# ANNUAL REPORT OF ACTIVITIES OF THE MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION RESEARCH LABORATORY


MICHIGAN DEPARTMENT OF
STATE HIGHWAYS AND TRANSPORTATION

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Research Laboratory Section
Testing and Research Division
Research Report No. R-1042

Michigan State Highway Commission
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Lansing, January 1977

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# INTRODUCTION

The purpose of this report is to illustrate the scope of the activities of the Research Laboratory during the 1976 calendar year. By better informing Department personnel of these activities, we hope to implement the research which is being conducted, and to integrate our research findings into Departmental practice.

The report is divided into six sections. The first section outlines some of the highlights of the past year's research. Section two consists of an index to projects as well as a listing of the title, purpose, scope, progress past year, and projected activities for the coming year, for all active Departmental and Highway Planning and Research projects (H. P. & R. projects are denoted by an asterisk). The third section contains abstracts of all Research Reports published during 1976. Section four consists of a list of New Materials projects completed during the year, the fifth section is a listing of Technical Investigations completed during the year and the sixth section is a listing of Action Plans completed during the year.

Further information on any project described herein may be obtained by contacting L. T. Oehler, Engineer of Research, Motor Wheel Building, Lansing, Michigan.

## RESEARCH HIGHLIGHTS - 1976

During 1976, a good deal of progress has been made in certain areas of research. Some of these have culminated in a Research Report, either closing out a project or describing significant progress made to date; others involved significant developments in on-going work in progress. Some of the more noteworthy projects are highlighted in this section of the Annual Report.

1) Five different types of experimental railroad crossing installations are now in service. They are: Fab-Ra-Cast (precast concrete); T-Core (rigid polyethylene foam); Steel Plank; Track-Span (epoxy mixture), and Saf and Dri (steel tubes enclosed in an elastomer). A progress report (R-1027) covering initial installation and early evaluation has been issued (75 F-143).

2) A trial installation of rumble strips in asphalt shoulders has been completed on M 78 east of Perry. Initial sound measurements indicate that the asphalt rumble strip has a sound level in about the same range as concrete rumble strips. A preliminary report was issued on the project last year (R-980). The effects of snow plow damage and general deterioration with time are being evaluated (74 TI-236).

3) Field work on the development of procedures for maintaining neoprene sealed pavements has begun. A selected section of I 69 in Calhoun County, consisting of 10 expansion joints and 40 contraction joints was subjected to repair. Tight and torn expansion seals were removed and replaced with new neoprene seals. Joint groove spalls were repaired using three different types of mortar. The performance of the repaired section to date has been excellent (75 G-217).

4) A computer program was written to utilize the latest Environmental Protection Agency methods for calculating vehicle exhaust emission factors. These exhaust emission factors are used in a mathematical model to estimate carbon monoxide concentrations for environmental impact statements. The effects of ambient temperature, percent of cold start vehicles (operating for less than 500 seconds after a four-hour shut off) and percent hot start vehicles (starting up after less than a one-hour cooling period) are now taken into account (71 G-182).

5) Meetings were held which included personnel from the Laboratory, the Environmental and Community Factors Division, and the Department of Natural Resources (Air Pollution Division). We arranged for the DNR to supply us with estimates of background concentrations of carbon monoxide, for use in air quality reports for locations where no actual air quality data are available. A procedure was set up for the DNR to review and comment on drafts of air quality reports so that their concerns could be

answered in the air quality reports subsequently submitted for their certification that the projects were consistent with the State implementation plan for meeting National air quality standards.

6) The air quality van operated in the field for all but two weeks in mid-December when it was called in for modification and maintenance. Data were provided for environmental assessment of some proposed projects. The data logging system in the van was enlarged to accept data from an ozone analyzer in addition to previously installed analyzers. Background air quality data have been recorded at four sites along the proposed corridor for I 196 between Lahser Rd and I 75, and monitored sites along proposed I 69 west of Lansing. Computer programs have been worked up to process data recorded on cassettes in the air quality van into a finished tabulated form, corrected for both zero and span drift of the instrumentation. This includes data for wind speed and direction, carbon monoxide, oxides of nitrogen, ozone, and temperature (71 G-182).

7) Construction of the second mobile air quality monitoring laboratory was begun. The motor generator and fuel tanks were mounted on the trailer, and electrical gear, lumber, and insulation were obtained to modify the trailer interior for installation of instrumentation (71 G-182).

8) Lighting design data based on GE, Westinghouse, McGraw-Edison, and American Electric, high pressure sodium luminaires were forwarded to the Design Division. The data showed average illumination and uniformity ratios of illumination for curb-mounted and median-mounted luminaires at heights of 40, 45, and 50 ft, with spacings of 5.0, 5.5, 6.0, 6.5, and 7 mounting height ratios. GE and Westinghouse have reviewed the data on their luminaires and have expressed considerable interest. Reviews by McGraw-Edison and a representative from the FHWA are scheduled (73 G-198).

9) NCHRP Report 160 presented a new computerized program for the design and management of flexible pavements. This program, referred to as SAMP6, was reviewed and evaluated to determine its potential use in Michigan. SAMP6 appears to hold significant promise for reducing total pavement cost (76 G-221).

10) The Chevron five-layer computer program has been put into the Department's computer system. It is presently being used to obtain strain data for typical Michigan pavement sections. These data are being used, in accordance with procedures suggested by NCHRP reports, to establish the equivalent thickness of bituminous bases compared to standard aggregate bases. The Chevron program has innumerable applications, ranging from the development of bituminous mix designs to establishing regional factors used for pavement design (71 E-49).

11) Time was spent completing the conversion to the Department's B7700 system of Soils Research computer programs. These include slope stability analysis, stress and strain analysis of flexible pavement layers, repetitive triaxial calculations, pavement feedback inventory, and nuclear gage calibrations (75 G-215).

12) A second instrument to detect delamination of concrete in bridge decks was constructed. This unit is a significantly improved version of the original previously described unit, developed in the Laboratory. The first unit is now being used by the Maintenance Division for bridge deck inspection and this second unit is currently being operated by the Construction Division for locating delaminated areas before scarifying (74 G-205).

13) The final report for the Highway Planning and Research Project concerning electroslag and submerged arc welding has been completed and sent to the FHWA for review and approval. We have received this approval and are readying the report for final printing (72 F-124).

14) The new 220,000-lb capacity electrohydraulic testing machine has been installed in the Structures laboratory. It has been checked-out and is now ready for work on fracture toughness evaluations of weldments and structural steel plate (75 F-144).

15) Cores have been taken from field exposure specimens containing galvanized and plain reinforcement, that have been subjected to an accelerated salt treatment for six winters. The concrete is being checked for chloride penetration and the bars are being evaluated to determine the amount of corrosion that has occurred (68 F-103).

16) In cooperation with members of the Field Testing Section and the Maintenance Division, we have been engaged in special coring of 36 concrete bridge decks scheduled for repair contracts in the 1976-77 fiscal year. The cores are used to determine the chloride content of the concrete and the condition of the top rebar sample obtained in the same cores is also determined. One of the two Research Laboratory delamination detectors is also used at the same time the coring operations are conducted to obtain an accurate estimate of the area of unsound concrete to be removed under the repair contract (74 G-205).

17) Nighttime inspections and brightness measurements of signs were completed on I 96 west of Lansing, and on I 675 and I 75 from Saginaw to Flint. The results were discussed with an ad hoc committee studying performance of signs. Recommendations were given to the committee regarding signing on I 96, from I 275 east to Schaefer; for overhead structures, lighted signs were highly recommended, followed by recommendations concerning the brightest reflective legend material available on a non-reflective background in lieu of lighting (76 TI-345).

18) A final report covering the use of lights and lighting for hazard warning and delineation was completed. Findings of the study showed that a flash rate of 100 flashes per minute at an 'on-time' of 20 percent, with an 'effective intensity' of 20 to 40 candela, was the most preferable combination (62 G-117).

19) A report on the reflectorization of flagman vests recommended a reflectorized yellow five-armed pattern to be used in field trials. The recommendation is being sent to the National Advisory Committee for the Federal Manual of Uniform Traffic Control Devices. School and County safety organizations are interested in the recommendations, as are the manufacturers of the reflectorized material (75 TI-164).

20) Machining and evaluation have been completed on more than 300 tensile specimens taken from beams of 76 bridges, statewide. Results have been reported to the Design Division (R-1018) for use in calculating safe load capacities. Approximately 95 percent of the specimens from the old structures exceeded minimum requirements by a considerable margin (76 F-146).

21) Three experimental bridge decks were completed containing epoxy coated, galvanized, and plain reinforcement. These were the first decks designed with the epoxy coated bars in Michigan. Present specifications now require such bars in the top mat of all decks (73 F-131).

22) Early results from the experimental pavement on US 10 north of Clare have shown the following: 1) extremely large quantities of water are able to penetrate the longitudinal and transverse joints, even on a new pavement; 2) pavements with traditional bituminous stabilized base and full-depth stabilized shoulders are collecting water around the slab, and have no way of getting rid of this water. This may cause problems in the future in some areas (73 F-136).

23) Eight pairs of locations were selected in Wayne County for comparative skid testing of asphalt pavements containing slag. Both pavements in each pair were constructed during the same years, 1971 - 1975, with one pavement in the pair using slag, the other natural aggregate. Each pavement within a pair had been subjected to similar traffic volumes. Results indicate that skid resistance values were similar for both types of aggregate. When tested with treaded tires, four pairs had natural aggregate with higher skid values, and four pairs were higher with slag. When tested with smooth tires, six pairs had higher skid resistance with natural aggregate and two pairs were higher with slag (76 G-218).

24) In August, the CMI Roto-Mill was used to texture about 20,000 sq yd of bituminous surface and 32,000 sq yd of concrete on M 58 in Saginaw. The work progressed smoothly and without major problems. A better method of cleaning residual dust from the pavement should be developed prior

to the next project, however. After texturing, the average skid coefficient (40 mph) was 0.65. A comprehensive report will be written after RTP data are processed. Additional projects are being planned for treatment by the Roto-Mill (76 TI-341).

25) Auto underbody rust proofers often extend the life of a car body by 100 percent or more. The Department has initiated a test to determine if they will work equally well on bridge structural steel. Applications are to be made on the Sargent Rd bridge over I 94 east of Jackson (76 G-219).

26) The Laboratory began monitoring an experimental bridge project on M 14 northwest of Plymouth which involved the use of a portland-pozzolan cement, type 1PA, in both the substructure and superstructure. The type 1PA cement contains about 20 percent of a waste product, fly ash, and must meet practically all of the requirements of type 1A, normal air-entrained portland cement. Although presently approved for use in concrete pavement, type 1PA cement has not been approved for structures, pending the results of this study. By our field testing and sampling, the placement, consolidation, finishing, early and later strength development, and durability of type 1PA cement concrete will be directly compared with normal specification structures (72 B-91).

27) Two experimental installations of a lightweight fill (Elastizell) were completed. The objective of these projects is to reduce pressures on deep deposits of soft clay and prevent lateral movement of adjoining bridge piers (75 E-54).

28) In connection with our cooperative project with Michigan State University on soil support values, field sampling for the research project was completed and the samples are now in the MSU laboratories for analysis (71 E-49).

29) An ad hoc committee was established to study and determine the practicality of implementing a field drainability test method and its application to a new subbase drainage criterion proposed by the Research Laboratory. If it proves practical, it should save a good deal of time during field testing operations (74 E-53 and 74 E-56).

30) Construction of an experimental section of cold-mix asphalt base was completed on Canal Rd near the State Secondary Complex. Its performance will be studied during the coming winter and spring (75 E-55).

31) Construction, assembly, and calibration was completed of five hook-bolt pull-out devices for use by the Field Testing Unit of the Testing and Research Division for lane tie device testing during concrete pavement construction.

32) An experimental study on the use of 'econocrete' in a ramp construction project was initiated to evaluate the construction and performance of a composite concrete pavement using a lower strength mix in the lower half of the slab. This econocrete contains a cheaper sand-gravel blend and lower cement content to ensure at least half of the normal strength level. The performance of this composite or dual strength slab section is being evaluated in a non-reinforced ramp carrying light commercial traffic from Shelby Rd to southbound US 31 in Oceana County. Field measurements, such as joint openings, slab movement, profilometer, load-deflection, and condition surveys are to be taken early in 1977 and at later intervals to evaluate the performance of this section as compared to a standard concrete control portion (76 B-95).

33) Bituminous shoulder material with wet bottom boiler slag aggregate was evaluated for photometric performance. The wet bottom slag shoulder wearing course was judged on the basis of pavement luminance values to impart a visibly darker appearance to the shoulder compared with traffic lane luminance (73 D-28).

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## STATISTICAL ANALYSIS UNIT

Title

*72 G-191 - Aggregate Gradation Quality Control (22A Field Experiment)

Purpose

1. To develop practical and meaningful sampling procedures at the production and construction site for sieve analysis of 22A aggregate.

2. To develop, based on the suggested sampling procedures, practical and meaningful aggregate inspection practices either for stockpile inspection or in-place inspection.

Scope

Development of the sampling procedures and the inspection practices for 22A aggregate, based on three available production pits.

Progress Past Year

The review draft of the final report has been completed and is currently under review by FHWA. The research had achieved the proposed purposes of this project and has generated a more efficient aggregate testing method which is proved to be equally as good as the current one in measuring the aggregate composition. The project has demonstrated the use of multivariate statistical analysis in the field of aggregate inspection.

Title

*73 G-193 - Accident Rates and Surface Properties--An Investigation of Relationships

Purpose

To construct an intersection model which will predict wet accident percentages from skid number and other relevant variables.

Scope

Development of the wet surface accident model for state trunkline intersections from knowledge of percentage wet time, skid number, seasonal drying factors and dry surface accident incidence. Data are for the entire state of Michigan for the period 1963-74.

Progress Past Year

Final report approved by FHWA. Also a smaller report accepted for presentation at the Second International Skid Prevention Conference.

Title

76 A-26 - Comparison of Laboratory Tests with Field Performance of Aggregates

Purpose

To develop statistical models for concrete pavement performance prediction.

Scope

The scope of the investigation will be limited to currently available data, such as the laboratory test results on coarse aggregate, condition survey data of concrete pavements, traffic volumes, and weather information.

Progress Past Year

The laboratory test results on coarse aggregate have been edited and stored in the computer. The weather data obtained from the Michigan Department of Agriculture Weather Service has also been stored in the computer.

Planned Program for Coming Year

The weather data obtained from the Michigan Department of Agriculture Weather Service shall be edited and transformed into the proper form for the purpose of statistical analysis. The condition survey data for concrete pavements will also be edited and stored in the computer. Once the proper form is achieved, we will perform the necessary statistical analysis to accomplish the goals of this project.

Title

76 G-222 - Statistical Analysis of Aggregate Base Course Inspected By End Result Aggregate Specification

Purpose

The End Result Aggregate Committee recommended an in-place aggregate acceptance sampling plan based on the research results of the project

"Aggregate Gradation Quality Control" (Report R-1024). This recommended acceptance sampling plan shall be used to accept or reject base aggregate for two construction projects: M 36021 and I 50062. The purpose of this research program is to analyze the aggregate base course of these projects so that the major purpose (aggregate uniformity) of the recommended acceptance sampling plan can be evaluated.

Scope

The scope of the investigation will be limited to data obtained from projects M 36021 and I 50062.

Progress Past Year

The review draft of the first interim report prepared for this research has been completed for editorial review. This interim report describes the detailed sampling, test, and acceptance procedures for aggregate base course inspection.

Planned Program for Coming Year

We will offer training sessions prior to construction in order to train personnel using the sampling test, and acceptance procedures described in the first interim report. We will analyze the data obtained from two construction projects to evaluate the aggregate base course at the end of the construction period.

Title

76 G-223 - Statistical Accident Prediction Model

Purpose

To construct statistical models which will predict the expected number of injury accidents.

Scope

The data needed for the development of the injury accident prediction models will be provided by the Traffic and Safety Division. These data include the number of injury accidents and the environmental and geometrical descriptions of every 2/10-mile roadway section of the Michigan trunkline system for the period 1971-75.

Progress Past Year

The data for District 1 have been furnished by the Traffic and Safety

Division. We are now thoroughly acquainted with the context and format of these data.

Planned Program for Coming Year

We shall perform extensive statistical analyses on these data to develop the injury accident prediction models.

Title

57 B-39 - Use of Latex Modified Mortar and Concrete in the Restoration of Bridge Structures

Purpose

To monitor the preparation and application of latex modified mortar or concrete thin bonded overlays on selected deck repair projects and new two-course decks. The long-term performance of these overlays was to be evaluated by selected field inspections.

Scope

This project started by closely following latex mortar repair on one structure in 1957-58. Larger scale usage of latex overlays with District Maintenance forces was observed in 1969-71, followed by contract repair projects in 1972-76. General usage of latex concrete or low slump high density (LSHD) concrete on selected projects began in 1976 and as alternate systems in 1977.

Progress Past Year

Latex concrete overlays continued to be used extensively on deck repair contracts, and on selected new structures, to increase cover over the top steel. Late in the year it was decided to call for two-stage construction on new decks in high traffic areas along with epoxy coated rebars in the top steel mat. Two supplemental specifications were finalized in December for jobs let after January 1, 1977 so that latex concrete or low-slump high density concrete could be bid as alternate systems.

Selected projects built with latex overlays up through 1975 were inspected, cored, and tested with a skid trailer and rapid travel profilometer to continue our long-term assessment of latex overlay performance.

Planned Program for Coming Year

Selected projects will be inspected and tested, including coring, in 1977 so that an updated performance report can be issued later in the year.

Title

*61 B-58 - Control and Prevention of Deterioration of Concrete Bridge Decks

Purpose

A field inspection was made of selected post-war structures built since 1949-50. The results of this condition survey were to be evaluated to determine effect of design, construction, and maintenance factors on the long term durability of concrete bridge decks.

Scope

A selective sampling was made of 5 and 10 year old structures which included both steel and concrete girder systems. The structures inspected also included different areas of the state having wide ranges in traffic, weather exposure, and maintenance practices.

Progress Past Year

The final report was finished and copies were transmitted to the FHWA. They approved the report in December for final distribution, thus closing out the project. The results of the original study of 1963-65 were out of date since so many basic changes in concrete and deck design had been made since then. The report documents all these changes along with salt usage data.

Title

72 B-90 - Experimental Use of Water Reducers in Slip-Formed Concrete Pavement

Purpose

The use of water reducers was tried both with and without a slight cement reduction on a number of concrete paving projects. The fresh concrete was sampled, placing and finishing observed, and finished pavement properties evaluated. Tests were to evaluate rideability as well as strength and durability.

Scope

Portions of a number of paving projects by several contractors were selected in which to use water reducers with 6.0 and 5.6 sacks of cement per cubic yard. Extensive field sampling was done to evaluate strength and durability and profilometer tests were run to check riding qualities.

Progress Past Year

Based on the extensive test data from seven projects paved in 1972-74 the Department approved the use of water reducers in paving concrete with

a slight reduction in cement. This usage in grades 35P and 30P concrete became part of the 1976 Standard Specifications (Table 7.01-1). The use of 5.6 sacks/cu yd with water reducer, in lieu of 6.0 sacks of cement, were widely used across the state in paving concrete.

