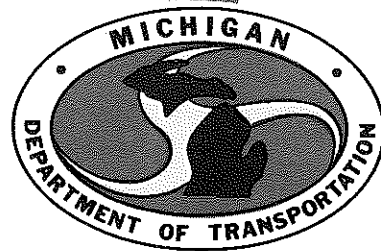


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ANNUAL REPORT OF ACTIVITIES OF
THE MICHIGAN DEPARTMENT OF
TRANSPORTATION RESEARCH LABORATORY

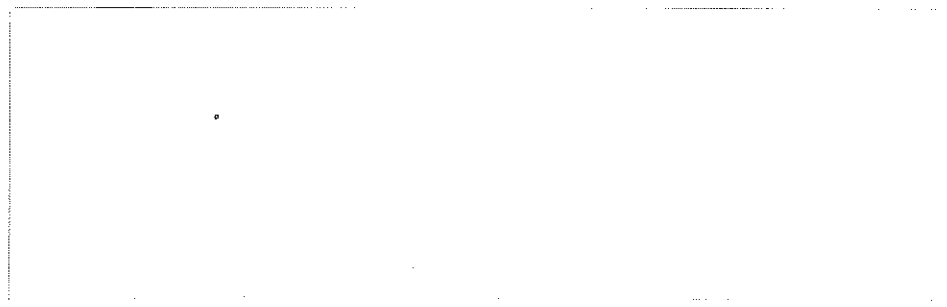
MDOT REPORT NO. 359(A)



**TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION**



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Annual report of
activities of the Michigan
Department of Transportation
Research Laboratory

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ANNUAL REPORT OF ACTIVITIES OF
THE MICHIGAN DEPARTMENT OF
TRANSPORTATION RESEARCH LABORATORY

MDOT REPORT NO. 359(A)

Research Laboratory Section
Testing and Research Division
Research Report No. R-1213

Michigan Transportation Commission
William C. Marshall, Chairman;
Lawrence C. Patrick, Jr., Vice-Chairman;
Hannes Meyers, Jr., Carl V. Pellonpaa,
Weston E. Vivian, Rodger D. Young
James P. Pitz, Director
Lansing, March 1983

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INTRODUCTION

The purpose of this report is to illustrate the scope of the activities of the Research Laboratory during the 1982 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 Department practice.

The report is divided into seven sections. The first section outlines some of the highlights of the past year's research. Section two consists of a general index of reports and projects. Section three contains abstracts of all Research Reports published during 1982. The fourth section contains 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 lists the Action Plans completed during the year. The seventh section lists the title, purpose, scope, progress past year, projected activities for the coming year, and salaries and wages for 1982, for all active Departmental and Highway Planning and Research projects (H. P. & R. projects are denoted by an asterisk).

Further information on any project described herein may be obtained by contacting L. T. Oehler, Engineer of Research, MDOT Secondary Governmental Complex, P. O. Box 30049, Lansing, MI, 48909.

RESEARCH HIGHLIGHTS - 1982

Further developmental work by our Materials Research Unit on dowel-
led concrete pavement repair was carried out on I 94 in Calhoun County.
A total of 36 lane repairs were constructed, representing six different
methods for constructing the joint between the existing and new concrete.
These methods consisted of variations in the number and size of the tie
bars installed, the use of dowels to construct either a contraction or ex-
pansion joint at the junction of the new and old concrete, and undercutting
the existing slab to provide a sleeper slab on which the ends of the old slab
would bear. A construction contract totaling approximately 2,700 lane re-
pairs on I 94 in Jackson County was let in May and is now about two-thirds
complete. About 2,100 repairs are being constructed with tied end joints
using a step-sawed end face and seven 3/4-in. diameter tie bars epoxied
into drilled holes. An expansion joint is being installed in the repairs'
centers to provide for slab movements. The remaining 600 repairs are
utilizing contraction joints at each repair end. These joints consist of nine
1-5/16-in. diameter dowels inserted in holes drilled into the existing pave-
ment joint face. The contractor installed the repairs at a rate of about 25
per day. The cost of the repairs is about 20-percent more than the un-
dowelled ones; however, based on the prediction that they will retain their
smooth riding characteristics for at least 10 years, it should be a cost-
effective way of repairing concrete pavements.

Installation was completed of the new non-contact system for the La-
boratory's Rapid Travel Profilometer. The system, known as ODS (optical
distance sensor), was developed by the Research Services Unit, and re-
places the follower-wheel assembly which was prone to damage from hitting
faulted joints, potholes, etc., during high-speed operation. The system
was used extensively during fulfillment of a request by management to pro-
file approximately 1,500 lane miles of I 94, I 75, and US 23. The testing
was conducted at 51 mph; whereas, with the older, conventional system, it
would have been necessary to operate as low as 17 mph on most of the road-
ways to avoid damage to the follower-wheel assembly. The data were also
presented in a different manner, using a format similar to the sufficiency
ratings now being published by the Planning Division. Riding Quality Index
(RQI) values were given for discreet sections of roadway, and a graph was
presented which allowed the RQI to be read for any half-mile segment.

In 1977, the End-Result Aggregate Committee adopted an in-place 22A
aggregate quality assurance plan provided by the Statistical Analysis Unit.
That plan was then implemented on four construction projects during the
1977 to 1980 seasons, to sample aggregate quality at the job site rather

than the plant's stockpiles. The concensus among contractors, aggregate inspectors, and project crew members was that the plan worked well. Based on the test results comparing the new and traditional methods, it was further concluded that in-place inspection procedures are beneficial to the Department in terms of better aggregate quality and lower testing cost. With minor changes and utilizing the same principles developed for the in-place 22A acceptance plan, the method is generalizable to other areas where in-place acceptance is desirable.

In cooperation with engineers of the Federal Highway Administration, our Soils and Bituminous Systems Research Unit sponsored a demonstration of a self-contained highway pavement evaluation device, called the 'Thumper,' at several flexible pavement test sites. Results will be compared with values obtained, at the same sites, using the Department's Benkelman beam deflection measuring system. Information obtained will provide the most economical and suitable method for evaluating the load carrying capacity of Michigan's flexible pavements.

This Unit also aided in the quest for more economical materials and methods by completing tests showing that acid treated steel furnace slag aggregates are slightly more susceptible to degradation than are natural and blast furnace slag aggregates of similar gradation. Monitoring of steel furnace slag use for open graded base construction was recommended and an installation of this type construction is now under observation. The Unit was also requested to supervise Michigan's contribution to the laboratory and field evaluation of calcium magnesium acetate (CMA), a proposed ice control chemical for the replacement of chloride use at restricted areas.

Our Structural Research Unit has completed experimental work on fatigue of anchor bolts for sign support structures, showing that the fatigue life of the bolts is reduced significantly by the presence of the galvanizing on the surface. It was known previously that heavily corroded surfaces also reduce fatigue life. Based on the experimental results, and the fatigue fractures that have occurred in the field, the Design Division has increased the size of anchor bolts required for large cantilever sign supports. The Unit carried out additional work on the relationship between D-cracking susceptibility of coarse aggregates used in pavements, and their performance in the field. It has become increasingly obvious that the long-term performance of the pavement, the amount of repair required, and the age at which repair is required, are directly related to the freeze-thaw durability of the coarse aggregates used.

In another crucial area, the Structural Unit has continued analysis of data from corrosion measurements on unpainted bridges. Results show,

in general, that the corrosive attack continues or increases with time, on those surfaces exposed to salt. Salt contamination results both from leakage, which usually covers limited portions of the steel surfaces; or from spray caused by traffic beneath the bridge, which covers nearly all of the steel surfaces. The data indicate that the severity of corrosion due to spray approaches that due to leakage, thereby affecting the major proportion of the structural steel on those structures with high-speed traffic below. There appears to be no significant difference in the attack of rural versus urban bridges, in that both corrode if subject to salt spray or leakage. Both urban and rural bridges not subjected to chloride leakage or spray, perform far better than those subjected to the chlorides. There appears to be no significant difference in the rate of attack on A36 and A588 steels, when they are subjected to chlorides.

Research has continued on the performance of guardrail posts throughout the State. Tools and techniques for evaluation were developed, which now are being used by Maintenance and Construction personnel in conducting Statewide surveys of the condition of wooden posts. Research sampling around the State disclosed surprising variety in species of posts that are in service. Some very old creosoted wooden posts are performing excellently, while some newer posts that were treated with other preservatives are beginning to decay. Preliminary results on steel posts show performance better than expected, and all galvanized steel posts were found to be in excellent condition.

The Photometry Group prepared a summary of research information and bibliography about the benefit of vehicle lighting during daylight storms or overcast conditions to enhance visibility and reduce accidents. The information was used as input into proposed Michigan House of Representative Bill No. 6096 which would require vehicles to display lighted lamps and illuminating devices during situations of insufficient light, or rain, smoke, fog, snow, or other reduced visibility atmospheric conditions. The Group also conducted a research study showing that the use of wet-bottom boiler slag in shoulder paving material can impart a significantly darker appearance to the shoulder, thus improving the visual contrast between the shoulder and the driving lanes. It was found that this darker appearance continues to be present after years of weathering. As a consequence, wet bottom slag was specified as an alternate shoulder aggregate material. Cone covers were developed for runway edge marking cones which were color coded to give pilots a visual indication of both runway width and distance to the end of the runway on unlighted daytime-use State operated airports.

The Spectrochemistry Group devised an analytical method based on atomic absorption spectrophotometry for checking wood guardrail posts for proper levels of copper/chromate/arsenic type preservatives. The method is applicable to both new and used posts. And, as part of a continuing effort to take advantage of new technology, the Group put into service an improved gas chromatograph with microprocessor control of analytical parameters and a sampling accessory which greatly reduces sample preparation time.

We should not neglect to acknowledge the day-to-day efforts of the dedicated staff members of the Laboratory, whose careful data gathering and attention to detail make these research highlights possible. The Research Laboratory has a staff of trained, conscientious technicians and specialists who are engaged in all facets of research and development, from such chores as routine data gathering to fabrication of sophisticated, specialized equipment and fixtures. Without their reliability and careful attention to detail—their exercise of initiative when the unexpected arises—there would be no 'highlights' to report.

