pavement Research Center of Excellence
45539	BRG	PS	1998	Polymer Composite Jackets for Column Repair
47877	BRG	PS	1999	Polymer Composite Jackets for Column Repair
97521	MAT	PS	1995	Polymers in Bituminous Mixtures
97721	PAV	PS	1997	Polymers in Bituminous Mixtures
47582	MAT	PS	1998	Polymers in Bituminous Mixtures
97512	ENV	PS	1995	Prototype Roadside Management and Development Plan
SPR 3 (045	PAV	PS	1996	Reclaimed Asphalt Under Superpave Specifications
SPR 3 (045	PAV	PS	1998	Reclaimed Asphalt Under Superpave Specifications
HPR 2 (158	MAT	PS	1997	Recycled Materials for Roadsides
97501	AD	O	1995	Research Program Administration
97601	AD	O	1996	Research Program Administration
97701	AD	O	1997	Research Program Administration
45480	AD	O	1998	Research Program Administration
47867	AD	O	1999	Research Program Administration
45551	PAV	PS	1998	Rigid Pavement Design Catalog

PROJECT	TYPE	STRATEGIC	YEAR	TITLE
48644	PAV	O	1999	SHRP - Superpave (FHWA)
HPR 2 (176	MAT	PS	1997	SHRP Asphalt Specifications
97760	AD	C	1997	School and Public Transportation Coordination
45493	AD	C	1998	School and Public Transportation Coordination
47868	AD	C	1999	School and Public Transportation Coordination
HPR 2 (178	PAV	PS	1997	Seasonal Changes in Pavements
97541	TS	C	1995	Smart Cruise Platform
97641	TS	C	1996	Smart Cruise Platform
45562	PAV	PS	1998	Study of Materials Related Distress in MI PCC Pavements
47890	PAV	PS	1999	Study of Materials Related Distress in MI PCC Pavements
97500	AD	O	1995	Subscription to TRB Correlation Service
97600	AD	O	1996	Subscription to TRB Correlation Service
97700	AD	O	1997	Subscription to TRB Correlation Service
45479	AD	O	1998	Subscription to TRB Correlation Service
47866	AD	O	1999	Subscription to TRB Correlation Service
47898	BRG	PS	1999	Superstructure Strengthening
45664	TS	O	1998	TMS
97553	TS	C	1995	Traffic and Safety Operations Research Center MSU
97653	TS	C	1996	Traffic and Safety Operations Research Center MSU
97753	TS	PS	1997	Traffic and Safety Operations Research Center MSU
45489	TS	C	1998	Traffic and Safety Operations Research Center MSU
47893	TS	C	1999	Traffic and Safety Operations Research Center MSU
47962	MATL	PS	1999	Trans Materials Research Center of Excellence
47895	TS	C	1999	Transit
97761	TS	PS	1997	Transit Research Center of Excellence
45552	PAV	PS	1998	Transverse Crack Propagation of JPCP
47882	PAV	PS	1999	Transverse Crack Propagation of JPCP
97530	BRG	PS	1995	Updating and Metrification of MDOT Bridge Design Guides
97630	BRG	PS	1996	Updating and Metrification of MDOT Bridge Design Guides
HPR 2	PAV	PS	1997	Use of Reclaimed Asphalt Pavements (RAP) under
97762	TS	C	1997	Voice Driven Passenger Information System
45560	MAT	PS	1998	Waste Materials in Hot-Mix Asphalt

TECHNICAL ASSISTANCE REVIEW
FY 1995-1999

Total Number of Technical Assistance Projects - 321

Average Per Year = 64 projects/year

MANAGEMENT OF UNIVERSITY RESEARCH

In March of 2000, the universities and MDOT will meet to re-engineer the process of managing university research. The key issues such as 1) Call for Research projects, 2) administering research contracts, 3) long-term commitments, 4) implementation/benefits of research, and 5) financial management.

The primary contact for the universities will be the chairpersons of Civil and Environmental Engineering Departments and for MDOT, the University Research Administrator, and the Engineer of Research.

SUMMARY AND CONCLUSIONS

Based on the review of the last five years of research program and the proposed five year research program in the areas of Bridges and Structures, Pavements and Materials, and Traffic and Safety, the following conclusions can be made.

1. The research program/projects provide impetus for continuous improvements in the delivery of product and services.

2. The diversity and complexity of technical areas make this program unique to team up with the universities and critically rely on in-house (MDOT) core expertise to provide overall direction and management of the program.

3. Efforts are needed to better document the benefits or savings of the overall research program and the success of research product implementation.

4. Research must be a tool to continuously improve services provided by MDOT.

5. Feasibility of public and private partnership to carry on research work needs to be studied.

APPENDIX A

RECOMMENDED LIST OF EQUIPMENT FOR UNIVERSITY RESEARCH CENTER
What equipment/facilities would be needed to do material research
(emphasis on concrete and rigid pavement)

Temperature controlled building with ability to zone areas
Overhead doors - extra high
Floor drain system designed for concrete work
Room to turn around a redi-mix truck
Overhead hoist system
Structural frame for accelerated loading
Walk-in freezer/cooler
Ovens
Freezers
Freeze-thaw unit - 40° temperature bath
Compression machine
Universal testing machine (compression/tension)
Lancaster pan mixer
Drum Mixers
Hobart paddle mixers
Concrete table saw - saw room and 24" (minimum) oil-bath trim saw
Automatic concrete polisher
Linear transverse system
Gilson shaker with sieves
Protected aggregate bins - extra units for speciality aggregates
Environmental chamber
Scanning electron microscope
X-ray defractometer
Fourier transfer infrared spectrometer
Rapid chloride permeability tester
Exhaust hoods
Dust collectors
Chemical storage room
Small equipment storage room
Sample storage room
Stereo microscope with ordinary and UV light illuminators
Apparatus for preparing thin sections
Curing room
Curing tank
Cement testing equipment, etc. and area
Moisture conditioning equipment
Specific gravity and absorption equipment
Capping equipment and area
Dock - loading and unloading area
Large limited access storage area!

Optional:
Concrete crusher
Concrete pulverizer
Portable core rig

APPENDIX B
TECHNICAL INVESTIGATIONS
FY 94-99

PROJECT LISTING BY PROJECT NUMBERS
NEW PROJECTS ADDED DURING SPECIFIED PERIOD
10/10/94 - 09/30/99

97A -0032	TBW	H	A2E03	A	12/08/97	Freeze-Thaw Durability Testing for 4AA Acceptance
94B -0109	DEB	H	A2B04	B	12/21/94	Partial Depth Repair of Concrete Pavements and Structures
95B -0110	JFS	H	A2E01	B	09/06/95	High Early Strength Concrete
97B -0111	TES	H	A2E05	B	06/19/97	415 Low Permeability Concrete
97B -0112	DEB	H	A2E05	B	07/09/97	Cocnrete Bridge Barrier and Substructure Protective Coatings
95D -0061	DLS	H	A2D03	D	09/01/95	Test Method to Determine the Existence of Segregation in Bituminous Mixture
95D -0062	GFS	H	A2B01	D	11/08/95	Improvement of MICHPAVE and MICHBACK
95D -0063	TEH	H	A2B01	D	11/08/95	Calibration of MICHPAVE's Rut and Fatigue Distress Models
96D -0064	TEH	M	A2D04	D	08/07/96	Resilient Modulus of Current Bituminous Mixtures
97D -0065	DEB	H	A2D05	D	07/08/97	Bituminous Pavement Resurfacing at Snowmobile Crossings
95E -0069	DLS	M	A2K07	E	03/31/95	Tensar Reinforced Slope - US-31 Relocation Berrien County, CS 11112/36100D
95F -0174	JFS	H	A2B02	F	11/29/95	Causes of Distress in JRCP on OGDC
94G -0305	RLM	M	A3C15	G	12/09/94	Products to Improve Corrosion Performance of Bridge Deck Patching
95G -0306	VTB	H	A2B06	G	03/14/95	Pavement Monitoring, Evaluation and Data Management
95G -0307	DLS	H	A2B06	G	09/01/95	Michigan Pavement Rehabilitation Methods and Selection Process
95G -0308	DLS	H	A2B03	G	09/01/95	Mechanistic Design Implementation Plan for Flexible Pavements & Overlays
96G -0309	TJH	H	A2B06	G	05/07/96	Pavement Rut Measurement Operations
96G -0310	ME	M		G	11/19/96	Development of Laboratory Tests for Crack and Joint Sealants/Fillers
97G -0311	RDT	M	A2C03	G	09/18/97	Prestressed Concrete Bridge Using Composite Materials
97G -0312	DAJ	M	A2C01	G	09/19/97	Non-Metallic Reinforcement for Concrete Bridge Decks
97G -0313	RDT	M	A3C06	G	09/19/97	Composite Wrapping of Columns for Repair
97G -0314	RDT	M	A2C01	G	09/19/97	Guide for Evaluation of Existing Bridges
97G -0315	RDT	M	A3C06	G	09/19/97	Carbon Fiber Sheets on Concrete Beams for Rehabilitation
97G -0316	RDT	M	A2C03	G	10/23/97	Prestressed Conc Brdg Superstructure Using Composite Reinforcement
97G -0317	DR	M	A3A04	G	12/23/97	Evaluation of Retroreflective Sheeting
97G -0318	DR	M	A3A04	G	12/23/97	Testing and Evaluation of Light Reflecting/Delineation Devices
97G -0319	DR	M	A3A04	G	12/23/97	Testing and Evaluation of Light Emitting Devices
98G -0320	DR	H	A3A04	G	05/04/98	Photometric Range Calibration
98G -0321	TES	H	A3C06	G	08/20/98	Epoxy Overlay of Bridge Decks
98G -0322	ME	H	A2B04	G	09/28/98	Evaluation of Whitetopping as a Pavement Rehabilitation Technique
98G -0323	ME	M	A2B04	G	11/18/98	Dowel Bar Retrofit (DBR) of Cracks in PCC Pavements
99G -0325	FMS	M	A1B04	G	03/26/99	Technical Assistance with Weigh Stations
99G -0326	DN	H	A3C06	G	05/07/99	Develop & Evaluation of Passive Cathodic Protection Systems..PCI-Beam Ends
99G -0327	DAJ	H	A2C01	H	05/07/99	Full Depth Precast Bridge Decks
99G -0328	BDB	M	A3C12	G	06/29/99	Maintain & Develop Specifications for Coating Systems
99G -0329	SCK	H	A3C15	G	08/03/99	Stainless Reinforcement in Bridge Decks
94NM-1109	ME	L	A3C13	G	11/08/94	Pro-Seal II Detector Loop Sealant
94NM-1110	FWH	H	A1F04	G	11/08/94	Noishield Transportation Sound Barrier
94NM-1111	DEB	M	A2B02	G	11/08/94	Thermal-Chem Eva Expansion Joint System
94NM-1112	DLS				11/08/94	Thermal-Chem Epoxy Polymer Concrete Overlay,3
94NM-1113	LJP	M	A2E05	G	11/08/94	Polymer Handhole
95NM-1114	DR	M	A3A02	G	03/13/95	Empco-Lite
95NM-1115	FWH	H	A1F04	G	03/13/95	Cavity Pier Noise Barrier
95NM-1116	BDB	M	A3C12	G	03/13/95	Barshot Blasting Abrasive
95NM-1117	LJP	L	A2A04	G	03/13/95	Earth Care Products (ECP)
95NM-1118	JFS	M	A2E05	B	03/13/95	HCC High Carbon Concrete
95NM-1119	LJP	L	A2A04	G	05/05/95	Polylumber
95NM-1120	FWH	M	A1F04	G	05/05/95	Faddis Concrete Products Noise Barriers
95NM-1121	LJP	M	A3A02	G	05/11/95	PFM (Polymer-Fiber Matrix)
95NM-1122	JFS	L	A2F05	G	05/11/95	Protecrete - MWC Mix Water Conditioner
95NM-1123	JFS	L	A2E05	G	05/11/95	Protecrete - CDS Concrete Densifier Sealer