Planned Program for Coming Year

The current list of approved water reducers will continue to be updated as new products are evaluated by the Testing Laboratory. A favorable decision on the use of type 1SA cement, at a reduction, with water reducers will be forthcoming in the first quarter.

Title

72 B-91 - Laboratory and Field Evaluation of Portland-Pozzolan Cement (Type 1P) in Concrete Pavement and Structures

Purpose

To determine the performance characteristics of portland-pozzolan cement concrete relative to our conventional concrete and recommend scopes of equal or superior usage.

Scope

One-third of a concrete paving project was selected to directly compare type 1P cement with type 1A. Selective sampling was done in 1974 to evaluate strength and durability. Structural grades of concrete are to be evaluated in a later phase of a bridge project. A dual structure was selected so that type 1P cement was to be used in both the substructure and superstructure concrete of one structure. Normal type 1A cement would be used in all concrete of the companion structure.

Progress Past Year

Work was started the latter part of the year on the selected structures, X01 and X03 of 82102 which carry M 14 over the C&O RR north of Plymouth. Half of the eastbound (X03) substructure concrete was poured with type 1P cement until cold weather halted its use at the end of November. All of the westbound substructure (X01) was to be poured through the winter of 1976-77 using type 1A cement. Extensive sampling was done on both structures to assess the flexural and compressive strengths, shrinkage, and freeze-thaw durability.

Planned Program for Coming Year

Sampling will be continued of both substructure and superstructure

concrete. Selected cores will be taken to check actual strength and consolidation within the structure.

Title

72 B-92 - Experimental Bridge Deck Surfacing Methods

Purpose

To evaluate the initial construction phase and long-term performance of two types of new bridge deck construction; namely, a revibrated deck and two-stage construction using thin bonded overlays.

Scope

Three structures were closely followed to evaluate construction phases of a revibrated deck, two-stage deck pour using 1-in. latex modified mortar, and a two-stage pour with 2-in. of a 7.5 sack concrete mix. Post-construction performance was to be evaluated by periodic testing and inspection.

Progress Past Year

The three subject structures on US 23 in northeastern Michigan were monitored during construction in the summer and fall of 1972. They were inspected and corrosion cell tests run late in 1975. Due to other high priority projects, selected coring and delamination testing could not be run before the onset of winter.

Planned Program for Coming Year

As soon as weather permits in the spring, complete condition surveys, selected coring, corrosion cell tests, and delamination surveys will be made so that a report can be completed for distribution.

Title

75 B-93 - Iowa Low-Slump Method of Bridge Deck Overlays

Purpose

Evaluation of low-slump concrete as an alternate to the presently used latex concrete method of bridge deck overlay on selected field projects.

Scope

Determine the effectiveness of low-slump concrete overlay in rehabilitating spalled and chloride contaminated bridge decks. For this purpose two projects on I 96 were selected to monitor and evaluate this system. Long-term performance will be evaluated by periodic post-construction testing. Starting in 1977 the low-slump overlays will be used both for deck repair as well as new two-course construction.

Progress Past Year

The construction and initial field testing were completed in late 1975 on the two I 96 projects; S03 of 33084 and S10 of 47065. Selected coring, field inspections, delamination surveys, skid tests, and profilometer tests were completed in 1976 and an initial report draft was finished.

Planned Program for Coming Year

The initial report including first year's performance is to be finalized for distribution the first quarter. Test procedures for nuclear density and quality control on 1977 low-slump high density (LSHD) overlay projects are to be finalized for implementation by Construction and Testing and Research personnel. Performance of the two 1975 projects, as well as additional jobs in 1977, will continue to be monitored to compare with latex concrete projects.

Title

75 B-94 - Evaluation of Type 1SA Cement When Used With Water-Reducer Admixtures

Purpose

To investigate the properties of this cement, and report on its characteristics, when used with and without a water reducer. Also, the curing properties of this type of cement at colder temperatures is to be evaluated.

Scope

A series of tests will be performed to compare properties of several grades of concrete made with type 1SA and type 1A cement with and without water reducers. Strength data will also be obtained at temperatures of 40 and 55 F to compare with normal room temperature cure and corresponding results with type 1A cement.

Progress Past Year

Tests have essentially been completed on specimens from 10 mixes of grade 35P concrete made with both type 1SA and 1A cements with and without water reducers. Tests are nearly complete on two batches of grade 30P concrete.

Planned Program for Coming Year

Two additional mixes of grade 30P concrete are to be made with type 1SA cement and one more mix of grade 35P. Results of these and the earlier tests are to be assembled for a report and decision on use of 1SA cement with water reducers by the end of the first quarter.

Title

76 B-95 - Experimental "Econocrete" Ramp Construction (Project F 64015-06526A), US 31 near Shelby

Purpose

This study was initiated to evaluate the construction and performance of a composite concrete pavement using an econocrete mix in the lower half of the slab. This econocrete was to contain a cheaper sand-gravel blend and lower cement content to ensure at least half of the normal strength level. The performance of this composite or dual strength slab section was to be evaluated in a non-reinforced ramp carrying light commercial traffic.

Scope

It was proposed to pave about 1,200 ft of Ramp A in the southwest quadrant of the Shelby Rd - US 31 interchange with a composite econocrete slab. This was to consist of using a mix containing 305 pounds of cement/cu yd, a water reducer, and a local 60-40 sand-gravel mix in the bottom 4 in. of the slab. The top 4 in. and the rest of the ramp, about 1,200 ft, was to use a standard grade 35P concrete.

Progress Past Year

Ramp A was poured essentially as planned on October 11, 1976, by the Sargent Construction Co. About 1,240 ft of the 4-in. econocrete plus 4 in. of grade 35P concrete was placed at the north end of the ramp. About 900 ft to the south was 8 in. of grade 35P. Samples of the fresh concrete were taken to evaluate compressive and flexural strength, freeze-thaw durability, and long-term shrinkage.

Planned Program for Coming Year

The initial report covering placement of the ramp concrete sections, including concrete test data, is to be finalized for distribution in the first quarter. Field measurements, such as joint openings, slab movement, profilometer, load-deflection, and condition surveys are to be taken early in the year and at later intervals.

Title

71 C-13 - Study of Aggregate and Mix Requirements for Durable and Skid Resistant Bituminous Mixtures

Purpose

This project is to re-evaluate the 1963 ban on the use of crushed limestone and high carbonate gravels in bituminous concrete wearing courses. Of particular concern was the effect of these restrictions on the skid resistance of bituminous mixes and the economic factors involved in obtaining suitable aggregate in critical areas.

Scope

Both bituminous concrete and bituminous aggregate skid data were re-examined on projects paved up to 1963 and also from 1963-72. Primarily, bituminous concrete projects were examined under Phase 1, and bituminous aggregate jobs and initial wear track construction were done under Phase 2.

Progress Past Year

As a result of this study, the use of high carbonate gravels in certain areas of the state was reinstated. The wear track was completed in 1975 and series 1 through 4 tests were finished to start evaluating particular aggregate sources under controlled wear conditions. Series 5 was started the end of the year to determine the relative wear characteristics of about 22 selected rock types from a detailed coarse aggregate study. Tests were initiated to obtain a correlation between the standard skid trailer and the laboratory tester on selected sites on trunklines.

Planned Program for Coming Year

Additional test series will be continued on the wear track to include more particular crushed gravel and quarried limestone sources and possibly blended materials. Wear data on sources completed on the wear track are to be assembled for a progress report and for possible application to the 1977 construction season. Field correlation tests of laboratory skid tester and skid trailer are to be continued.

Title

74 F-141 - Development of Procedure for Epoxy Injection Repair of Bridge Deck Delamination (Kansas Method)

Purpose

To adapt the bridge deck epoxy injection concept, as pioneered by the State Highway Commission of Kansas, to similarly afflicted Michigan bridges, and to evaluate the permanence of this type repair by long-term evaluation.

Scope

Select a test bridge in early stages of delamination to develop techniques of locating, drilling, injecting, and evaluating hollow areas. Evaluation of injection repair in combination with surface patching is also to be made. After completion of this first phase, select several other structures for delamination repair on a contract basis to be closely monitored by the Research Laboratory.

Progress Past Year

In a joint voluntary venture with the Eisenhour Construction Co., the Department sought to develop a procedure by which a bridge deck, in early stages of deterioration, could be restored to its original integrity without resorting to costly chipping and patching. The procedure involved locating the delaminated or "hollow" areas on the surface of the deck and pumping them full of a low viscosity epoxy resin before they could grow larger and spall. During the 1975 construction season, the bridge which carries Capitol Ave over I 496 in the City of Lansing was repaired by this procedure.

In 1976 an injection repair contract was awarded Structural Bonding Co. of Flint to do additional work on the Capitol Ave structure and three others in Lansing. Injection repair work was almost completed on two structures before cold weather halted operations (Walnut St and Capitol Ave over I 496).

Planned Program for Coming Year

In early summer some areas on Capitol Ave are to be finished and then selected spans of two other structures will be done (Clemens St over I 496 and westbound I 496 over the Red Cedar River). An initial report will then be issued including cost and evaluation data for distribution by the end of the year.

Title

67 G-157 - Evaluation of Bridge Deck Surfacing for the Orthotropic Bridge Carrying Creyts Road over I 496

Purpose

The bridge was erected on an experimental basis to determine whether the orthotropic design and epoxy wearing surface were practical in this climate.

Scope

Two different epoxy mortars were selected for use on the two spans of the Creyts Rd structure. The field application was closely followed and annual inspections are made to determine long-term performance of the surface.

Progress Past Year

Epoxy mortar surfacing was applied during September and October of 1969 to a minimum thickness of 5/8 in. Guardkote 250 mortar was applied to the south half of the bridge and Epon 815-Versamid 140 mortar to the north half. Subsequent inspections revealed several types of deterioration; shrinkage craze cracking was very distinct in the GK-250 and less prominate in the E815-V140; both mortars developed tensile fatigue cracks in negative moment areas of the deck; and changing features each year suggested significant traffic abrasion. The annual inspection of 1975 found spots where the GK-250 mortar had spalled off and left the steel deck exposed. At these areas it was discovered that the thickness of the mortar was 1/8 in. or less; traffic abrasion has removed approximately 1/8 in. of mortar per year. The rate of abrasion in the E815-V140 appeared to be less. In 1976 several square ft of the Guardkote 250 mortar have come off the south span exposing the steel plate. The north span epoxy mortar has not worn nearly as much and remains intact.

Planned Program for Coming Year

Another inspection report is to be issued early in the year with recommended remedial measures. Hopefully, repairs and/or resurfacing can be done by the Maintenance Division in cooperation with the Research Laboratory later in 1977.

Title

71 G-180 - Effects of De-Icing Salts on the Chloride Levels in Waters and Soil Adjacent to Roadways

Purpose

To study the effects of de-icing salts on the chloride levels in water and soil adjacent to roadways, and to recommend remedial measures if environmental or health hazards are found to exist.

Scope

Long-term monitoring of chloride levels in water and soil adjacent to roadways both during and after the winter season by water sampling at selected ground water wells and surface water sites. Salt usage and precipitation data are to be included for possible correlation. Additional test sites may be added as study progresses.

Progress Past Year

Water sampling was conducted during the 1972 and 1973 winter seasons. The study was suspended in 1973 due to the loss of personnel. The project was reactivated near the end of 1975 and surface and subsurface water samples to monitor chloride levels at a number of selected sites have been taken starting with the 1975-76 winter season. A progress report was issued in October (Research Report R-1022). Water and soil sampling is continuing through the 1976-77 winter as some test wells had to be lowered due to drop in water table.

Planned Program for Coming Year

Sampling is to continue on a year around basis and a second, more detailed progress report is planned which will include data from the past two winters.

Title

72 G-188 - Experimental Preformed Waterproofing Membranes for Concrete Bridge Decks

Purpose

To monitor and evaluate the application of three different sheet membranes applied to five widened and repaired structures prior to bituminous surfacing. Post-construction testing and long-term evaluation was to include visual inspections, resistance tests, and selected coring.

Scope

The initial work plan (No. 19) covered the use of three sheet membranes on five deck widening jobs on I 75 near Flint in the fall of 1973. A

number of other membrane waterproofing jobs done subsequent to the 1973 projects have been added to the study. The long-term performance of these membrane jobs was to be evaluated by periodic inspections and selected testing.

Progress Past Year

Due to other high priority field projects before the onset of cold weather, many of the membrane waterproofing projects placed in 1973 to 1976 could not be evaluated. Our first job done with the Johns-Manville hot mix membrane was placed on the Blue Water Bridge in Port Huron to be described in a Testing Laboratory report.

Planned Program for Coming Year

A detailed listing of all membrane jobs done in 1973 to 1976 is to be prepared in cooperation with the Testing Laboratory Bituminous Unit and the Construction Division. An organized inspection and field testing program on these structures, including the original I 75 jobs at Flint, is to be made for a summary report later in 1977.

Title

74 G-205 - Pre-Engineering for Bridge Deck Rehabilitation

Purpose

This continuing project is to document and follow specific sampling, testing, and recommendations for particular deck repair projects programmed for major repair or widening contracts. This is to include jobs using thin bonded overlays or deck waterproofing systems.

Scope

The initial scope of this project was to cover data from special cores and corrosion cell tests on 32 Interstate structures scheduled for thin bonded overlays in 1975. Proposed limits on chloride content of the deck concrete and evaluation procedures of the FHWA initiated in 1974 prompted this open-ended study. Subsequent deck repair projects were added as they were programmed by the Design Division for repair contracts.

Progress Past Year

Chloride and corrosion data from cores on the initial 32 Interstate structures were finished and transmitted in two packages early in 1975. Data from cores on 29 additional primary structures, and also eight other

structures, were transmitted in 1975. In 1976 we continued coring and processing chloride data on 21 structures for lettings in 1976 and 30 jobs for a February 1977 letting. Delamination survey data were obtained at the time deck coring was done to be used by the Design Division in estimating areas to be chipped.

Planned Program for Coming Year

We will continue to process deck samples for chlorides and finish transmitting data on about 22 jobs for March and April lettings. We plan to work closely with the Soils Unit to establish a rotohammer procedure to obtain chloride samples at the level of the top steel in lieu of actually drilling cores. About 47 additional decks are to be sampled later in the year.

Title

74 G-210 - Bituminous Aggregate Resurfacing with High Shale Content Aggregate

Purpose

To evaluate the wear and durability of bituminous aggregate surfaces made with a particular high shale content material.

Scope

Laboratory wear tests and other related evaluations are to be run on the aggregate and bituminous aggregate surfacing containing high shale percentages. A comparison aggregate of intermediate shale content is also to be included.

Progress Past Year

Samples of the two test aggregates of high and intermediate shale content were received, screened, and preliminary petrographic tests run. Test slabs were made and wear track tests completed.

Planned Program for Coming Year

A report covering both the laboratory tests and field evaluations will be prepared early in the year.

Title

47 G-36(29A) - 1976 Supplemental Traffic Paint Performance Tests

Purpose

This project is the 1976 phase of annual, repetitive field performance and laboratory tests conducted on producers' samples to determine the best performing yet most economical paints to be purchased for roadway marking in 1977.

Scope

This is a cooperative project with Traffic and Safety Division who assume responsibility for application of the paints in field performance tests while we assume responsibility for the field ratings, laboratory analyses, and the reporting.

Progress Past Year

The project is on schedule with application of the paints in field tests, including a white and yellow "super" paint from the 1975 tests, applied the second week of June 1976. Periodic ratings were made with an interim progress report submitted to the Committee for its November 18, 1976 meeting.

Planned Program for Coming Year

Ratings of the paints in field tests will continue until termination of 1977, when results will be submitted in a formal report, ending the project.

Title

49 G-50 - Study of Protective Coatings for Structural Steel

Purpose

To determine the potential merit of a variety of paint-type coatings for structural steel in construction and maintenance painting, by means of laboratory and field service tests.

Scope

As noted by the number, the project was initiated in 1949 and is meant to be continuing in order to evaluate the latest developments in paint coatings. The project has two phases, (a) evaluation of paint systems by laboratory techniques, and (b) field evaluation on actual structures of the best performing systems as determined previously in laboratory tests. Since the service life of a good paint system is more than 10 years, determining the merits of paints under phase (b) is lengthy and time consuming.

Progress Past Year

No work was done on phase (a) testing. Under phase (b), about half the paint systems under field tests were inspected for performance, with data to be compiled for subsequent, periodic reporting. The structure on I 94 painted in 1976 under HPR Project 76 G-219 will ultimately be added to phase (b) listings for long-range performance data.

Planned Program for Coming Year

We may start phase (a) testing in the fall on new paints, and will inspect the other half of paint systems under phase (b). Phase (b) testing utilizes about 15 structures total.

Title

57 G-87 - Revision of Existing Paint Specifications

Purpose

As per title, to revise and update existing Department paint specifications (other than for highway structural steel).

Scope

Work under the project is periodic, and continuing. Automotive-fleet paints, sign paints, wood post paints, picnic table varnishes, etc., fall under this project, as do required surface preparation procedures and required solvents. Requested revisions are accomplished by our obtaining and furnishing technical background and meshing it with application requirements of the using Division, compiled in accordance to a Specifications Unit format.

Progress Past Year

The project has been inactive for several years. The last significant work was on No. 18(2) Highway Orange Automotive Paint in 1971.

Planned Program for Coming Year

No work is currently scheduled; it will be performed as needed.

Title

57 G-87(1) - Revision of Existing Structural Steel Painting and Cleaning Specifications

Purpose

As per title, to revise and update existing painting and cleaning specifications for structural steel required in construction or maintenance contracts.

Scope

Work under this project entails revision of standard Department painting specifications and also writing specifications for experimental paint systems scheduled for field service tests. Technical background information is often obtained from work under Research Project 49 G-50. Revisions are generally cooperative with the using Division and are drawn-up to a Specifications Unit format.

Progress Past Year

Final editing of painting specifications for the 1976 edition of Standard Specifications was completed. We cooperated with Maintenance Division on specifications for painting of deck steel on the main span of the Mackinac bridge, and on testing painting of four grade separation structures utilizing a two-coat system based on an inorganic zinc primer and available modifications. Three of the latter structures are in Allegan County, while the fourth is in Livingston County.

Planned Program for Coming Year

A definite schedule is not available, though specifications will be required for painting the approach spans on the Blue Water Bridge, and perhaps the Houghton and Cut River bridges. Work will be done as requested.

Title

60 G-102(2) - Evaluation of Aluminum Coatings on Guardrails

Purpose

To field evaluate the merits of subject hot-dip aluminum coating on steel beam guardrails.

Scope

The Maintenance Division received and installed 40 subject guardrails and 12 standard galvanized controls at three locations (one Detroit and two Lansing) about mid-1970. The comparative performance was then to be monitored by us via periodic inspections.

Progress Past Year

We found that the Detroit installation on the Lodge freeway just south of I 94 was replaced in 1975 in a modernization project, while a 1975 visit to the M 43 installation, east of I 96 showed that the test railings had been replaced by the low-alloy type. The remaining installation on US 127 (I 69) near Michigan Ave is performing satisfactorily.

Planned Program for Coming Year

Inspect railings in remaining test site to determine comparative performance of the aluminum coating.