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ABSTRACTS OF RESEARCH REPORTS
(January 1982 Through December 1982)

- R-1184 - "Implementation of Modern Statistical Methods for Improving the Accuracy of Highway Laboratory and Field Data," (78 G-238).
W. H. Kuo

Accident rate, traffic count, accident severity index, proportion of wet surface accidents, pavement friction coefficients, highway noise levels, aggregate gradations, etc., are parameters commonly used in the transportation field. The estimated values of these parameters are often the basis of information used in administrative decision making, e.g., the development of effective safety improvement and testing programs. Highway administrators also use parameter estimates to develop effective quality control systems. This Highway Planning and Research project report, conducted in cooperation with the Federal Highway Administration, demonstrates that estimation errors significantly affect the accuracy of the developed program guidelines and, consequently, decisions based on these guidelines. Thus it is of fundamental importance to reduce estimation errors as much as possible. The usual estimate of each parameter is the 'best' information for decision making on a single location. However, this estimate is no longer the best one when the purpose is to develop operation programs involving numerous locations, material sources, etc. Methods which further improve usual parameter estimates were first made by Stein and later extended by Effron and Morris. We generalize their theoretical results so that these methods can be used for estimating parameters from various types of transportation data. We show mathematically that the proposed estimation methods are always better than the usual ones in terms of the overall estimation error. Based on the proposed estimation methods, we provide four computer programs with examples for estimating parameters commonly used in the transportation field.

- R-1185 - "A Five-Year Evaluation of Preventive Maintenance Concepts on Jointed Concrete Pavement - I 75 and I 696, Oakland County," (71 F-122 and 74 F-140). C. J. Arnold, M. A. Chiunti, and K. S. Bancroft

Experimental jointed concrete pavement preventive maintenance procedures were used on 270 lane miles of I 75 and I 696 during the summer of 1975. Joint condition was rated, the worst being selected for replacement, and the use of pressure relief joints at structures and at least every 850 ft in unrepaired pavement sections was instituted. The intent was to limit or eliminate emergency repairs, or extensive contract repairs for a period of at least five years. The experiment found that pressure relief

joints are effective in 99-ft slab reinforced pavements with base plates and poured joint sealants—but they are not recommended for neoprene sealed pavements. For the type of pavement considered, the intended goal of five years without repairs was met. Some consideration of causes of the problems of these two pavements, neither of which reached its 20-year design life, is included and it was concluded that for the design of the pavement, and the existing traffic, coarse aggregate was the significant variable. It is recommended that these methods continue to be used for this type of pavement, and that care should be taken in the selection of the coarse aggregate in new construction.

R-1186 - "Petrographic Analysis of Crushed Gravel Coarse Aggregate: Lindberg #3 Pit No. 52-9 and Co. Road Comm. #12 Pit No. 52-67 combined. Testing Laboratory Sample No. 81 A-2457," (78 TI-510). R. W. Muethel

A sample of crushed aggregate from the subject pits 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-1187 - "Annual Report of Activities of the Michigan Department of Transportation Research Laboratory."

R-1188 - "Degradation of Steel Furnace Slag as an Open Graded Base Course for Concrete Pavement," (80 TI-643). E. C. Novak, Jr.

Because experience and research have indicated that dense graded steel furnace slag should not be used as a base material, some concern was expressed as to the Department's allowing open graded steel furnace slags, meeting the coarse aggregate 6A, 9A, or 17A gradations, to be used in open graded bases. A testing program was set up comparing three sources of steel furnace slag, a blast furnace slag, and natural aggregates from two sources as subjected to the following tests: Los Angeles Abrasion, Freeze-Thaw Durability, Impact Resistance, Swelling Potential, and Cyclic Loading tests. The study indicated that coarse graded steel furnace slag aggregates are somewhat more susceptible to degradation than blast furnace slag or natural aggregates, but the differences are not significant enough to warrant restricting its use for open graded base construction without further study. It is recommended that any further installations using this material be considered 'experimental' and its performance monitored on a long-term basis.

R-1189 - "Evaluation of Sulphlex as a Binder in Pavement Resurfacing Mixtures: Progress Report," (79 D-38). J. H. DeFoe

The purpose of this study is to evaluate pavement resurfacing mixtures composed of mineral aggregates combined with Sulphlex, a plasticized sulfur binder. A test section of Sulphlex was paved on M 54 in Genesee County, and samples of Sulphlex binder and paving mixture were obtained for laboratory testing. Laboratory tests of resilient modulus, thermal contraction coefficient, penetration, and viscosity were completed. This progress report describes the initial installation, and testing. No problems were encountered placing the mixture with conventional bituminous paving equipment, and temperatures are lower throughout the construction for Sulphlex than for conventional bituminous material. The blend used on this project yielded a stiff, brittle mixture which seems to be more susceptible to reflective cracking than conventional bituminous. Performance of this test section is to be evaluated on a long-term basis, and further reports will be forthcoming.

R-1190 - "Petrographic Analysis of Combined Crushed and Natural Gravel Coarse Aggregate: M. Glancy Pit No. 60-29. Testing Laboratory Sample No. 81 A-1994," (78 TI-510). 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 the specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1191 - "Early Cracking of a Bituminous Concrete Section of US 2 Located in District 2," (81 TI-776). E. C. Novak, Jr.

A brief field study is reported upon, which was based on pavement surface distress features, foundation drainage properties, and the pavement's load carrying capacity in order to identify the principal causes of early cracking in this eight-year old bituminous pavement in the Upper Peninsula. Recommendations are included for correcting these conditions, as well as comments upon their probable causes.

R-1192 - "Petrographic Analysis of Crushed Stone Coarse Aggregate: Gogebic Range Ski Corp. Pit No. 27-74. Testing Laboratory Sample No. 82 A-190," (78 TI-510). 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 the specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1193 - "Evaluation of Various Types of Railroad Crossings: Fifth Progress Report," (75 E-143). J. E. Simonsen

Michigan has been conducting an on-going research project in cooperation with the Federal Highway Administration to investigate various proprietary railroad crossing materials and designs. This report describes eight such crossings: T-Core, Fab-Ra-Cast, Steel Plank, Track-Span, Saf and Dri, Parkco, Gen-Trac, and Cobra-X. Two of these—T-Core and Fab-Ra-Cast—are now dropped from the study as being unsatisfactory. Each of the crossing materials is described, as are the construction procedures for each. Seven criteria were used to evaluate the effectiveness of the crossings: surface wear, surface damage, alignment of units, fastening of rails, pavement/crossing joint, and crossing smoothness. In general, with the exception of the two noted above, the materials continue to perform satisfactorily, though some problems have developed which have resulted in modification of the original designs or the design of new panels. We shall continue to monitor these installations, as some of the redesigned materials have only been subject to two or three years' wear, and periodic reports will be issued.

R-1194 - "Frost Heave Investigation of I 275," (79 TI-622). E. C. Novak, Jr.

As a result of early longitudinal cracking and punch-out failures on segments of I 275, investigations were initiated which indicated that differential frost action in the base was the most probable cause of the longitudinal cracking, and that volume change, or expansion of the subbase on freezing, was responsible for development of abnormally high stresses in the continuously reinforced concrete during the thaw cycle, at which time the consolidating subbase changes from a fluid to an elastic pavement support condition. It was recommended that cracks be sealed and retrofit drains installed, and that elevation measurements be taken to determine slab movement due to frost action, and whether the drains performed as expected. Although the cracks were not sealed, this report presents the results of two years' elevation measurements.

R-1195 - "Evaluation of Wet Bottom Slag Bituminous Wearing Course, I 94 in Dearborn Heights: Final Report," (73 D-28). G. M. Smith

This reports upon an investigation as to whether the use of wet bottom boiler slag in the wearing course of a bituminous shoulder would provide

better pavement/shoulder contrast due to the darker color imparted to the shoulder by this material. Annual evaluations from 1976 through 1981 are presented comparing these shoulders with conventional bituminous shoulders constructed at the same time. Contrast levels of the wet bottom slag shoulders have remained nearly the same, while those of conventional shoulders were generally much lower. The experimental shoulder delineation has provided about twice the visibility for over seven years as have the conventional shoulders.

R-1196 - "A Study to Monitor the Deicing Chemical Pollution Prevention System at the Reed City MDOT Maintenance Garage," (77 G-227).
R. W. Muethel

It was decided to include further data in this report, and to expand upon its contents. Thus it will appear in 1983 in a revised form.

R-1197 - "Static and Dynamic Properties of Anchor Bolts for Sign Supports," (77 F-153). C. J. Arnold, D. F. Johnson, and M. A. Chiunti

This report presents brief background information concerning anchor bolt failures that have occurred in cantilever sign structures. Fatigue tests are described, and the results of these showed that galvanizing dramatically reduced the fatigue life of anchor bolts and that thread root configurations can also affect fatigue life. Static test results showed that nut engagement should be at least equal to the diameter of the bolt plus 1/4 in. in order to develop the strength of the bolt and that variation of thread interference (closeness of fit) encountered in this experiment, all within specified tolerances, did not adversely affect the strength of the assemblies.

R-1198 - "Concrete Pavement Cracking, Interim Report," (78 G-240).
R. L. Felter

This project was to evaluate the effectiveness of cracking (sometimes called "shattering") concrete pavement prior to placing a bituminous overlay in order to reduce reflection cracking. This brief report describes the locations and physical characteristics of three projects that are to be monitored in the future, and describes the initial observations on their conditions.

R-1199 - "Post-Construction Air Quality Monitoring for M 99 in Lansing," (79 TI-564).

This report covers our first opportunity to monitor a site subsequent to construction that was given our now-standard pre-construction monitoring for predicting air quality. Although the parameters for the model used

for predicting the effect of construction on air quality have changed somewhat since 1973 when the first survey was made, the current model was used with updated emission factors to compare carbon monoxide levels. The correlation between the calculated carbon monoxide levels, and the measured concentrations is acceptable. The model had correctly indicated that observed carbon monoxide concentrations would be well below the Federal air quality standard levels.

R-1200 - "Evaluation of Slurry Seal Surface Treatment for Application on the Mackinac Bridge," (78 TI-536). R. L. Felter and J. E. Norton

This project was initiated to evaluate the slurry seal process as a possible surface treatment for the bituminous lanes on the Mackinac Bridge. The existing cracks on the bridge are quite narrow with virtually no spalling, and appear to be of thermal and fatigue origin. Due to the nature of the cracking, it was believed that a surface treatment would be more efficient than extensive removal and replacement effort. Seven different types of slurry seal mixtures were placed on Woodward Ave near 12 Mile Rd. Based on their performances after one winter, one mixture (9.5 percent QS-KH emulsion with slag sand) seemed to offer the most promise and was recommended for use on the bridge.