95NM-1124	JFS	L	A2E05	G	05/11/95	Protecrete - SPP Steel Preservation Penetrant
95NM-1125	JFS	L	A2C01	G	05/11/95	SS40 Chain Link Fence Framework
95NM-1126	RLM	M	A3C15	G	07/31/95	Corrosion of Storm Drain Cover-Locking Device
95NM-1127	JFS	L	A2E05	G	05/11/95	Perma-Crete
95NM-1128	TRL	L	A2A04	G	05/18/95	Lifegard Channelizer
95NM-1129	TJH	M	A2E06	B	07/31/95	Metamax High Reactivity Metakaolin
95NM-1130	REN	L	A3A02	G	08/09/95	Qwick Kurb
95NM-1131	DLS	L	A2J06	G	08/18/95	Soil Cement
95NM-1132	TEH	L	A2D02	C	08/25/95	Royston Rosphalt 50 Asphalt Additive
95NM-1133	DAJ	L	A2A04	G	08/30/95	Telespar Sign Support System
95NM-1134	DEB	L	A2C01	G	09/13/95	Matrix Blue
95NM-1135	DR	M	A3A02	G	10/19/95	BARREL WRAP
95NM-1136	LED	L	A2H01	G	10/19/95	EDS Ice Warning System
95NM-1137	DN	M	A2A04	G	10/25/95	Composite Post 40
95NM-1138	TRL	L	A3C05	G	10/25/95	Grade-Loc
95NM-1139	DR	M	A3A02	G	12/20/95	Safe T Spin
96NM-1140	DEB	M	A2C01	F	01/10/96	Silcoflex
96NM-1141	DCL	M	A3C12	G	02/12/96	Aquron CPT-2000, Aquron 7000 Prewash (Part A), Aquron 7000 (Part B)
96NM-1142	DLS	L	A2K06	G	03/20/96	Polydrain
96NM-1143	RLM	L	A3C15	G	03/20/96	American Step Company Manhole Step
96NM-1144	DCL	M	A3C12	G	03/27/96	Truco
96NM-1145	DAJ	M	A2E01	G	04/01/96	MRC-150
96NM-1146	ME	L	A3C13	G	04/04/96	MP-52 Bituminous Joint Compound
96NM-1147	ME	L	A3C13	G	04/04/96	Pro-Stik Butyl Sealant
96NM-1148	TEH	L	A3C05	G	04/04/96	Bond-X High Performance Cold Mix
96NM-1149	ME	L	A3C13	G	04/04/96	C-56 Joint Sealant
96NM-1150	RDT				05/31/96	Supertie-Fiberglass Formtie System
96NM-1151	SCK	L	AC315	G	06/07/96	Splice Seal-Reinforcement Protection System
96NM-1152	ME	M	A2B02	F	06/03/96	Fiber Dowel-FRP Joint Restraint System
96NM-1153	LJP	L	A2A04	G	06/24/96	Dura-Bull Blockout
96NM-1154	JFS	H	A2C01	G	06/25/96	Volclay Waterrstop-RX Betonite Waterstop System
96NM-1155	ME	L	A3C06	G	09/23/96	KIM (Krystol Internal Membrane) T-1
96NM-1156	DLS	L	A2D07	G	09/27/96	RAUPAVE/ARMAPAL-G
96NM-1157	LED	L	A3A02	G	10/10/96	Fiber Optic Pedestrian Signal Kit
96NM-1158	LJP	L	A2A04	G	10/16/96	Mailbox Post - Recycled Plastic
96NM-1159	DCL	M	A2C02	G	11/07/96	Armex Cleaning and Coating Removal System
96NM-1160	DR	M	A3A04	G	11/27/96	LLV Strobe Light Kits
96NM-1161	REN				12/11/96	Fiber Optic Turn Arrow
96NM-1162	LED				12/11/96	Fiber Optic Lane Control
96NM-1163	LED				12/11/96	Fiber Optic Blank-Out Sign
97NM-1164	REN				03/03/97	Lane Control Signs
97NM-1165	DR	M	A3A04	G	02/03/97	Flexi-Guide Model 527 High Impact Guardrail Delineators
97NM-1166	DR	M	A3A04	G	02/03/97	Flexi-Guide Model 427 High Impact Guardrail Delineators
97NM-1167	REN				02/04/97	Blank Out Signs
97NM-1168	REN				02/04/97	Dual Color Turn Arrow
97NM-1169	REN				02/04/97	Pedestrian Signal
97NM-1170	DR	M	A3A04	G	02/26/97	Opposing Lane Divider-Vertical Panel, Directional Indicator Barricade
97NM-1171	ME	L	A3C13	G	04/04/97	Butyl Sealant
97NM-1172	LJP	L	A2A04	G	04/30/97	Structural Polymers
97NM-1173	ME	L	A3C13	G	04/30/97	Flexible Cement II or Flex II - Resubmittal
97NM-1174	LJP	L	A3C05	G	06/09/97	Infra Riser
97NM-1176	RDT	M	A2C01	G	06/18/97	Extren Structural Shapes & Plate (Fiberglass)
97NM-1177	JFS				06/18/97	Carat Products
97NM-1178	DCL	M		G	07/23/97	Safety Beacon Light
97NM-1182	LJP	L	A3A02	G	09/08/97	Qwik-Punch
97NM-1185	SCK	L	A3C15	G	09/19/97	Nuovinox - Stainless Clad Reinforcing Steel
97NM-1186	RDT				09/30/97	Vylon Slipliner Pipe Diameters 21" - 54"
97NM-1187	RDT				09/30/97	Insider Slipliner Pipe Diameter Range 12" - 18"
97NM-1188	RDT				09/30/97	Lamson Vylon Direct Bury Sewer Pipe 21" - 54"
97NM-1189	SCK	L	A3C15	G	10/09/97	Link-Pipe Inc

Errata Booklet

Corrections to the 1st, 2d, and 3d printings of *Trip Generation*, 4th Edition

The enclosed pages include corrections and changes to the first, second, and third printings of the fourth edition of *Trip Generation.* Please keep this booklet with your copy of *Trip Generation,* and place the enclosed labels on the pages in the book that correspond to the pages in the errata booklet, to serve as a reminder that changes have been made.

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202/554-8050

3.1M/AGS/789

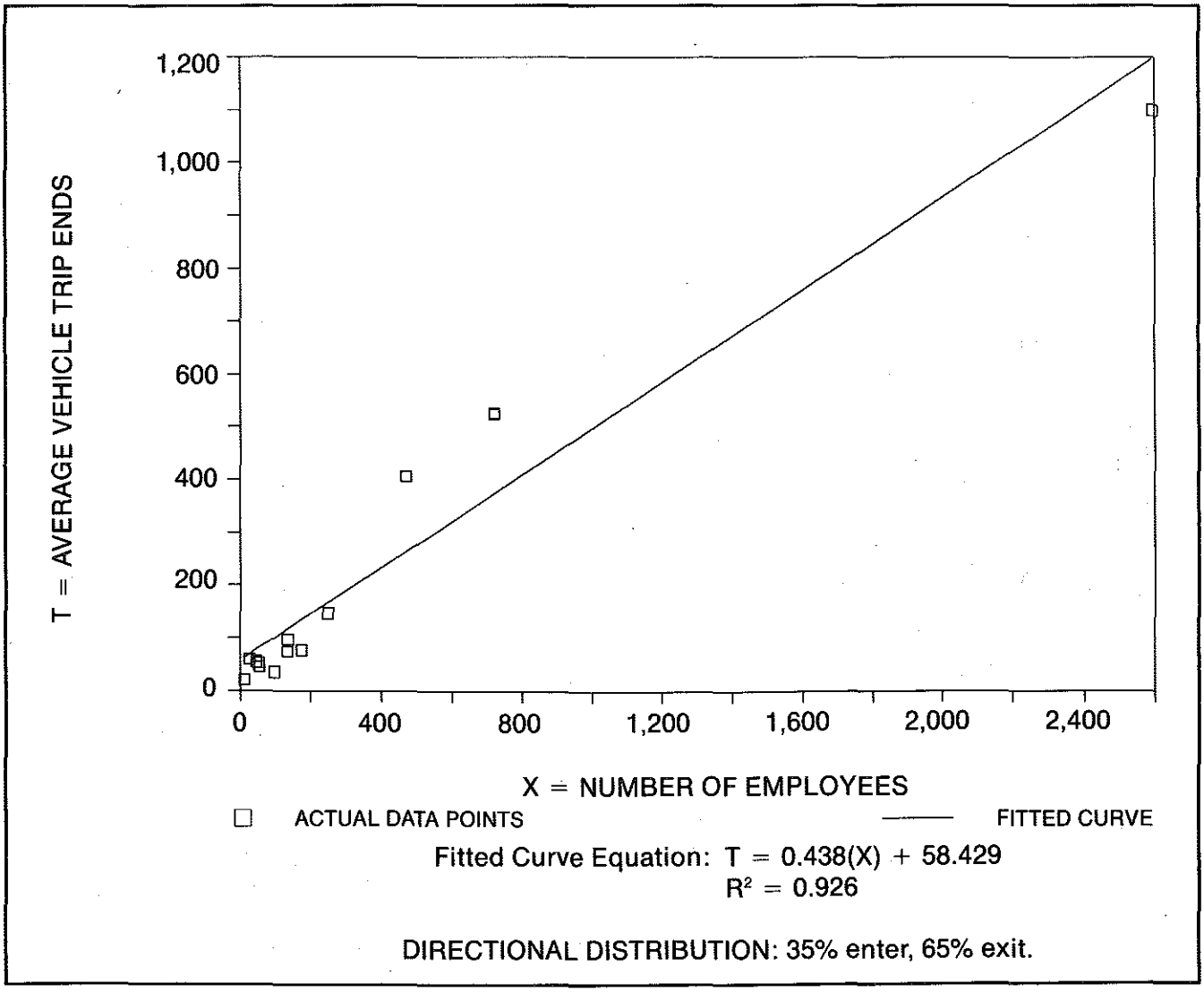
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **EMPLOYEES**
On a: **WEEKDAY**
PEAK HOUR OF ADJACENT STREET TRAFFIC, ONE HOUR BETWEEN 4 AND 6 P.M.

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—Peak Hour of Adjacent Street Traffic, One Hour Between 4 and 6 PM) per Employee				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Employees*
0.588	0.367–2.222	*	14	391.9

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = 0.438(X) + 58.429$

$R^2 = 0.926$

DIRECTIONAL DISTRIBUTION: 35% enter, 65% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

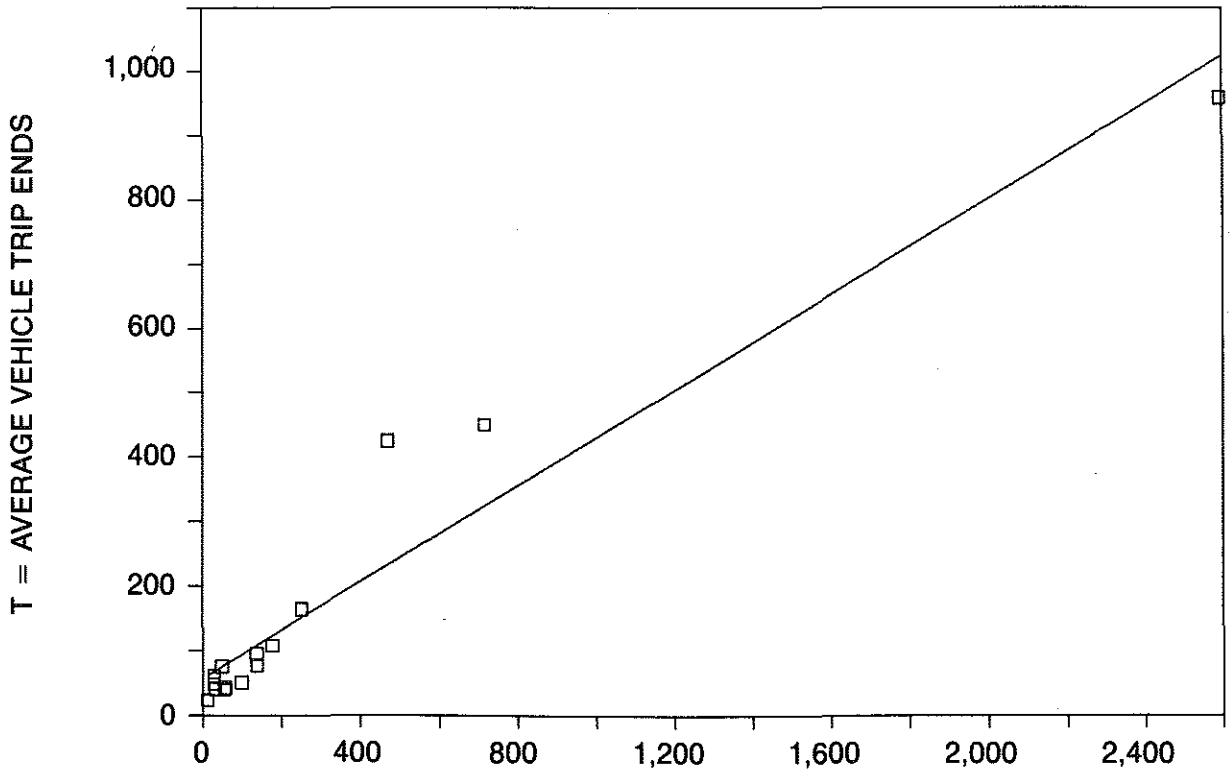
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **EMPLOYEES**
On a: **WEEKDAY**
A.M. PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—A.M. Peak Hour of Generator) per Employee				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Employees*
0.550	0.370–2.143	*	15	321.9

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = 0.373(X) + 56.944$

$R^2 = 0.927$

DIRECTIONAL DISTRIBUTION: 50% enter, 50% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

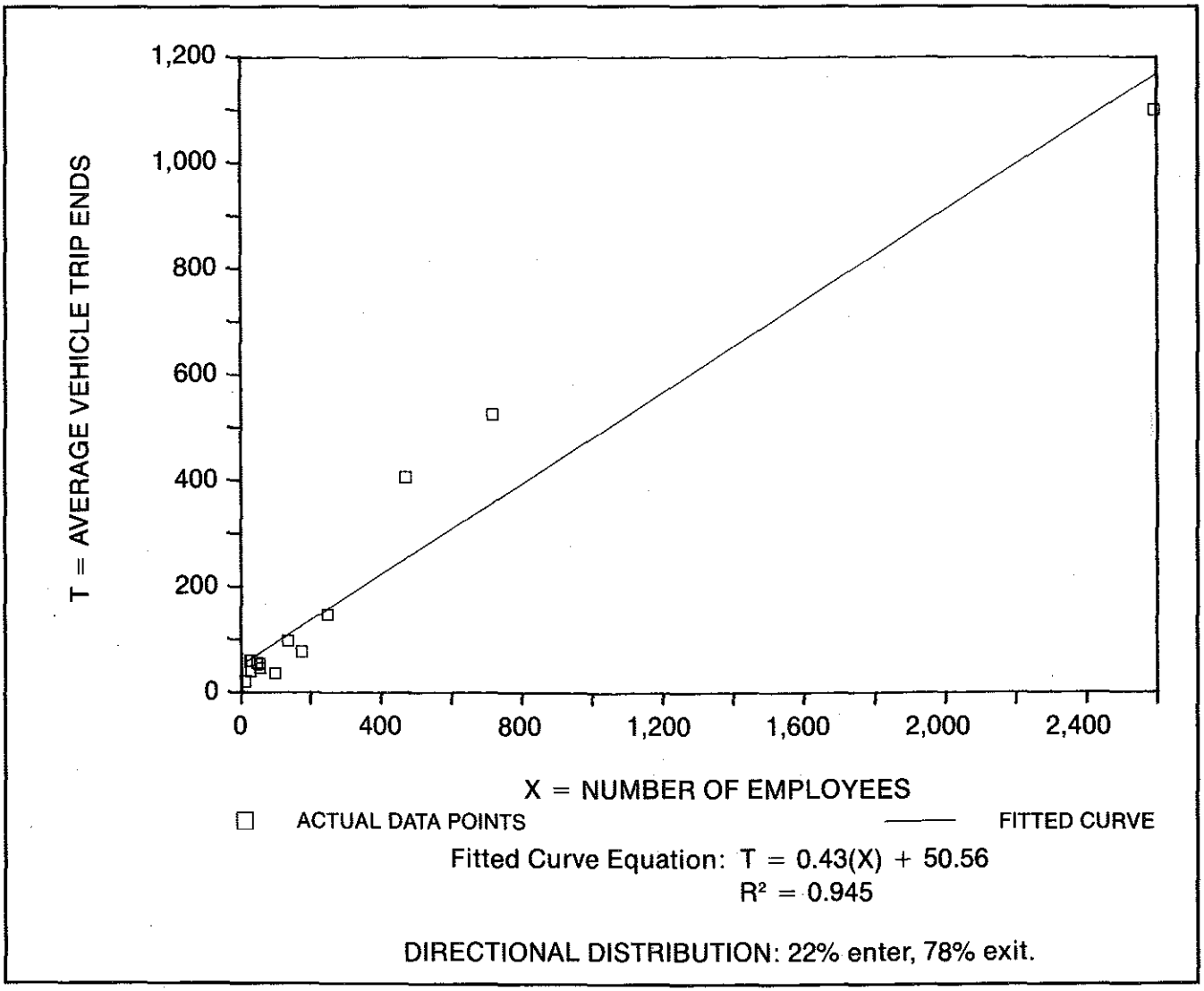
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **EMPLOYEES**
On a: **WEEKDAY**
P.M. PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—P.M. Peak Hour of Generator) per Employee				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Employees*
0.580	0.367–2.222	*	14	335.2