Title

72 G-113 - Evaluation of Galvanized Coatings on Highway Appurtenances

Purpose

To determine the merits and performance of galvanized coatings on highway structural steel, with emphasis on appurtenances.

Scope

The Department is specifying galvanized coatings on an increasing variety of highway hardware, from guardrails to bolts. Under this project, we are observing the performance of galvanizing in a variety of end-uses, i.e., bridge girders and diaphragms, girder-support hardware, guardrails and bridge railings, etc., as background information to be used in specifying protective coatings on highway steel.

Progress Past Year

Several inspections were made on field test installations including guardrails on M 78, and bridge beams and hardware on structures on M 78, and US 27 north of Houghton Lake.

Planned Program for Coming Year

Continue periodic inspections of test installations.

Title

62 G-114 - Peeling of Paint on Treated Wood Posts

Purpose

The current phase of this project involves following the comparative resistance of peeling of the standard oil-based white paint vs. a latex white on round wood posts of cable guardrail installations, maintenance repainted.

Scope

This project was reactivated in 1973 on request from the Maintenance Division to monitor the current phase, with field test installations in the Kalamazoo District. Their preference for use of a latex white paint has required our laboratory evaluation of several white latex formulas.

Progress Past Year

Three white latex formulas plus the standard oil-based white control were applied on wood post specimens and exposed on the roof of the Laboratory for performance purposes. The field test installations were not inspected.

Planned Program for Coming Year

Check performance of field and laboratory exposures and write latex specifications, if exposures provide adequate performance data.

Title

62 G-122 - Use of Low-Alloy Steel in Highway End-Uses

Purpose

To determine merits and/or service life of subject steel, unpainted, in highway end-uses, mainly on bridge beams, guardrails, and light posts.

Scope

Since accelerated laboratory tests are unsuited, we used field service tests to determine performance of unpainted subject steel in bridge girders and beam guardrail. The oldest bridge and beam guardrails date from 1964. In cooperative tests with the producer, exposed panels on the oldest bridge were removed periodically over an eight-year period to determine weight loss of metal through corrosion. Physical measurements of thickness loss of steel are made at a few other test sites. Loss of girder metal was shown to be increased under leaking deck joints, with those localized areas now requiring shop and field painting in new construction, per our specifications.

Progress Past Year

The cooperative panel weight loss tests conducted on the M 102 structure over the Lodge freeway, completed in May 1974, were finally reported by the producer early in the year. The tests appear to have been conducted in an aggressive area since the losses were higher than normal for the eight-year long tests. Because of the abnormality, the tests will be continued with Phase 2 panels. Since the producer did not submit the new test panels until mid-December, all were exposed on the Detroit Armory roof on December 17, 1976.

Planned Program for Coming Year

In the spring of 1977 2/3 of the Armory roof panels will be removed for service exposure at the bridge site, while retaining the remainder on the roof for comparative purposes. Continue our surveys of older structures and appurtenances utilizing the low-alloy steel to obtain performance information with emphasis on cooperative surveys to determine whether preventive maintenance is recommended under leaky deck joints requiring either painting or joint sealer replacement on early bridges whose beam ends were not protected by painting.

Title

71 G-178 - Guardrail Wood Post Deterioration

Purpose

To determine the relative effectiveness of specification preservatives in minimizing decay, especially at ground line, on wood post supports for steel beam guardrails, via field inspections of installations.

Scope

The initial phase of the project covering preservative treatments allowed by past specifications was completed with Report No. R-954, which showed the water-borne treatment to be inferior. A current, secondary phase of the project endeavors to determine whether the current water-borne treatment (CCA) is superior to the former, superseded one (FCAP), and equivalent to the two organic-based treatments. The oldest known (CCA) treated posts are about seven years old.

Progress Past Year

Research Report No. R-954 was completed in January 1975. Surveys conducted in 1975 and 1976 in most Districts showed all seven to eight-year

old treated posts to be decay-free, though we did not find CCA treated posts in some Districts, and not many in some others.

Planned Program for Coming Year

Complete the surveys of guardrail and post installations made in 1969. With the aid of the Maintenance and Traffic and Safety Division, determine locations of all guardrail and post installations made subsequently; determine the treatment used on the wood posts. Use these files to determine the relative performance of the CCA treatment vs. the organic-chemical treatments in service exposure on Michigan highways, by future inspections.

Title

73 G-197 - Investigation of Structural T's, Galvanized in Sections, in a Truss-Type Pedestrian Bridge (Work Plan No. 22)

Purpose

As per title, which is very descriptive. The test structure is P01 of 52042 over US 41 southeast of Marquette, completed in 1972.

Scope

The project is a "Category 2" experiment carried out in cooperation with FHWA as per MDSHT Work Plan No. 22, which was developed by the Department. After construction of the test structure, the project was transferred to us for follow-up surveys and reporting. The initial survey was covered by us in the first Progress Report No. R-896 issued January 1974. The report lists several contemporary pedestrian bridges for comparison of subject bridge's main features.

Progress Past Year

No work was done on the project, as we requested the Upper Peninsula Bridge Inspection Team to transfer survey data to us for compilation and eventual reporting. This was done because of test site distance from Lansing.

Planned Program for Coming Year

Periodically, we will coordinate joint surveys of the test structure with the U. P. Inspection Team, and also joint surveys of the comparison structures with other, involved, Bridge Inspection Teams.

Title

62 G-116 - Extruded Neoprene Joint Sealer

Purpose

To evaluate the performance of neoprene seal installations.

Scope

Since neoprene has become a standard material, this project has been used to cover the study of special problems as they occur. Evaluations of new designs are included.

Progress Past Year

Evaluation of one manufacturer's newly designed line of road seals was initiated.

Recommendations for improvement of the expansion joint groove design were made and incorporated in the Standard Plan.

Planned Program for Coming Year

The feasibility of upgrading the lubricant for installation of seals will be considered.

Title

72 F-128 - Evaluation of Various Bridge Deck Joint Systems

Purpose

To evaluate the effectiveness of various types of bridge deck joint systems covered by Category 2, NEEP Project No. 11.

Scope

Field inspections are made of each installation at least twice annually to rate the systems for watertightness, durability, ride, noise, etc.

Progress Past Year

Field surveys of seven different types of systems on over 200 structures were made during 1976.

Planned Program for Coming Year

Field surveys will continue. A progress report is being prepared and will be completed after current winter survey data are obtained.

Title

*73 G-195 - Effectiveness of Neoprene Seals in Preventing Pavement Joint Deterioration

Purpose

To determine whether there is sufficient penetration of de-icing chemicals to cause joint deterioration; and the rate of concrete deterioration and chloride penetration if it proves to be significant.

Scope

Joints on construction projects of different ages and geographical locations are cored annually to measure de-icing chemical penetration and the amount of concrete deterioration. Samples of base materials are taken for permeability measurements.

Progress Past Year

Seventeen construction projects were cored and base materials were sampled. Chloride penetration, amount of concrete deterioration, and permeability of base materials were determined.

Planned Program for Coming Year

Construction projects previously cored will be recored for comparison. Freeze-thaw durability data from tests conducted on the aggregates used in construction of the different projects will be studied for possible correlation with rates of concrete deterioration.

A final report will be prepared.

Title

73 G-199 - Preformed Elastomeric Pavement Joint Sealing Systems - Field Evaluation Phase

Purpose

To verify or modify as appropriate, by the conduct of a field study program, the tentative guide specifications developed under Project 4-9

(NCHRP). This is Project 4-9A assigned to the Utah State Highway Department with Michigan cooperating.

Scope

Neoprene seals from three different manufacturers were installed in a Michigan construction project near Belleville. Seal samples are removed every six months for a period of four years. Performance is rated under the direction of the Utah representative and samples are tested by them for change in properties.

Progress Past Year

Two sets of seal samples were removed and their performances were rated. Seals removed were replaced with new material using a one-component urethane lubricant for installation. We are using this opportunity to study different techniques of seal installation.

Planned Program for Coming Year

We will continue to cooperate with Utah in their sampling and rating of seal performance. Our work will be terminated in September of 1977 when the last test seals will be removed.

Title

*76 G-219 - Alternate, More Economical Repainting Systems for Structural Steel

Purpose

To determine by service evaluation whether a bridge structural steel coating system based on SSPC-PS 8.01, Specification for a Thick-Film Rust Preventive, can provide comparable protection to the Department's currently specified four-coat system, when applied as either a one or two-coat system at equivalent dry-film thickness.

Savings would be realized primarily by reducing the number of needed applications per maintenance recoating. Hazards involved in such maintenance operation would be reduced accordingly.

Scope

This HPR project was initiated to study the feasibility of lowering the cost of maintenance repainting of bridge structural steel by use of a one-coat or two-coat paint system based on an auto underbody rust proofer for-

mulation. The study utilizes a grade separation structure, with its structural steel divided into four areas, for the tests. One area was coated with the rust proofer in one coat, while another was coated in two coats. One of the remaining areas was coated with the Department's standard four coat system, while the other was coated with a promising two-coat test system based on an inorganic zinc-rich primer. The performance of the paint systems will be determined comparatively by continued inspections.

Progress Past Year

The bridge structure for the tests was S01 of 38103 (Sargent Rd over I 94 east of Jackson) built in 1960 and in need of maintenance repainting. The repainting was by contract, let August 18, 1976, with the actual repainting done in the October-December period.

Planned Program for Coming Year

Complete taking dry-film thickness measurements of the four test areas, which could not be taken after completion of the applications, due to lateness in the season. Initiate annual inspections to monitor performance of the four test systems. Incidentally, the test structure is scheduled for a 1977 deck overlay which will remove a possible variable affecting the performance of the test systems.

## SPECTROCHEMISTRY AND PHOTOMETRY

Title

73 G-200 - Experimental Settling and Oil Skimming Chamber

Purpose

To determine the quality with respect to sediment and oily material of water being discharged into Lake St. Clair from the storm sewer system serving I 696 between I 75 and I 94 in Oakland and Macomb Counties. Also, to determine the effectiveness of the settling and oil skimming chamber which has been built to remove sediment and oily materials from the storm sewer water.

Scope

The study is planned in three phases. Phase I provides for manual sampling of the water entering and exiting the skimmer chamber after completion of construction, but before the associated highway is open to traffic. Phase II is a continuation of Phase I after the highway is open to traffic. Phase III is an extensive program, using automated sampling equipment, designed to study the system after traffic on the highway and operation of the skimmer chamber has stabilized.

Progress Past Year

The storm sewer was recently completed and small quantities of water are entering the pumphouse. No water samples were analyzed.

Planned Program for Coming Year

Proceed with Phase I of the project as permitted by available traversing of the system.

Title

54 G-73(3) - Revision of Specifications for Traffic Control Devices

Purpose

To develop specifications for traffic control devices, specifically, lights and lighting for hazard warning.

Scope

Evaluate the performance of warning and delineation lighting; prepare specifications and specification revisions.

Progress Past Year

Warning lights were not submitted for test.

Planned Program for Coming Year

Continue to evaluate lights as sampled from construction sites by project engineers.

Title

68 G-165 - Edge-Marking Criteria from Contrast Ratios

Purpose

Develop a means of determining necessity for edge-marking based on visibility factors.

Scope

Evaluate visual contrast of shoulder and pavement materials under vehicle headlamp illumination. Develop a rank order need for edgestriping on various combinations of shoulder and pavement materials.

Progress Past Year

Final report completed.

Title

71 G-182 - Investigation of Air Quality Test Equipment and Procedures

Purpose

Assemble equipment and develop procedures for acquiring air quality information as required in preparing environmental impact statements.

Scope

Review State and Federal air quality regulations and determine their applicability to transportation projects. Review the literature on and performance of commercially available instrumentation and purchase measuring equipment. Review the literature, review the experiences of other agencies and develop procedures for measuring air quality. Develop a data bank of meteorological and air quality data.

Progress Past Year

Federal and State air quality regulations were reviewed as issued and a file maintained of material relevant to transportation. Information was obtained to maintain a current file on analyzers available to monitor air quality. Any analyzers purchased in the future must meet federal standards for accuracy and reproducibility if our data are to be accepted. The air quality monitoring van was completed. Carbon monoxide concentrations along with wind speed and direction were recorded at 15 locations for time periods of one week to one month. Some data for nitrogen oxides and ozone were also recorded.

Locations monitored include Lansing, Charlotte, Detroit Zoo area, Oak Park City Hall area, Dearborn, Highland Park, area of National Guard Armory (8 Mile Rd), M 59 west of Pontiac, and an area north of Grand Rapids. Carbon monoxide concentrations from our data bank were supplied to DNR to augment their data. Installation of equipment in a trailer was begun to ready the second mobile air quality laboratory for operation. A data logger unit was ordered and a carbon monoxide analyzer and wind recorder are on hand. This equipment is sufficient to begin field operations.

Planned Program for Coming Year

Complete construction of the trailer air quality monitoring unit and start the field monitoring of air quality. Continue air monitoring with the van. Assemble battery operated samplers to collect air samples in plastic bags for subsequent analysis. Update the data bank of meteorological information on file, and the data bank for air quality. Maintain current information on state and federal air quality regulations relating to transportation. Maintain current information on equipment available to monitor air quality. Obtain a second ozone analyzer for the trailer.

Title

52 G-54 - Revision of Standard Specifications for Reflectorized Signs and Reflective Materials

Purpose

Develop specifications for reflective materials.

Scope

Evaluate reflective materials used for traffic control devices. Develop methods of evaluation and prepare specifications or specification revisions.

Progress Past Year

In conjunction with specific new materials evaluation projects; mechanical, photometric, and weathering tests were conducted on encapsulated bead reflective sheeting manufactured by the Seibu Polymer Chemical Co., the Fasson Corporation, and the suppliers of Kiwilite. Assistance was given to the Traffic and Safety Division and to the Specifications Section in preparing revisions for the new edition of Standard Specifications.

Planned Program for Coming Year

Continue evaluation of reflective materials as submitted.

Title

73 G-198 - Specification for Roadway Luminaires

Purpose

To develop specifications for roadway luminaires, especially high-pressure sodium luminaires.

Scope

Evaluate the performance of roadway luminaires except tower lighting luminaires. Develop methods of evaluation. Correlate evaluation with the manufacturers. Prepare specifications and specification revisions and provide roadway lighting design criteria.

Progress Past Year

Continued collection of photometric data from sodium vapor luminaires supplied by manufacturers. Data were analyzed and collated. For each type luminaire as supplied by each manufacturer, we computed and tabulated lighting design criteria such as fixture mounting height, pole spacing, average illumination, uniformity ratio, half-maximum intensity, and utilization coefficients. The data were submitted in graphic form to the Design Division.

Planned Program for Coming Year

Evaluate low-pressure sodium vapor sources and underbridge luminaires.

Title

75 G-214 - Forward Antiglare Screen Evaluation - Category 2 Experimental Project (Work Plan No. 43)

Purpose

To determine the suitability of the forward antiglare screen installed on concrete median barrier for general use.

Scope

Evaluate oncoming vehicle headlamp glare prior to, and after, installation of the antiglare screen at two locations. I 94 over the Dequindre Yard and on M 39 from Village Rd to the Penn Central Railroad in Wayne County.

Progress Past Year

Glare evaluations before installation of screen have been completed.

Planned Program for Coming Year

If glare screen is installed, glare will be evaluated.

Title

73 G-192 - Evaluation of Glare Sources

Purpose

To provide data which can serve as a basis for legislation controlling glare sources.

Scope

Measure sources of glare designated by citizen complaint and visual evaluation by Department personnel. Determine driver task and determine luminance and luminance contrast necessary to perform the task. Develop criteria for specifying vision performance. Evaluate brightness of acceptable light sources. Propose basis for legislative control.

Progress Past Year

A preliminary report on nine major glare sites was prepared.

Planned Program for Coming Year

Continue development of quantitative criteria for evaluating impact on driver vision of various types of glare sources. Evaluate glare complaints as complaints are received.

Title

68 G-163 - Delineator Condition Survey

Purpose

To determine type and possible cause of delineator failure in the field by periodic observations of representative delineators.

Scope

Observe delineator condition periodically on approximately 5,000 delineators on both urban and rural roadways in all counties in the lower peninsula. Record installation characteristics or parameters.

Progress Past Year

None.

Planned Program for Coming Year

Complete the project with a final report.

Title

73 G-196 - Experimental Tower Interchange Lighting (Federal Work Plans No. 21 and No. 31)

Purpose

To determine maintenance factors for tower lighting. To determine pavement illumination produced by tower lighting compared with design levels of pavement illumination, and with pavement illumination produced by conventional lighting. To determine disability veiling glare of tower interchange lighting (roadway lighting mounted in tower clusters at heights above 50 ft) compared with conventional low-mounted interchange lighting. To determine the need for underbridge lighting at interchanges. To determine the aesthetic value of tower lighting. To determine the value of tower lighting during inclement weather--fog, haze, sleet, snow, and rain.

Scope

Work Plan No. 31 of this project will evaluate the parameters of pavement illumination (illuminance) and brightness (luminance), and system disability glare in six interchanges in the Grand Rapids area before installation of tower lighting and after installation of tower lighting at six month intervals up to 2-1/2 years. Work Plan No. 21 will investigate pavement

illuminance and system glare for two interchanges in the Detroit metropolitan area after tower lighting installation. The project will provide design criteria to the Utilities Design Section.

Progress Past Year

Pavement luminance and system glare were recorded for the six Grand Rapids interchanges. Recorded illumination data were found unsatisfactory. We participated in inspection of the interchange with FHWA representatives.

Planned Program for Coming Year

Construct a digital data acquisition system for field use which will monitor four photocells mounted on each corner of the instrumentation van. Data to be collected with van traveling at 40 to 50 mph. Measure pavement illumination at six interchanges in Grand Rapids.

Title

57 E-15(2) - Sodium Chloride Stabilization - M 28 East of Bruce Crossing

Purpose

The objective in this project is to evaluate the effects of adding sodium chloride to a base course aggregate in a concentration much greater than is conventionally used and to compare salt-treated bases with untreated bases.

Scope

Sodium chloride in concentrations of 40 lb/ton of base course aggregate were used to stabilize two 1/2-mile test sections of a 24-ft bituminous paved roadway. Performance of these sections will be compared with that of alternating adjacent sections in which untreated aggregate is used in the base, and with sections constructed containing 12 lb/ton of salt, a concentration used as standard on the rest of this contract. Evaluation of the test sections will be made by field and laboratory compaction tests, laboratory measurement of base and subbase strength, frost susceptibility studies, and periodic rut depth measurements of the finished road surface over a five-year period.

Progress Past Year

Due to travel restriction and to the lack of change in conditions over the past three years, it was decided to omit measurements during 1976. Future tests will also be spaced at greater intervals. There were no visible changes in any of the test sections.

Planned Program for Coming Year

Fifth year measurements and analysis of rut depth changes will be made and a short progress report prepared. The scheduling and scope of future measurements will be decided at this time.

Title

68 E-42 - Evaluation of Component Layers in Bituminous Pavement Design

Purpose

To develop comparative thickness equivalency factors for asphalt-treated and untreated aggregate base course layers. A secondary purpose is to provide knowledge needed to develop rationally based design procedures.