R-1201 - "Evaluation of ClaPak and ClaSet as Soil Stabilizing Agents," (79 TI-602). R. C. Mainfort and J. H. DeFoe

The objective of this study was to evaluate the soil stabilizing capability of two materials, 'ClaPak' and 'ClaSet' ('Soil stabilizing agent comprising an acid sludge-sulfuric acid product'). Six small field test sections were constructed at a Maintenance garage, one each of ClaPak and ClaSet and one combination of the two, along with adjacent untreated control sections. Laboratory analyses of the contents of the materials were also undertaken. As a result of the above work, it was found that the addition of these two products, alone or combined, produced no significant changes in the engineering properties of the clay loam soil to which they were applied.

R-1202 - "Evaluation of Noise Barriers on I 275 for Structural and Visual Integrity," (82 TI-799). F. W. Harwood and K. S. Bancroft

This report concerns a condition survey of concrete noise barrier walls along I 275, from Koppernick Rd to Edward Hines Dr, in eight areas. The walls were built of individual panels 20 ft long, 6 in. thick, and in widths of 1, 2, and 4 ft. They were made with one smooth side and one rough side. This survey was conducted after about two years' service, and recommendations are made for both the Design and Maintenance Divisions.

R-1203 - "Further Evaluation of Black Base and Aggregate Base Construction (M 20 and M 66)," (75 E-59). R. C. Mainfort

This report describes a performance comparison of a hot mix bituminous stabilized base (an eight-mile section of M 66) and an aggregate base (an eleven-mile section of M 20) located such that they have about the same traffic volumes, soil conditions, climate, and completion date. An earlier report describing construction, etc., is updated by this report which consolidates the three-year and six-year evaluations. Based on deflection measurements, rut depth measurements, and visual inspection, it was concluded that the thinner black base section has performed as well or slightly better than the conventional aggregate base, and that both sections are in excellent general condition. Although the immediate objectives of the project have been met, it is suggested that long-term observations of the test sections be made.

R-1204 - "Use of Deflection Basin Characteristics for Flexible Pavement Analysis and Overlay Design," (82 TI-802). J. H. DeFoe

For several years, Benkelman beam measurements have been used by the Laboratory to evaluate the structural capacity of flexible pavements. Since we will continue to use these techniques, this report provides a description of the procedures; specific research projects are described where these techniques have been utilized. The three-step procedure is described; deflection measurements are first taken at selected test sites, then the measured deflections are used to compute the structural parameters for the pavement system, and finally estimated layer properties are used to compute theoretical deflection values which should match the measured pavement deflections. These methods for using deflection measurements to analyze flexible pavements and for the design of bituminous overlays over flexible pavements can form the basis for more refined procedures as experience in this area of pavement analysis is developed.

R-1205 - "ASTM E501 Test Tire Correlation, B. F. Goodrich vs. McCreary," (54 G-74). P. T. Luce

Because the manufacture of ASTM pavement friction test tires (E501 and E524) changed from B. F. Goodrich to the McCreary Tire Co., it was thought advisable that a correlation study be undertaken to see whether appropriate correction factors should be developed. Friction measurements were conducted at 19 sites, chosen to reflect as wide a range of available friction as possible. Based on the information acquired, it was found that there was no need to apply correction factors to equate McCreary with Goodrich E501 test tires.

R-1206 - "Petrographic Analysis of Coarse Aggregate: Wallace Stone Co. Pit No. 32-4. Testing Laboratory Sample No. 82 A-2195," (78 TI-510). 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 the specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1207 - "Petrographic Analysis of Coarse Aggregate: Wallace Stone Co. Pit No. 32-4. Testing Laboratory Sample No. 82 A-2196," (78 TI-510). 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 the specific gravity and absorption data. Detailed rock type descriptions of the material in the sample are also provided.

R-1208 - "Degradation of Acid-Treated and Untreated Steel Furnace Slag as an Open Graded Base Course for Concrete Pavement," (80 TI-643). E. C. Novak, Jr.

Upon reviewing R-1188 (above) concerning the durability of acid-treated steel furnace slag for use as an open graded base course, a major slag producer indicated that steel furnace slag should be more durable when untreated, and requested that another study be done using untreated material. This report summarizes the durability properties measured for acid-treated and untreated steel furnace slag, blast furnace slag, and natural aggregates. The study indicated that there was little difference in the degradation of the two slags, except under the T-180 compaction effort where the untreated slag degraded more than did the acid-treated slag.

R-1209 - "Use of Recycled Asphalt Material in the Construction of a Bituminous Stabilized Base, I 75, Cheboygan County," (75 D-30). J. H. DeFoe

This is the final report describing features of Michigan's first large-scale cold recycling project; a previous report (R-1088) described the construction procedures, specifications, and road history. This report summarizes material characteristics determined by laboratory tests and

measurements of the road's performance over the five-year evaluation period. The report concludes that cold in-place recycling of an existing bituminous pavement was successfully accomplished, and the recycled base roadway is structurally equivalent to a comparison roadway constructed with a separation course between the new and old bituminous material. Reflection cracking was essentially eliminated, and the physical properties of the recycled material as measured in the laboratory were equivalent to those of hot plant mixed black base materials typically used in Michigan.

LISTING OF NEW MATERIALS PROJECTS
COMPLETED DURING THE YEAR

- 71 NM-286 - "Petro-Mat" Fabric Asphalt Membrane for Bridge Decks and Prevention of Reflection Cracking
- 75 NM-435 - Fasson Reflective Sheeting
- 79 NM-594 - "Terra Tack II" Mulch Binder
- 80 NM-603 - Mitsubishi "Super" Engineering Grade Reflective Sheeting
- 80 NM-609 - "Sinak Internal Sealers" to Permanently Seal, Preserve, Densify and Harden All Concrete Structures
- 81 NM-637 - Reflexite A/C 1000 Reflective Sheeting
- 81 NM-641 - Welded Beam for Guardrail and Sign Post
- 82 NM-646 - L & L Coating Mastic #300 for Structural Steel or Concrete
- 82 NM-649 - Everlube Bridge Bearing Lubricant
- 82 NM-661 - AKT-18 Delineator

LISTING OF TECHNICAL INVESTIGATIONS
COMPLETED DURING THE YEAR

- 74 TI-258 - Noise Impact, West Side I 275 Between Joy and Ann Arbor Rds
- 78 TI-461 - Investigation of Joint Shattering at Intersection of Transverse and Longitudinal Joint Highway Pavement, I 75 South of Flint
- 78 TI-469 - Field Evaluation and Artificial Weathering of Mitsubishi Reflective Sheeting
- 78 TI-506 - AASHTO Subcommittee on Developing Procedures for Responding to Vibration Complaints
- 79 TI-564 - Air Quality Monitoring of M 99 (Logan St and Barnes Ave)
- 80 TI-634 - Greyhound Bus Suit
- 80 TI-644 - Glare from Royal Scot Parking Lot Lights, West Grand River, Lansing
- 80 TI-690 - Vibration Study on Bridges B03 and B04 of 64015-13530A
- 80 TI-699 - License Plate Study for Iowa
- 81 TI-732 - Use or Disposal of Aged Reflective Sheeting
- 81 TI-773 - Investigation of Removal Characteristics of Latex Cover Material on Lottery Tickets
- 81 TI-783 - Study of Possible Segregation in Prestressed Concrete I-Beam (S10 of 77023)
- 82 TI-788 - Statistical Analysis of Aggregate Wear Index
- 82 TI-791 - Noise Investigation on I 475, Ottawa Hills, Grand Blanc Township (Mr. Stanley Zbiciak)
- 82 TI-797 - Rochester Rd Turnback
- 82 TI-798 - Failure of Link Plate Nuts, S21 of 77111, Water St Over I 94, West of Port Huron
- 82 TI-799 - Evaluation of Noise Walls, I 275/I 96 Ford Rd to Six Mile Rd

- 82 TI-800 - Evaluation of Anchor Bolts for Pedestrian Crossing, P01 of 81063, Over I 94, Near Georgia St, Washtenaw County
- 82 TI-803 - Investigation of Failure of Aluminum Expansion Joints on S05 and S06 of 82194, I 75 Over Fort St in Detroit
- 82 TI-804 - Investigation of Soundness of Timber Piling on B01 of 17991-19191C, FFH 42 Over Halfaday Creek
- 82 TI-810 - EIA to TDI Converters for Computer Services Division
- 82 TI-814 - Investigation of Failure of Bolts Supporting Sign Face
- 82 TI-816 - Noise Investigation, M 25 Near 47 E. Elm, Monroe
- 82 TI-817 - Noise Investigation, I 96 Near Brighton Church of the Nazarene Parsonage
- 82 TI-822 - Noise Measurements; I 94 in the City of Roseville (East of I 94, South of Masonic Blvd, and North of 13 Mile Rd)
- 82 TI-825 - Styrofoam Testing for Under the Footings, I 696 Retaining Walls
- 82 TI-826 - Evaluation of Dywidag Mechanical Rebar Couplers
- 82 TI-827 - Cement Content of Footing Concrete Pier 1 of S05 of 54014
- 82 TI-834 - Study of Latex Modified Concrete Overlay on City of Milford Structure (Wackerly Rd over Sturgeon Creek)
- 82 TI-835 - Noise Attenuation at Mr. Lance Wesener Residence, I 75, Clio
- 82 TI-836 - Noise Investigation at Mrs. Thomas Bilan Residence, 124 Tremont St, Monroe
- 82 TI-843 - Comparison of Reflectivity of Old and New License Plates
- 82 TI-844 - Peters — Class Action Suit — I 696
- 82 TI-851 - Analyze Substance Plugging Computer Plotter Pens
- 82 TI-855 - Testing of Guardrail Post; Court of Claims #8078, Hanzel vs. MDOT

- 82 TI-863 - Cement Analysis B02 of 11031/02501A, M 139 Over St. Joseph River
- 82 TI-864 - Noise Investigation on I 75 Between King Rd and West Rd, City of Woodhaven
- 82 TI-869 - Toll Equipment Blue Water Bridge
- 82 TI-870 - Load Carrying Capacity of Street in Wayne County
- 82 TI-873 - Investigation of Contaminated Stockpile of Fine Aggregate

LISTING OF ACTION PLANS
COMPLETED DURING THE YEAR

80 AP-33(A) - Air Quality Monitoring for Reconstruction of M 50 in Monroe

81 AP-35(A) - Air Quality Monitoring for Reconstruction of Grand River Avenue and M 102 Interchange

81 AP-36(A) - Air Quality Monitoring, US 23 from Standish to M 65

81 AP-37(A) - Air Quality Monitoring, US 31, Mason/Manistee County

STATISTICAL ANALYSIS UNIT

Title

82 F-161 - Concrete Pavement Evaluation

Purpose

The purpose of this study is to compare newer construction projects since about 1965 with the performance of immediate post-war construction. Data must be obtained from tabulations of condition surveys. Specific variables such as joint spacing and joint seal will be examined.