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = 0.43(X) + 50.56$

$R^2 = 0.945$

DIRECTIONAL DISTRIBUTION: 22% enter, 78% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **EMPLOYEES**
On a: **SATURDAY**

TRIP GENERATION RATES

Average Saturday Vehicle Trip Ends per Employee				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Employees*
0.484	0.370–0.505	*	2	1532.0

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: Not available.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **EMPLOYEES**
On a: **SATURDAY**
PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Saturday—Peak Hour of Generator) per Employee				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Employees*
0.101	0.050–0.379	*	2	1532.0

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: 64% enter, 36% exit.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **EMPLOYEES**
On a: **SUNDAY**

TRIP GENERATION RATES

Average Sunday Vehicle Trip Ends per Employee				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Employees*
0.241	0.231–0.294	*	2	1532.0

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: Not available.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **EMPLOYEES**
On a: **SUNDAY**
PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Sunday—Peak Hour of Generator) per Employee				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Employees*
0.057	0.023–0.243	*	2	1532.0

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: 52% enter, 48% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

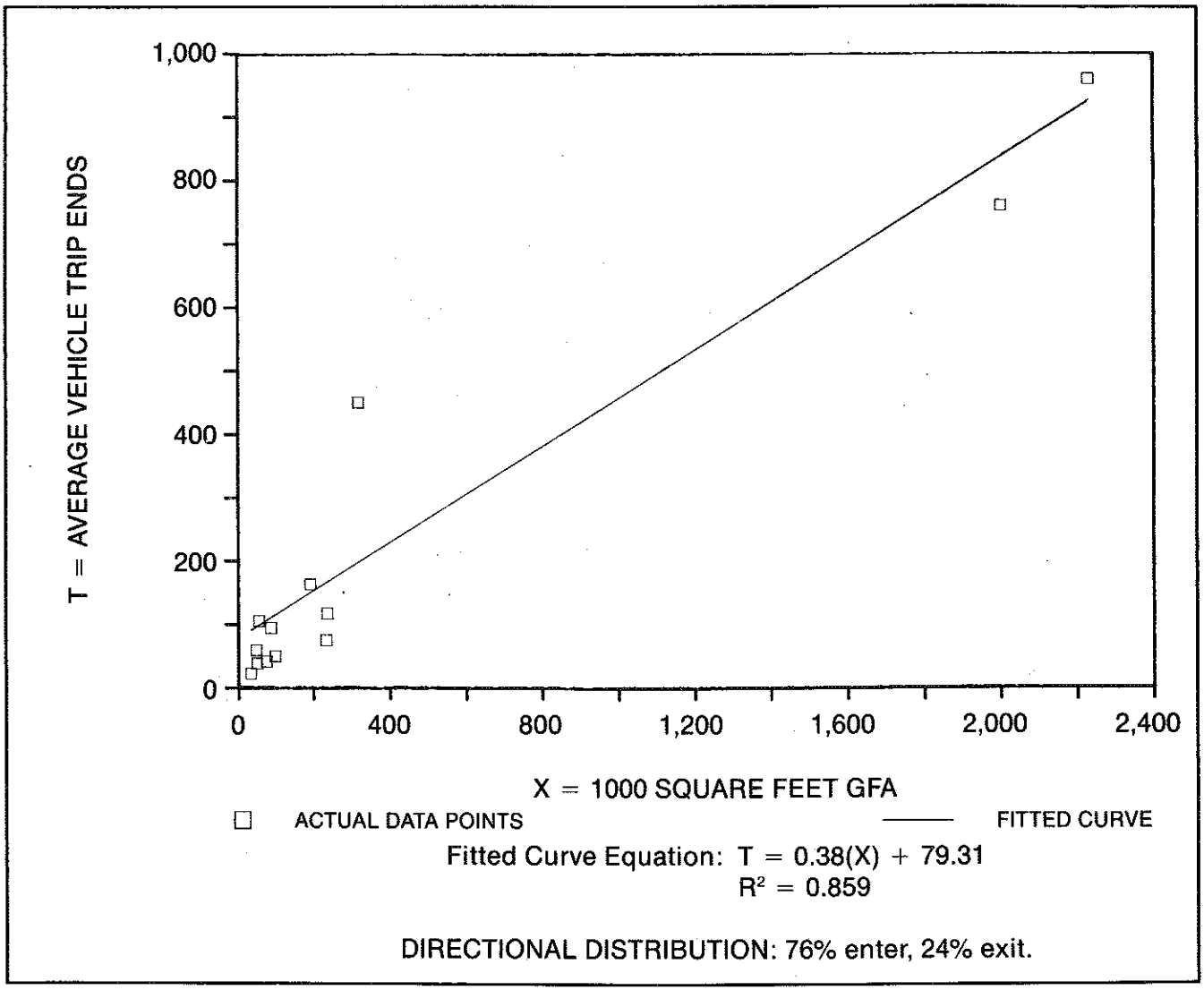
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **WEEKDAY**
PEAK HOUR OF ADJACENT STREET TRAFFIC, ONE HOUR BETWEEN 7 AND 9 A.M.

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—Peak Hour of Adjacent Street Traffic, One Hour Between 7 and 9 A.M.) per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
0.569	0.326–1.927	*	14	426.5

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = 0.38(X) + 79.31$

$R^2 = 0.859$

DIRECTIONAL DISTRIBUTION: 76% enter, 24% exit.

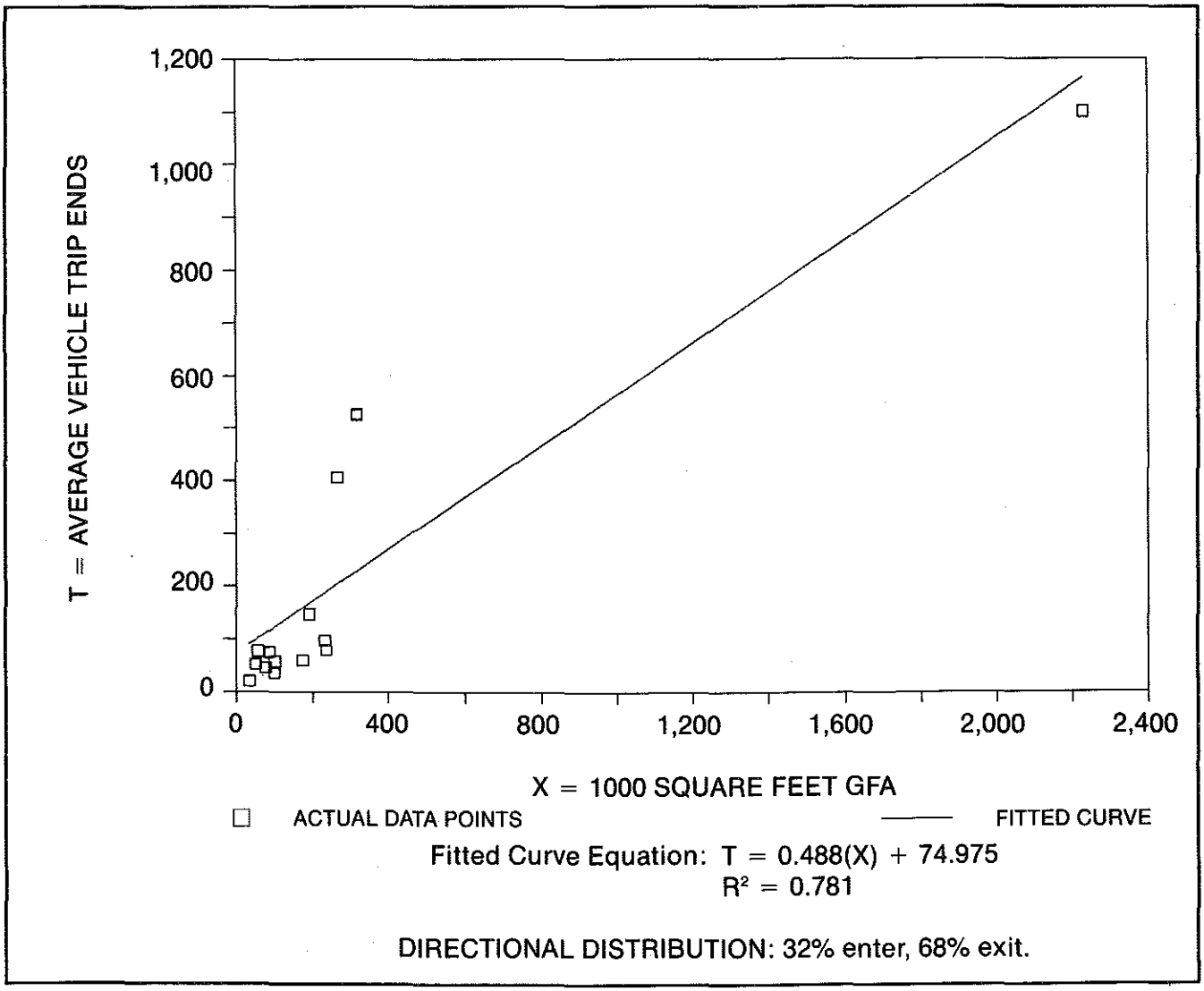
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **WEEKDAY**
PEAK HOUR OF ADJACENT STREET TRAFFIC, ONE HOUR BETWEEN 4 AND 6 P.M.

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—Peak Hour of Adjacent Street Traffic, One Hour Between 4 and 6 PM) per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
0.740	0.340–1.657	*	15	297.6

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = 0.488(X) + 74.975$

$R^2 = 0.781$

DIRECTIONAL DISTRIBUTION: 32% enter, 68% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

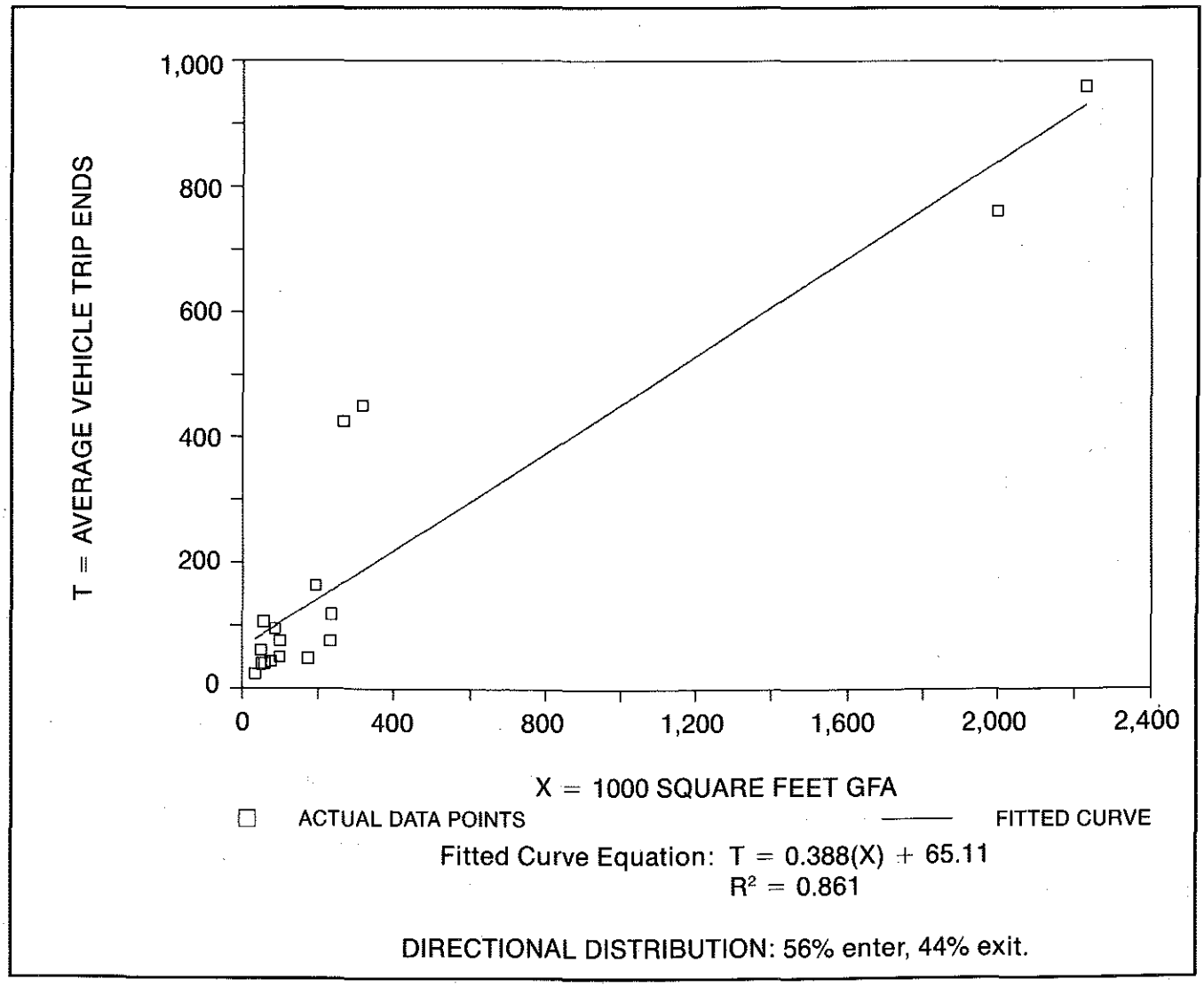
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **WEEKDAY**
A.M. PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—A.M. Peak Hour of Generator) per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
0.565	0.276–1.927	*	17	367.8

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = 0.388(X) + 65.11$

$R^2 = 0.861$

DIRECTIONAL DISTRIBUTION: 56% enter, 44% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **SATURDAY**

TRIP GENERATION RATES

Average Saturday Vehicle Trip Ends per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
0.594	0.587–0.652	*	2	1248.5

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: Not available.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **SATURDAY**
PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Saturday—Peak Hour of Generator) per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
0.123	0.058–0.667	*	2	1248.5

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: 64% enter, 36% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **SUNDAY**

TRIP GENERATION RATES

Average Sunday Vehicle Trip Ends per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
0.296	0.269–0.516	*	2	1248.5

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: Not available.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **SUNDAY**
PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Sunday—Peak Hour of Generator) per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
0.070	0.027–0.427	*	2	1248.5

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: 52% enter, 48% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