Scope

Implementation of a laboratory testing procedure for determining rheologic properties of each pavement layer. Develop computer capability for stress strain analysis of five or more layer systems. Determine rheologic properties of typical materials used in Michigan for constructing pavements. Develop theoretical equivalencies, based on AASHTO failure criteria, of base course materials, i.e., bituminous stabilized and gravels. The final phase will be verification of theoretical equivalencies developed by this study.

Progress Past Year

A study of our data, in comparison with results obtained by others, indicates that our quasi-elastic modulus testing techniques, used to measure the properties of flexible pavement materials, may not accurately simulate traffic loading conditions, particularly where applied to asphalt treated layers.

A theoretical equivalency study was completed, using the Chevron five-layer computer program, in which the resilient moduli values used were those obtained from the literature rather than from our own laboratory tests. A report of this study has been completed and is in the hands of the printer.

The repetitive loading tests of the MSU Soil Support project have not developed sufficiently, so far, to be of use in this project.

A detailed condition survey was made of the black base and aggregate base test sections of I 75 and an updated report on their relative condition is being prepared.

Planned Program for Coming Year

Publish and distribute Research Report, "Thickness Equivalencies for Asphalt-Treated and Untreated Aggregate Base Course Layers."

Prepare report concerning the present conditions of the I 75 test sections.

The third phase of this project, development of a correlation between Benkelman Beam data and theoretical analysis results, will be emphasized. Because Benkelman Beam results are derived from static loading and the resilient modulus values are based on cyclic loadings, relating the two may be a difficult task. Preliminary study will be made to determine the required scope of such a project before getting too deeply involved.

Title

68 E-43 - Evaluation of Open-Hearth Slag

Purpose

To determine the feasibility of using open-hearth and basic oxygen slags for base and subbase aggregates; specifically, to develop specifications and inspection testing procedures to assure adequate quality.

Scope

The project will require a review of all available information concerning existing projects constructed with these materials. Tests will be performed attempting to correlate heaving with particle size gradation, chemical composition (especially lime content), moisture absorption, and freezing. Where possible, these characteristics will be studied at particular locations before and after heaving.

Progress Past Year

The riding quality of the comparative test sections of I 75 were measured again with the rapid travel profilometer. This completes the series of planned measurements.

Planned Program for Coming Year

A final project report will be prepared as soon as the rapid travel profilometer information obtained during 1976 has been analyzed. The project will then be completed.

Title

71 E-49 - Development of Soil Support Values and Coefficients of Relative Strength of Michigan Highway Soils

Purpose

To develop a method for calculating the soil support values of subgrade soils used in Michigan and use the method for assigning typical values to

soil groups, enabling the Department to more fully implement the AASHTO Interim Guide for the Design of Flexible Pavements. In addition, to develop a method to calculate strength coefficients of Michigan pavement materials.

Scope

Originally the project was to be conducted in the laboratories of the Research Laboratory using triaxial tests developed for the equivalency studies under Research Project 68 E-42. During 1975, however, the project was expanded, through a contract with Michigan State University, to develop additional testing methods and procedures for relating soil support values to measured soil properties. The laboratory results will be correlated with field test site data to check the method developed for calculating soil support values. Tests will include cyclic triaxial, conventional triaxial and CBR, using cohesionless soils, supplemented by tests to determine the behavior of asphalt concrete, base and subbase materials under repeated loading. An in-depth study of existing multilayer elastic solutions and finite element techniques will be made to determine the test best suited for meeting project objectives.

Progress Past Year

MSU has completed background investigations of the test method to be used to measure soil properties and of the AASHTO design method. The test method background investigation has been summarized into a report that is now ready for publication. MSU has also developed a procedure for establishing soil support values which includes laboratory testing of samples from selected field test sites. Two of the four test sites to be utilized for this study have been sampled. The remaining sites are to be sampled next spring. Laboratory testing of the samples collected has two phases, 1) the Research Laboratory will test field collected samples using standard department procedures, 2) MSU will test the samples using resilient modulus and other test techniques. About 1/3 of the laboratory testing to be conducted by the Research Laboratory has been completed. MSU has devoted all of their laboratory time to the development of cyclic load test equipment and are presently working on the test method.

Planned Program for Coming Year

MSU is scheduled to complete this project by December 1977 at which time a report will be furnished the Department. The extent of any disruption and delays to the project, due to the departure of Dr. Vinson, is not known at this time.

Title

72 E-50 - Shoulder Drains in Reinforced Shoulders

Purpose

To evaluate the effectiveness of improved subbase drainage as a measure of preventing heaving of concrete base shoulders.

Scope

Concrete base shoulders with and without supplemental shoulder drains were investigated.

Progress Past Year

Due to the higher priority of other projects the final report on this study could not be completed. All data have been assembled and the report is about 90 percent completed.

Planned Program for Coming Year

The final report will be completed and distributed.

Title

*73 E-51 - Tranverse Cracking of Flexible Pavements

Purpose

To determine if the model, developed by Hajek and Haas, for predicting transverse cracking frequency is reliable for use in Michigan; and if necessary, revise the model to improve its accuracy. If the model is found not reliable, to make appropriate recommendations based on project findings.

Scope

To determine the actual frequency of occurrence of transverse cracks of flexible pavements located throughout Michigan and compare these results with crack frequency predicted by the model. In addition, to perform a laboratory study of actual bituminous stiffness in a section of pavement observed to have widely varying transverse cracking frequency but whose predicted cracking frequency is a constant.

Progress Past Year

The final report of this HP&R project was completed and approved by the FHWA. However, the FHWA inquired as to how the Department planned to implement the findings. A Departmental committee was appointed to study the request.

Planned Program for Coming Year

The committee formed to determine how best to use the findings of this project will review the matter and make their recommendations.

Title

74 E-53 - Development of a Field Permeability Test

Purpose

To develop a reliable field permeability test, easy to use in the field, and comparable to, for example, the standard density test in speed and simplicity of operation.

Scope

Limited to development of such a field test and its evaluation through trial field use.

Progress Past Year

A report of the project findings was published and a committee, consisting of Design, Construction, and Testing and Research personnel, established to determine the suitability of the proposed drainability testing procedure to construction conditions. The committee decided to evaluate the test method on a field construction project. A special provision for constructing experimental subbase drains has been prepared to be included in a selected contract. In addition, instructions for inspecting personnel have been prepared for accepting or rejecting subgrade or subbase material and for placement of supplemental subbase drains.

Planned Program for Coming Year

Utilize the field test method and equipment on a construction project and from the reaction of the committee make recommendations for further action.

Title

75 E-54 - Use of Low Density Concrete as a Light Fill Material for Bridge Abutment (Work Plan No. 42)

Purpose

To determine the performance of a lightweight cellular (low density) concrete as a fill material to prevent further vertical movement in the area around a bridge abutment.

Scope

Approximately 3,500 cu yd of low density concrete will be used to replace a portion of the existing backfill material for the east abutment of this bridge structure. Annual visual and instrument surveys will be conducted to observe performance.

Progress Past Year

During the year a second low density concrete "Elastizell" fill installation, located on M 29 at the Pine River bridge in St. Clair, was added to the study, which originally included only the Waiska River site. Both fills, totaling 5,500 cu yd of low density concrete, were constructed with the technical assistance of Research Laboratory personnel. During construction it was found that changes in specifications and inspection procedures are necessary. Field collected samples have been tested in our laboratory and the data analyzed. Each site has been instrumented for observing horizontal and vertical abutment and pavement movement. However, additional monuments will have to be placed at the Waiska River site next spring.

Planned Program for Coming Year

Place required additional reference monuments at the Waiska River site.

Publish a construction report of the project and conduct annual instrument readings.

Title

75 E-55 - Evaluation of Cold-Mix Emulsion Black Base at the Secondary Complex

Purpose

To determine the handling, construction and performance of a cold-mix black base in relationship to conventional black base construction.

Scope

A cold-mix base will be included as part of a black base construction using normal construction procedures so that a performance evaluation can be made under typical traffic and environmental conditions.

Progress Past Year

Construction of the experimental test section was completed. A re-

port describing construction procedures and presenting test data has been completed and is being reviewed.

Planned Program for Coming Year

A construction report will be published. Periodic observations of field performance of the test sections will be made.

Title

75 E-56 - Subbase Drainage Criteria and Supplementary Drainage Design for Michigan Highways

Purpose

To investigate and calculate the time required for the subbase drainage. To investigate the best location of supplementary drains as well as their sizes.

Scope

Using Darcy's Law and the concept of effective porosity to develop approximate theoretical analysis for subbase drainage. Different subbase cross-sections for various Michigan pavements are investigated and the minimum required material characteristic factors, k/ne, are calculated by this analysis method. Using program Darcy, a finite element computer program, to determine the quantity of flow for supplementary drains at various locations for different subbase cross-sections.

Progress Past Year

Investigation was completed and a final report published.

Title

75 E-57 - Evaluation of Particle Index for Measuring the Influence of the Coarse Aggregate Fraction on Stability of Granular Mixtures

Purpose

To investigate the practical significance of being able to measure the geometric properties of the coarse aggregate fraction (+ No. 4 sieve) of granular materials, and an attempt will be made to establish how significant are the influences of geometric properties on stability compared to the influence exerted by gradation and density.

Scope

The study is limited to literature review and supplemental laboratory study sufficient to indicate the potential of the Particle Index Test as a means of measuring geometric properties. To minimize variables in this study only the -1 in. + No. 4 sieve size fraction will be studied.

Progress Past Year

The final report of this project was substantially completed and should be ready for publication during the first quarter of 1977.

Planned Program for Coming Year

Complete and publish the final report for this project.

Title

75 E-58 - Relationship Between Pavement Performance and Subsurface Drainage Conditions

Purpose

To determine if the subsurface drainage condition of a flexible pavement's foundation can be related to pavement performance characteristics.

Scope

Test sites are limited to the flexible pavement portion of US 27 and I 75 where traffic volumes and pavement design are very uniform but performance varies from excellent to poor. The study is preliminary in nature, intended to provide a basis for future study of flexible pavement performance and its relationship with the engineering properties of its several layers.

Progress Past Year

Due to the pressure of higher priority projects work on the project was deferred.

Planned Program for Coming Year

This project should be completed and reported during 1977.

Title

75 E-59 - Comparative Study on Performance of Bituminous Stabilized Bases (M 66 and M 20)

Purpose

To determine if there is any significant difference in the strength of the two base designs - aggregate base for M 20 and bituminous stabilized base for M 66.

Scope

Benkelman Beam measurements will be conducted on comparable sites of these two pavements. Comparison of the strength of the two base layers is to be made based on the life expectancy of the pavements as calculated from the surface deflection data.

Progress Past Year

The first year field measurements were made and the data analysis completed. A progress report was prepared and is now being reviewed.

Planned Program for Coming Year

Publish progress report. No measurements are scheduled until 1978.

Title

75 E-60 - Use of Frost Depth Indicators and Benkelman Beams to Determine When Load Restrictions Should be Lifted

Purpose

Research will be conducted in District 1 to formalize procedures for applying and lifting weight restrictions based on information provided by frost depth indicators. In addition, this study will also provide a procedure for approving overload requests based on Benkelman Beam deflection. The procedures developed in this study would be applicable statewide.

Scope

The project will include study of up to 12 one-mile long sites in which frost depth, pavement surface deflection, climatological data and pavement foundation conditions will be utilized to achieve the project's purpose.

Progress Past Year

All frost indicators were modified to improve readability and additional indicators were installed.

Seasonal Benkelman Beam deflection measurements were made and the soil surveys were completed.

Planned Program for Coming Year

Periodic frost depth and Benkelman Beam readings will be continued, soil samples will be tested in the laboratory and a preliminary report of initial findings will be prepared.

Title

68 D-26 - Evaluation of Nuclear Methods for Asphalt Testing

Purpose

The purpose of this work plan is to outline procedures for continuing the study with the added provision for evaluating nuclear soil gages as well as a nuclear gage manufactured specifically for measuring the asphalt content of bituminous mixtures.

Scope

This study will consist of laboratory and field evaluation of both a Troxler Model 2226 Asphalt Content Gage and a Troxler Model 2401 Soil Density-Moisture Gage which may also be suitable for measuring asphalt content. The Model 2226 Asphalt Content Gage will be evaluated for accuracy and adaptability to job control by the Bituminous Technical Service Unit of the Testing Laboratory, in accordance with the work plan they have prepared which includes a preliminary study of the accuracy and precision of the instrument, followed by field evaluation on selected paving projects.

Progress Past Year

Experimental end-result compaction testing of selected projects was completed and data obtained from both the Testing Laboratory and the Soils-Density Unit. Time has not permitted an analysis of the data.

Planned Program for Coming Year

Data gathered during this study will be completed and analyzed and a report prepared concerning the use of nuclear methods for asphalt content measurement and bituminous compaction testing.

Title

72 D-27 - Evaluation of Cold-Mix Black Base Construction

Purpose

To determine the handling, construction and performance of a cold-mix black base in relationship to conventional black base construction.

Scope

A cold-mix base will be included as part of a black base construction using normal construction procedures so that a performance comparison can be made under nearly equivalent conditions.

Progress Past Year

Final inspection of the test sections were made with no signs of distress showing in the experimental section. The final report on this project is in preparation, and is about 60 percent complete.

Planned Program for Coming Year

Project will be completed with the publication of the final report.

Title

74 D-29 - Sulfur-Asphalt

Purpose

The purpose of this experimental construction project is to evaluate the feasibility of using sulfur-asphalt mixtures for resurfacing highways.

Scope

Test sections will be constructed as part of a 1976 resurfacing contract on M 18 in Gladwin County (Mb 26011, 11032A). A process of blending hot liquid elemental sulfur with hot asphalt cement to form a sulfur-asphalt (S/A), binder has been developed by Gulf Oil Canada Ltd. and will be used to prepare paving mixtures for this project. Two different sulfur to asphalt ratios and two sulfur-asphalt binder levels will be compared with adjacent sections of the same road which will be paved with a conventional mixture.

Progress Past Year

A work plan has been prepared, a project selected and the contract is scheduled for bidding in February 1977.

Planned Program for Coming Year

Construction is scheduled for the 1977 season. Preconstruction mix design testing, on-the-job testing and construction observations will be performed. A construction report will be prepared.

Title

75 D-30 - Recycling of Asphalt Pavement

Purpose

The objective of this study is to evaluate the overall applicability and effectiveness of this specific recycling technique for rehabilitation of flexible pavements characterized by extensive cracking and roughness.

Scope

Altogether, 31 miles of I 75 freeway is to be rehabilitated in Otsego and Cheboygan Counties. Of this mileage, 11 miles of northbound roadway is to be recycled by mixed-in-place stabilization procedures, and will involve pulverizing, blending and compacting 254,000 sq yd of shoulder base and pavement materials.

Progress Past Year

Construction plans and specifications have been completed, Federal-Aid Interstate funding approved and application for FHWA demonstration funds has been submitted. The contract is scheduled for bidding in January 1977.

Planned Program for Coming Year

Experimental construction involving field tests and observations will be completed. A report describing construction procedures will be prepared.

Title

75 D-32 - Reclaimed Rubber-Asphalt

Purpose

To evaluate the benefits of reclaimed ground rubber when included in asphalt paving mixtures with emphasis on the reduction of reflective cracking on resurfacing projects.

Scope

The study will involve laboratory tests of engineering properties for several mixtures and a field test road incorporating different thicknesses and mix proportions.

Progress Past Year

A work plan was prepared and an experimental project selected. Construction was postponed, however, until 1977.

Planned Program for Coming Year

Experimental test sections will be constructed.

Title

72 F-125 - Mixed-In-Place Stabilization

Purpose

The purpose of this study is to prepare guidelines and specifications for mixed-in-place construction of bituminous stabilized soils and aggregates with provision for reclamation of existing materials.

Scope

This study will consist of a literature study, laboratory testing, and a review of construction experience within the state. Literature will be reviewed in order to compile guidelines for the selection of materials (both soils and asphalts), appropriate test methods, specifications, construction equipment and methods. A laboratory testing program will be conducted to determine appropriate mix design and construction control tests. The relationship between mix designs based on stability and field tests of density will be determined so that existing conventional soil compaction inspection methods may be utilized as much as possible. Wherever possible, construction experience will be compared with the compiled information as a check on its appropriateness for Michigan conditions. The study will be initially limited to gravels and sands, either pit-run or processed and include pulverized bituminous mixtures.

Progress Past Year

This project was expanded to include in-place strength comparisons of bases stabilized with emulsions, cutbacks, and asphalt cements. These tests were completed, data analyzed, and the results are being included in

the final report which is now 90 percent complete (review draft has been completed).

Planned Program for Coming Year

Final report will be completed.

Title

75 G-215 - Pavement Feedback System

Purpose

To establish a computerized, retrievable compilation of historical data and updated information on existing pavement systems for use in shaping decisions affecting optimum utilization of highway materials, overlays, upgrading.

Scope

For the present, the system will consist of information obtained on two sections of I 75 from the Oakland-Genesee Co. Line to Bridgeport. Eventually, the system should include 80 to 90 percent of the state trunkline system.

Progress Past Year

Formats for the primary, or historical, file have been set up and reviewed.

Performance factors for the secondary file have been compiled, some of these coming from the SAMP 6 requirements (see Research Project 76 G-221).

Planned Program for Coming Year

Write and test the retrieval programs for the secondary file and combine them with those for the historical file to complete the study on the I 75 sections. Then, extend applicability to other pavement sections to be chosen in consultation with the Soils and Materials Section.

Title

75 G-216 - Evaluation of Prewetted Salt for Ice Control

Purpose

The purpose of this investigation is to evaluate the effectiveness of the method with respect to efficiency and overall economy in ice control application of rock salt.

Scope

The Research Laboratory will make observations on both normal and prewetted sodium chloride ice control applications during the 1975-76 season. These observations will include the calibration of spreading equipment, testing the pattern of spread on the road, and its melting effectiveness during actual storm applications. Such observation will be made on both conventional and prewetted operations.

Progress Past Year

Field observations were made during the 1975-76 winter season. No conclusions could be reached from these tests as to whether there was any advantage in favor of using prewetted salt as compared with the normal application. Preparation of a report on this work has been delayed due to higher priority projects.

Planned Program for Coming Year

A report of the comparative studies will be prepared. Unless specifically requested by Maintenance, no further work on this project is planned.

Title

76 G-221 - Investigating the Feasibility of Implementing Samples in Michigan Flexible Pavement Design

Purpose

To determine if the model for systems analysis of pavements developed in Texas for NCHRP Project 1-10 is applicable to Michigan flexible design methods.

Scope

Since the results of model calculations are summarized as feasible designs in order of increasing total cost (initial construction, maintenance, overlays, etc. less salvage value), the sensitivity of total cost to variations in soil support value, asphalt layer strength coefficient, percent commercial vehicles, estimated number of 18-kip equivalents of traffic load per

thousand commercial vehicles, and other governing parameters, will be analyzed. Input for the sample problem accompanying the model will be used for testing sensitivity during the first phase, then parallel procedures will be applied to chosen sections of existing flexible pavements in Michigan during the second phase.

Progress Past Year

We developed a testing version of the computer model SAMP 6, and simplified run procedures. Wider choice on the part of the user of reports obtainable directly from the remote unit was developed. The computer data for analyzing the effect of varying the value of percent commercial vehicles have been compiled from multiple runs (approximately 1,400 so far) and have been tabulated, and examined.