Scope

Examination of pavement performance for all post-1965 concrete construction.

Progress Past Year

Review of preliminary data suggests that joint performance varies considerably among projects and even between roadways of the same project.

Planned Program for Coming Year

Complete tabulation of remaining projects and make performance comparisons.

Salaries and Wages 1982: \$2,062

Title

77 G-231 - Pre-Icing of Bridge Decks

Purpose

The purpose of this study is to determine the magnitude of the bridge pre-icing problem. Accident histories for selected highway bridges and their approaching roadways will be examined and the various weather conditions noted. Variables such as relative humidity, air temperatures, precipitation history, etc., will be measured in order to certify hazardous

conditions. Any quantitative relationships between these variables and accident frequency will be incorporated into an accident prediction model.

Scope

Ten-year accident histories including time of occurrence for at least 200 bridges will be tabulated together with weather data from the nearest weather station.

Progress Past Year

All data have been collected and analyzed; report writing, graphics, etc., remain. Our findings indicate that the pre-frosting condition is either not frequent enough or strong enough to appreciably affect bridge accident occurrence. Rather precipitation, either prior or current, together with below freezing temperatures are strongly associated with relative increases in bridge accidents. Further, these conditions are especially critical in late fall when approach pavement is warm enough to keep from icing. Also of interest is the finding that accidents on bridges are much more numerous between 7 and 8 a. m. than any other hour of the day. Additional data have been obtained that identify all accidents coded to bridges (0.2 mile sections) under conditions of icy/snowy pavement surface. About 10 years of these data are now available and are currently undergoing analysis to determine if the same factors of precipitation and time of day and year are associated with bridge deck accidents.

Planned Program for Coming Year

Completion of final report.

Salaries and Wages 1982: \$10,109

Title

*78 G-238 -- Implementation of Modern Statistical Methods for Improving the Accuracy of Highway Laboratory and Field Data

Purpose

The end product will be a manual and computer program designed to bring engineers and scientists up to date on newly developed statistical estimation procedures. Benefits will be realized in the improved accuracy

of test results taken from groups of samples and/or the reduction of test samples required to achieve desired precision.

Scope

Development of procedures for sample average improvements for aggregate testing, materials testing, accident estimates, pavement friction tests, etc.

Progress Past Year

Final report completed and approved by the FHWA.

Planned Program for Coming Year

None.

Salaries and Wages 1982: \$367

Title

78 G-239 - Comprehensive Analysis of Skid Resistance Data

Purpose

The Unit was asked to prepare a proposal on the examination of the Laboratory's records of bituminous surface skid resistance.

Scope

Fifteen years of friction test data for bituminous surfaces will be examined for correlations with design and construction variables.

Progress Past Year

None

Planned Program for Coming Year

Completion of proposal, and pending approval, tabulation of friction test and mix design variables.

Salaries and Wages 1982: - 0 -

Title

*80 G-249 - The Development of Acceptance Sampling Plans Assuming the Percentage of In-Place 22A Aggregate Within the Specification Limits

Purpose

The purpose of this project is to reduce sampling costs by changing the statistical approach (plan design) of the usual fraction defective procedure.

An example demonstrating usage of the manual for designing an in-place 22A aggregate inspection plan will be given.

Scope

Development of procedures for using sample information (sample averages and covariance) to estimate the percentage of material falling within specification limits.

Progress Past Year

Development of a theoretical basis for the new plans.

Planned Program for Coming Year

Completion of a procedures manual for the various plans.

Salaries and Wages 1982: \$1,133

MATERIALS RESEARCH UNIT

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 is to be evaluated by selected in-depth 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 to 1971, followed by contract repair projects in 1972 to date. General usage of latex concrete or low slump high density (LSHD) concrete on selected projects began in 1976 and as alternate systems in 1977. In 1978 a latex admixture produced by Arco Polymers (Dylex 1186) was used in the latex modified concrete overlay of 11 structures on one repair project. In 1979 and 1980 a third alternate latex, Thermoflex 8002, was used on three structures on I 496 in Lansing under one repair contract.

Progress Past Year

A performance survey of 23 latex modified concrete deck overlays was conducted. The age of the overlays ranged from six to 10 years. The survey included a check for delaminations, half-cell corrosion readings, sampling the concrete for chloride contamination, and visual inspection for cracks and surface defects. A more general visual inspection was conducted on some early overlays where traffic volumes were too great for closing a lane for an in-depth evaluation. The use of high pressure water blast instead of scarifying the deck surface prior to overlaying was tried.

Planned Program for Coming Year

The collected data will be analyzed and a report prepared. Inspections of overlays will continue on a periodic basis and new preparation or construction procedures will be observed where used.

Salaries and Wages 1982: \$8,504

Title

72 B-90 - Experimental Use of Water-Reducers in Slipformed 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.

Based on the results of the extensive test data from seven projects paved in 1972 to 1974, 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 and 1979 Standard Specifications (Table 7.01-1). The 5.6 sack/cu yd mix with water-reducer, in lieu of 6.0 sacks of cement, has been widely used across the state in paving concrete.

Progress Past Year

Due to the continuing work load and higher priority assignments, the project was not closed.

Planned Program for Coming Year

Complete a report to finalize the project although results of the study have been implemented in the Standard Specifications.

Salaries and Wages 1982: - 0 -

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 for both pavements and structures.

Scope

One-third of a paving project on I 275 was utilized in 1974 to directly compare Type 1P cement with Type 1A. Sampling of the fresh and hardened concrete was done to evaluate strength and durability. In 1976 and 1977, structural grades of 1P-A cement concrete were evaluated against 1A control concrete in the bridges X01 and X03 of 82102 that carry M 14 over the C&O RR northwest of Plymouth. The portland-pozzolan cement was used in the eastbound structure (X03). Test specimens molded from fresh concrete samples were tested from both types of concrete. In 1977 and 1978, test cores to evaluate the hardened concrete were cut horizontally from the substructure units and vertically full-depth through the superstructure deck. These cores were tested to yield information on the concrete's compressive strength and consolidation characteristics. A performance inspection of the experimental portion of the I 275 paving project was made in 1978 and was included in the draft of the final report.

Progress Past Year

Reports on the I 275 paving project and the M 14 bridges were in the review process.

Planned Program for Coming Year

Complete review and issue reports which will close the project.

Salaries and Wages 1982: \$2,767

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 in 1972 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. The revibration technique was not successful and the latex modified concrete overlay has become a standard system for two-course construction.

They were inspected and corrosion cell tests run late in 1975. The structures with the latex modified mortar overlay and with the concrete overlay were inspected, cored, and tested with a corrosion cell and delamination detector during 1977. Laboratory tests were run on selected cores to measure chloride penetration and shear bond.

Progress Past Year

Due to higher priority work, a final inspection and report on these three projects was not completed.

Planned Program for Coming Year

Make final inspections and include data with all previous information for final report on this project.

Salaries and Wages 1982: - 0 -

Title

75 B-93 - Low Slump High Density (LSHD) Concrete 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 high density overlays 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 inspection and testing. In 1977 the low slump high density overlays were used both for deck repair and on new two-course construction as an alternate to latex modified concrete. Additional structures were overlaid in 1978 with low slump high density concrete overlays. These included 11 decks under two repair contracts and eight new two-course structures on I 475 in Flint.

Progress Past Year

The performance of the three experimental deck overlays on I 96 was checked by conducting delamination tests, half-cell readings, sampling the concrete deck for chloride content and visual inspection of the deck surface. In addition, all overlays of this type were visually inspected, including a deck overlaid in 1981 with a LSHD concrete containing a superplasticizer. Two badly cracked LSHD overlays were treated with a sealer.

Planned Program for Coming Year

The data collected during 1982 will be analyzed and summarized. Performance inspections will continue until sufficient data have been obtained to warrant conclusions.

Salaries and Wages 1982: \$6,470

Title

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

Purpose

To investigate 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 was performed to compare properties of several grades of concrete made with Type 1SA and Type 1A cement with and without water-reducers. Strength data were obtained at temperatures of 45 and 57 F to compare with normal temperature cure both with Type 1SA and 1A cements.

Progress Past Year

Final report was in review process.

Planned Program for Coming Year

Close project with the publishing of the report.

Salaries and Wages 1982: - 0 -

Title

76 B-95 - Experimental 'Econcrete' 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

In 1976, about 1,240 ft of Ramp A in the southwest quadrant of the Shelby Rd-US 31 interchange was constructed of a composite econocrete pavement. About 1,200 ft of Ramp A was constructed with 8 in. of grade 35P concrete. The econocrete mix contained 305 lb/cu yd of cement, a water-reducer, and a local 60-40 sand-gravel aggregate. The composite econocrete pavement consisted of two layers each of 4-in. depth; the lower layer being econocrete and the upper layer being grade 35P concrete. The construction of the composite econocrete pavement was closely monitored. Fresh concrete specimens of both econocrete and grade 35P concrete were obtained and tested in the laboratory. Future inspections and testing were to include coring, measurements of joint openings, slab movement, profilometer, load-deflection and condition surveys of both the composite econocrete pavement and the grade 35P concrete pavement.

Progress Past Year

No work was done on this project due to higher priority work assignments.

Planned Program for Coming Year

A final survey is planned and a report is to be written to close the project.

Salaries and Wages 1982: - 0 -

Title

77 B-96 - Experimental 'Econocrete' Shoulder Construction, M 14 Near Wayne County Line, and I 69 Near Lansing

Purpose

To evaluate the construction and performance of econocrete shoulders on M 14 near Wayne County line and I 69 near Lansing. The econocrete mix on I 69 is proposed to contain a cheaper peastone aggregate. The econocrete mix on M 14 incorporated cement reductions intended to provide compressive strengths of 3,000, 2,500, and 2,000 psi at 28 days age.

Scope

About three miles of the outside shoulders of M 14 were paved in 1978 in half-mile sections. The sections consisted of, alternately, grade 30P concrete, 3,000, 2,500, and 2,000 psi grade 'econocrete,' or 30E, 25E, 20E, respectively. The econocrete mixes utilized a locally available 20AA aggregate containing about 68 percent sand.

Almost three miles of I 69 north of Lansing was to utilize peastone aggregate in the concrete shoulders of the dual roadway in 1981 and 1982.