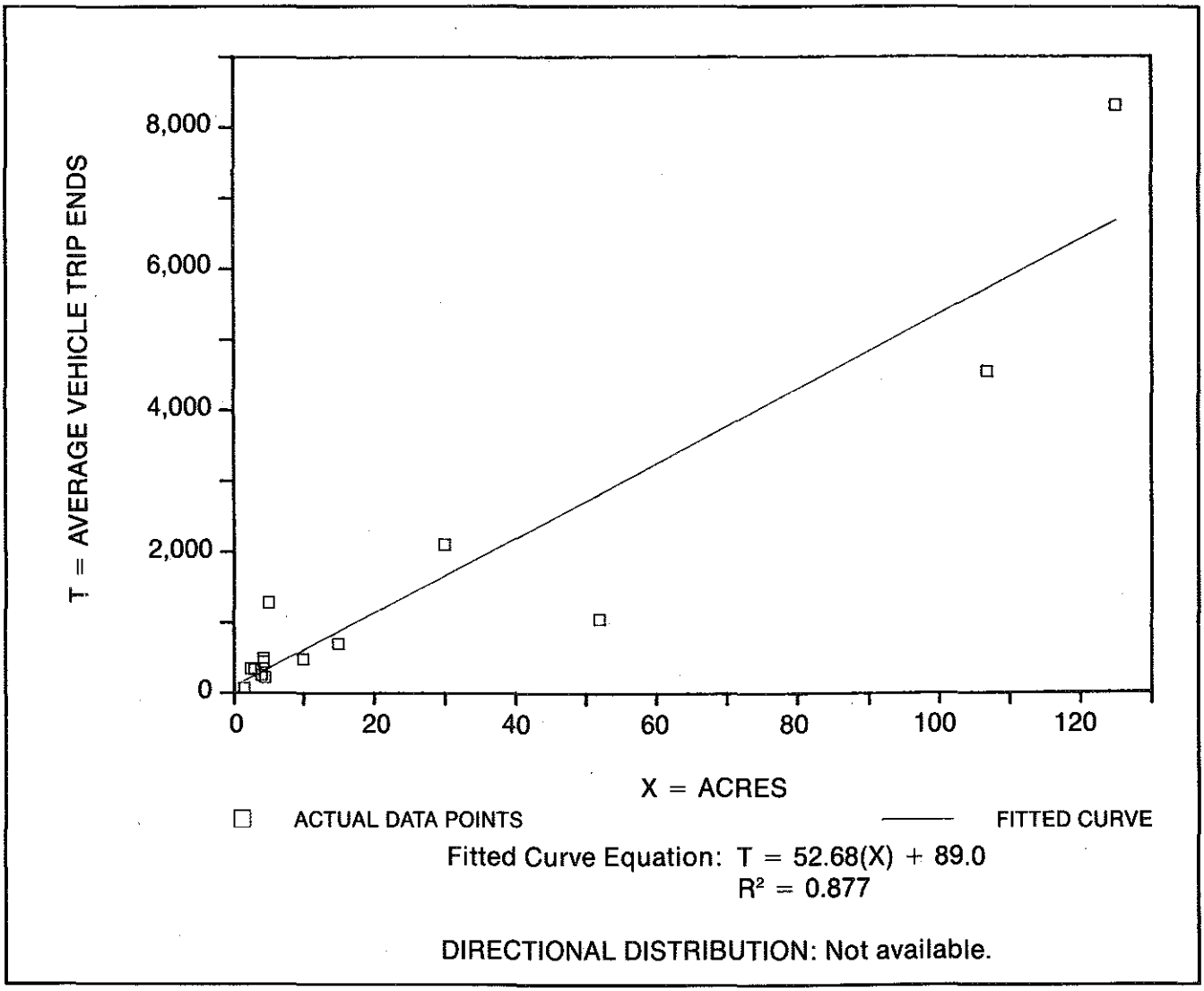
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **ACRES**
On a: **WEEKDAY**

TRIP GENERATION RATES

Average Weekday Vehicle Trip Ends per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
56.080	20.231–255.800	*	14	26.3

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = 52.68(X) + 89.0$

$R^2 = 0.877$

DIRECTIONAL DISTRIBUTION: Not available.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

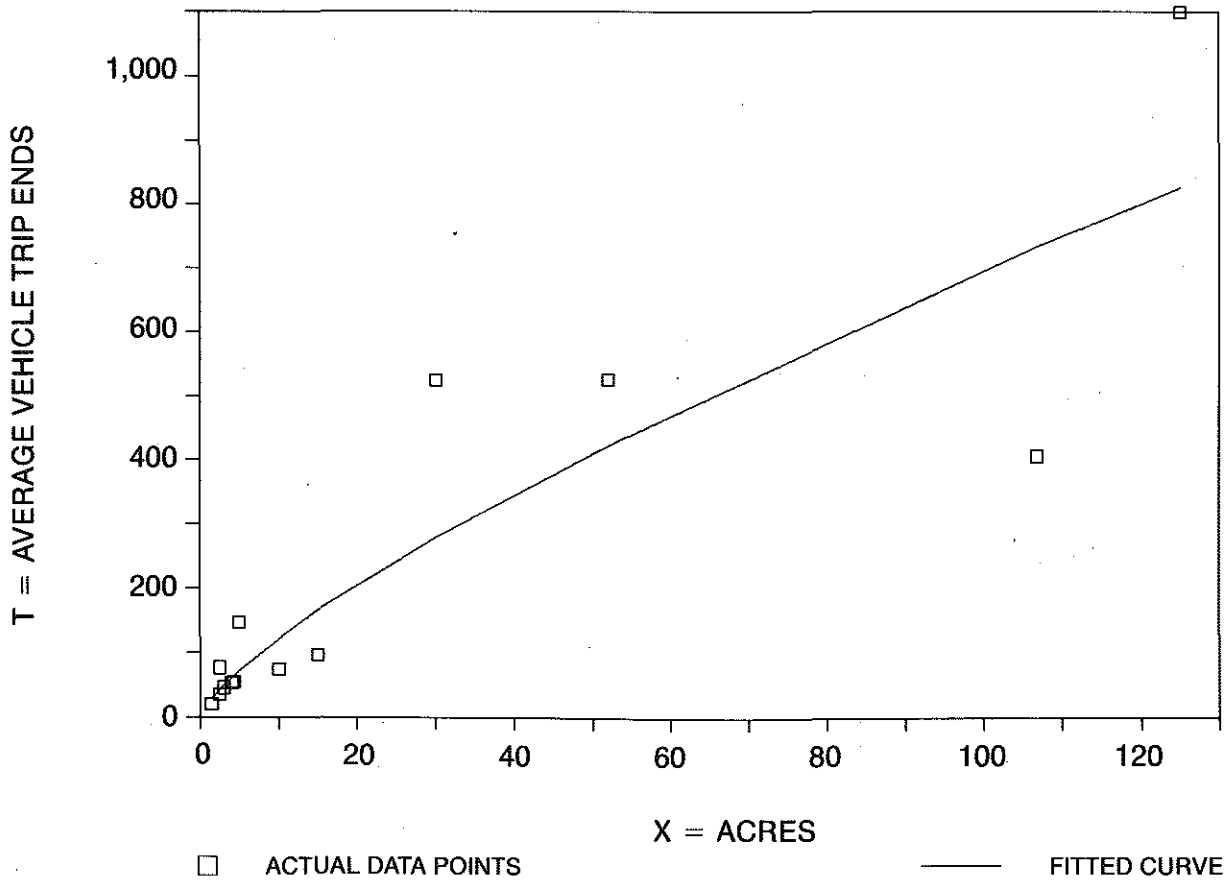
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **ACRES**
On a: **WEEKDAY**
PEAK HOUR OF ADJACENT STREET TRAFFIC, ONE HOUR BETWEEN 4 AND 6 P.M.

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—Peak Hour of Adjacent Street Traffic, One Hour Between 4 and 6 P.M.) per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
8.753	3.801–30.800	*	13	27.8

DATA PLOT AND EQUATION



Fitted Curve Equation: $Ln(T) = 0.758\ Ln(X) + 3.055$
$R^2 = 0.865$

DIRECTIONAL DISTRIBUTION: 35% enter, 65% exit.

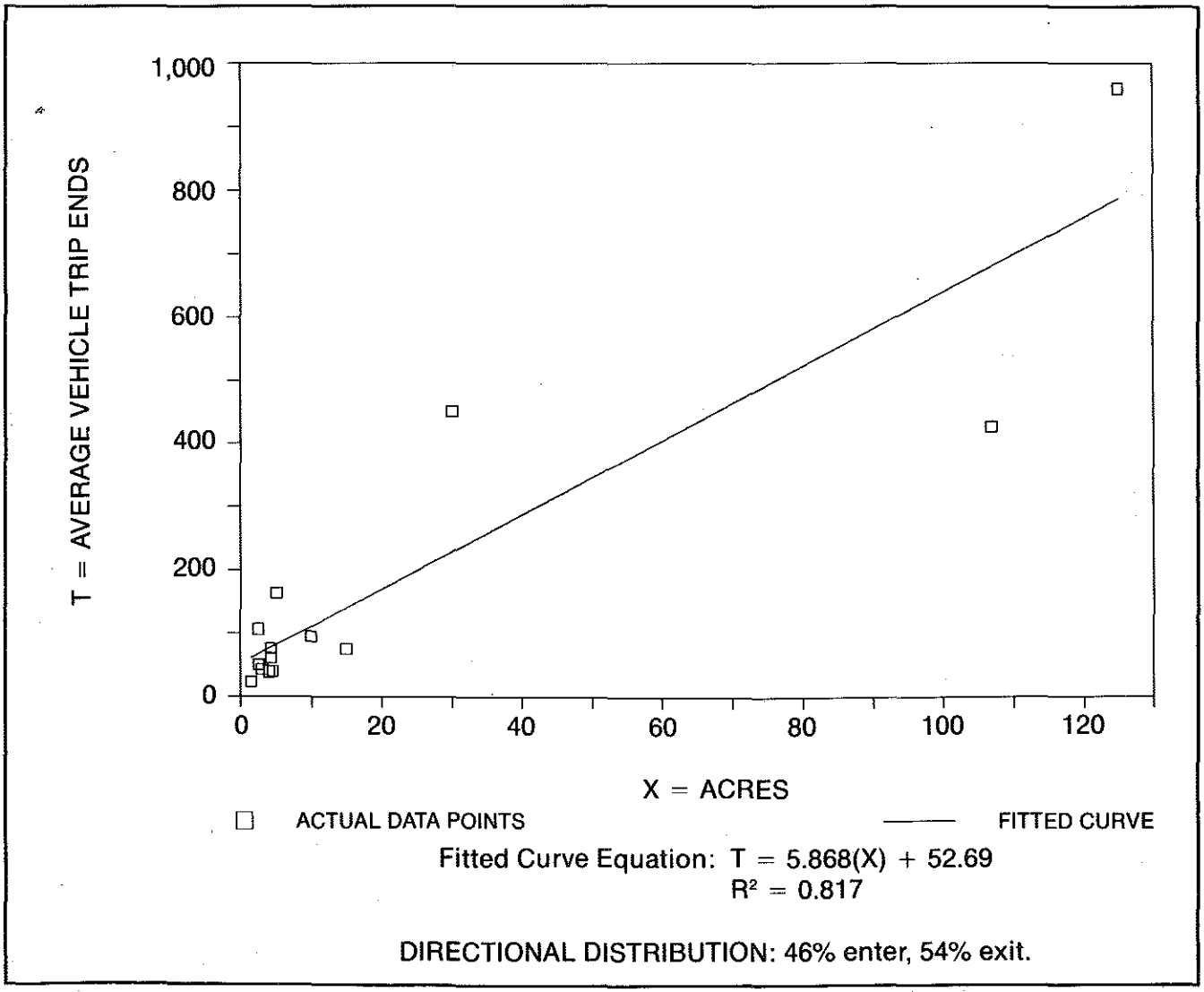
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **ACRES**
On a: **WEEKDAY**
A.M. PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—A.M. Peak Hour of Generator) per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
8.185	3.979–42.400	*	14	22.7

DATA PLOT AND EQUATION



Fitted Curve Equation: T = 5.868(X) + 52.69
R^2 = 0.817

DIRECTIONAL DISTRIBUTION: 46% enter, 54% exit.

Trip Generation, Errata Booklet/July 1989
(Replaces corresponding page in 1st, 2d, and 3rd printings of Trip Generation, *September 1987)*

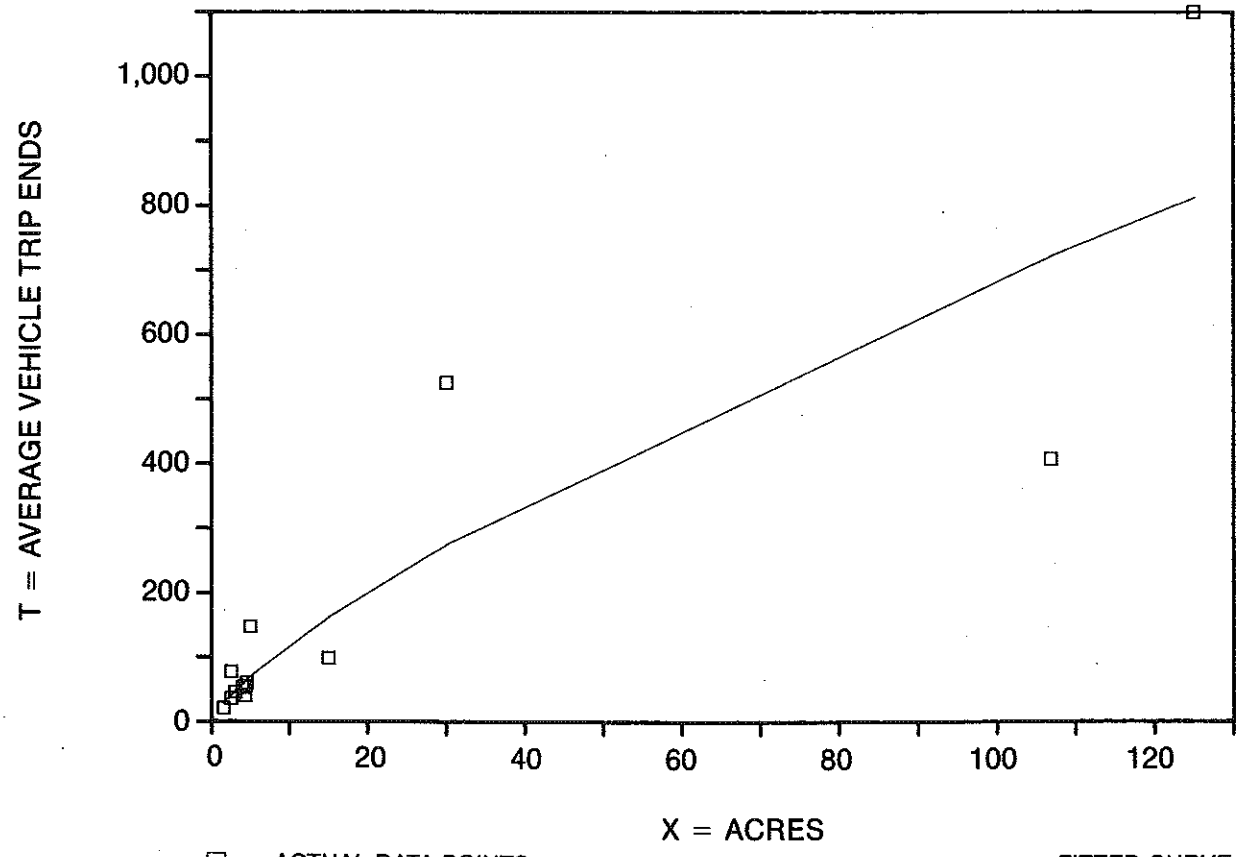
WAREHOUSING (150)

Average Vehicle Trip Ends vs: **ACRES**
On a: **WEEKDAY**
P.M. PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—P.M. Peak Hour of Generator) per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
8.638	3.801–30.800	*	13	23.7

DATA PLOT AND EQUATION



Fitted Curve Equation: $Ln(T) = 0.76\ Ln(X) + 3.03$
$R^2 = 0.858$

DIRECTIONAL DISTRIBUTION: 22% enter, 78% exit.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **ACRES**
On a: **SATURDAY**

TRIP GENERATION RATES

Average Saturday Vehicle Trip Ends per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
6.402	1.629–10.480	*	2	115.9

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: Not available.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **ACRES**
On a: **SATURDAY**
PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Saturday—Peak Hour of Generator) per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
1.329	1.040–1.667	*	2	115.9

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: 64% enter, 36% exit.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **ACRES**
On a: **SUNDAY**

TRIP GENERATION RATES

Average Sunday Vehicle Trip Ends per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
3.184	1.292–4.800	*	2	115.9

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: Not available.