Planned Program for Coming Year

Continue the analyses of effects of the other determinant parameters and report significant findings on the analyses.

Title

72 G-190 - Improvement of Techniques for Handling Experimental Data

Purpose

To develop continually improved data processing techniques (programming and hardware) for the laboratory.

Scope

This is a continuing project to design and develop programs or construct instruments for all Laboratory units.

Progress Past Year

1) Development of a process to produce high quality printed circuit boards for use in instruments constructed at the Laboratory. 2) Development of photocell data acquisition system for luminaire testing. 3) Development of a computer program to convert raw data obtained from luminaire photometric testing and place this information in a form acceptable to the Departments B7700 computer. 4) Design and construction of input-output interface for the PDP 8/e computer to provide for x-y plotting and analog data.

Planned Program for Coming Year

Develop the hardware and computer programs required to program read-only-memories. These memories will be used in a control system for a second air pollution data acquisition system.

Title

72 G-189 - Sources and Effects of Environmental Noise

Purpose

To investigate the various sources of transportation related noise and to determine their effects upon the environment.

Scope

This is a continuing research project which is intended to consist of a series of investigations into the varied aspects of vehicle-generated noise.

Progress Past Year

Study has been completed on peak noise levels generated by various types of highway vehicles as they pass by a monitoring station. Measurements have been conducted at several sites in order to ascertain the effects of various roadway surfaces and grades. The resulting data base will provide information for setting limits in vehicle noise legislation in Michigan.

A verification project has been initiated to verify our capability of predicting noise levels at sites very near to at-grade roadways carrying low volume traffic (i.e., certain service drives, city arterials, or county roads).

Planned Program for Coming Year

Completion of the vehicle pass-by peak noise level survey report is expected during 1977.

Noise model verification is scheduled for completion during 1977.

Title

75 G-211 - Noise Level Inventory of Michigan Freeways

Purpose

To provide an inventory of the existing noise levels along all Michigan freeways. The resulting data base will provide the information necessary to determine the priorities of noise abatement projects along our freeways.

Scope

To catalog and rank the noise levels and respective land use categories in existence along all Michigan limited-access freeways.

Progress Past Year

Research Report R-1013 completed and Report R-1013A is due to be sent to the printer shortly.

Planned Program for Coming Year

In several years, these reports will be updated to reflect new roadways and new traffic data.

In addition, we have been directed to separate those ranked residential sites which predate the highway contract award date from those which were developed later.

Title

75 G-217 - Maintenance of Neoprene Sealed Concrete Pavements

Purpose

To develop a maintenance procedure for concrete pavements sealed with neoprene seals.

Scope

The project consists of maintaining a several mile long section on I 69 in Calhoun County by utilizing new materials, methods, and equipment. It is a continuing project where new developments in concrete pavement maintenance can be applied and evaluated.

Progress Past Year

A short section (3/4 mile) of pavement was repaired. Pavement spalls were repaired with three types of mortar each capable of supporting traffic after a few hours cure. Malfunctioning seals were removed and replaced with new ones. An inspection procedure guideline was developed and an initial survey of the entire project was made.

Planned Program for Coming Year

Repair of spalled joints and replacement of failed seals will continue. A second survey of the entire section length will be made. Evaluation of the 1976 repairs will be made.

Title

57 F-76 - Continuously Reinforced Test Project, I 96, M 66 to Portland

Purpose

To study durability, construction efficiency, and costs as compared to standard jointed pavement practice.

Scope

The test pavement consists of approximately a four-mile long portion of I 96. It is composed of four distinct parts: continuously reinforced sections with deformed bar mat, continuously reinforced sections with welded wire mesh, a standard section with contraction joints spaced at 99 ft, and relief sections at the ends of the continuously reinforced sections.

Progress Past Year

Measurements on joint widths in the relief sections, on crack widths in the continuously reinforced sections, and on construction joint widths were taken on a semi-annual basis. Visual observations of the general conditions of the pavement were made periodically. Request for FAI funds for rehabilitation of the mesh reinforced section was denied by the FHWA. Funds for repairs under the FHWA 3-R program have been requested.

Planned Program for Coming Year

Measurements and observations of the performance of the pavement will be continued. If 3-R funds are approved the mesh reinforced section will be repaired with concrete repairs.

Title

61 F-64 - Continuously Reinforced Concrete Pavement No. 2, I 96, Phillips Rd to Meridian Rd

Purpose

To determine end movements of anchorage and crack openings at transverse cracks.

Scope

The test pavement consists of approximately six miles of mesh reinforced pavement on the eastbound roadway and an equal length of bar mat reinforced pavement on the westbound roadway. The ends of the continuously reinforced sections are anchored with lugs.

Progress Past Year

Semi-annual measurements on movements at end anchors and at crack openings were taken on the bar mat reinforced section. The mesh reinforced section has failed in continuity at close to 100 locations. Visual inspections of the failures and of the general condition of the pavement were

made periodically. FAI funds for rehabilitation of the eastbound roadway were requested but this was denied. Repairs have been made at severely deteriorated locations by Maintenance forces.

Planned Program for Coming Year

The movements at end anchors and at selected cracks will continue on the bar mat reinforced section.

Title

61 F-64(1) - Continuously Reinforced Pavement (Seaway Freeway - Fisher Freeway)

Purpose

To establish design considerations for use on continuously reinforced pavements in metropolitan freeway locations. To handle problems during construction, to follow performance and to make recommendations for future construction.

Scope

This project includes all continuously reinforced pavements in the Detroit Metropolitan area constructed by using equipment riding on pavement forms. Various types of reinforcement were used and free ends were anchored or allowed to move at special constructed WF joints. A variety of construction joints were used.

Progress Past Year

The performance of the pavement was observed by conducting twice-a-year inspections. Special attention is given to detect signs of corrosion of the steel, wide cracks, spalls, and construction joint problems.

A special survey was conducted by Maintenance and Research personnel to determine location and area where repairs are needed. This information was transmitted to the Design Division for their use in preparing contracts for median barrier and repair work. Specifications covering repair of continuously reinforced pavement were written.

Planned Program for Coming Year

The twice-a-year inspections will be continued and appropriate recommendation concerning maintenance will be made if warranted.

Title

67 F-95 - Evaluation of Acme Load Transfer Devices

Purpose

To evaluate Acme assemblies with respect to load transfer capability, joint movement restraint, joint deterioration, and corrosion of load transfer unit. Also, to determine the feasibility of using a two-part dowel assembly in construction joints.

Scope

The test section is located on M 52 south of Owosso and consists of about one mile of pavement containing Acme assemblies and one mile of standard pavement with steel dowels used for comparison purposes. Eight construction joints contain the new type of dowel bar assembly.

Progress Past Year

Joint width measurements were taken on a summer-winter basis. Annual surveys of transverse crack formation and of joint deterioration were conducted.

Planned Program for Coming Year

Monitoring of joint width variations, crack formation, and joint deterioration will continue. Samples of dowel bars may possibly be removed for corrosion analysis.

Title

68 F-104 - Plastic Coated Dowels for Pavement Joints

Purpose

To evaluate plastic coated dowels with respect to load transfer capability, joint movement restraint, joint deterioration, and corrosion of dowel.

Scope

The test section is located on M 52 south of Owosso and consists of 10 consecutive joints containing plastic coated dowels manufactured by Republic Steel Corporation.

Progress Past Year

Semi-annual joint width measurements were taken and crack formation and joint deterioration surveys were conducted.

Planned Program for Coming Year

Monitoring of joint width variations, crack formation, and joint deterioration will continue. Samples of dowel bars may possibly be removed for corrosion analysis.

Title

70 F-118 - Development of Procedures for Replacing Joints in Concrete Pavements

Purpose

To develop procedures for replacement of distressed joints with permanent type repairs that can be opened to traffic within a few hours after installation.

Scope

A total of 100 lane repairs were made; 20 on westbound I 96 between Lowell exit and Thornapple River in Kent County; 40 on east I 96 also between Lowell exit and Thornapple River, and 40 on westbound temporary I 69 just west of the M 52 intersection in Shiawassee County. Various repair lengths, joint types, and both precast and cast-in-place repairs are included in the study.

Progress Past Year

Data on the following factors were obtained: changes in elevation between old and new slabs, changes in joint widths at the repairs, load deflection at leading joint of the repairs, and rocking of slabs caused by a moving load. A final report covering the five-year HPR phase of the study was written and is currently in review by the FHWA. The project will be continued under State funds for long term evaluation of the repairs performance.

Planned Program for Coming Year

Data collection on the above factors will continue.

Title

72 F-123 - Comparative Field Study of Joint Repair Techniques to Reduce Blowups

Purpose

To evaluate the merit of preventive maintenance of concrete pavements to eliminate blowups.

Scope

Approximately seven miles of US 127 between Mason and Leslie were selected for this project. The southbound roadway was pressure-relieved by installing precast slabs, cast-in-place repairs, or relief joints at selected locations. The northbound roadway is used as a control section.

Progress Past Year

Semi-annual measurements of relief joint movements were made. Annual inspections of joint spall deterioration on both roadways were conducted. Records on yearly blowups or full-depth repairs conducted on the northbound roadway were brought up to date.

Planned Program for Coming Year

Measurements of relief joint movements, inspection of joint deterioration, and blowup surveys will be continued. A progress report will be issued.

Title

73 F-129 - Evaluation of Slipform Paving Methods for CRCP

Purpose

To determine if concrete is adequately consolidated, to determine accuracy of steel placement, and to evaluate the overall performance of slipformed CRCP.

Scope

All slipformed CRC pavements in Metropolitan areas as well as in rural areas are included. Various consolidation methods, steel placement procedures, and reinforcement sizes have been used.

Planned Program for Coming Year

Continue periodic surveys to monitor the performance of this type of pavement. Also, continue to check on construction procedures when the need arises, and assist Design and Construction Divisions in preparing plans and specifications.

Title

75 F-143 - Evaluation of Various Types of Railroad Crossings

Purpose

To evaluate the performance of new crossing materials, to obtain information on construction procedures, and to determine the relative cost of each crossing type.

Scope

This is an open-ended Category 2 project. Initially, ten crossings and three new materials were included. Five new crossings and two new materials have been added since the study was initiated.

Progress Past Year

Three T-Core, two Steel Plank, two Track-Span, and one Saf and Dri crossings were constructed. Observation of construction procedures and evaluation surveys of completed crossings were made. A progress report was issued.

Planned Program for Coming Year

Observation of the construction of authorized crossings will be made and evaluation data obtained on new as well as on previous year's installations.

Title

74 F-140 - Maintenance Procedures to Prevent Blow-Up of Concrete Pavement Joints

Purpose

To develop procedures for preventive maintenance of concrete pavements to delay the occurrence of joint failure due to compressive stress, and to try to prevent joint blow-up.

Scope

Procedures for rating pavement joints and selecting locations for joint replacement or installation of pressure relief joints were developed. These concepts were applied on approximately 80 miles of divided highway. Pressure relief joints and adjacent joints and cracks were instrumented at 10 locations on I 696 and 16 locations on I 75.

Progress Past Year

Three projects totaling approximately 175 lane miles were submitted to Design for contract letting, these projects provide pressure relief in joint repairs. Two additional projects totaling approximately 85 lane miles were submitted for pressure relief joints. Performance surveys were conducted on past projects.

Planned Program for Coming Year

Two projects have already been submitted, totaling approximately 200 lane miles, for pressure relief joint installation. Surveys will continue to be conducted to evaluate the performance of all preventive maintenance projects.

Title

75 F-148 - Pavement Roughness for Non-Reinforced Ramps and Service Roads

Purpose

Compare riding quality of non-reinforced pavements with pavements which are reinforced.

Scope

Ramps and service roads are now being constructed of short length non-reinforced concrete slabs. A sample of these will be selected and measured for riding quality.

Progress Past Year

Project just established.

Planned Program for Coming Year

Select pavements for evaluation, measure their riding quality, and make a comparison of reinforced vs. non-reinforced construction.

Title

69 F-111 - Construction and Performance Evaluation of Mixed-In-Place Bituminous Stabilized Shoulder

Purpose

To evaluate the use of different bituminous materials for mixed-in-place stabilization of existing shoulders.

Scope

Five different bituminous materials were used to stabilize about 42 linear miles of shoulder on I 75 near Flint.

Progress Past Year

Shoulders were inspected.

Planned Program for Coming Year

Survey shoulders and write final report.

Title

65 F-82 - The Effects of Safety Studded Tires on Pavement Surfaces

Purpose

To evaluate the effects on pavement of studded tires.

Scope

Measurements are made of ruts woven in pavements throughout the state. Accident data related to tire studs have been analyzed, annual surveys of stud use are made, and legislation was developed regulating the use of studs.

Progress Past Year

Annual stud use surveys and pavement rut depth measurements were made. A proposed amendment to the law regulating stud use was prepared.

Planned Program for Coming Year

Evaluate new studs for compliance with pavement wear rules.

Title

39 F-7(14) - Performance of Postwar Pavements (Concrete Pavement Design)

Purpose

To evaluate the performance of concrete pavements built subsequent to World War II and recommend changes in design or construction practices where warranted.

Scope

The entire trunkline system of concrete pavements constructed after World War II are condition surveyed and used as sources of data for evaluating performance.

Progress Past Year

Condition surveys were made of pavements scheduled for such.

Planned Program for Coming Year

Continue surveys, investigate and report on problems of particular interest.

Title

69 F-105 - Effects of Transverse Saw Cutting PCCP on Reflection Cracking

Purpose

To evaluate the effectiveness of saw cutting concrete pavements prior to resurfacing in reducing reflection cracking in the overlay.

Scope

Two test sites are suggested, one in the north and one in the south, each with replicate sections of varying saw cut intervals and thickness of stabilized lift.

Progress Past Year

Work plan was revised to require a smaller test area.

Planned Program for Coming Year

Refer to Engineering Operations Committee for selection of test sites.

Title

74 F-137 - Performance of Pavement - 7-in. Plain Concrete with 6-in. Pozzolanic Base (Work Plan No. 35)

Purpose

Evaluate performance of pozzolanic (slagcrete) base course for concrete pavement.

Scope

Pavements were designed and constructed by Oakland County. We observed construction and will conduct condition and profile surveys to evaluate performance.

Progress Past Year

Project completed. Slagcrete strength was much too variable for use.

Planned Program for Coming Year

Write report to complete project.

Title

75 F-142 - Predesign Evaluation of Pavement Serviceability

Purpose

Provide "Pavement Serviceability Index" for pavements as requested.

Scope

Compute "PSI" of a pavement based on roughness and condition surveys.

Progress Past Year

None requested.

Planned Program for Coming Year

Respond to requests as received.

Title

74 F-138 - Review of Special Permits for Overloaded Vehicles

Purpose

Structurally analyze the affects of overloads on pavements to determine whether a special permit should be given for moving such overloads.

Scope

Requires an engineering analysis of stresses induced in the pavement system by extreme loads.

Progress Past Year

None requested.

Planned Program for Coming Year

Requests will be responded to as they come in.

Title

75 F-147 - Pavement Riding Quality

Purpose

Conduct surveys with the Rapid Travel Profilometer to measure the roughness or riding quality of Michigan pavements.

Scope

Conduct surveys and report results on all new construction and on past construction at 5, 10, 15 and 20 year service levels.

Progress Past Year

4,400 lane miles of concrete, bituminous, and overlays were tested and data are on tape to be processed.

Planned Program for Coming Year

Continue with established survey procedures.

Title

70 F-114 - Broomed Concrete Pavement Surfaces

Purpose

Develop, construct, and evaluate new methods of texturing new concrete pavements.

Scope

Develop or procure equipment for texturing concrete pavements during construction. Evaluate performance of the treated surface.

Progress Past Year

Experimental textured sections were tested with the Department's skid vehicle.

Planned Program for Coming Year

Continue observing and testing experimental textures. Try new textures as they are conceived.

Title

75 F-145 - Rehabilitation of Old Concrete Pavement

Purpose

To determine the most feasible and economical way of recycling and rehabilitating old reinforced, concrete pavement located on US 2, Mackinac County.

Scope

Literature search and review in the areas related to concrete sawing, breaking and crushing and handling mesh-reinforced concrete slabs in place; also in the areas related to the characteristics of crushed concrete as aggregate material for recycling at job sites.

Progress Past Year

Portion of available information reviewed. Recycling of concrete does not appear to be practical at this time.

Planned Program for Coming Year

Close project.

Title

*69 G-173 - Determination and Improvement of Relevant Pavement Skid Coefficients

Purpose

To investigate various factors affecting skid resistance and to develop means for improving skid resistance.

Scope

Using a new skid test unit obtained for this project, effects on skid resistance of rain, season, temperature, speed, etc. are being investigated.

Progress Past Year

Completed rough draft of final report and submitted it to the FHWA for review and approval.

Planned Program for Coming Year

Publish final report.

Title

54 G-74 - Survey of Skid Resistance of MDSHT Surfaces

Purpose

To conduct a program of skid testing, interpretation, and research.

Scope

A systematic program of skid testing Michigan's trunkline system throughout its service life is being conducted. Data from the program are used to locate slippery areas, evaluate surface textures, and study materials.

Progress Past Year

About 12,000 skid tests were made throughout the state.

Planned Program for Coming Year

Continue skid testing program.

Title

54 G-74(5) - High Accident Areas (for Traffic Research) (Survey of Skid Resistance of MDSHT Surfaces)

Purpose

To skid test areas where accidents on wet surfaces are disproportionately high.

Scope

All areas on the state trunkline system are under observation.

Progress Past Year

About 400 skid tests were made and reported on.

Planned Program for Coming Year

Continue program.

Title

74 G-209 - Investigation of Truck Litter Problem

Purpose

Document problem of highway litter from uncovered trucks to initiate legislative action for a bill requiring the covering of loads.

Scope

Initial plans involved several means of quantifying the type and amounts of material deposited along the roadways by uncovered trucks.

Progress Past Year

Bill passed requiring covering of trucks. Project completed.

Title

73 G-203 - Experimental Evaluation of Extended Establishment Period for Freeway Landscape Projects

Purpose

To evaluate the results of extending the establishment period to two summer growing seasons following the completion of planting.

Scope

To assist the Roadside Development Section in evaluating the relative performance of two adjacent landscape projects (a conventional, one-growing season to be compared with an experimental, two-growing season); provide assistance for analyzing plant care work and interpreting maintenance cost records required for both experimental and control projects.

Progress Past Year

Observations continued through the year.

Planned Program for Coming Year

Conclude evaluation of field results and maintenance cost records; write a final report on this project.

Title

75 G-212 - No-Discharge Recirculating Sewage System for Freeway Rest Areas

Purpose

To evaluate Chrysler Recirculating Sewage System for use at rest areas.

Scope

To cooperate and participate in the proposed experimental installation of a Chrysler Aqua-Sans Recirculating Sewage System for the I 275 rest area (southbound) 58171, north of Monroe.

Progress Past Year

Approval of installation granted.

Planned Program for Coming Year

Install and observe system.

Title

74 G-207 - Sewage Treatment Systems at Freeway Rest Areas

Purpose

To develop methods of upgrading rest area sewage treatment systems to meet land treatment, disposal, and water control regulations.

Scope

To follow-up the development of this research project assigned to Michigan State University personnel.