Progress Past Year

Paving of the econocrete shoulders on I 69 was completed. Fresh concrete measurements as well as samples for laboratory tests were obtained. Testing of concrete samples for determination of compressive and flexural strength, freeze-thaw durability, shrinkage, and chloride penetration was completed.

Planned Program for Coming Year

The collected data will be included in a brief construction report. Long-term performance evaluation on this project will be carried out by the Structural Research Unit.

Salaries and Wages 1982: \$2,462

Title

78 B-98 - Experimental Resurfacing of Chloride Contaminated Concrete Bridge Decks with Latex Modified Concrete

Purpose

This study is to assess the long-term performance of 1-1/2-in. latex concrete overlays on selected decks containing more than 4 lb/cu yd of chloride. The effect of the residual high chloride on possible continued corrosion of the top rebars and integrity of the overlay is to be assessed by corrosion cell tests, delamination surveys, selective coring, and visual surveys.

Scope

It was proposed that latex modified concrete be used to repair deck spalls and increase the cover over the top steel by at least 1-1/4-in. on five structures in the I 96-US 23 area east of Brighton. Four of the structures contain concrete having more than 4 lb/cu yd of chloride and the deck performance was to be compared with the fifth structure having an average of 1.6 lb/cu yd of chloride.

This study was initiated as a Category 2 project and Work Plan No. 64 was submitted and approved by the FHWA. Since the project was initiated, over 50 more structures have been approved for inclusion in the study. All of these structures were found to contain more than 4 lb/cu yd of chloride in portions of their decks.

Progress Past Year

The 10 decks selected for evaluating the overlay performance were subjected to delamination detection tests, half-cell corrosion readings, and visual inspection of cracks and surface defects. Rotohammer samples of the deck to a depth of 3 in. were taken for chloride analysis of each deck. On the basis of visual observations of these overlays, they are until now performing as well as overlays on less contaminated decks.

Planned Program for Coming Year

Only a visual inspection of the decks is planned. The collected samples will be analyzed for chloride content, and a report covering the evaluation to date is planned.

Salaries and Wages 1982: \$9,068

Title

81 B-100 - Vibratory Consolidation Methods for Bridge Deck Concrete

Purpose

The purpose of this project was to demonstrate the improved bridge deck performance that could be obtained through uniform consolidation of the concrete. The importance of uniform consolidation was recently established by a research project on pozzolan concrete, where the test results indicated high variability of concrete consolidation. The report concluded that the random application of a probe vibrator was responsible and that isolated areas of high permeability were partially responsible for galvanic corrosion problems.

Scope

Voluntary field test arrangements with the Bidwell Co. were secured in an existing contract to construct a six-span bridge to carry relocated Francis Rd over I 69 about two miles northwest of Lansing. It was originally intended that the machine be used to provide consolidation for three or more of these spans during the 1981 construction season. Subsequent to its construction, concrete cores will be used to evaluate the machine's effectiveness in comparison to cores from spans placed and finished by conventional means and equipment.

Progress Past Year

The consolidation machine to be furnished by the Bidwell Co. was not available at the time the Francis Rd bridge deck was poured. Consequently, the deck was placed using standard consolidation methods.

Planned Program for Coming Year

An attempt will be made to arrange for machine consolidation of another deck pour to evaluate the performance of concrete consolidated in this manner.

Salaries and Wages 1982: \$1,171

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 pavement friction resistance of bituminous mixes and the economic factors involved in obtaining suitable aggregate in critical areas.

Scope

Both bituminous concrete and bituminous aggregate pavement friction data were re-examined on projects paved up to 1963 and also from 1963 to 1972. Primarily, bituminous concrete projects were examined under Phase 1, and bituminous aggregate jobs and initial wear track construction were done under Phase 2. Extensive wear track tests were to be run on selected coarse aggregates used in 4.12 and 4.11 mixes to define their relative wear characteristics.

Progress Past Year

Wear track Test Series No. 16 was completed in February of 1982. The test results were incorporated in a progress report with the results of Series Nos. 13, 14, and 15 completed in 1981. Included in Series No. 16 were four blends of high-polishing limestone with blast furnace and steel furnace slags. The slag-limestone blends were found to exhibit considerably higher long-term friction values than the unblended limestone. Wear track Test Series No. 17 completed in August of 1982 included blends of crushed and rounded gravel to determine the effect of uncrushed material on the polishing value of coarse aggregates. The tests indicate an approximate 8 percent reduction for each 20 percent of rounded material. This information is to be used in formulating an adjustment factor for the Aggregate Wear Index which was developed from previous wear track test results.

Planned Program for Coming Year

Wear track Test Series No. 18, currently in progress includes gravel samples submitted to the laboratory for Aggregate Wear Index determination by wear track testing. The series also includes two additional carbonates to be tested for Aggregate Wear Index. Series No. 19, following completion of the current series, includes a follow-up study of crushed and rounded blends from two additional gravel sources. Series No. 20 is tentatively scheduled to include samples of arenaceous limestone from the Wallace Stone Co. quarry at Bayport.

Salaries and Wages 1982: \$19,718

Title

77 C-18 — Evaluation of the Performance of Bituminous Wearing Course Containing Sandy Limestone

Purpose

Laboratory wear track data have indicated that sandy limestone from the Bayport Formation exhibits wear characteristics approximately equivalent to crushed gravel. This study was initiated to evaluate the field performance of an experimental pavement containing sandy limestone in the wearing course.

Scope

In July of 1977, approximately one mile of a resurfacing project on US 23 in Standish (Project Mb 06071-11004A) was paved with a bituminous wearing course specifying Bayport sandy limestone. Adjoining pavement sections contain crushed gravel. Annual trailer pavement friction tests are scheduled for a five-year period to monitor the long-term pavement friction performance of the test pavements. Included in the study are supplemental insoluble residue determinations and petrographic analyses of the test aggregates.

Progress Past Year

Annual pavement friction measurements were conducted by the Pavement Performance Group. The test pavements containing sandy limestone coarse aggregate versus high carbonate crushed gravel in the bituminous surface course both recorded satisfactory friction numbers. The sandy limestone section recorded friction numbers ranging from FN 33 to FN 42, and the high carbonate gravel section recorded friction numbers ranging from FN 35 to FN 45.

Planned Program for Coming Year

A final report on the study, which was scheduled as a five-year project, is to be drafted. Annual pavement friction measurements will be scheduled if additional information is requested.

Salaries and Wages 1982: \$39

Title

57 F-46 - 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

The bar mat section continues to give good service with a minimum amount of maintenance. The mesh sections have numerous undowelled repairs, but these repairs have given good service to date. Surface deteriorations continue to develop and are being maintained with bituminous material. A few steel fractures have occurred in the mesh reinforced sections.

Planned Program for Coming Year

Periodic surveys will be made to monitor the performance of both the repairs and the original pavement.

Salaries and Wages 1982: - 0 -

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

The undowelled repairs installed on the eastbound roadway in 1981 have performed satisfactorily to date. The tied and dowelled repairs on the westbound roadway continue to provide a smooth ride. Surface deteriorations are developing on both types of reinforced sections.

Planned Program for Coming Year

Observations of the repairs and pavement's performance will be made periodically and measurements of the repair joint movements are planned.

Salaries and Wages 1982: - 0 -

Title

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

Purpose

Establish design considerations for use on continuously reinforced pavements in metropolitan freeway locations; 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 with equipment riding on pavement forms. Various types of reinforcement were used and free ends were anchored or allowed to move at specially constructed WF joints. A variety of construction joints were used.

Progress Past Year

About two miles of the northbound I 75 roadway north of the Rouge River were overlaid with a latex modified bituminous mixture. Prior to

overlay, the deteriorated and delaminated areas were repaired with bituminous material. The 1/4-mile section on the southbound roadway, overlaid in 1980, continues to give good service. A contract is in preparation for repairing deteriorated areas with bituminous hot mix materials.

Planned Program for Coming Year

The pavement will be inspected periodically to monitor the performance of the overlays, the repairs, and the pavement itself.

Salaries and Wages 1982: \$278

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 slip-formed CRCP.

Scope

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

Progress Past Year

Longitudinal cracking on I 196 and US 31 appears to have stabilized, but spalling along the cracks has developed. On I 275 the increase in longitudinal cracking was less than the previous year. The cracks in some areas appear to have opened somewhat over the years and slight faulting and spalling have occurred. About 1,000 lin ft of cracks were routed and sealed early this summer using hot-poured rubber-asphalt sealants to determine the feasibility of using this type of seal in the longitudinal cracks. It was determined that a soft type seal would be satisfactory for use on the entire project. The Maintenance Division is currently involved with sealing the cracks. About 50 percent of the work was completed this fall with the remainder to be done in the spring. Only a few more punch-outs occurred last year and these as well as previous ones are being maintained with bituminous (Sylvax) patching.

Planned Program for Coming Year

Surveys will be conducted periodically to monitor the pavements' performance with respect to continued increase in longitudinal cracking and formation of new punch-outs. The performance of sealed cracks will also be evaluated.

Salaries and Wages 1982: \$1,804

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 used on bridges in Kansas to similarly affected 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. A procedure and the expertise are to be developed to adapt the epoxy injection technique to the repair of concrete bridge deck delaminations. Injection on an annual basis of newly developing delaminations on a bridge deck are to be made to see if the deck can be returned to a condition of long-term functional stability, and annual inspections conducted of the bridge deck to determine if the procedure is achieving the desired results.

The first phase of this project was done as a joint voluntary venture between a contractor and the Department in 1975 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 second phase of this project consisted of repairing the delaminations on four bridge decks that were in the initial stages of deterioration in the fall of 1976 and the summer and fall of 1977. The third phase of this project was carried out under contract in the summer of 1978, and the same bridges were surveyed and all newly developed delaminations injected. A portion

of the repaired deck of one of the subject bridges was coated with a sealant to preclude the entrance of additional surface moisture and chlorides. Inspection in 1979 revealed that several new delaminations had developed, most of them occurring adjacent to areas successfully injected in 1978, others occurring as refractures in areas successfully injected in 1977. The performance was no better in the areas where the deck had been sealed; however, the performance of the sealants under traffic was less than ideal.

Progress Past Year

Higher priority work precluded additional work on this project.

Planned Program for Coming Year

A final inspection of the decks and a report is planned.

Salaries and Wages 1982: - 0 -

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; therefore, new crossing surface materials will be evaluated as requested by the Department's New Materials Committee.

Progress Past Year

Four single crossings were added to the study in 1982; two Steel Plank, one Gen-Trac, and one Saf and Dri. The total number of crossings now included in the program is 72. The yearly inspection revealed problems with the Gen-Trac crossings field side units. On heavily traveled crossings the side units wear away the wood tie which results in low pads. One Steel Plank crossing had two side units removed and replaced with bituminous materials. Foundation problems were observed at two Parkco crossings, but failure in the surface pads had apparently not occurred.