WAREHOUSING (150)

Average Vehicle Trip Ends vs: **ACRES**
On a: **SUNDAY**
PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Sunday—Peak Hour of Generator) per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
0.751	0.480–1.067	*	2	115.9

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.

NO PLOT OR EQUATION AVAILABLE—INSUFFICIENT DATA

DIRECTIONAL DISTRIBUTION: 52% enter, 48% exit.

Errata Booklet

Trip Generation, 4th Edition, 2d printing

The enclosed pages include corrections and changes to the *second* printing of the fourth edition of *Trip Generation.* Please keep this book with your copy of *Trip Generation,* and place the enclosed labels on the pages in the book that correspond to the pages in the errata booklet, to serve as a reminder that changes have been made.

Institute of Transportation Engineers
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202/554-8050

1300/AGS/388

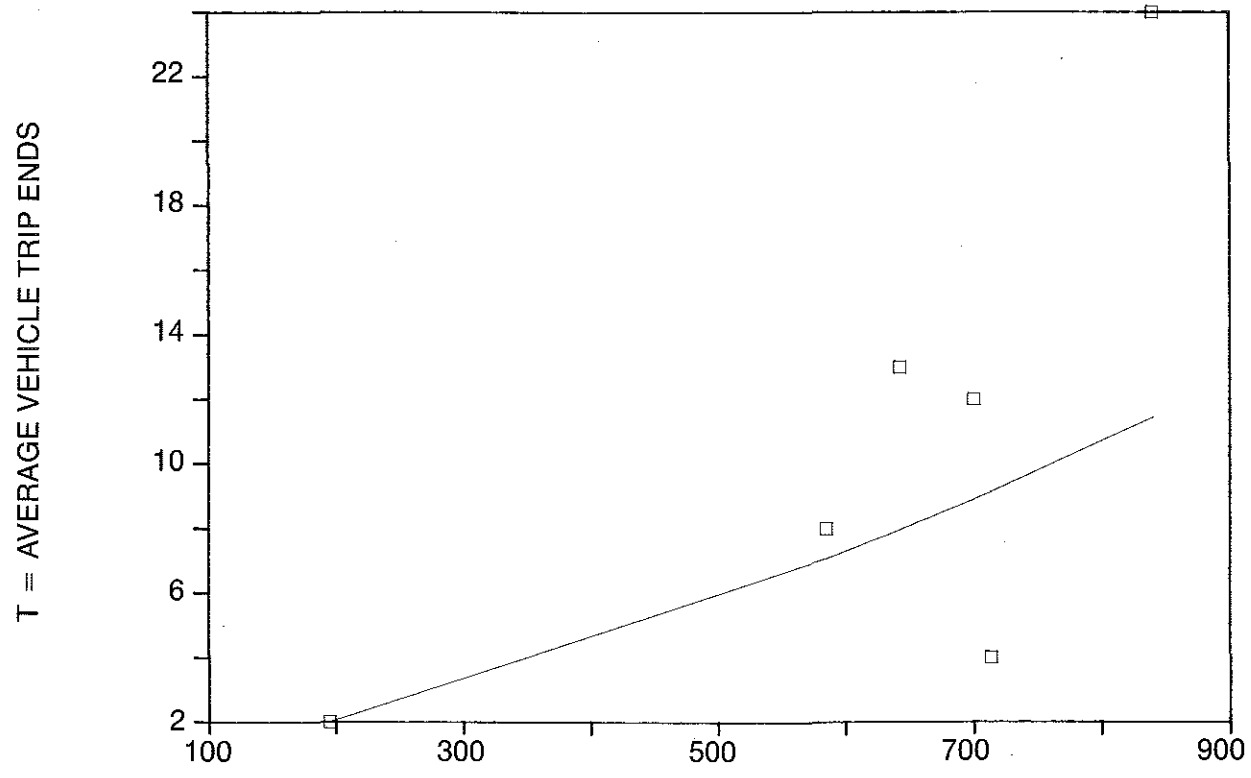
MINI-WAREHOUSE (151)

Average Vehicle Trip Ends vs: **STORAGE UNITS**
On a: **WEEKDAY**
PEAK HOUR OF ADJACENT STREET TRAFFIC, ONE HOUR BETWEEN 7 AND 9 A.M.

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—Peak Hour of Adjacent Street Traffic, One Hour Between 7 and 9 A.M.) per Storage Unit				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Storage Units*
0.017	0.006–0.029	*	6	612.5

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = [(104.45/X) - 0.037]^{-1}$
$R^2 = 0.831$

DIRECTIONAL DISTRIBUTION: Not available.

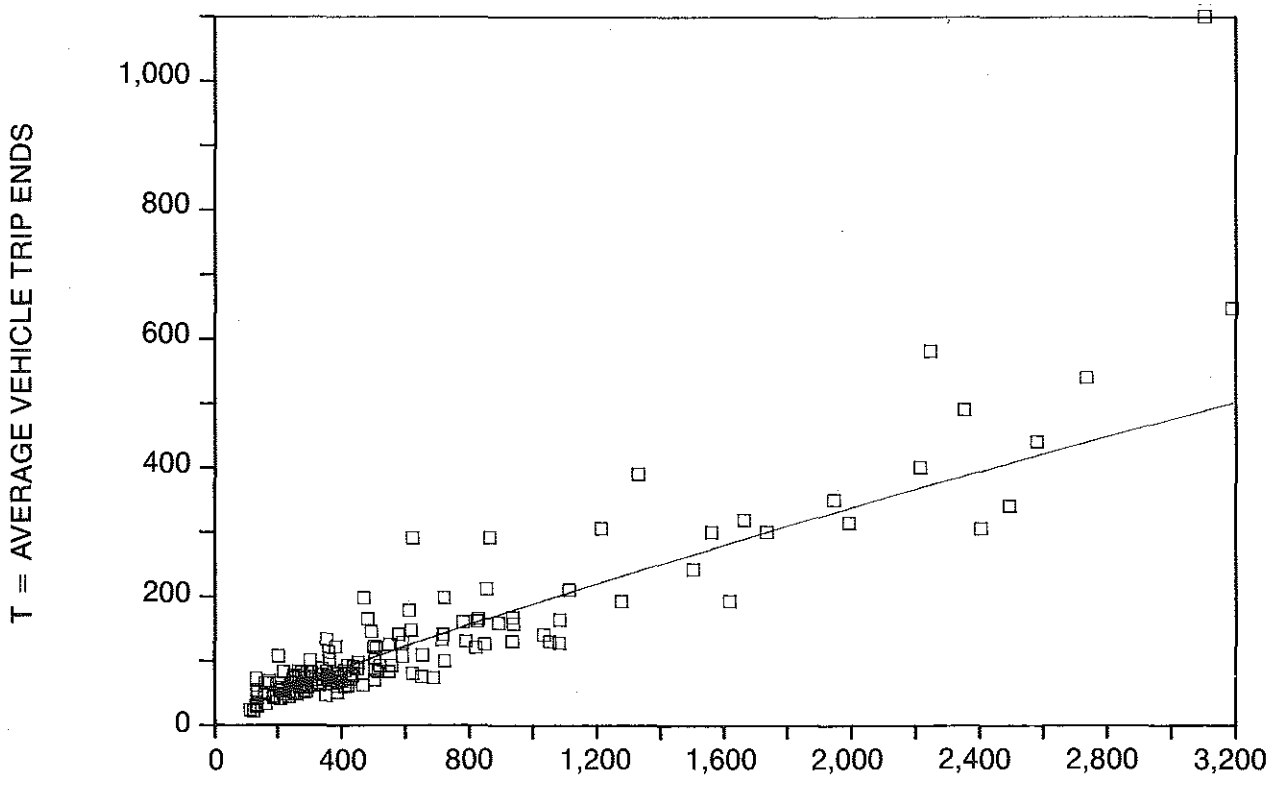
SINGLE FAMILY DETACHED HOUSING (210)

Average Vehicle Trip Ends vs: **PERSONS**
On a: **WEEKDAY**
A.M. PEAK HOUR OF GENERATOR

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—A.M. Peak Hour of Generator) per Person				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Persons*
0.204	0.106–0.554	*	159	702.5

DATA PLOT AND EQUATION



Fitted Curve Equation: $Ln(T) = 0.84\ Ln(X) - 0.56$

$R^2 = 0.848$

DIRECTIONAL DISTRIBUTION: 32% enter, 68% exit

MARINA (420)

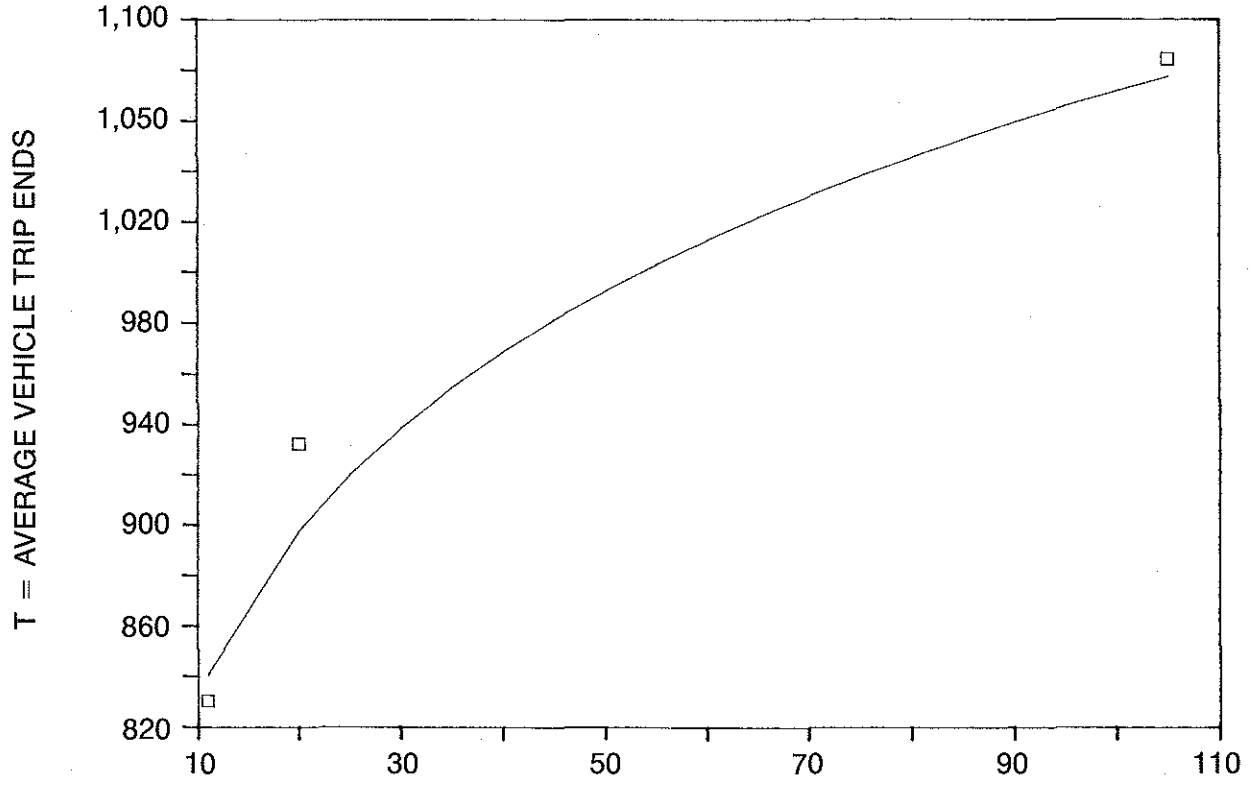
Average Vehicle Trip Ends vs: **ACRES**
On a: **WEEKDAY**

TRIP GENERATION RATES

Average Weekday Vehicle Trip Ends per Acre				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Acres*
20.926	10.324–75.455	*	3	45.3

DATA PLOT AND EQUATION

CAUTION—USE CAREFULLY—SMALL SAMPLE SIZE.



Fitted Curve Equation: $Ln(T) = 0.11\ Ln(X) + 6.47$

$R^2 = 0.965$

DIRECTIONAL DISTRIBUTION: Not available.