Progress Past Year

Five experimental sites selected for groundwater monitoring test well borings and cross-section plots for Sites No. 1 and 2 submitted to the Michigan Department of Natural Resources as standard procedure.

Planned Program for Coming Year

Waiting for further development of the proposed project.

Title

75 G-213 - Erosion Control and Turf Establishment on Roadside Slopes

Purpose

To assess the relative performance of three methods for turf establishment and erosion control under field conditions.

Scope

To provide assistance for evaluating the comparative performance of these methods; for determining the most feasible and economical way of controlling erosion; and for establishing roadside turf on selected projects.

Progress Past Year

Proposal submitted, discussed and revised.

Planned Program for Coming Year

Waiting for further development of the proposed project.

Title

75 C-16 - Performance Evaluation of Trinidad Asphalt Cement for Bituminous Pavement

Purpose

To assess the relative performance of Trinidad Asphalt cement compared with conventional 85-100 penetration grade asphalt in bituminous concrete mixtures.

Scope

To compare the qualities and properties of the asphalt concrete mixes and their service performance under traffic and weather conditions at an experimental site covering 4.9 miles of four-lane divided highway; compile and analyze field data in terms of surface compaction, skid resistance, riding quality, and surface durability in resisting long-term cracking, deformation, and other pavement failures; discuss construction problems if any; and compile and compare construction costs.

Progress Past Year

Interim report prepared and published.

Planned Program for Coming Year

Continue seasonal surveys and field inspections of the experimental project until the resurfaced area is old enough for comparative evaluation; write subsequent progress reports as needed.

Title

72 C-14 - An Evaluation of Mastic-Type Paving Mixtures for Resurfacing a Roadway and a Bridge Deck

Purpose

To determine whether mastic-type paving mixes could be successfully placed without using special construction equipment. Then to evaluate the performance of the mastic surfaces.

Scope

Two different mastic-type surfaces were placed on a length of US 31 pavement south of Ludington and one of the mastic mixes was placed as part of a waterproof deck surface on a bridge on US 31. The two mastic mixes are known as Gussasphalt and Mastiphalt.

Progress Past Year

The surfaces were inspected, skid measurements were made, and the bridge deck was tested for permeability.

Planned Program for Coming Year

Inspect surfaces, and make skid measurements. Prepare report.

Title

68 F-101 - Experimental Concrete and Bituminous Shoulders (Experimental Work Plan No. 4)

Purpose

To determine the relative costs and performance of the experimental shoulder designs.

Scope

An experimental portland cement concrete shoulder design, two experimental bituminous shoulder designs, and the standard (1970) shoulder for Interstate construction were installed in a test area on a rural freeway. Three sections, approximately 1/2-mile in length, of each type, were built. Only the outside shoulders were included in the experiment.

Progress Past Year

A progress report was issued during the first quarter. Winter and summer readings were completed and the yearly condition survey was made. Since this is a long term evaluation, no other work was required. Data are kept tabulated and performance information is used in discussions pertaining to present design and construction practices. Additional problems were noted at expansion joints in the shoulders.

Planned Program for Coming Year

Make periodic evaluations as in the past. Condition is still quite good, so the project will last several more years.

Title

*70 F-103 - Galvanized Steel Reinforced Concrete Bridge Decks

Purpose

To determine the feasibility of using galvanized reinforcement in Michigan bridge deck construction, and to evaluate the effect of galvanized reinforcement on the performance of laboratory specimens and full scale bridge decks.

Scope

Twenty-nine test slabs 3 ft x 4 ft x 7-1/2 in. were cast in the Laboratory and subjected to outdoor exposure with periodic applications of salt. A 30 ft x 5 ft composite simulated deck section was cast in the field for similar treatment. One half of the bars in the top mat were galvanized and the other half plain. Clear cover over the bars, and concrete mix were varied. Five experimental bridge decks were built, and approximately one-half of the top mat of reinforcement was galvanized on each deck.

Progress Past Year

Weekly treatment of the field exposure slabs was continued through the sixth winter. Routine maintenance was done at the field exposure site. Field inspections, "corrosion-cell" readings and delamination detector surveys were completed on the five experimental decks. "Corrosion-cell" readings and condition surveys were completed on the field exposure specimens. All data were tabulated and records were brought up to date. Quarterly reports on the project were prepared for the FHWA. A status report was presented at an FHWA sponsored meeting at Penn State University in October. A progress report on the project has been written and is being printed.

Planned Program for Coming Year

Next year's work will be essentially the same as last year's. The project has been kept up to date and on schedule.

Title

70 F-113 - Experimental Concrete Pavement Ramps (Experimental Work Plan No. 7)

Purpose

To determine the relative cost and performance of experimental non-reinforced ramps.

Scope

Experimental unreinforced ramp pavements were built on two interchanges having considerable differences in projected traffic volumes. Thickness of the aggregate base course was increased to 6-in. to provide additional support for construction machinery and slight additional strength to the pavement system. Standard ramps were included for comparison.

Progress Past Year

A progress report was prepared for the FHWA, condition surveys, faulting and joint opening measurements, and profilometer surveys were completed, and all data were reduced and tabulated. Information derived from the project was used as background material in discussions pertaining to proposed changes in design and construction practice, and for the Clare test road.

Planned Program for Coming Year

Next year's work will closely follow that outlined above for the past year, as this is a long-range evaluation type project.

Title

70 F-116 - Experimental Joint Spacing Project (Work Plan No. 10)

Purpose

To determine the relative performance of the experimental pavement types.

Scope

Experimental pavements having 71-ft 2-in., 57-ft 3-in., and 43-ft 4-in. slab lengths, were installed in a test area on I 75 between M 55 and the Roscommon County line. All experimental joints have load transfer, with plastic coated bars. Sections of standard pavement with 71-ft 2 in., slabs and plain steel dowel bars are included for comparison. Joints are sealed with preformed neoprene seals. The weight of the reinforcing mats is the same in all slab lengths. No expansion joints were placed in experimental areas, except those at bridges. Experimental pavements have chamfered joint grooves.

Progress Past Year

A progress report was prepared for the FHWA. Condition and roughness surveys, summer and winter joint readings were recorded, and all data reduced and tabulated.

Planned Program for Coming Year

Next year's work will be very similar to the work outlined above for last year. This is a long-range evaluation, and deterioration has not yet begun in any consequential amount. Therefore, we expect several more years of observation before having sufficient information available to issue a final report.

Title

71 F-122 - Experimental Pressure Relief Joints, US 23 North of M 36

Purpose

To evaluate the performance of pressure relief joints placed at variable spacing.

Scope

Ten ethafoam pressure relief joints were placed, with spacing varied from approximately 400 to nearly 4,000 ft. Foam was placed in the joints without precompression, during the spring of the year. Joints were instrumented for measurement of closure.

Progress Past Year

Condition surveys were completed on the pressure relief area and the adjacent control section. Summer and winter joint readings were made, and data were reduced. Information from this project was used in the development of concepts for preventive maintenance. No repairs have been required in the relieved section, while 9 percent of the joints have been repaired in the control section of the opposite roadway.

Planned Program for Coming Year

This project will be monitored for a few more years to gain further information on the behavior of pressure relief joints over the long term. Readings and surveys will be continued.

Title

*72 F-124 - Fracture Toughness and Fatigue Properties of Steel Plate Butt Joints Welded by Submerged Arc and Electroslag Welding Procedures

Purpose

To investigate the electroslag welding procedure in comparison to the submerged arc welding procedure for fabricating steel plate butt joints for highway bridges.

Scope

Fatigue, impact and metallographic experiments were made on electroslag and submerged arc welds in ASTM A 36 and A 588 steels, 1-3/4 and 3-in. thick.

Progress Past Year

The final report was reviewed, and a draft copy was submitted for FHWA approval, which was obtained. The final report now is being printed for distribution.

Planned Program for Coming Year

Print and distribute the report.

Title

72 F-126 - Experimental Concrete and Bituminous Shoulders (Work Plan No. 13)

Purpose

To determine the relative cost of improved shoulder designs.

Scope

Twenty-nine projects were selected for installation of improved shoulder designs, including 16 bituminous and 13 portland cement concrete.

Progress Past Year

A progress report was prepared for the FHWA. Sixteen projects were reported in October 1974, several of the remaining projects were not scheduled for letting until 1976. The last project was let in October. A report

of prices for the projects is in preparation. Concrete prices have decreased and bituminous prices have increased.

Planned Program for Coming Year

Report the new price information available.

Title

*73 F-131 - Epoxy Resin Coated Reinforcing Steel

Purpose

To determine the feasibility of using epoxy coated reinforcement in Michigan bridge deck construction, and to evaluate the effect of epoxy coated reinforcement on the performance of laboratory specimens and experimental decks.

Scope

The project includes three epoxy coatings previously evaluated by the FHWA and NBS, in comparison with galvanized and uncoated steel. Small specimens for laboratory testing, slabs for outdoor exposure, and full scale experimental decks are included.

Progress Past Year

Quarterly progress reports have been prepared for the FHWA. Treatment of small size laboratory specimens was continued. Three experimental bridges have been built. Weekly "corrosion-cell" readings have been made on the laboratory specimens. Field exposure specimens were treated periodically, and evaluated. "Corrosion-cell" readings were made on the field exposure specimens. All data have been recorded and kept current.

Planned Program for Coming Year

Continue treatment and evaluation of the laboratory and field exposure specimens and experimental decks.

Title

73 F-135 - Experimental Concrete Glare Screen (Work Plan No. 28)

Purpose

To determine the relative cost, performance, and durability of concrete and metal mesh type glare screen.

Scope

Approximately 1,000 ft of experimental concrete glare screen is in direct comparison with a similar length of mesh. Subjective evaluation of another construction project was added at the request of the FHWA.

Progress Past Year

A progress report was prepared for the FHWA. Recommendations were made relative to use of glare screen with the revised "New Jersey" type concrete median barrier.

Planned Program for Coming Year

Check condition of experimental glare screens, and report any significant developments.

Title

73 F-136 - Experimental Short Slab Pavements (Work Plan No. 34)

Purpose

To compare performance of several types of pavement systems.

Scope

Three experimental pavement types were installed at a rural freeway site. Plain concrete slabs with and without load transfer, on three different types of base course, were installed for comparison with the standard Michigan pavements with load transfer and reinforcement. Three, half-mile sections of each type were built. Asphalt treated porous base, a more conventional bituminous base and aggregate base courses were placed on sand grade.

Progress Past Year

Joint and fault measurements were recorded, and profilometer runs made. A construction report was published.

Planned Program for Coming Year

Continue all experimental measurements and data reduction.

Title

74 F-139 - Study of Laminations and Other Rolling Flaws in Structural Steel Plates and Shapes

Purpose

To explore, document, and aid in the determination of acceptability of plates and shapes containing rolling flaws.

Scope

Work on this project is done only when one of the welding inspectors finds evidence of flaws in material delivered for girder fabrication. Therefore, the scope is somewhat indeterminate, depending upon the occurrence of such flaws in the steel purchased by fabricators.

Progress Past Year

Several consultations were held with welding inspectors, a few specimens were prepared and polished to determine the extent of flaws, and some field checks were made for extent of delamination type flaws in existing bridge beams.

Planned Program for Coming Year

Respond to any requests for assistance from the welding inspection group.

Title

*75 F-144 - Bridge Girder Butt Welds; Resistance to Brittle Fracture, Fatigue and Corrosion

Purpose

To evaluate electroslag and submerged arc butt weldments for their fracture toughness, fatigue and corrosion properties, in two grades of steel commonly used in bridge construction.

Scope

Metallurgical and mechanical properties of the weldments will be determined. Fracture toughness will be measured by both Charpy and fracture mechanics type evaluations. Cyclic loadings will determine fatigue crack initiation and propagation. Specimens will be prepared for outdoor exposure.

Progress Past Year

The electrohydraulic machine was ordered, delivered, installed and checked out. The environmental chamber was purchased, and fatigue grips were ordered. Additional background and preparatory work was done, and the experimental weldments for the project were fabricated.

Planned Program for Coming Year

Begin specimen preparation and experimentation.

Title

75 F-146 - Steel Sampling, 76 Bridges

Purpose

To remove, test and evaluate, steel samples from girders of bridges throughout the state, to determine whether the bridges should be posted for load limits.

Scope

Samples were taken from four girders each of 76 different bridges. Tensile, impact and chemical properties were determined.

Progress Past Year

All bridges were sampled, about 300 tensile and chemical specimens were prepared, analyzed and reported. About 1,000 Charpy specimens were made and tested.

Planned Program for Coming Year

Prepare a final report covering the Charpy impact evaluation, to close the project.

Title

75 F-149 - Experimental Project for Variable Spacing of Expansion Joints

Purpose

To compare the performance of experimental roadways, having expansion space at various intervals.

Scope

Several experimental sections are to include variable spacing between expansion joints (from every joint to about every 1/4-mile).

Progress Past Year

The proposal was approved by the Engineering Operations Committee, and sent to Design for inclusion in a contract.

Planned Program for Coming Year

Coordinate with Design Division to select site and incorporate special provisions in the plans and specifications.

Title

75 F-150 - Experimental Project Concerning Joints for Concrete Pavement Repairs

Purpose

To develop data on the movement and relative performance of five different types of joint design details in order to choose suitable designs for future repair contracts.

Scope

This investigation includes the construction, instrumentation and evaluation of a major concrete pavement repair contract on a deteriorated route, to compare the reaction and performance of slabs with various types of joints and seals.

Progress Past Year

A proposal was prepared, and was approved by the Engineering Operations Committee. The project site was selected, a new type of rating system was used to choose locations for repair. The project was let, and about 60 percent of the construction was completed. Approximately 15 joints of each type were selected for instrumentation, and instrumentation was completed on all selected joints that were built. Initial readings were taken on all of these joints.

Planned Program for Coming Year

Monitor remainder of construction, complete instrumentation, take readings and compile data.

Title

76 F-151 - Field Evaluation of Guardrail to Bridgerail Connection

Purpose

To evaluate the strength of cast-in-place and drilled-in anchors for securing guardrail end shoes to New Jersey and concrete parapet type bridge rails.

Scope

Thirty-six anchorages will be loaded to failure; included cast-in-place "spiders," self-drilling flush-type anchors, and taper-bolt inserts set at two different distances from the end of two different types of concrete bridge rail.

Progress Past Year

The project proposal was prepared and approved. The site was selected and graded. Materials for building the modules were obtained, and forms for the concrete were cut to size. The load cell and fixtures were designed, and materials for same were obtained.

Planned Program for Coming Year

Build the modules, load cell and fixtures, calibrate the load cell, conduct experimental loading and report results.

Title

76 G-218 - Skid Resistance of Asphalt Pavements Containing Slag Aggregates

Purpose

To compare skid resistance of asphalt pavements containing slag aggregates with those containing natural aggregates.

Scope

Eight pairs of locations were skid tested in Wayne County with each pair consisting of a bituminous surface containing slag and a bituminous surface containing natural aggregate. Each pavement in a pair had the same service age and carried similar traffic volumes.

Progress Past Year

Project completed. Slag was found to provide skid resistance equal to but not better than natural aggregates.

Title

76 C-17 - Evaluation of Heater-Scarifier Methods for Recycling Asphalt Pavements

Purpose

To evaluate the use of a heater-scarifier in recycling the top 3/4 in. depth of a distressed asphalt pavement.

Scope

A five-mile length of I 75 will be heater-scarified to a depth of 3/4 in. Chemical rejuvenator will be added to increase the penetration of asphalt from its current 24 to at least 80. The rejuvenated material will be resurfaced with a 250 lb/sq yd bituminous concrete mat.

Progress Past Year

Completed work plan and specification.

Planned Program for Coming Year

Recycle a length of I 75.

R-987 - "Recommended Capacities for Expansion Anchor Lane Ties, and Evaluation of Frazer and Jones Concrete Expansion Anchors," (75 TI-306/75 TI-281). M. A. Chiunti.

This report presents the results of testing conducted to evaluate the torque-type anchors submitted by the Frazer and Jones Co., to determine their suitability for use as lane ties. The anchors were subjected to pull-out tests which are routinely used by the Laboratory for this type of evaluation. Based on the test results, and current specifications, it was recommended that these anchors not be used for lane ties. The report further recommends some changes in utilization of anchors, in general, and of suggested design values.

R-988 - "Reflectorized License Plates and Night Accident Reduction." (75 TI-286). L. F. Holbrook.

This report involves the comparison of the cost-effectiveness of reflectorized license plates with other alternative accident reduction programs. It includes a literature review of 'before and after' investigations, non-randomized simultaneous investigations, and randomized simultaneous investigations, as performed by various highway agencies. For cost-effectiveness purposes, license plate reflectorization is compared with: two to three-lane pavement widening, four to five-lane pavement widening, and high-accident intersection skid proofing (considered both from Michigan's own experience, and from a theoretical point of view). Some studies in the literature review appeared to present higher quality data, and these data were combined to provide an overall estimate of plate reflectorization accident reduction potential. When this combined estimate was compared on a dollar investment basis with other, well understood safety programs in a cost-effectiveness study, plate reflectorization could not deliver enough benefit to warrant more than a low priority.

R-989 - "Feasibility Study to Convert Regular-Dry Traffic Paint Application to Fast-Dry Use," (74 TI-255). A. J. Permoda.

Because of the Department's exclusive use of fast-dry roadway striping paint, our regular-dry applicator was no longer able to be used for applying test paint markings. This report describes an attempt at converting the regular-dry laboratory applicator for fast-dry paint application by installing a heater on the unit. For reasons detailed in the report, this didn't prove to be feasible.

R-990 - "Fiberglass Reinforced Pultrusions," (75 NM-446). M. A. Chiunti.

A fiberglass hollow beam (in two configurations) was submitted to the Department by the Creative Pultrusion Co., for use as a material for barricades, and as a signpost material. The Type I barricade submitted by the manufacturer appears to be a satisfactory alternate to wood and metal barricades; their Type II barricade, however, is extremely light, and the horizontal members are not sufficiently rigid. Large deflections, due to its lack of weight and rigidity, are apt to crack the reflective material. Though it was felt that the material could be used as signposts, the extra cost, as compared with wood, was felt to preclude its use by the Department.

R-991 - "Subbase Drainage Criteria," (75 E-56). F. T. Hsia.

Gradation—and to some extent permeability—have been used as criteria for subbase drainability in Michigan; however, it has been noted that effective porosity, as well as permeability, should also be incorporated in drainage analysis. In this report, an approximate theoretical analysis method (based on Darcy's law and the concept of effective porosity), which was developed for the more simple geometries of airfield subbases, is extended to establish a method for the analysis of drainability of the more complex pavement cross-section geometries, in order to distinguish between acceptable and unacceptable subbase materials. Drainability formulas are derived for 9 basic geometric shapes.

R-992 - "Corridor Air Quality Report for Proposed M 59, Utica to I 94," (75 AP-3(A).

This report was prepared as part of the Environmental Impact Statement for this proposed route location. In accordance with Federal directives, the terrain and demography, meteorology, existing ambient air quality, and pollution estimates were all explored. Pollution estimates are based on a model which includes as inputs: estimated peak and off-peak traffic volumes, worst and most probable meteorological conditions, road profile, and width of roadway sections. The report concludes that no adverse environmental effects are expected. Since the actual route location has not been finalized, planners are cautioned to be alert for possible sensitive sites that might require further investigation in detail.