Planned Program for Coming Year

The yearly inspections will be continued and special inspections will be made as requested. The installation of new materials will be observed when possible.

Salaries and Wages 1982: \$5,131

Title

78 F-154 - Evaluation of Promising Proprietary Bridge Deck Expansion Joint Devices

Purpose

The purpose of this project is to evaluate continuous single unit sealing element types of proprietary bridge expansion joint devices in the field. This is to include installation details and problems as well as long-term performance through a regular inspection program.

Scope

A progress report on field findings is to be made whenever at least three of any given type have been installed. Since difficulties sometimes do not appear for some time, field inspections will be made for several years.

Progress Past Year

In lieu of a progress report being issued, any problems noted for a particular device were discussed with the manufacturer and with the appropriate MDOT Divisions. In this way, revisions could be rapidly made.

Standard detail and installation procedures have been completed for all expansion dam systems in use. However, in view of problems encountered with various aspects of the systems, particularly the anchorage methods, as well as changes in Federal guidelines for maximum joint openings, revision of these standard details was begun.

During this construction season, one new expansion dam system was installed on four structures.

Planned Program for Coming Year

The changes now under consideration for the standard details will be completed and evaluated, surveillance of the present installations and the installation of any new devices will continue, and a progress report will be finalized early in the year.

Salaries and Wages 1982: \$9,595

Title

79 F-159 - Development of Tied Joints for Concrete Pavement Repairs

Purpose

To develop a tied joint detail for use between existing and new concrete that can be constructed rapidly without extensive hand labor.

Scope

Different types of tied joints will be tested in the Laboratory, and promising ones are planned for testing in the field.

Progress Past Year

Stage 2, the installation of experimental repairs on I 94 east of Marshall (5,000 commercial ADT volume), was completed in early June. A total of 36 lane repairs were constructed. Six different joints between the new and old concrete were used: step-cut with tie bars, straight cut with tie bars, dowelled contraction joint, dowelled expansion joint, tied joint, and undercutting existing slab. Stage 3, the construction of dowelled and tied repair joints on a contract basis on I 94, was begun in June. About 2,000 lane repairs have been done to date with another 700 to be constructed next year. About 600 repairs utilize dowelled contraction joints and the rest have step-cut tied end joints with an expansion joint in their center. The experimental stage 1 and 2 repairs are all performing satisfactorily to date. Some problems were experienced in obtaining satisfactory epoxy grouted tie bars on the I 94 contract project.

Planned Program for Coming Year

The contract repairs will be completed and evaluation of these as well as previously installed repairs with tied or dowelled joints will continue. Dowelled contract repairs are planned for other projects.

Salaries and Wages 1982: \$34,920

Title

47 G-36(35) - 1982 Supplemental Traffic Paint Performance Tests

Purpose

This project is the 1982 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 1983.

Scope

This is a cooperative project between the Research Laboratory, the Traffic and Safety Division, and the Maintenance Division. Personnel from the three groups cooperate in applying the test stripes while the Research Laboratory is responsible for the laboratory work, evaluation of test stripes, and reporting.

Progress Past Year

Field tests were initiated in July 1982 for both the alkyd type fast-dry paints and polyesters. The fast-dry paints included two whites and two yellows from each of five producers. The polyesters included a total of six yellow and six white from four producers. Periodic ratings were made and will be continued until each paint has reached the end of its useful life as defined by ASTM D 713. A progress report was made to the Paint Committee in December of 1982.

Planned Program for Coming Year

Rating of the paints in field tests will continue until all paints have reached the limit of their useful lives. A final report will be made to the Paint Committee including recommendations as to eligibility of paints for 1984 purchases.

Salaries and Wages 1982: \$8,536

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 77 G-230. Revisions are generally cooperative with the using Division and are drawn-up to a Specification Unit format.

Progress Past Year

The first formal training sessions for inspectors were held to inform them of reasons for specification provisions and to train them in the use of instruments necessary for enforcement.

Several specification revisions were made and a specification for complete shop painting of structural steel was written.

Planned Program for Coming Year

Continue inspector training program and develop a similar program for contractors.

Specification revisions will be made as necessary.

Salaries and Wages 1982: \$113

Title

62 G-116 - Extruded Neoprene Joint Sealer

Purpose

To evaluate the performance of neoprene seal installations in concrete pavement contraction and expansion joints.

Scope

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

Progress Past Year

One new seal design was evaluated but not approved.

Planned Program for Coming Year

Evaluate new design sections as submitted.

Salaries and Wages 1982: \$826

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 unsuitable, 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.

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 1977. The tests appear to have been conducted on an aggressive area since the losses were higher than expected for the eight-year long tests. Because of the abnormality, the tests were continued with

Phase 2 panels. Since the producer did not submit the new test panels until mid-December 1976, all were exposed on the Detroit Armory roof on December 17, 1976.

On June 29, 1977, two-thirds of the above panels were removed from the Armory roof and installed over the Lodge freeway. Half were installed on the eastbound service structure over northbound traffic and half were installed on the westbound service structure over southbound traffic.

The first set of panels were removed in July 1979 and shipped to the producer's laboratories for corrosion measurements. Some of the panels from the initial eight-year tests had been cleaned, and then coated by the producer. These showed failure after 2-1/2 years outdoor exposure, probably because of insufficient film thickness.

The second set of panels were removed from the Armory roof and the structure over the Lodge freeway in September 1981. These were shipped to the producer after visual examination in the laboratory. It should be noted that another research study (78 G-241) is being conducted to assess actual corrosion in areas of high salt usage and atmospheric contaminants for both A588 and A36 steel structures.

Progress Past Year

None. No activity was scheduled.

Planned Program for Coming Year

The third set of test panels are planned to be removed after eight years in 1985.

Salaries and Wages 1982: \$522

Title

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

Purpose

This bridge was erected on an experimental basis to determine whether the orthotropic design and epoxy wearing surface on the steel plate deck 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 in 1979 and annual inspections are made to determine long-term performance of the surface.

Epoxy mortar surfacing was applied in 1969 to a minimum thickness of 5/8 in.; Guardkote 250 was applied to the south half of the bridge, and Epon 815-Versamid 140 to the north half. Subsequent inspections revealed several types of deterioration; shrinkage craze cracking was very distinct in the GK-250 and less prominent 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 had removed approximately 1/8 in. of mortar per year. The rate of abrasion in the E815-V140 appeared to be less. In 1978, several bare areas in the Guardkote 250 mortar surfacing had enlarged in the south span. The north span epoxy mortar, though sustaining an undetermined amount of traffic abrasion, remained essentially intact.

Arrangements were made with domestic producers in 1980 to apply a Mobilplast system, used very successfully in Europe, as a wearing course. The original experimental epoxy wearing surface was removed and a 2-in. Mobilplast protection system applied.

Progress Past Year

A third electrical resistance survey and an inspection were made.

Planned Program for Coming Year

The collected data will be analyzed and a final report prepared.

Salaries and Wages 1982: - 0 -

Title

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

Purpose

To study the effects of deicing 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 the study progresses.

Progress Past Year

Monthly water samples were obtained from the 32 ground water monitor wells located at four test sites along state trunklines. Additional water samples from selected streams and roadside ponds were also obtained monthly. A total of 469 samples were collected and tested for chloride content in 1982. A progress report to include the 1982 sampling data has been initiated. Information from the long-term sampling indicates a gradual increase in ground water chlorides through 1978. Ground water chlorides from 1978 through 1982 indicate no overall increases, with average ground water chlorides below 100 ppm Cl^- at the Clare US 10, Grayling I 75, and West Branch I 75 test sites. Ground water chlorides at the Kinderhook I 69 site exhibit seasonal fluctuations between approximately 50 to 150 ppm Cl^- .

Planned Program for Coming Year

A continuation of the monthly monitoring of the ground water wells and surface water sources is scheduled. Soil sampling at the Kinderhook I 69 site is tentatively scheduled for the high and low chloride periods to determine if a seasonal relationship exists between soil chlorides and ground water chlorides, and to determine if large amounts of salt may be accumulating in the soil above the water table.

Salaries and Wages 1982: \$6,439

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

Resistance tests were run on deck waterproofing systems on five structures in the Lansing area. These include reinforced sheet systems and hot applied mixes with synthetic fibers.

Planned Program for Coming Year

It is planned to schedule final inspections on the initial 1973 projects on I 75 and selected membrane projects done since then. Results of these inspections and tests are to be assembled into a report for distribution late in the year or early 1984.

Salaries and Wages 1982: \$94

Title

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

Purpose

To evaluate performance and durability of galvanized open-section members for use in pedestrian bridge structures. The test structure is

P01 of 52042 over US 41 southeast of Marquette, completed in 1972. The long-term corrosion protection of the galvanized coating was to be evaluated through periodic inspections.

Scope

The project is a Category 2 experiment carried out in cooperation with the FHWA as per MDOT Work Plan No. 22, which was developed by the Department. After construction of the test structure, the project was transferred to the Research Laboratory for follow-up surveys and reporting. The initial survey was covered by the Research Laboratory 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

None. No activity was scheduled.

Planned Program for Coming Year

An inspection trip is scheduled for 1984.

Salaries and Wages 1982: - 0 -

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

Only cores from one structure were tested for compressive strength and chloride content prior to redesign. Standard rotohammer samples continued to be taken and processed by the Testing Laboratory prior to letting deck repair contracts.

Planned Program for Coming Year

Special cores for bridge deck overlay projects or for major reconstruction work will be processed as required.

Salaries and Wages 1982: - 0 -

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

Because of higher priority projects, no work other than a cursory inspection of the experimental spall repairs was done. It appears that no significant new spall repair failures have occurred.

Planned Program for Coming Year

A survey will be conducted to determine the condition of the repaired joints as well as of the originally constructed joints. If arrangements can be made with the Maintenance Division, spall repairs will be conducted to upgrade the joints on the experimentally maintained pavement section.

Salaries and Wages 1982: \$489

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 rustproofer formulation. The study utilizes a four-span grade separation structure, with its structural steel divided into four areas for the tests. One area was coated with the rustproofer 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

Final inspection was made and final report was written and typed.

Planned Program for Coming Year

Send report to the FHWA for final review and distribution to close the project.

Salaries and Wages 1982: \$452

Title

77 G-224 - Evaluation of Servicized Flex-Lok Filler for Pressure Relief Joints

Purpose

To evaluate the effectiveness of the subject material in performing the function of sealing pressure relief joints in concrete pavement against intrusion of water and incompressible materials.