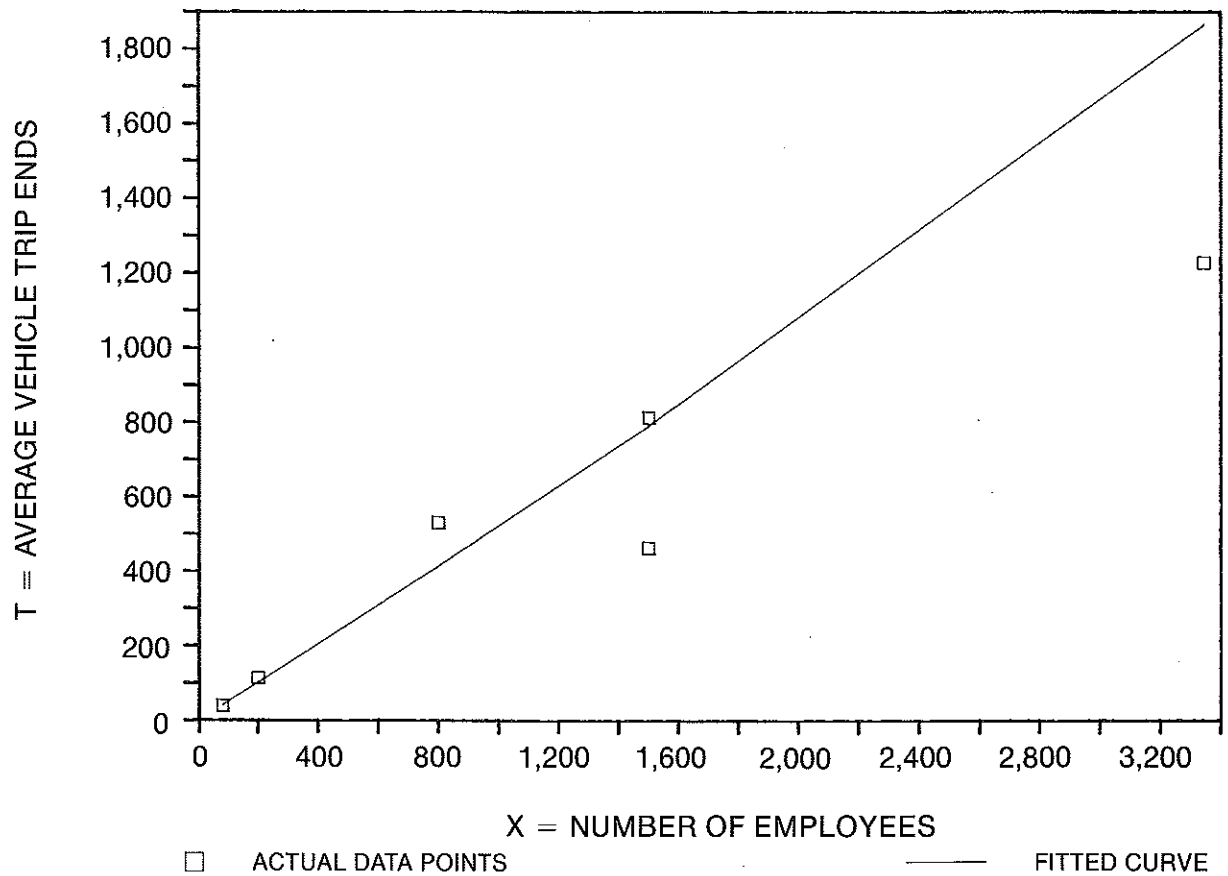
OFFICE PARK (750)

Average Vehicle Trip Ends vs: **EMPLOYEES**
On a: **WEEKDAY**
PEAK HOUR OF ADJACENT STREET TRAFFIC, ONE HOUR BETWEEN 7 AND 9 A.M.

TRIP GENERATION RATES

Average Vehicle Trip Ends (Weekday—Peak Hour of Adjacent Street Traffic, One Hour Between 7 and 9 A.M.) per Employee				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Employees*
0.430	0.309–0.663	*	6	1237.5

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = [(1.97/X) - 0.000053]^{-1}$

$R^2 = 0.995$

DIRECTIONAL DISTRIBUTION: 92% enter, 8% exit.

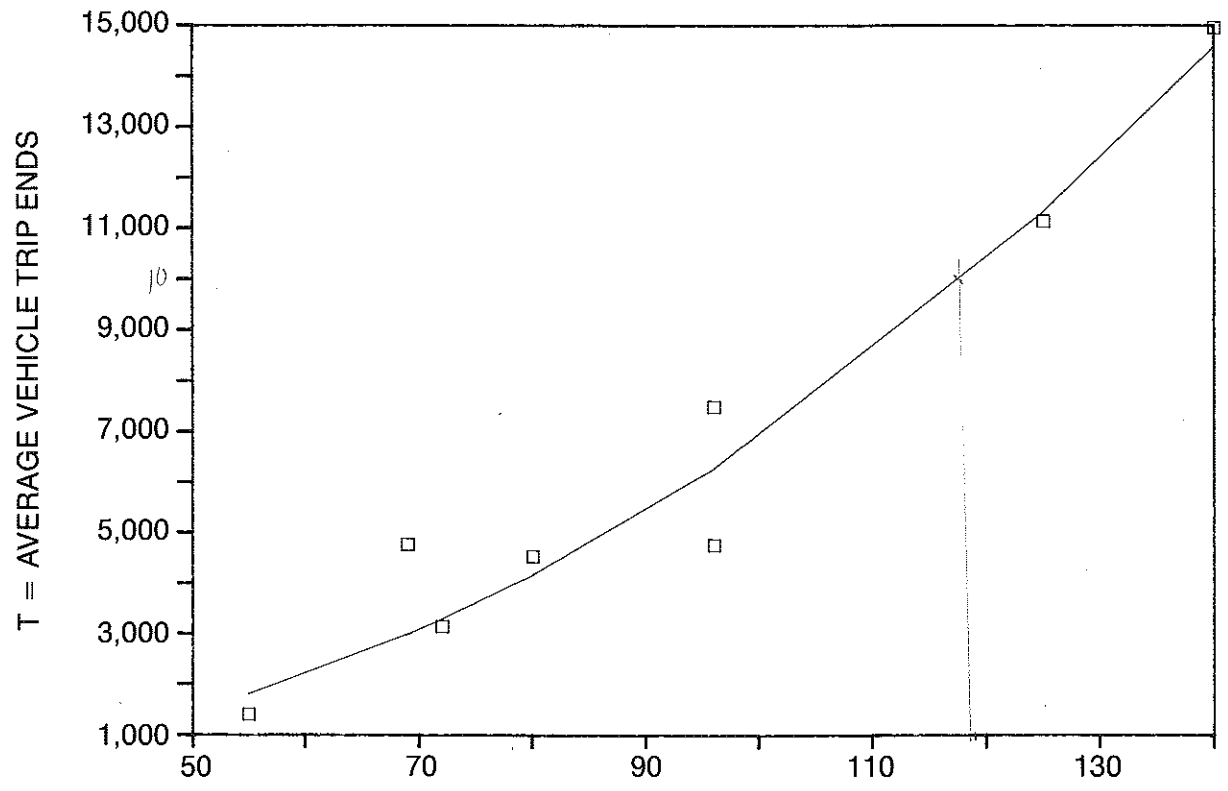
DISCOUNT STORE (815)

Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **WEEKDAY**

TRIP GENERATION RATES

Average Weekday Vehicle Trip Ends per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
71.160	25.527–106.879	*	8	91.6

DATA PLOT AND EQUATION



Fitted Curve Equation: $Ln(T) = 2.24\ Ln(X) - 1.48$
$R^2 = 0.898$

DIRECTIONAL DISTRIBUTION: Not available.

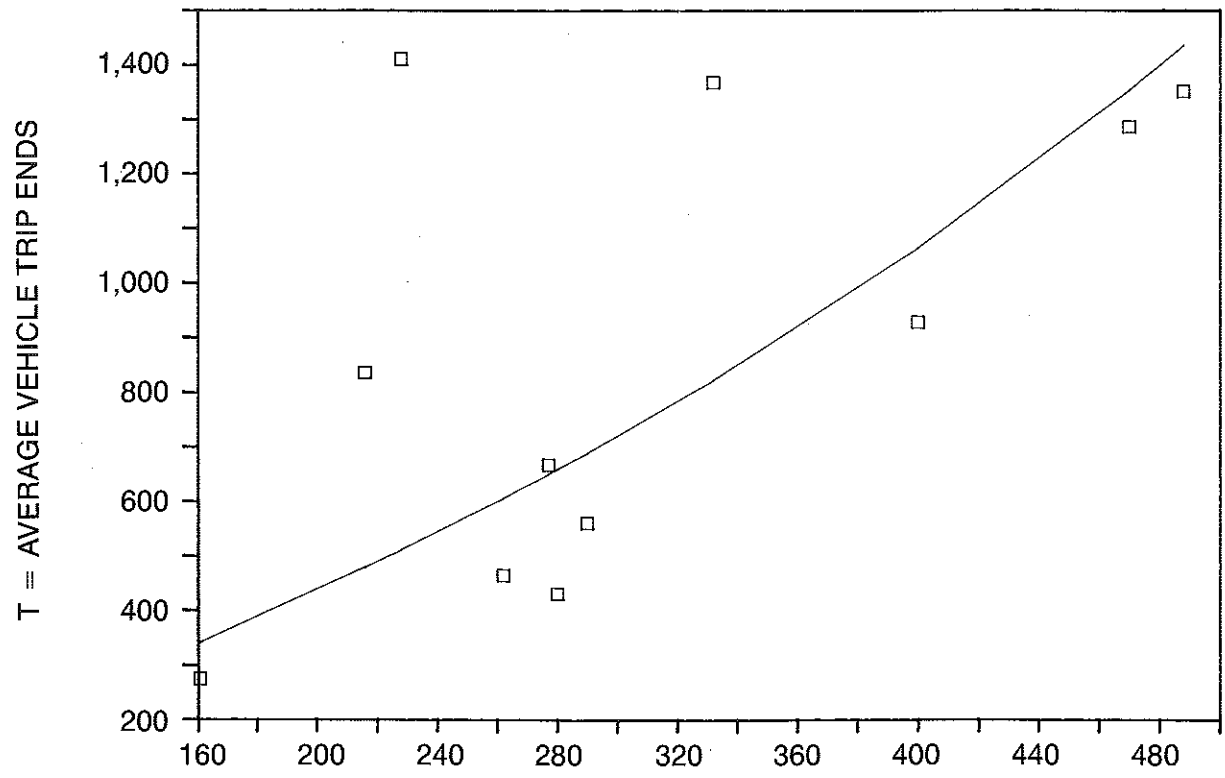
QUALITY RESTAURANT (831)

Average Vehicle Trip Ends vs: **SEATS**
On a: **SATURDAY**

TRIP GENERATION RATES

Average Saturday Vehicle Trip Ends per Seat				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average Number of Seats*
2.810	1.530–6.180	*	11	309.0

DATA PLOT AND EQUATION



Fitted Curve Equation: $T = [(0.54/X) - 0.0004]^{-1}$

$R^2 = 0.507$

DIRECTIONAL DISTRIBUTION: Not available.

97NM-1190	DAJ	L	A3C07	G	10/31/97	Safety End Section
98NM-1192	ME	L	A3C13	G	02/19/98	Roadpatch
98NM-1193	ME	L	A3A13	G	02/19/98	RJS-2
98NM-1194	JFS	L		G	02/19/98	TA-500 Inductive Loop Sealant
98NM-1195	DR	L		G	02/19/98	IRS Tubular Marker/Delineator
98NM-1196	SCK	L	A3C15	G	02/19/98	Stainless Reinforcement Rebar
98NM-1198	DR	M	A3A02	G	11/05/98	Glarescreen Evaluation
94PI-0136	SDZ	H			11/04/94	82000/UPTRAN Greyhound Bus Terminal
95PI-0137	MF				01/09/95	25081/33928B M-21(COURT ST.),FLINT
95PI-0138	SDZ	M			07/13/95	41031/34695B PSI M-37/KENT CO.
95PI-0139	TJM	H			07/20/95	63192/34936B HAGGERTY PARCEL 1826
94TI-1728	CPD	M	A1F04	G	10/25/94	Vibration Monitoring, M-77 at US-2
94TI-1729	FWH	H	A1F04	G	10/27/94	Noise Analysis, I-94 Near Woodman
94TI-1730	FWH	M	A1F04	G	10/31/94	Noise Analysis, I-96 Eastbound Near Pine Tree Road, East Lansing
94TI-1731	DAJ	H	A2C05	F	10/31/94	Bridge Load Testing
94TI-1732	RJM	H	A3A03	G	11/08/94	Blue Water Bridge Truck Charge System
94TI-1733	RJM	M	A2H01	G	11/08/94	Freeze-Thaw Data Logger
94TI-1734	RDT	M	A2C02	G	11/18/94	Abutment Settlement, S05 of 17033, I-75 Under Dafter Road
94TI-1735	CPD	M	A2C06	G	11/18/95	Culvert Inspection of M-129, District 2, B05 & B06 of 17022
94TI-1736	JFS	H	A2E03	B	11/21/94	Preliminary Mix Design for 40 HDP Concrete
94TI-1737	DAJ	H	A2C05	F	11/29/94	Instrumentation of Concrete Tee Beam Bridge During Deck Replacement
94TI-1738	DAJ	H	A2C05	F	11/29/94	Link Plate Stresses Beam Ends in Contact
94TI-1739	CPD	H	A1F04	G	11/29/94	Vibration Monitoring in Lansing, Dept. of Agriculture - Metrology
94TI-1740	FWH	H	A1F04	G	12/05/94	Noise Analysis I-75 BL/Opdyke Road Interchange
94TI-1741	LEL	M	A2F06	G	12/05/94	Dowel Bar Drill Framework Fabrication, Grand Ledge Garage
94TI-1742	LED	H	A1F04	G	12/14/94	Noise Analysis and Technical Assistance Along M-43 Near Riverside Dr.
94TI-1743	LEL	M	A2F06	G	12/22/94	Survey Tripods
95TI-1744	DAJ	H	A3C15	G	01/06/95	Field Inspection of Galvanized Light Standards, I-96 in District 9
95TI-1745	LJP	M	A2E01	G	01/06/95	Mechanical Reinforcement Splices
95TI-1746	DAJ	M	A2C02	G	01/06/95	Steel Pier Cap Investigation
95TI-1747	JFS	H	A2E01	G	01/12/95	Investigation of Low 28-Day Strength of PCC
95TI-1748	ME	M	A3C05	G	02/03/95	Retrofitting PCC Pavements to Improve Load Transfer at Cracks
95TI-1749	BDB	H	A3C12	G	02/10/95	Development of the Data Handling System for Bridge Paint Research
95TI-1750	FWH	H	A1F04	G	02/14/95	Noise Analysis, I-196 Near Stonebridge Drive, Grandville
95TI-1751	LEL	M	A2F06	G	02/16/95	Portable Heat Tables
95TI-1752	DAJ	H	A1F04	G	02/21/95	Potential Vibration Impacts at Second Blue Water Bridge
95TI-1753	DAJ	H	A2C05	G	02/21/95	Integral Abutment Bridges
95TI-1754	FWH	H	A1F04	G	03/03/95	Noise Analysis; M-14, Plymouth Township
95TI-1755	LEL	M	A2F06	G	03/07/95	Survey Bipods
95TI-1756	FWH	H	A1F04	G	03/20/95	Noise Analysis, M-59 Between Crooks & Livernois Road
95TI-1757	JFS	M	A2E01	G	03/20/95	Investigation of PCC Pavement Using GGBFS
95TI-1758	LEL	M	A2F06	G	04/03/95	Collapsible Mandrel for Plastic Pipe 12, 15, 18, 21, 24-Inch
95TI-1759	LEL	M	A2F06	G	04/04/95	Frost Tubes - District 7
95TI-1760	FWH	H	A1F04	G	04/06/95	Noise Analysis, I-75 Southbound Near Wattles Road
95TI-1761	CPD	M	A1F04	G	04/06/95	Noise Analysis of M-14 Near Robinwood Rd., Plymouth Twp.
95TI-1762	MCI	H	A2C02	G	04/10/95	Bridge Fire Damage Investigation - Metro District
95TI-1763	FWH	H	A1F04	G	04/18/95	Noise Analysis NW Quadrant, I-94/Hartford Interchange
95TI-1764	FWH	M	A1F04	G	05/03/95	Noise Analysis, Fir Road, Niles
95TI-1765	FWH	H	A1F04	G	05/05/95	Noise Analysis, I-94 From Jackson Avenue to Saline Road
95TI-1766	RDT	M	A2C05	G	05/09/95	Bridge Load Distribution for Heavy Trucks
95TI-1767	RJM	H		G	06/08/95	Project Record Computer Program
95TI-1768	DAJ	H	A2E03	G	06/20/95	Rouge River Bridge, B01 of 82194, Pier Cap Inspection
95TI-1769	FWH	H	A1F04	G	07/06/95	Noise Analysis, I-696/11 Mile/Bell Road
95TI-1770	FWH	H	A1F04	G	07/06/95	Noise Analysis, I-94/Saline Road, Ann Arbor
95TI-1771	CPD	M	A2A03	G	07/06/95	Scour Monitoring - B01 of 11111
95TI-1772	TRL	H	A1F04	G	07/11/95	Vibration Monitoring: US-23 at Harrisville
95TI-1773	FWH	H	A1F04	G	07/13/95	Noise Analysis: I-696 Near 26831 Barbara Street, Roseville
95TI-1774	LED	M	A2B07	G	07/20/95	Computer Upgrade for Field Friction Program Equipment
95TI-1775	FWH	H	A1F04	G	07/31/95	Noise Analysis, 15401 Knolson Road, Near Ford Road
95TI-1776	LJP	H	A1F04	G	07/31/95	Vibration Monitoring - District 3 Bike Path