R-993 - "Strength Comparison Between Water Reducer Concretes of Portland-Pozzolan and Type 1A Cements," (71 NM-284/72 B-91). H. L. Patterson.

Prior research work had found that a reduction in cement could be effected without loss of strength when a water-reducer admixture was used

with Type 1A cement. A later laboratory report showed that an approved portland-pozzolan cement could be substituted for Type 1A cement without any loss of strength or performance. It was not known, however, whether the same cement reduction allowed for water-reduced Type 1A cement could also be applied to portland-pozzolan cements. The research described in this report studied this matter. It was concluded that we now can extend to the portland-pozzolan cements, the same cement reduction associated with water-reducers that we have allowed for the Type 1A cements. At the time of this research, this recommendation was confined to pavement concretes; further research is now being carried out regarding bridge structures.

R-994 - "Accident Rates and Surface Properties - An Investigation of Relationships," (73 G-193). L. F. Holbrook.

This Highway Planning and Research report examines both urban and rural state trunkline intersections with regard to their wet accident percentages. The examination first takes account of the estimated percentage of highway surface wet time for each month from January to December. Because precipitation data are only available for the amount of precipitation for designated time intervals, a method is developed to convert these data into percent wet time--a factor necessary in assessing wet surface exposure. Using this conversion method, the precipitation data from 120 of Michigan's weather stations are transformed to give a month by month wetness profile for the entire State for the years 1963 to 1974. The range in monthly wetness for this period is from less than 1 percent to more than 20 percent. This potential 20 to 1 ratio is very influential in wet accident incidence and should be taken into account before other wet accident variables are examined.

Over 20,000 accidents occurring at over 2,000 intersections for which a skid number value was available were tabulated to provide wet accident proportions. These data, together with the location's wet time proportion, as estimated from the nearest weather station, provided an opportunity to statistically fit the wet accident model for the variables included, and for each of three surface types in common use. The fit is satisfactory and suggests an accelerating function for skid number; for all levels of wetness, and taking all surfaces together, a skid number of less than about 30 is accompanied by an accelerating increase in wet accident percentages, although the actual shape of the curve depends on wet time.

In general, it appears that there is no skid number hazard threshold—wet accident incidence increases monotonically and continuously, albeit at an increasing rate, as skid number deteriorates. This relationship appears strongest for the bituminous aggregate surfaces.

R-995 - "A Literature Survey of Median Barriers and Highway Safety," (76 TI-329). L. F. Holbrook and W. H. Kuo.

Because of the Department's involvement in litigation regarding a head-on collision in a service-road/freeway situation, a literature search was conducted on the subject of guardrail and median barrier installation. Research literature seems to indicate that barriers in narrow medians of high traffic volume roadways may slightly decrease fatalities; however, this will also produce a substantial increase in property damage and injury accidents. It is equally clear from the survey that what will be considered good median barrier policy depends upon the accident statistic selected as the criterion. The median barrier warranting policies in the literature, were all concerned with the division of two opposing roadways with nearly equal traffic volumes; not with the freeway/service drive situation. Thus, a collision probability model was generated, based on two moving objects—rather than the fixed object (barrier)/moving object (automobile) used in the literature. On the basis of this model, it was found that installation of a guardrail at the location of the particular accident in question would not have been recommended on the basis of probabilistic analysis.

R-996 - "Comparative Performance of Contraction Joints on I 75, Saginaw and Genesee Counties," (75 TI-303). F. Copple.

This report summarizes the investigation of the reason for the dramatic difference in performance of contraction joints on two different lengths of I 75. The only discernable difference in the materials used in the two pavements was the coarse aggregate used (the better of the two used a limestone coarse aggregate). Past research in Michigan and elsewhere has shown that coarse aggregate has an effect on joint blowups. The reason for this is not clear, and the mechanism of coarse aggregate influence on joint performance would require a major research project.

R-997 - "Investigation of Straw Fire Damage to CRCP, I 96 Near Novi (I 63191-03586A)," (75 TI-294). W. K. Kruger.

On July 26, 1975, a semi-trailer loaded with straw caught fire and burned on I 96. The Construction Division requested that the Research Laboratory investigate to ascertain whether any damage had been caused to the concrete. Swiss Hammer readings were taken at selected areas in the burned-over area, and cores were taken as well. Although some craze-cracking was evident at the site, the Swiss Hammer tests indicated no strength loss, and the cores showed no disintegration in freeze-thaw testing. From this, it was deduced that the fire damage was slight and no repair procedures were recommended.

R-998 - "Petrographic Analysis of Coarse Aggregate: Superior Sand and Gravel Pit No. 31-45," (Testing Laboratory Sample 75 A-152). R. W. Muethel.

A sample of combined crushed and natural gravel coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-999 - "CMI Autograde Pavement Profiler," (76 TI-341). F. Copple.

This report concerns an observed demonstration of the CMI cold-planer for pavements and bridge decks at an Oklahoma test site. This new machine was used to remove the surface of a bridge deck to a depth of about 1/2 in. in preparation for overlayment with low-slump concrete. Specifications of the machine, operational costs, etc., are included in the report. The unit appeared to be well suited for high production planing and texturing of both bituminous and concrete surfaces, and close grade tolerances can be achieved. The report suggests that such a machine holds great promise and recommends trying it on a Michigan site.

R-1000 - "Petrographic Analysis of Coarse Aggregate: Gogebic Sand and Gravel Co. Pit No. 27-55," (Testing Laboratory Sample 75 A-203). R. W. Muethel.

A sample of combined crushed and natural gravel coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1001 - "Development and Evaluation of a Field Drainability Test Method," (75 E-53). E. C. Novak, Jr.

Since prior research has shown that drainability test results can be used to accept or reject subbase and porous backfill materials, the Department's Porous Materials Research Committee requested that the Research Laboratory establish a consistent drainability field test procedure which would be rugged, provide reliable drainability data, and be comparable to other field tests in simplicity and time required to perform the test. This report discusses the development of a 'field permeameter' and the results obtained therefrom, and compares them with laboratory drainability test results. It was found that the test method and equipment developed were well suited to field conditions, and the values obtained with the field test

and the standard ASTM test methods were essentially the same. It is easier and more quickly performed than the standard density control tests, and it is felt that the use of drainage criteria and the proposed field drainability test method should result in considerable cost savings and increased availability of porous materials suitable for subbase use.

R-1002 - "Bulkhead Joints for Concrete Base Shoulders - Final Report," (70 F-117). M. A. Chiunti.

This is the final report of the 'Category 2' project covering the performance of lane ties used in bulkhead joints for concrete base shoulders in order to discover whether installation of such ties would reduce horizontal and vertical displacement of these shoulders. Hookbolt lane ties were installed in the concrete base course shoulder widening for ramps on and near the La Porte Rd interchange on I 94. All the ramps were instrumented with steel rivets which have a conical recess in their tops to accept mating cones on the ends of reading devices. Readings were taken periodically and are included in the report. Because of their effectiveness in reducing joint opening and vertical displacement of the slabs, and the minimal initial costs of installation, it is recommended that the lane ties be used on all future concrete base course shoulders and widenings.

R-1003 - "Petrographic Analysis of Coarse Aggregate: Wallace Stone Co. Pit No. 32-4," (Testing Laboratory Sample 75 A-2501). R. W. Muethel.

A sample of crushed stone coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1004 - "Petrographic Analysis of Coarse Aggregate: Wallace Stone Co. Pit No. 32-4," (Testing Laboratory Sample 75 A-2500). R. W. Muethel.

A sample of crushed stone coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1005 - "Evaluation of Four Organic Resin Binder Systems," (67 NM-171/68 NM-192/69 NM-225/69 NM-229). H. L. Patterson.

Four products (Cy Bond 2501, Epo Traz, Steelcote PE-101, and Epi Top 100) were forwarded to the Research Laboratory by the Committee on

New Materials for evaluation. These materials have been proposed for use in four different areas: as a binder when mixed with dry sand, forming a mortar for patching spalled and broken concrete; as a surfacing material on orthotropic steel bridge decks; as a concrete sealant; and, when covered with sand, as a skid-resistant surface. These mortars—along with control materials—were tested for: compressive strength, tensile strength, shear bond strength, shrinkage, thermal coefficient of expansion, tensile modulus of elasticity, and flexural fatigue characteristics. Results of this testing program showed that, in general, most resin mortars are not well suited for orthotropic bridge deck surfacing because of shrinkage and high thermal stresses. Moreover, resin mortars are totally unsuited for patching concrete bridge decks because of their shrinkage, high thermal coefficients of expansion, and low compressive modulus of elasticity. They do, however, satisfactorily perform as a surfacing or penetrating sealant for concrete, as a bonding material for bonding fresh concrete to existing concrete, as an injection grouting material to repair cracked or fractured concrete, and as a mortar or grout to secure anchor bolts or rebar. Flexibilized epoxies have performed quite well as thin and uniform (up to 1/2 in.) wearing surfaces with hard aggregates for skid resistance and also in thin, flexible bridge deck waterproofing membranes under bituminous surfaces.

R-1006 - "Petrographic Analysis of Coarse Aggregate: Caspian Lumber Co. #2, Pit No. 36-40," (Testing Laboratory Sample 75 A-291). R. W. Muethel.

A sample of combined crushed and natural gravel coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1007 - "Petrographic Analysis of Coarse Aggregate: Construction Aggregates Corp, Pit No. 70-9," (Testing Laboratory Sample 75 A-2162). R. W. Muethel.

A sample of combined crushed and natural gravel coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1008 - "A Review of Bridge Deck Problems and a Final Report on the Performance of Several Berrien County Structures Widened Under Traffic," (65 F-84). C. J. Arnold, M. A. Chiunti, K. S. Bancroft.

A general review of bridge deck problems is provided. Although evi-

dence of a porous plane-of-weakness in bridge decks has existed for several years, it has not received broad acceptance or wide distribution in the highway field. Often times, excess water in the mix causes porous and weak areas sandwiched between higher quality concrete. Insofar as possible, water content of the mix should be limited; water reducers and water-reducing retarders should help in this respect. Coated rebar, while not solving the problem, can be expected to lengthen the life of the deck by avoiding the expansive forces that are associated with the corrosion of uncoated reinforcement. Performance surveys on some I 94 bridges in Berrien County that were widened under traffic 10 years ago show no advantages gained by those spans that were shored over unshored spans.

R-1009 - "1975 Performance Tests of 'Fast-Dry' White and Yellow Pavement Marking Paints," (47 G-36(28a)). A. J. Permoda.

These tests varied from our normal testing procedure for traffic paints in that they consisted of performance evaluation of two groups of paints; those submitted for regular, annual tests which later determine the supplier of white and yellow paints for the Department's 1976 roadway marking program, and some alleged 'super' paints solicited from the producers for information purposes and applied later in the year. The regular test stripes, and later those of the 'super' paints, were applied on US 27 south of St. Johns and periodically rated by a visual inspection team. Ratings consisted of evaluation of the paints' appearance, durability, night visibility, and drying time. The results of these ratings were conveyed to the Traffic Control Devices Committee and they selected the producers for bids on the basis of these data. One of the 'super' paints appeared to have interest to the Department because of superior performance.

R-1010 - "Petrographic Analysis of Coarse Aggregate: Lindberg Pit No. 22-69," (Testing Laboratory Sample 75 A-410). R. W. Muethel.

A sample of combined crushed and natural gravel coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1011 - "Fracture Toughness and Fatigue Properties of Steel Plate Butt Joints Welded by Submerged Arc and Electroslag Welding Procedures," (72 F-124). J. D. Culp.

In this Highway Planning and Research project, welded butt joints, typical of those used in the flanges of steel plate girders, were welded by the electroslag and the submerged arc welding processes in ASTM A 36 and A 588 steel plates. The electroslag weldments were made by the consum-

able guide method using both the water cooled and non-cooled retaining shoes. Complete metallurgical studies were done on the weldments to define and document the various weld metal and heat-affected zones that were present. Chemical compositions of the various weldment zones are present and discussed. Deficiencies were discovered in the alloy composition of some of the weldments in A 588 steel that were approved for use in a bare, unpainted exposure. Control of weld metal chemistry is seen to be very difficult in an electroslag weldment. Tensile tests on the various weldments reveal significant nonhomogeneous and anisotropic behaviors in the electroslag weld metal. Three series of Charpy V-notch impact evaluations were conducted on the weldments. The first series evaluated the performance of all the weld metal zones, the heat-affected zones, and the base metal at a test temperature of 0 F. These tests revealed the nonhomogeneous nature of the impact toughness in electroslag weld metal and a failure to meet acceptance criteria by some of the weldments. The 2nd series involved impact testing over the temperature range of -40 to +40 F and revealed the temperature-transition characteristics of the weldment zones. The 3rd series revealed the highly anisotropic nature of the impact toughness of the electroslag weld metal zones. Fatigue crack initiation tests were conducted on small tensile specimens taken from the weldments with crack starter notches machined in them. These tests revealed that the submerged arc weld metal has a significantly longer crack initiation life than the electroslag weld metal and that in some cases the electroslag weld metal was inferior to the base metal. Recommended changes in specifications are also included.

R-1012 - "Bridge Deck Repair and Development of Procedures for Epoxy Injection Grouting of Bridge Deck Delaminations," (73 NM-381/74 F-141). H. L. Patterson.

This report covers the repair procedures and materials used to patch a bridge deck carrying Capital Ave over I 496, City of Lansing. Three types of material were used for this experimental repair: 'Sinmast,' a material used for the injection grouting; a special laboratory shrinkage compensating patching concrete (using an 8 sack/cu yd Type I cement and 40 percent 'Embeco Metallic Aggregate,' as an expansive component); and—as a control mixture—'Embeco 411A,' a material that had proved durable in an earlier field installation. The report covers laboratory work on the materials, the development of an injection grouting technique, and the work performed on the bridge deck. Delaminated areas were grouted by injection, and removed and replaced with the two mortars. The deck will be periodically examined by research personnel and findings will be reported as they become pertinent.

R-1013 - "An Inventory of Traffic Noise Levels Along Limited Access Freeways in Michigan," (75 G-211). G. H. Grove, M. E. Scarlata.

In certain instances, Federal funds are available for reducing the impact of traffic generated noise on existing roadways. In order to aid man-

agement in deciding where such funds should be expended, an inventory of noise levels was taken in the 42 counties of the State that contain Interstate routes (or US and M routes built to Interstate standards). All lands adjacent to these routes were categorized as to their use, in terms of Activity Categories as described by the FHWA. Tabular material is included recording the measurements as taken along the routes, and estimates are made regarding the cost of constructing barriers as a noise abatement measure.

R-1014 - "High-Index, Wet-Performance Glass Beads for Pavement Markings from Potter Brothers," (70 NM-270). A. J. Permoda.

A test stripe of the subject beads, along with equivalent striping of Potter Brothers' standard beads, were applied on the low traffic volume drive in front of the Laboratory. Initial observation showed that the subject high-index beads provided brighter night visibility in dry weather than the standard beads; however, they failed to provide their alleged improvement in the rain, though it was noted that they kept their effectiveness a bit longer after the start of a rain and regained it a bit more quickly after the rain had stopped. Massachusetts had also tried these beads in their own paint and reported the same negative results as we did.

R-1015 - "Snow-Glow Glass Beads for Pavement Markings from Snofast Co. of Italy," (72 NM-332). A. J. Permoda.

The subject glass beads differ from standard beads in that they have a single layer of microspheres cemented to them. The beads were reported to have initially poor reflection until traffic wears the microspheres from the dome of the core. Test stripes of the subject beads were placed along with control comparison stripes. It was found that the initial poor visibility ratings did not improve with age, they did not show appreciably better night visibility in the rain, and because of this the report recommended discontinuation of their evaluation.

R-1016 - "Experimental Short Slab Pavements: Construction Report," (73 F-136). M. A. Chiunti

The purpose of this study is to obtain relative performance information on several alternate pavement designs for concrete pavements that require less steel and/or can be constructed at lower costs. Short slab, unreinforced concrete pavement was placed on a conventional base, on a porous bituminous drainage blanket, and on a bituminous stabilized base on an experimental portion of freeway on relocated US 10 northwest of Clare. Three miles of dual 24-ft pavement were constructed with sections containing the following types of experimental features: 1) short slab, unreinforced, skewed joints, variable joint spacing, no load transfer, with an asphalt-treated porous material base; 2) short slab, unreinforced, 90-degree joints, vari-

able spacing, with load transfer, and an aggregate base; 3) short slab, unreinforced, skewed joints, variable spacing, and no load transfer, with a bituminous base. Sections of standard pavement, 9-in., reinforced, aggregate base, are included for comparison of performance. This report describes the construction of the sections and the initial measurements of joint movement, transverse cracking, joint groove spalling, and pavement roughness. Periodic measurements will be taken over the coming years and compared with these initial measurements, as well as general visual surveys of pavement performance.

R-1017 - "Application for Federal Financial Participation in Traffic Noise Barrier Construction Along a Selected Segment of I 75 in the City of Taylor in Southeastern Michigan," (73 TI-191).

This report describes the Department's recommendation to the Federal Highway Administration that applicable funds be granted for Federal participation in a noise abatement project, as established by the Federal-Aid Highway Act of 1973. These funds are intended for use on projects that were approved before current environmental regulations went into effect. The subject route segment of I 75 is located along the southern edge of the Detroit metropolitan area. The area immediately adjacent to the freeway is occupied by a moderate density group of single-family dwellings. After exploring the options, and presenting the pertinent noise measurement data, it was recommended that a 12-ft high, 2,000-ft long noise barrier be constructed at the edge of the shoulder.

R-1018 - "Steel Sampling: 76 Structures," (75 F-146). C. J. Arnold.

This report covers the results of physical and chemical evaluations of more than 300 specimens removed from 76 Michigan bridges in all parts of the State. It was requested by the Design Division to aid in calculating revised load capacities. Testing and Research personnel removed the samples in the winter of 1975-76, and tensile specimens were prepared and tested in the Research Laboratory. Chemical analyses were performed by the Kawin Co. of Chicago. The locations of the samples are given in tabular form, along with the copper, manganese, sulfur, and phosphorus content of the metal, and the yield strength, ultimate strength, reduction of area, and elongation. The scope of the project was also expanded to provide some valuable research information relating to the impact resistance of steel from older structures. Charpy impact specimens were machined from the samples for this purpose and, upon completion of testing, a further report will be issued concerning these results.

R-1019 - "Expansion Anchor Evaluation - Hilti HDI Anchors," (76 NM-474). C. J. Arnold.

This report presents the results of testing conducted to evaluate the Hilti expansion anchors to determine their suitability for use as lane ties.

The anchors were subjected to pull-out tests which are routinely used by the Laboratory for this type of evaluation. Based on the test results, and current specifications, it was recommended that these anchors be allowed for use as lane ties.

R-1020 - "Development of Procedures for Replacing Joints in Concrete Pavement," (70 F-118). J. E. Simonsen.