Scope

Servicized Flex-Lok urethane foam filler was specified for pressure relief joints on construction Project F 29011-12241A, etc., which covers 50.9 miles of US 27 in Gratiot, Isabella, and Clare Counties. The installation and performance are to be monitored biannually for performance.

Progress Past Year

Due to pressure of other projects, only a minimal amount of work was done on the final report.

Planned Program for Coming Year

Complete final report to conclude the project early in the year.

Salaries and Wages 1982: \$1,128

Title

77 G-227 - A Research Study to Monitor the Deicing Chemical Pollution Prevention System of the MDOT Maintenance Garage at Reed City

Purpose

To monitor the effectiveness of deicing chemical containment procedures at the new maintenance facility at Reed City.

Scope

Containment of deicing chemicals at the location is to be monitored by continued sampling from ground water wells placed at selected sites down-gradient from a brine retention lagoon, sand-salt storage pile, and salt

storage shed. A supplemental study of salt leaching from winter maintenance sand-salt piles, bituminous-coated and uncoated, is included in this investigation. Periodic sampling of leachate from selected sand piles is planned.

Progress Past Year

Monthly water samples were obtained from the four monitor wells at the Reed City garage. Samples were also obtained from the sand stockpile sump, retention basin, and diversion drain. A total of 69 water samples were collected and tested for chloride content in 1982. A final report on the monitoring study has been drafted and is pending inclusion of a Pollution Incident Prevention Plan to be approved by the DNR Water Quality Division. The chloride monitoring at the Reed City facility has detected the presence of excessive chlorides in the ground water south of the retention basin. Periodic letter reports of the results of monitoring have been issued.

Planned Program for Coming Year

The monitoring study was scheduled to terminate at the end of 1982. However, a request from the Engineer of Maintenance for a continuation of monitoring for an additional year may result in an extension of sampling through 1983. The Department of Natural Resources may also require continued monitoring.

Salaries and Wages 1982: \$2,338

Title

77 G-230 - Development of Non-Proprietary Specifications for Inorganic Zinc-Rich Coating Systems

Purpose

The purpose of this study is to develop a workable specification for inorganic zinc-rich coatings which will assure us of quality products, ease of application, and long service life.

Scope

In this study, we plan to establish specifications for inorganic zinc-rich coating systems. This will involve determining applicable procedures for both performance and acceptance testing.

Progress Past Year

The fourth series of tests were started and will be completed in June 1983. Writing of a progress report was begun. Special provisions were revised and issued for both the cleaning and painting of existing steel structures and for the shop coating of new steel beams.

Planned Program for Coming Year

The qualified product list will be updated based on results from the 1982 tests.

A fifth series of tests will be started.

Work will continue on a progress report with a projected 1984 completion date.

Salaries and Wages 1982: \$17,964

Title

78 G-234 - Construction and Testing of an Instrument to Measure the Night Visibility of Traffic Paints

Purpose

To develop an instrument to measure the night visibility of traffic paints. Ideally, this will eliminate the subjective aspect of rating the field performance of traffic paints for subsequent purchases.

Scope

In this study we would develop a photometric method of evaluating both longitudinal and transverse traffic stripes. We would also compare our instrument data with our present evaluation program to ensure meaningful data, and an accurate correlation of results.

Progress Past Year

A new self-contained model has been constructed which will record data on computer tape. This instrument was used to rate stripes in Michigan, Ohio, and Pennsylvania under Federal financing to further correlate

data with ratings done at night with observers. This is being done at about two month intervals.

Planned Program for Coming Year

The above Federally financed program will continue until failure of test stripes in the three states. The instrument will continue to be used on our field performance stripes also.

Salaries and Wages 1982: \$22,430

Title

78 G-242 - Determination of Allowable Movement Ratings for Various Proprietary Bridge Deck Expansion Joint Devices at Various Skew Angles

Purpose

The purpose of this project is to determine the movement capabilities of proprietary bridge joint devices when installed at high skew angles so that they can be specified for use under conditions where the Department has been using the steel sliding plate design.

Scope

Four-foot sections of proprietary bridge expansion joint devices of the continuous sealing element type will be cycled in the laboratory to determine their limitations for movement in skew angles up to 60 degrees.

Progress Past Year

Seven devices were evaluated and as a result, several were modified by the manufacturers.

Planned Program for Coming Year

Several new or modified devices will be evaluated and a report will be prepared.

Salaries and Wages 1982: \$4,020

Title

79 G-245 - Procedures for Contract Maintenance of Neoprene Sealed Pavements

Purpose

To evaluate the developed procedures, materials, and specifications for use in contract maintenance of neoprene sealed pavements, and to determine the performance of liquid sealant in joints spaced 71 ft apart.

Scope

A 12-mile section of I 75 between M 61 and Maple Ridge Rd in Arenac County has been selected for spall repairs, resealing, and crack repairs.

Progress Past Year

The project was resurveyed to determine current condition of the pavement. Previously prepared specifications have been updated to reflect latest developments concerning this type of pavement maintenance. A contract is in the process of being prepared for an April 1983 letting.

Planned Program for Coming Year

If a contract is let and work begun, Research personnel will observe the construction processes and evaluate the initial performance of the repairs.

Salaries and Wages 1982: \$900

Title

79 G-246 - Field Evaluation of Plural Component Pavement Marking Materials

Purpose

To establish cost-benefit data for the more durable plural component epoxy and polyester pavement marking materials compared to standard alkyd materials now used.

Scope

Select high traffic areas for contract application of significant quantities of epoxy and polyester pavement marking materials. Make field inspections and ultimately assess the relative cost effectiveness of these materials on both portland cement and bituminous concrete surfaces.

Two areas in Grand Rapids were selected by the Traffic and Safety Division; 28th St and US 131. Approximately 110,000 lin ft of markings were applied in August 1980.

Progress Past Year

Periodic inspections were made of test installations in the Grand Rapids area on 28th St and US 131.

Planned Program for Coming Year

Periodic field inspections will continue to determine ultimate effective life of the test materials and their relative cost effectiveness.

Salaries and Wages 1982: \$2,205

PHOTOMETRY AND SPECTROCHEMISTRY UNIT

Title

73 D-28 - Evaluation of Wet Bottom Slag for Bituminous Shoulder Wearing Courses, I 94 in Dearborn

Purpose

To determine whether wet bottom slag can impart a significantly darker appearance to the shoulder, thus improving the visual contrast between the shoulder and the pavement.

Scope

Evaluate photometrically the visual contrast between the shoulder and pavement resulting from the use of wet bottom slag in the bituminous shoulder mix.

Progress Past Year

The day and night pavement-shoulder contrast was measured and evaluated.

The final report No. R-1195, "Evaluation of Wet Bottom Slag Bituminous Wearing Course, I 94 in Dearborn Heights," was completed and transmitted to the Division Administrator, Federal Highway Administration, on July 23, 1982.

The Department's Engineering Operations Committee, in reviewing this report, concluded that wet bottom slag should be allowed as an alternate shoulder aggregate material but because of its limited availability, it should not be specified.

Planned Program for Coming Year

None.

Salaries and Wages 1982: \$667

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 obtained from manufacturers and users was used to keep current on instrumentation available to monitor air quality. Guidelines from the U. S. Environmental Protection Agency were used to maintain quality control for air quality data added to the Department's data bank. Three mobile air monitoring laboratories operated in the field to obtain data at eight sites. Data banks for air quality data and meteorological data were updated and expanded. Air monitoring data were supplied to the Bureau of Transportation Planning, and the Department of Natural Resources. A draft of the material for this project report was prepared.

Planned Program for Coming Year

Conduct air quality monitoring with mobile units. Expand the air quality data bank. Provide air quality data to the Bureau of Transportation Planning, and to the Department of Natural Resources. Maintain current information on State and Federal air quality regulations relating to transportation. Keep current information on instrumentation and methods available to monitor air quality. Prepare a report on the equipment assembled and the procedures developed.

Salaries and Wages 1982: \$5,342

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 as designated by citizen complaints and visual evaluation by Department personnel. Determine driver's visual task and determine luminance and luminance contrast necessary to perform the task. Develop criteria for specifying visual performance. Evaluate luminance of acceptable light sources. Propose basis for legislative control.

Progress Past Year

The disability glare affecting motorists from parking lot lighting at a bowling lanes establishment was evaluated. Recommendations for reduction of the glare through alteration of the lighting were adopted by the management of the lanes.

Planned Program for Coming Year

- 1) Negotiate with off right-of-way owners of glare sources for which complaints have been received.
- 2) Study drivers' reactions to glare sources by measuring vehicle performance of motorists on standardized visual tasks with standardized glare sources.

Salaries and Wages 1982: - 0 -

Title

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

Purpose

- 1) To determine maintenance factors for tower lighting; 2) to determine pavement illumination produced by tower lighting compared with design levels of pavement illumination, and with pavement illumination produced by conventional lighting; 3) 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; 4) to determine the need for underbridge lighting at interchanges; 5) to determine the aesthetic value of tower lighting; and, 6) 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, and to the FHWA.

Progress Past Year

Little progress was made last year because of higher priority work. A research program outline was prepared which included instrumentation and techniques to resolve problems in data gathering experienced with preliminary evaluation of illumination.

Planned Program for Coming Year

- 1) Calibrate and test mobile instrumentation,
- 2) Record illuminance levels at the interchanges,
- 3) Record disability glare levels at the interchanges,
- 4) Complete progress report on evaluation of interchange lighting.

Salaries and Wages 1982: \$70

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 water entering Lake St. Clair from the skimmer is to be analyzed for oil and sediment content, at irregular intervals. Records will be compiled of costs to operate the skimmer and of the volume of sediment removed when the chamber needs to be cleaned. This data will be assembled into an annual report for the Federal Highway Administration.

Progress Past Year

Water samples from the skimmer entrance and exit were analyzed for oil and sediment content and records of operating costs and sediment removed from the chamber were compiled. A letter report was sent to the Federal Highway Administration.

Planned Program for Coming Year

Perform water analyses and assemble records of operating costs and sediment collected. Prepare a report.

Salaries and Wages 1982: \$4,174

Title

77 G-229 - Further Research on Reflectorized Flagman's Vests

Purpose

To provide answers to a request dated November 1, 1977, from R. E. Conner, Chief Traffic Control Systems Division, Office of Traffic Operations, FHWA, for further research into the areas of vest color and of a fully reflectorized vest.