95TI-1777 LEL M A2F06 G 08/02/95 Equipment Development - Used Sieves
95TI-1778 LED 08/02/95 Equipment Development - Used Sieves
95TI-1779 LED M A1F04 G 08/04/95 Noise Analysis I-496/Jenison Before and After Tree Planting
95TI-1780 FWH H A1F04 G 08/17/95 Noise Analysis, M-59/Rochester Road, SW Quadrant
95TI-1781 VCA H A3A02 G 08/17/95 Evaluation of Flexible Delineator Posts
95TI-1782 LJP H A2A04 G 08/24/95 Investigate Length of Steel Guardrail Posts
95TI-1783 DCL M A2E05 G 08/29/95 Procedure for Analyzing Quantity of Latex in Concrete
95TI-1784 LEL H A2F06 G 08/30/95 Aggregate Shakers - District 6
95TI-1785 DLD H A2B06 G 09/06/95 RTP Longitudinal Profiles
95TI-1786 DAJ H A2C02 G 09/06/95 A588 Hanger Assembly
95TI-1787 RDM M A2F05 G 09/18/95 Half Sheet Program for Construction Project
95TI-1788 DAJ H A2C02 G 09/19/95 Fatigue Crack Evaluation, I-94 Over Conrail/Grand River, Jackson
95TI-1789 DAJ H A2C02 G 09/19/95 Fatigue Crack Evaluation, I-94 WB Over Hannan Road
95TI-1790 JFS M A2F01 G 10/04/95 Construction and Performance Monitoring of Hinged Joint Pavement, I-94
95TI-1791 FWH H A1F04 G 10/09/95 Noise Analysis; I-696 West of Gratiot
95TI-1792 JFS H 2AE06 G 10/19/95 Investigation of Air Content by Roll-A-Meter
95TI-1793 DAJ H A2C03 G 10/26/95 Vehicle Impact Damage Evaluation - S11 of 19033
95TI-1794 LED H A1F04 G 11/22/95 Noise Project I-696, Oak Park
95TI-1795 LED H A1F04 G 11/22/95 Noise Analysis I-94, Roseville
95TI-1796 RDT M A2C03 G 11/22/95 Precast Deck Panels
95TI-1797 LED H A1F04 G 12/04/95 Noise Compliant
95TI-1798 RJM H A3A12 G 12/06/95 Rehosting New Materials Inventory
95TI-1799 LJP H A2C01 G 12/20/95 Overhead Sign Failure Westbound I-94 Ramp to Westbound I-69
96TI-1800 CPD M A1F04 G 01/12/96 Vibration Monitoring at M-59
96TI-1801 LED H A1F04 G 01/19/96 Noise and Vibration Analysis US-223 near Beecher St (M-34), Adrian
96TI-1802 LED H A1F04 G 01/19/96 Noise Analysis I-94 near Telegraph Rd, Taylor
96TI-1803 LED H A1F04 G 01/22/96 Noise Analysis I-94 near 30th Street, VanBuren Co.
96TI-1804 LED H A1F04 G 03/15/96 Noise Analysis: I-96 between 44th St & 32nd Avenue Exits
96TI-1805 LJP H A3C15 G 03/13/96 Field Inspection of Light Standards - Capac Rest Area
96TI-1806 LED H A1F04 G 03/20/96 Noise Analysis: Union Lake Meadows
96TI-1807 LJP H A2C01 G 03/25/96 Cantilever Sign Support Inspection - Metro
96TI-1808 LJP H A1F04 G 04/12/96 Vibration Monitoring - I-96 at Beech Daily Rd
96TI-1809 CPD H A1F04 G 04/10/96 Vibration Monitoring - Masonic Temple, Eaton Rapids
96TI-1810 LEL H A2C05 G 04/15/96 Bridge Inspection Vehicle
96TI-1811 DR M G 04/17/96 Operation and Application of the Pritchard 1980A Photometer
96TI-1812 LED H A1F04 G 05/01/96 Noise Analysis: I-75/Maybee Rd
96TI-1813 LED H A2B07 G 05/13/96 Texas A&M Road Profiles
96TI-1814 LED H A1F04 G 05/31/96 Noise Analysis for EIS on US-41 in the City of Houghton
96TI-1815 TES M A2E01 G 05/31/96 Evaluation of GGBFS Concrete Bridge Deck, Hubbard Dr over Southfield Frwy
96TI-1816 LED H A1F04 G 06/13/96 Noise Analysis - I-94 West of Harris Rd in Ypsilanti
96TI-1817 CPD H A2C05 G 06/13/96 Tilt Monitoring - R01 of 33034
96TI-1818 LED H A1F04 G 06/21/96 Noise Analysis: M-53 near 18 Mile Rd
96TI-1819 LEL H A2F06 G 06/24/96 Water Depth Indicator - Metro District
96TI-1820 DR H G 06/20/96 Specification Development for Type C LED Warning Lights
96TI-1821 CPD H A2C02 G 07/03/96 Investigation Pier Settlement - S Curve Bridge in Grand Rapids
96TI-1822 LED H A1F04 G 07/31/96 Noise EIS - Proposed M-64 Bridge Replacement over Ontonagon River
96TI-1823 LJP H A2C02 G 07/31/96 Weldability of Steel in Blue Water Bridge
96TI-1824 LJP H A1F04 G 08/14/96 Vibration Monitoring M-120 Causeway
96TI-1825 RDT H A2C02 G 08/26/96 Sign Trusses on Zilwaukee Bridge - B03 of 73112
96TI-1826 LED H A1F04 G 08/27/96 Noise Analysis - I-196 Westbound, West of 8th Avenue
96TI-1827 LED H A1F04 G 09/04/96 Noise Analysis - NE Quadrant of I-94/US-131
96TI-1828 LED H A1F04 G 09/23/96 Noise Analysis for EIS of US-131 Relocation
96TI-1829 CPD H A1F04 G 09/23/96 Vibration Monitoring - I-75 over D&M Railroad (Gaylord)
96TI-1830 LED H A1F04 G 09/26/96 Noise Analysis EIS for I-96/Wixom Rd/Beck Rd
96TI-1831 RDT M A3C15 G 09/19/96 Pre-Galvanized Guardrail
96TI-1832 LED H A1F04 G 10/09/96 EIS Review Consultant Project
96TI-1833 LED H A1F04 G 10/09/96 Noise Analysis - I-96/M-6 Interchange at the Thornapple River
96TI-1834 LED H A1F04 G 10/14/96 Noise Analysis - I-275/I-696 SE Quadrant - Proposed Townhouse Development
96TI-1835 LJP M A1F04 G 10/14/96 Vibration Monitoring - Telegraph Rd (US-24)
96TI-1836 TES H A2B05 F 10/01/96 Factors Affecting Shear Capacity of Transverse Cracks in Jointed Conc Pvmt

96TI-1837	DR	M	A3A04	G	10/23/96	Establish Calibration Procedure for Hunter Lab Scan Colorimeter
96TI-1838	LED	M	A1F04	G	10/22/96	Noise Study I-94 - Marshall Public School
96TI-1839	LED	M	A1F04	G	10/16/96	Noise Study M-59 - Covington Place
96TI-1840	DR	L	A3A04	G	10/25/96	Evaluation of Klemmfix Flexible Barrier Wall Reflector
96TI-1841	LED	H	A1F04	G	11/26/96	Noise Analysis: I-275/8 Mile Rd
96TI-1842	LED	H	A1F04	G	12/19/96	Noise Analysis: Adrian Blcok Grant
96TI-1843	DN	H	A2C02	G	12/11/96	Crack Evaluation: I-75 over Old M-76
96TI-1844	TES	M	A2E05	B	12/18/96	Eclipse Shrinkage Reducing Admixture
96TI-1845	TES	M	A2E03	F	12/06/96	Evaluation of Concrete Permeability by Ultrasonic Testing Techniques
97TI-1175	DEB				06/09/97	Heavy Duty Rubber Preformed Loop Detector (HDR)
97TI-1846	TES	M	A2E05	G	01/15/97	Experimental Resurfacing of Brdg Decks with High Reactivity Metakadlin Conc
97TI-1847	LED	H	A1F04	G	01/24/97	Noise Analysis: US-23 between Caprenter/Plank Rds, City of Milan
97TI-1848	FMS	M	A3C04	G	01/27/97	Work Zone Median Barrier Sign
97TI-1849	LED	H	A2H01	G	01/29/97	Blue Water Bridge Toll System Replacement
97TI-1850	LED	H	A1F04	G	02/11/97	Noise Analysis: Elms Rd from Flushing Rd to Pierson Rd, Genesse County
97TI-1852	DR	H	A3A04	G	02/19/97	Preparation of QPL for Type C Solar Assist Warning Arrow Panels
97TI-1854	LED	H	A1F04	G	04/07/97	Noise Analysis: I-94 East of Mile Marker 111
97TI-1855	RDT	H	A3C06	G	04/14/97	Fatigue Crack Evaluation of Gussett Plates at Cantilever Sign Support Arm
97TI-1856	LED	H	A1F04	G	04/17/97	Noise Analysis: I-96 between Forest Hill Ave & Burton St, City of Kent
97TI-1857	DN	H	A2E03	G	05/14/97	Pier Inspection - X02 of 82291
97TI-1858	DR	M	A3A02	G	05/16/97	Retesting of TRPM (Temporary Raised Pavement Markers)
97TI-1859	LJP	M	A3A02	G	05/21/97	Temporary Concrete Barrier Connection
97TI-1860	LED	H	A1F04	G	06/17/97	Noise Analysis: Square Lake Rd near Douglas Dr
97TI-1861	LED	H	A1F04	G	06/23/97	Noise Analysis: I-94/US-131 near Angling School
97TI-1862	VTB	H	A2F01	G	07/02/97	Monitor the Reconstruction of I-75 and I-275 in Monroe & Wayne Counties
97TI-1863	LED	H	A1F04	G	07/11/97	Noise Analysis: M-53 between Van Dyke and 18 Mile Rd, Sterling Heights
97TI-1864	SCK	H	A3C15	G	07/17/97	Electrochemicl Chloride Extraction
97TI-1865	DN	H	A2E03	G	07/23/97	Pier Investigation - R01 of 34081
97TI-1866	CPD	M	A2C02	G	08/01/97	Evaluate Section Loss on Pedestrian Bridge Structure - P01 of 81063
97TI-1867	LED	H	A1F04	G	08/04/97	Noise Analysis - M-24 EIS from 1 Mi N of Lapeer/Oakland Cty Line to I-69
97TI-1868	LEL	H	A2F06	G	08/12/97	Survey Tripods
97TI-1869	LJP	H	A2C02	G	08/13/97	Cover Plate Inspection
97TI-1870	LED	H	A1F04	G	08/22/97	Noise Analysis: I-96 Wbd from Pleasant Valley Rd to Kensington Rd
97TI-1871	DR	M	A3A04	G	09/02/97	Evaluation of PCBM Barrier Reflector (with abrasion resistant sheeting)
97TI-1872	BDB	H	A3C06	G	09/02/97	Bridge Deck Overlay Performance
97TI-1873	DN	H	A3C06	G	09/05/97	Prestressed Concrete Beam End Repair
97TI-1874	CPD	H	A1F04	G	09/15/97	Vibration Monitoring of Pile Driving - US-12 near Moscow
97TI-1875	LJP	H	A3C06	G	09/23/97	Web Cracking Evaluation - S07, S08 & S18 of 82293
97TI-1876	LED	H	A1F04	G	10/06/97	Noise Analysis: I-75 N of US-10 near Old Pond Rd, Oak Valley Estates
97TI-1877	CPD	M	A1F04	G	10/13/97	Ground Vibrations - X04 of 63017
97TI-1878	LED	H	A1F04	G	10/21/97	Noise Analysis: M-53 EIS Almont & Imlay Twp, Lapeer County
97TI-1879	LEL	M	A3C08	G	11/05/97	Frost Tubes for Metro Region - Macomb & St. Clair Counties
97TI-1880	DN	H	A3C06	G	10/29/97	Temporary Support Loads at Abutments
97TI-1881	LEL	M	A3C08	G	11/07/97	Frost Tubes for Metro Region - Wayne County
97TI-1882	CPD	H	A1F04	G	11/07/97	Vibration Monitoring - Loehnis & Allison Residences near I-94
97TI-1883	DN	M	A2A04	G	11/07/97	Scouring Monitoring - B02 of 13021
97TI-1884	LED	H	A1F04	G	11/13/97	Noise Analysis: I-94 WB between Exits 26 & 27
98TI-1886	DN	H	A2F07	G	02/05/98	High Mast Luminaire Inspection and Repair
98TI-1888	FMS	M		G	02/24/98	Remote Monitoring of Remediation System at Zilwaukee Bridge
98TI-1889	DN	H	A2C02	G	03/02/98	Fire Damage Evaluation - S08 of 82191
98TI-1890	RJH	H	A1F04	G	03/20/98	Noise Analysis - US-12, MI Ave to Jefferson St, Coldwater
98TI-1891	FMS	H	A1F04	G	04/02/98	International Bridge - Truck Noise
98TI-1892	DN	H	A3C06	G	04/01/98	Investigation of Prestressed Box Beam, Plaza Bridges Z01-03 of 63103
98TI-1893	CPD	H	A3C06	G	04/13/98	Span Wire Failure Investigation
98TI-1894	RJH	H	A1F04	G	05/13/98	Noise Analysis: I-94 BR near Longman Lane
98TI-1895	LEL	H	A2F06	G	06/10/98	Bag Funnels for Newberry TSC
98TI-1896	LJP	H	A3C06	G	06/18/98	Light Standard Inspection - B01 of 62031
98TI-1897	RJH	H	A1F04	G	07/20/98	Noise Analysis - Autumn Ridge Apartments
98TI-1898	FMS	M	A3A02	G	07/20/98	Vehicle Actuation of OPEN/CLOSE Sign at Fowlerville Weigh Station
98TI-1899	FMS	H	A3C06	G	07/20/98	Bridge Under Clearance Measuring Device