This is a final report on the performance of precast and cast-in-place concrete slabs used for pavement repair, conducted in cooperation with the Federal Highway Administration. This type of repair requires full-depth sawing of the repair limits, removal of the distressed concrete without disturbing the existing base, placement of the slab, and installation of sealed joints between new and old slabs. Evaluation of both types of repair indicate that they will perform reasonably well for at least five years and it is expected that the majority of the repairs will continue to give good service for ten years. Some faulting develops at the joints, but deflection under load and slab rocking do not appear to have a serious effect on the performance of the repairs. The developed repairs are suggested for use as interim repairs on roadways scheduled for overlays, rehabilitation, or reconstruction within five to ten years.

R-1021 - "Reflectorized Flagman Vests," (73 TI-164). G. M. Smith and M. H. Janson.

This report summarizes the results of research conducted concerning the reflectorization of flagman vests. Earlier research had given some indication of observer preference as to the shape of the vests (a humanoid 'X' or 'Y' pattern), and this was further investigated in detail. Results of observer daytime and nighttime preference tests showed that the reflectorized 'Y' pattern is preferred, as is the FHWA Highway Yellow color. It was also noted that reflectorized arm and leg gauntlets provide further positive emphasis. Another suggestion which resulted from this study is to silkscreen the flagman's STOP sign on silver encapsulated lens or 'high intensity' sheeting, rather than on silver enclosed lens sheeting as is now the practice. It was recommended that the Department propose these as possible revisions for the Federal "Manual of Uniform Traffic Control Devices."

R-1022 - "Effects of Deicing Salts on the Chloride Levels in Water and Soil Adjacent to Roadways," (71 G-180). R. W. Muethel.

In order to study the effects of deicing salts on the chloride levels in roadside soils and groundwater, 29 test wells at four locations were constructed to check the chloride levels of groundwater. In addition, 47 locations were selected to check the chloride content of meltwater on the soil adjacent to the roadway. Preliminary findings indicate that chloride levels

associated with deicing salts in Michigan are similar to the findings of other snowbelt states. The general association between the increased chloride levels in the soils and meltwater adjacent to roadways in the winter is evident. The same increase is noted in well water, though it occurs later in the year. These sites will continue to be monitored and subsequent reports, when further data have been accumulated, will further explore this area.

R-1023 - "Air Quality Report for Davison Freeway, City of Highland Park, Wayne County," (76 AP-11A). W. L. Frederick.

This report was prepared as part of the Environmental Impact Statement for this proposed route location. In accordance with Federal directives, the terrain and demography, meteorology, existing ambient air quality, and pollution estimates were all explored. Pollution estimates are based on a model which includes as inputs: estimated peak and off-peak traffic volumes, worst and most probable meteorological conditions, road profile, and width of roadway sections. The report concludes that no adverse environmental effects are expected. Additional data are provided for two potentially sensitive receptor sites; a school and a church located near the proposed route.

R-1024 - "Aggregate Gradation Quality Control," (72 G-191). Wen-Hou Kuo.

The techniques of multivariate statistical analysis are used to study the segregation pattern of a stockpile, which leads to the design of a stratified random sampling method for stockpiled aggregate. This method is compared statistically with the current method in estimating aggregate composition for the final selection of stockpile sampling methods. Based on the suggested method, we designed several potential variables plans for stockpile aggregate inspection. The effect of handling and compaction on aggregate composition was investigated and models for estimating the degradation rate of each aggregate size due to handling and compaction from that before compaction of stockpile aggregate are presented. Several plans of 'acceptance sampling by attributes' to control the fraction of failing spots at the job site are recommended for in-place inspection. To find out whether aggregate inspection at the stockpile, or at the job-site before or after compaction, is the most beneficial, factors to be considered for choosing the inspection sites between stockpile and job-site are discussed. Because the current gradation test is time consuming, a more efficient test method is proposed. Samples are collected and tested by the current and proposed methods in a statistical experiment. The data are then analyzed by means of multivariate statistical analysis to see whether the two methods give comparable results. An estimation procedure for converting the test results of the proposed test to those obtainable with the current test is also proposed. The estimation precision of the estimation procedure is statistically evaluated.

R-1025 - "Thickness Equivalencies for Asphalt-Treated and Untreated Aggregate Base Course Layers," (68 E-42). F. T. Hsia.

Asphalt-treated base courses, commonly referred to as 'black base' are reported to increase the strength of the pavement as a whole and act as a waterproofer, maintaining base strength under all moisture conditions. They do, however, have the disadvantage of higher cost, and require high quality aggregate. When situations arise where it appears advantageous to use black base, this report provides a means for determining an economical thickness, while still obtaining a structural strength equivalent to conventional base. Included in the report are base thickness design curves which can be used to determine the equivalent thickness of various base course materials for equal pavement performance characteristics.

R-1026 - "Air Quality Report for M 99 in Ingham and Clinton Counties," (76 AP-12A). W. L. Frederick.

This report was prepared as part of the Environmental Impact Statement for this proposed route location. In accordance with Federal directives, the terrain and demography, meteorology, existing ambient air quality, and pollution estimates were all explored. Pollution estimates are based on a model which includes as inputs: estimated peak and off-peak traffic volumes, worst and most probable meteorological conditions, road profile, and width of roadway sections. The report concludes that no adverse environmental effects are to be expected.

R-1027 - "Evaluation of Various Types of Railroad Crossings," (75 F-143). J. E. Simonsen.

Michigan has been conducting an on-going research project in cooperation with the Federal Highway Administration for the investigation of various proprietary railroad crossing materials and designs. This report describes the construction and installation techniques used to construct four types of crossings: T-Core, Fab-Ra-Cast, Steel Plank, and Track-Span. Though these crossings have been in service but a few months, certain general observations are made about them. A section is also included concerning general problems involving the installation of railroad crossings. These installations, as well as some prior and subsequent ones, will continue to be monitored and reports will be periodically issued as significant developments occur.

R-1028 - "Study of Deck Concrete in S03 of 64014, US 31 Under Winston Rd West of Rothbury," (76 TI-355). M. G. Brown.

Subsequent to obtaining low beam breaks and modified cube tests from the first span of the subject structure, the Research Laboratory were requested to test cores from the bridge, and review the construction data.

The strength levels of all four pours were found to be about 70 to 80 percent of what should be expected, apparently due to high water-cement ratios and, in some cases, in combination with somewhat high air levels. These lower strength levels will probably not impair the structural performance of the deck, but might result in larger than normal penetration of chlorides. Some possible precautionary protective measures are recommended in the report.

R-1029 - "Steel Evaluation on Vehicle-Damaged Structure (S08 of 39022), 38th St Over I 94 Near Kalamazoo," (75 TI-275). J. D. Culp.

On March 14, 1975, the subject structure was damaged by a truck-trailer that was transporting two large fork-lift trucks. The truck was traveling in the westbound lane when a post on one of the fork-lifts struck several bridge beams, causing one of them to fracture and fall to the pavement. The purpose of this investigation was to determine the physical properties of the steel in the beam that developed brittle fracture. The steel was analyzed and found to meet all requirements for A7 steel that existed at the time the bridge was built. The fracture was initiated by a severe and unusual concentrated impact loading; the properties of the beam cannot be deemed as inadequate for the intended loading.

R-1030 - "Performance Evaluation of Trinidad Asphalt Cement for Bituminous Concrete Resurfacing," (73 C-16). C. A. Zapata.

The purpose of this study is to evaluate the relative performance of Trinidad asphalt-asphaltic cement blend compared with conventional 85-100 penetration grade asphalt in bituminous concrete overlays. A test area, nearly five miles long, was resurfaced with these mixtures and earlier reports gave the details of construction and the initial condition of the finished overlay. Recent data collected from the project are brought forth in this report including skid tests, riding quality, progressive cracking, and cost comparisons. After a two-year period, the test data show no superiority of one material over the other at this time. A cost-benefit analysis is included that shows that in order to be competitive, the Trinidad construction should give 17 to 20 years of service life, if a 10-year service life is assumed for conventional construction. Further continued observations and tests will be made and reported upon as they develop.

R-1031 - "Air Quality Report for the Reconstruction of I 94 BL Southwest of Battle Creek, Calhoun County," (76 AP-13A). W. L. Frederick.

This report was prepared as part of the Environmental Impact Statement for this proposed route location. In accordance with Federal directives, the terrain and demography, meteorology, existing ambient air quality, and pollution estimates were all explored. Pollution estimates are

based on a model which includes as inputs: estimated peak and off-peak traffic volumes, worst and most probable meteorological conditions, road profile, and width of roadway sections. The report concludes that no adverse environmental effects are to be expected. Detailed data are provided on two possibly sensitive sites; a day care center and a church.

R-1032 - "Petrographic Analysis of Coarse Aggregate: Gaspardo Pit No. 31-65," (Testing Laboratory Sample 75 A-1121). R. W. Muethel.

A sample of natural gravel coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are the specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1033 - "Galvanized Steel Reinforced Concrete Bridge Decks: Progress Report," (68 F-103). C. J. Arnold.

This project was initiated in 1969 as a cooperative study with the Federal Highway Administration. It includes construction of laboratory specimens and experimental bridge decks for evaluation of galvanized reinforcement as a deterrent to bridge deck deterioration. After undergoing six winters of heavy salt exposure, the following general conclusions can be made about the field specimens: all typical types of deterioration have appeared in the specimens, serious deterioration is significantly less on the sections with galvanized rebar, at least 3 in. of concrete cover is recommended over the steel, and no significant effects could be noted where galvanized and ungalvanized rebar were placed in direct contact in the concrete. After four winters, all five experimental bridge decks with galvanized rebar are in excellent condition. The feasibility of using galvanized bars in Michigan bridge deck construction has been demonstrated by this experiment. Further reports will be issued on this project as more data are collected.

R-1034 - "Control and Prevention of Deterioration of Concrete Bridge Decks," (61 B-58). M. G. Brown.

This report gives a brief historical summary of concrete mix design, and bridge deck design in Michigan from the inception of the project in 1963 to the present day. The original project called for the evaluation of Michigan's principles and practices of structural design, construction, and maintenance by means of a detailed field survey of a number of five and ten-year old bridge decks. Because of rapid technological advances, both in Michigan and in other states, changes in design and construction techniques were adopted with such rapidity that the original data collected for the project were rendered obsolete. The report cites some pertinent literature, presents data concerning Michigan's use of deicing salts, and makes observa-

tions on current bridge deck practices in the state. As of the end of 1976, Michigan now specifies epoxy coated rebars in the top mat and 3 in. of clear cover in all new bridge decks. Single-stage construction is used in lower traffic areas and two-stage, with either 1-1/2 in. latex modified concrete or 2-in. low-slump concrete is used in high traffic areas.

R-1035 - "Experimental Concrete and Bituminous Shoulders: Progress Report," (72 F-126). K. S. Bancroft.

This report covers the comparative cost phase on this on-going project; construction details were covered in an earlier report, and qualitative evaluation of the two shoulder types will appear in a later report. Twenty projects were selected for the installation of portland cement concrete and improved bituminous stabilized shoulders and are cited in this report. The report shows that the average cost of concrete shoulders is approximately 50 percent higher than the experimental bituminous shoulders; however, the projects let during 1976 show only slightly higher costs for concrete than for bituminous shoulders, since bituminous prices have increased considerably and concrete prices were lower than for any of the other jobs listed.

R-1036 - "Petrographic Analysis of Coarse Aggregate: Boyd Pit No. 54-54," (Testing Laboratory Sample No. 75 A-1625). R. W. Muethel.

A sample of combined crushed and natural gravel coarse aggregate from the subject pit was submitted to the Research Laboratory's Materials Research Unit for petrographic analysis. The general petrographic composition of the material is included in the report, as are specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

## LISTING OF NEW MATERIALS PROJECTS COMPLETED DURING THE YEAR

63 NM-85 - Polyurethane Joint Sealer (Dow Chemical Co.)

64 NM-114 - Silicone Construction Sealant (General Electric Co.)

69 NM-243 - 3M Bi-Symmetry Beads for Paint Marking

70 NM-276 - "Scotch 7700" 3M Arc and Fireproof Tape

71 NM-291 - "New Alert" Reflection Liquid (Catephote) and "Beads-In-Paint" (Flexolite)

72 NM-310 - Polymer "Rhoplex E 330" for Modifying Portland Cement Concrete (Rohm and Haas Co.)

72 NM-332 - "Snowglow" Beads (Snofast Co.)

74 NM-417 - "Formula FS-16 Pre-Krete" Fast Setting Hydraulic Cement

75 NM-430 - "Taper Bolt" (U. S. Expansion Co.)

75 NM-432 - "Super-Lite" Retro-Reflective Sheeting (Kozuki Sangyo, Ltd.)

75 NM-434 - "Sta-Fil" for Patching Chuckholes, Blacktop or Concrete

75 NM-446 - Glass Reinforced Pultrusions for Traffic Barricades

75 NM-450 - "Epoflex" Joint Seal Compound (Elastomer Seals, Inc.)

75 NM-455 - "Gyro-Kleen" Acoustical Panel for Noise Control

75 NM-456 - "Dzus" Fastener for Guard Rails

75 NM-459 - "Cadweld" Rebar Mechanical Butt Splice

75 NM-460 - Use of "Impreglon" Process in Highway Truck Engines

75 NM-461 - "Fabreeka-PTFE" Structural Bearing (Fabreeka Products Co.)

75 NM-464 - Aluminum Manhole Frames and Covers (Castings, Inc.)

75 NM-465 - "Plasticones" Traffic Control Cones (Best Barricade Co.)

75 NM-466 - "Plasticade" Traffic Barricade (Best Barricade Co.)

75 NM-467 - Hudson Rip Rap Bags (Hudson Pulp and Paper Co.)

76 NM-468 - "Lion D 200" Concrete Joint Sealant

76 NM-469 - Royston Unidam Bridge Expansion Dam

76 NM-470 - Am Tech, Inc. Polyrif Fiber Reinforcement for Concrete in Salt Scaling Environment

76 NM-474 - Hilti Drop-In Expansion Anchor

76 NM-475 - Flange Band for Coupling Helical Corrugated Steel Pipe (Janson Bridge and Supply Co.)

76 NM-478 - "Poly-Post" Highway Fence Post (U.S.S. Chemicals)

76 NM-480 - "Empigard" Protection for Zinc Coating (Empigard Corp.)

76 NM-493 - Metalock Repair Service for Rebuilding or Restoring Equipment

76 NM-494 - "Surfacite" High Impact Tungsten Carbide in Stainless or Soft Bronze Matrix

76 NM-496 - "Rodstik" Adhesion Coated Metal Foils (Teledyne Rodney Metals)

76 NM-503 - Styropor Concrete-Pavement Insulation with Strong Resilient Lightweight Concrete

76 NM-504 - Hi-Lock Nut Torque Controlled (Hi-Shear Corp.)

76 NM-506 - "Sound Fighter LSE-1000" Noise Protection Wall System

## LISTING OF TECHNICAL INVESTIGATIONS COMPLETED DURING THE YEAR

73 TI-164 - Evaluation of Reflectorized Flagmen's Vests

73 TI-183 - Air Quality Study on US 31 Glendora Rd to I 96, Berrien Co.

74 TI-205 - Air Quality Impact on Southbound US 25, Mt. Clemens

74 TI-233 - Experimental Finishing on Latex Mortar Bridge Overlays

74 TI-236 - Rumble Strips for Asphalt Shoulders

75 TI-268 - Construction and Installation of Frost Depth Indicators

75 TI-293 - Noise Problem, I 75 Between 13 and 14 Mile Rds

75 TI-294 - Investigation of Fire Damaged Pavement, Eastbound I 96 Near Haggerty Rd/Grand River Intersection

75 TI-303 - Comparative Concrete Pavement Joint Performance on I 75 in Genesee and Saginaw Counties

75 TI-307 - Noise Problem, I 94 Northeast Corner Martin Taylor Rd, Belleville

75 TI-309 - Evaluation of Pavement Groove Dimension Variation, US 31, Rothbury

75 TI-310 - Survey and Recommendations for Ethafoam Failure Problems

75 TI-316 - Investigation of Cracking in Concrete Repair Slabs

75 TI-317 - Noise Problem Telegraph Rd, Hickory Grove and Through Foxdraft Subdivisions

75 TI-323 - Mound Rd Noise Analysis, M 53 Freeway, From Mound Rd to Existing M 53

76 TI-325 - Noise Barrier Proposed for I 696 Between Frazho and Eleven Mile Rd

76 TI-326 - New Jersey and "Break-Safe" Steel Couplings for Breakaway Sign Supports

76 TI-331 - Noise Complaint - I 75 Hazel Park

76 TI-332 - Evaluation of Revised Button-Head Bolts for Guard Rail Splices

76 TI-333 - Effect of Traffic Vibration on Three Story Brick Home, North Side of Chicago Rd, US 31 Relocated, Berrien County

76 TI-335 - Noise Study, I 94 at Knapp Dr in Battle Creek Twp

76 TI-337 - Noise Study, I 96 Farmington Hills

76 TI-339 - Vibration Problem, Mr. Pavich Residence, Lake Linden

76 TI-340 - Continuous Reinforcement Pavement Investigation, I 69, Indiana

76 TI-341 - Demonstration of C.M.I. Autograde Pavement Profiler

76 TI-344 - Noise Contour Request - I 96 Livonia Between Ellen Dr and Gill Rd

76 TI-348 - Recommendations for Salt Retention Lagoon Liners

76 TI-351 - Noise Problem Red Cedar Community Association (Ivanhoe Subdivision) East Lansing Near I 496 and US 127

76 TI-352 - Experimental Installation of Collapsible Ring High Performance Barrier

76 TI-353 - Noise and Vibration Complaint on M 153, Dearborn

76 TI-355 - Study of Deck Concrete in S03 of 64014, US 31 at Rothbury

76 TI-357 - Evaluation of Velmont Industries Utility Pole Specifications

76 TI-360 - Noise Problem I 96 - M 39 Interchange Area

76 TI-363 - "Hog-Ring" Fasteners for Chain Link Fence

76 TI-364 - Pedestrian Bridges - Vibration Analysis

76 TI-367 - Noise Problem I 75 at Stephenson Highway

76 TI-368 - Noise Problem I 96 and 8 Mile Rd

76 TI-370 - Investigation of Cores from Farm Lane Bridge, MSU Campus

76 TI-371 - Continuously Reinforced Pavement Failure Eastbound I 94 East of Rawsonville Rd

76 TI-372 - Noise Complaint, I 75 in Lincoln Park South

76 TI-374 - Study of Truck Tax Structure

76 TI-376 - Evaluation of 1/2 in. Diamond Self-Drilling Anchors

## LISTING OF ACTION PLANS
## COMPLETED DURING THE YEAR

75 AP-3(A) - Air Quality Impact, M 59 from Utica to I 94, Macomb Co.

76 AP-6(A) - Air Quality Impact, US 23 Reconstruction from Standish to M 65, Arenac Co.

76 AP-9(A) - Air Quality Impact for US 12 (One-Way Pair) City of Dearborn, Wayne Co.

76 AP-10(N) - Noise Impact, Davison Freeway - Highland Park

76 AP-11(A) - Air Quality Impact, Davison Freeway - Highland Park

76 AP-12(A) - Air Quality Impact, M 99 (Logan St) from Kalamazoo St to Proposed I 69 North of Clark Rd

76 AP-13(A) - Air Quality Impact for I 94 BL Southwest of Battle Creek