98TI-1900	DN	H	A2C05	G	07/29/98	Loads on Hanger Assemblies
98TI-1901	CPD	H	A1F04	G	08/24/98	Vibration Monitoring - US-131 Relocation; CS 83033/43613A
98TI-1902	CPD	H	A3C06	G	09/14/98	Abutment Monitoring - B01 of 79031
98TI-1903	RJH	H	A1F04	G	09/21/98	Noise Analysis - US-23 Iosco Co for E.A.
98TI-1904	LJP	H		G	10/05/98	Scour Survey - B03 & B04 of 50111; I-94 over Clinton River
98TI-1906	CPD	H	A1F04	G	10/20/98	Vibration Monitoring - Zerilli Home at I-94
98TI-1907	RJH	H	A1F04	G	10/21/98	Noise Abatement Request S of M-14 between E & W Junctions with US-23
98TI-1908	FMS	H	A3A01	G	10/21/98	Closed Circuit TV Monitors for the International Bridge
98TI-1909	RJH	H	A1F04	G	10/29/98	Noise Analysis from US-131 E.A. on the S-Curve in Grand Rapids
98TI-1910	DAJ	H	A3C06	G	11/17/98	Procedure for Evaluation of Bridge Decks
98TI-1911	RDT	H	A2C01	G	11/17/98	Guide for Evaluation of Existing Bridges - Phase 2
98TI-1912	RJH	H	A1F04	G	11/23/98	Noise Analysis: I-69/Marshall TSC
98TI-1913	LJP	H	A3C06	G	12/21/98	Fire Damage - S06 of 81074
98TI-1914	DN	H	A3C06	G	12/15/98	Prestressed Box Beam Cracks - R01 of 23061
99TI-1915	CPD	H	A1F04	G	01/26/99	Vibration Monitoring US-12 over the St. Joseph River - B01 of 30061
99TI-1916	LJP	H	A2C02	G	02/04/99	Rocker Bearing, Pier Investigation - R02 of 33045
99TI-1917	DR	H	A3A02	G	02/16/99	Work Zone Traffic Control Devices - Impact Study
99TI-1918	LJP	H	A3C06	G	03/08/99	S01 of 25084 - Fire Damage Evaluation
99TI-1919	DN	M	A3C14	G	03/08/99	Adhesive Anchors Under Sustained Loading
99TI-1920	RDM	H	A2H01	G	04/01/99	Upgrade of Curve & Grade Vehicle
99TI-1921	DAJ	H	A2A04	G	03/17/99	Crash Test Guardrail to NCHRP 350 Requirements
99TI-1922	RJH	H	A1F04	G	04/02/99	Noise Analysis - City of Allegan
99TI-1923	CPD	H	A1F04	G	04/05/99	Vibration Monitoring - M-96 at Hodges Residence
99TI-1926	FMS	H	A3C06	G	05/27/99	Repair of Prestressed Bridge Cables - US-31 over old US-31 - Berrien County
99TI-1927	LEL	H	A2D04	G	06/16/99	Bituminous Sampling Templates
99TI-1928	RJH	H	A1F04	G	07/09/99	Noise Analysis - Lenawee County
99TI-1929	BDB	M	A3C12	G	07/30/99	Update Specifications for Epoxy Coating & Repair Materials for Steel Reinf.
99TI-1930	RJH	H	A1F04	G	07/23/99	Noise Analysis for the Detroit Intermodal Terminal Project
99TI-1931	CPD	H	A1F04	G	08/02/99	Vibration Monitoring - Rubblizing US-31 in Elk Rapids
99TI-1932	LJP	M	A2C03	G	09/13/99	Mechanical Reinforcement Splices

TOTAL PROJECTS - 321

APPENDIX C

Research Partnership

Since 1995, the Michigan Department of Transportation has developed new a partnership with the universities in the State of Michigan. The Civil and Environmental Departments of the universities provide great academic support along with the graduate students who will be the future practicing engineers. This partnership under the banner of ***Research Center of Excellence*** covers the following areas:

A. Bridges and Structures

B. Intelligent Transportation System (ITS)

C. Pavement

D. Transit

E. Traffic and Safety

F. Transportation Materials Research Center of Excellence

The research centers of excellence are at the following universities:

1. Michigan State University (A, C, E)

2. Michigan Technological University (A , F)

3. University of Michigan (A, B)

4. Wayne State University (A)

The Federal Highways Administration (FHWA) plays a key role in overseeing the entire research program from regional and national perspective.

APPENDIX D

Public and Private Partnership in Transportation Research

Introduction

There is an urgent need to find new and better materials, improve construction methods and maintenance practices in order to provide safe and durable highway system to the public. A well-maintained highway system provides economic benefits. The public and private partnership where financial, technical and human resources are jointly shared would be desirable in high priority research areas.

Areas of Interest

Pavement performance, material durability, and improving condition of bridges are major focus areas of the research. Implementation of research findings should help to meet the strategic goals of the department. Improvements in the traffic operations such as in the construction work zones, are needed to improve safety and mobility of the motorists.

Advantages of Partnership

This offers not only the added resources, but also a buy in for the implementation of the research findings. Reduction of cycle time from a concept to implementation, focus of high priority areas and overall economic benefits are possible due to the partnership.

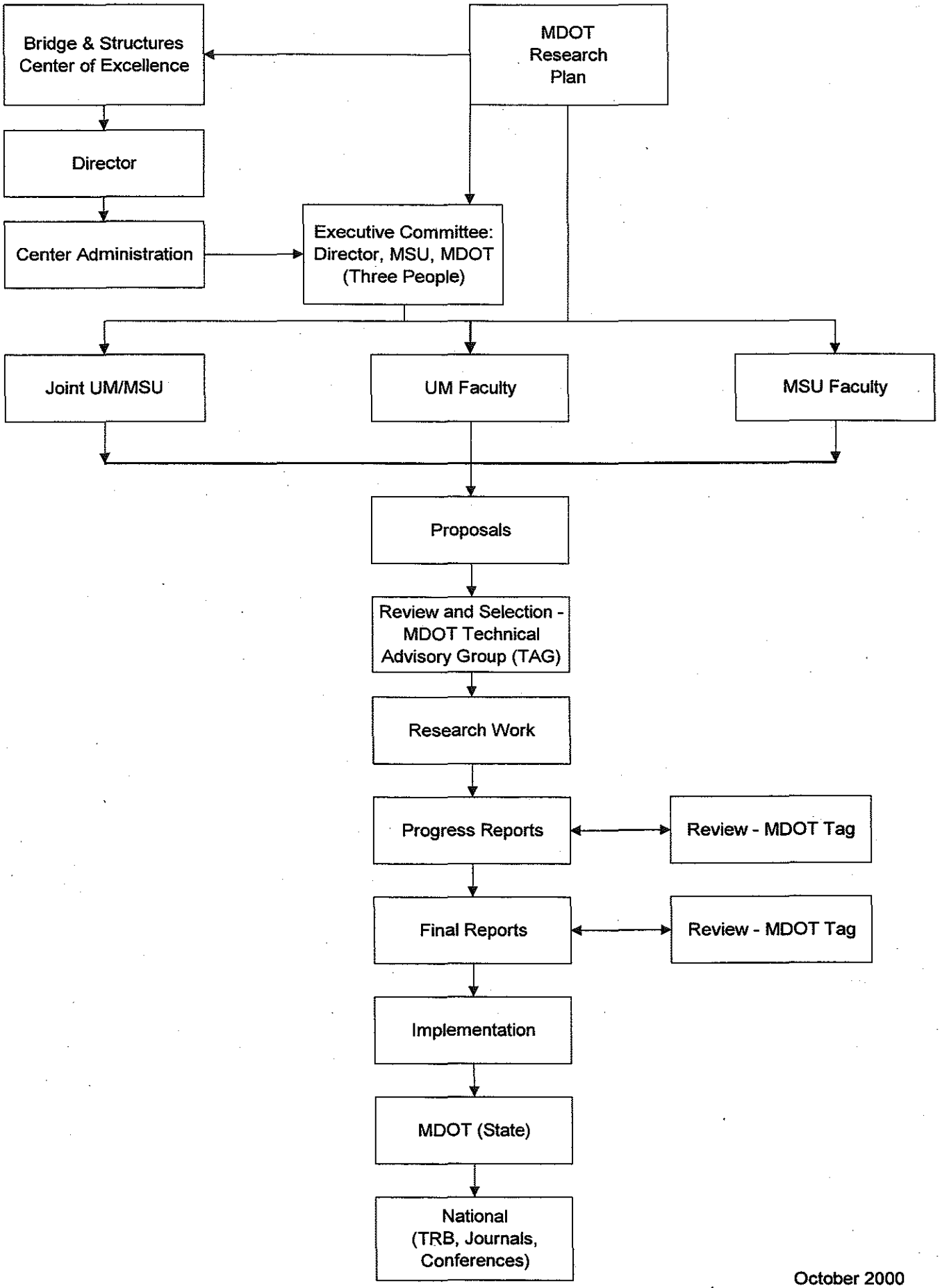
Areas of Concern

The public and private interest may be driven by goals which some times can be conflicting. When the goals are mutually acceptable, both public and private stakeholders can work together with a win/win strategy. Policy and guideline for such effort need to be developed.

Conclusion

This public and private partnership has some great potential benefits. Even at the national level, efforts are being made to study and promote this concept. The Michigan Department of Transportation has formed new partnership with the universities in the State of Michigan to conduct the transportation research. Inviting the other private agencies to join this research work is the next important step.

Appendix E
Bridge and Structures Research Center of Excellence



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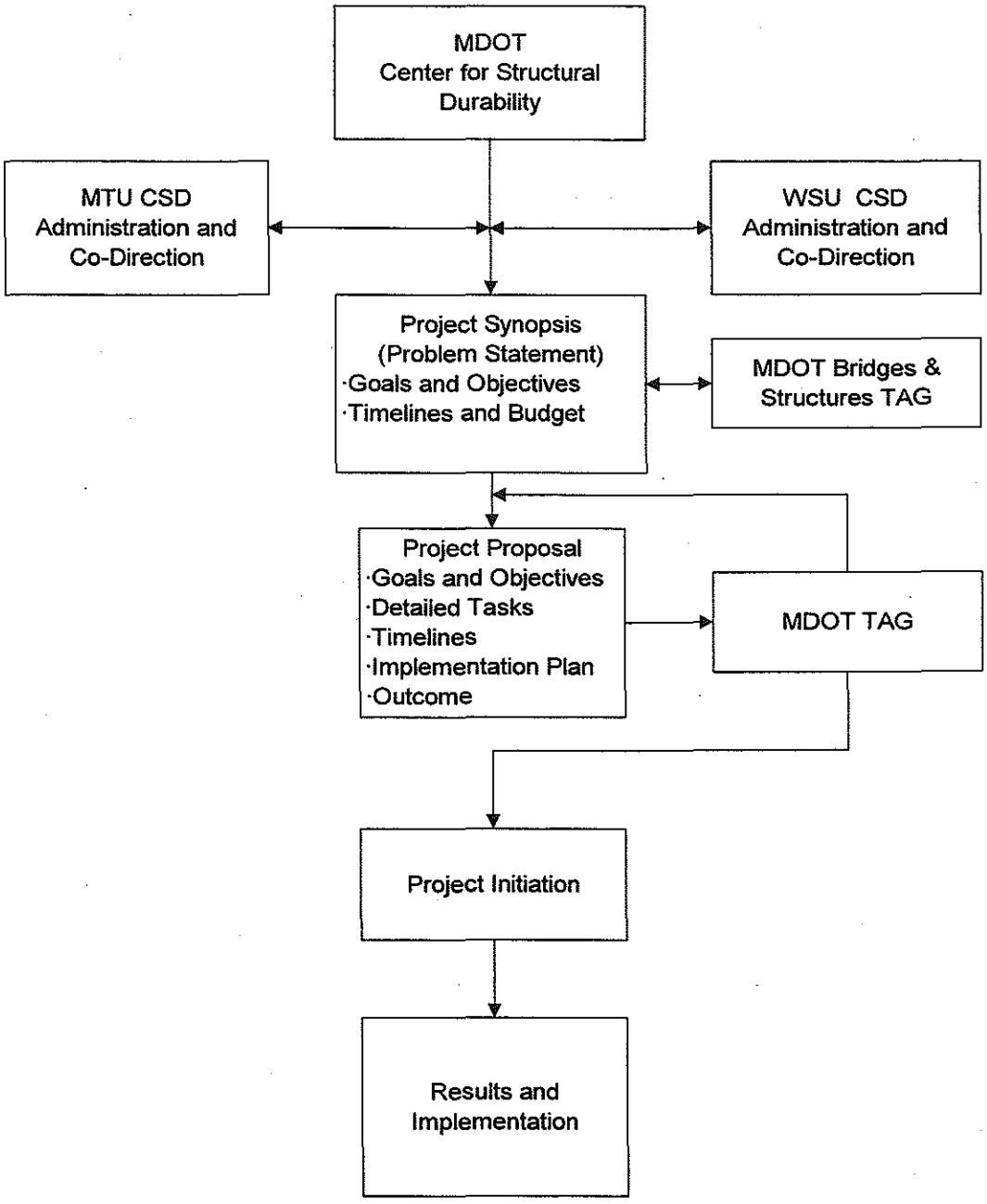
Appendix F
Center for Structural Durability (CSD)
Michigan Technological University (MTU) and
Wayne State University (WSU)



October 2000

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