Scope

An industry-wide search is to be conducted in order to develop a yellow-orange reflectorized material which is similar to the current daytime fluorescent color or 'Blaze Orange' of traffic regulator vests.

Nighttime and daytime observations in both rural and urban lighting environments will be made of reflectorized vest patterns previously found

to be effective and of a fully reflectorized vest with observers driving a vehicle.

Progress Past Year

A rough draft was completed which reported the results of:

1) The Phase II study with 30 observers comparing a simplified chevron-shape and pattern with the stick-man pattern as well as five colors comprised of a brighter material than used in Phase I (Research Report R-1185, May 1980).

2) A Phase III study with nine observers evaluating the:

a) Effect of reflectorized strips on the side of the flagger vest in addition to a reflectorized pattern on the frontal portion of the vest because of a field survey which showed that traffic regulators generally stand sideward to the traffic flow.

b) Comparison of a reflectorized (encapsulated prism type) stop sign with an engineering grade reflective sheeting stop sign held by the traffic regulator.

Planned Program for Coming Year

Complete final report.

Salaries and Wages 1982: \$7,125

Title

78 G-235 - Air Quality Measurements for Movable Asphalt Plants for Recycling Paving Asphalt

Purpose

To determine if asphalt plants processing recycled asphalt paving can comply with Federal and Michigan particulate emission standards.

Scope

Several asphalt plant stacks will be monitored during successive construction seasons.

Progress Past Year

Equipment was modified to improve operation and calibrated to EPA standards. Two asphalt plants were monitored for particulate emissions when recycled paving was being processed. A report on the work was prepared.

Planned Program for Coming Year

Measure particulate emissions from several asphalt plants while recycled material is being processed, and report the results.

Salaries and Wages 1982: \$3,897

SOILS AND BITUMINOUS SYSTEMS RESEARCH UNIT

Title

79 C-19 - Evaluation of Sprinkle Treatment for Improving Skid Resistance of Asphalt Surfaces

Purpose

The purpose of the experimental overlay construction is to evaluate the sprinkle treatment method of achieving adequate friction values on wearing surfaces in accordance with FHWA Demonstration Project No. 50. Sprinkle treatment is the relatively light application of precoated, high quality aggregate particles on the surface of the wearing course mat following lay-down, and partial embedment during the compaction operation. This technique minimized the use of high quality aggregate in areas where they are scarce or expensive. A savings in energy would also be realized from the elimination of long aggregate hauls.

Scope

An experimental test section, approximately five miles in length, was constructed using the sprinkle treatment method and its performance, measured by pavement friction levels, will be studied over a three-year period. The research project is to be completed in 1982.

Progress Past Year

Final friction measurements were made which show the sprinkle treatment to be more skid resistant than the control section.

Planned Program for Coming Year

A final report summarizing findings and recommendations will be prepared.

Salaries and Wages 1982: \$296

Title

74 D-29 - Sulfur in Bituminous Mixtures

Purpose

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

Scope

Test sections were 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, developed by Gulf Oil Canada Ltd., was used to prepare paving mixtures for this project. Two different sulfur-to-asphalt ratios and two sulfur-asphalt binder levels were compared with adjacent sections of the same road which were paved with a conventional mixture.

Progress Past Year

Final rut depth, friction measurements, and crack surveys were made.

Planned Program for Coming Year

A final report will be prepared.

Salaries and Wages 1982: \$346

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 which show extensive cracking and roughness.

Scope

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

Progress Past Year

The physical properties of the recycled material were summarized in a final report (Research Report R-1209).

Planned Program for Coming Year

Project terminated.

Salaries and Wages 1982: \$3,172

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 resurfaced projects.

Scope

The study involves laboratory testing of engineering properties for several mixtures and a field test road incorporating different thicknesses and mix proportions. A five-year evaluation period is called for in the research proposal.

Progress Past Year

Rut depths and friction measurements were made. Cores were obtained and tested for resilient modulus at two temperatures and three loading times.

Planned Program for Coming Year

Continue observations of performance. Information obtained from the project will be presented in a final report to be prepared in 1984.

Salaries and Wages 1982: \$3,142

Title

78 D-36 - Comparison of Cracked and Uncracked Flexible Pavements in Michigan

Purpose

The purpose of this study is to analyze flexible pavements representing both unusually good and unusually poor performance in order to identify factors causing good and poor performance.

Scope

A total of 16 one-mile pavement sections, representing pavements throughout the upper and lower peninsula, are to be evaluated in pairs such that the design, specifications, traffic loading, age, and foundation conditions are the same—the only difference being the level of performance. Structural capacity of the pavements will be determined on the basis of Benkelman beam surface deflection data, the modulus of resiliency of the subgrade, and the drainage capacity of the pavement's foundation. The bituminous concrete will be tested to evaluate its fatigue, thermal cracking susceptibility, and resilient modulus characteristics. In addition, standard bituminous analyses will be conducted on all bituminous concrete samples collected. This project is being conducted as a joint study involving the Bituminous Technical Services Unit of the Testing Laboratory.

Progress Past Year

Rough draft reports dealing with engineering properties of the bituminous concrete, analysis of bituminous concrete aggregates, and structural foundation analysis have been reviewed, analyzed, appropriate data extracted for statistical analysis, and a statistical study completed preparatory to writing a final report.

Planned Program for Coming Year

Prepare a final summary report of the project.

Salaries and Wages 1982: \$3,067

Title

79 D-37 - Evaluation of Sulfur-Extended Asphalt for Bituminous Resurfacing Mixtures

Purpose

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

Scope

Test sections were constructed as part of a 1979 resurfacing contract on M 99 in Calhoun County (Mb 13091-15321). The process of blending hot liquid elemental sulfur with hot asphalt cement to form a sulfur-asphalt

(S/A) binder as developed by Gulf Oil Canada Ltd., was used to prepare paving mixtures for this project. Two different sulfur-to-asphalt ratios and two sulfur-asphalt surfacing thicknesses were compared with adjacent sections of the same road paved with a conventional mixture.

Performance evaluations will be made for several years and will include condition surveys (crack mapping), rut depth measurements, pavement friction values, and Benkelman beam deflection measurements. Prior to construction, mix proportions were determined in the Testing Laboratory. During construction, testing for compaction, asphalt content, temperature, and other investigative tests, were performed.

Laboratory tests are being performed on both the sulfur-extended asphalt (SEA) mixtures and conventional mixtures to compare fatigue life and low temperature cracking potential. Benkelman beam deflections were measured on the roadway before and after resurfacing so that field performance can be compared with performance as predicted by initial deflections and laboratory measured resilient modulus values. The comparison will be made through use of the CHEV 5L computer program for flexible pavement analysis. A five-year evaluation period is called for in the research project proposal.

Progress Past Year

Rut depth and friction measurements were made. Analysis of deflection measurements has been partially completed.

Planned Program for Coming Year

Field measurements and observations will be continued. Structural and material analyses will continue. A final report is to be prepared in 1984.

Salaries and Wages 1982: \$605

Title

79 D-38 - Evaluation of Plasticized Sulfur as a Binder in Flexible Pavement Resurfacing Mixtures

Purpose

The purpose of the study is to evaluate flexible pavement resurfacing mixtures composed of mineral aggregate combined with Sulphlex, a plasticized sulfur binder.

Scope

An experimental section of pavement overlay using the Sulphlex mixture was constructed. Laboratory mix designs were made to establish job control quantities. Laboratory tests were performed to measure resilient modulus and low temperature cracking potential, and performance is being monitored.

Progress Past Year

Performance of the test and control sections were monitored via friction and rut depth measurements, a crack survey and photographs. Two sets of cores were obtained, one for the FHWA and the others were tested for resilient modulus in the Research Laboratory. A progress report was submitted to the FHWA to comply with our Task Order agreement.

Planned Program for Coming Year

Final field performance tests and observations will be made in July. A final report is to be submitted to the FHWA in October 1983.

Salaries and Wages 1982: \$8,401

Title

80 D-39 - Feasibility of Paving Over Sylvax Patches

Purpose

To evaluate the feasibility of applying bituminous resurfacing over existing Sylvax patches.

Scope

A highway which was resurfaced in 1980 which had been patched with Sylvax is involved. Existing patch locations were logged and the condition of the patches noted. Performance evaluations will be made on a periodic basis after resurfacing. Cores will be obtained at selected patches after six months service to measure bonding and stability. The research project is scheduled for completion in 1983.

Progress Past Year

Recent paving over Sylvax patches was inspected, photographed, and coring was attempted. There were no signs of distress in the pavement over the patches but cores could not be obtained with the patch material

attached. The Bituminous Technical Services Unit has developed a patching mix for the Department which is equivalent to Sylvax and can be obtained at a much lower cost. Trial of a small quantity (100 to 200 tons) of the Department's mix is planned.

Planned Program for Coming Year

Termination of the project is recommended.

Salaries and Wages 1982: \$1,411

Title

81 D-41 - Foamed Asphalt Sand Stabilization

Purpose

The purpose of this project is to develop experience and test data on stabilization of sand with foamed asphalt using mixed-in-place construction methods.

Scope

The existing shoulders of a 5.6 mile section of freeway in Muskegon County (Control Section FUR 71151-16044) consist of a seal coat placed on a sandy granular base course. The existing seal coat surface was pulverized, mixed with the sand base and stabilized to a depth of approximately 5 in. using foamed asphalt. This operation required a single pass stabilizer modified to permit the addition of water to the hot asphalt cement prior to the spray bar, in the mixing chamber. Water was added to the mixing chamber at a rate between 1 and 3 percent of the liquid bitumen volume. Total bitumen required was between 3 and 5 percent of the sand volume being stabilized. Modification of existing equipment was minimal for the operation.

Progress Past Year

Indirect tensile tests were run on molded samples to determine rate of curing and ultimate strength of granular material stabilized with the foamed asphalt process.

Planned Program for Coming Year

Complete testing and prepare a final report.

Salaries and Wages 1982: \$910

Title

82 D-42 - The Effects of Coarse Aggregate on the Durability of Bituminous Concrete Mixtures

Purpose

To determine if bituminous concrete durability, as measured by its resistance to cracking, is significantly related to the tensile strength of the aggregate. If so, to develop the ability to determine, by test, the durability of bituminous concrete mixtures.

Scope

To determine if aggregate tensile strength is related to the tensile strength of bituminous concrete in such a way as to have practical significance. To establish a test method for indicating how much influence the selected aggregate will have on durability of the bituminous concrete product. To establish procedures that could be used to establish discount factors for aggregate, based on the aggregate's effect on durability of the bituminous concrete product.

Progress Past Year

Three types of coarse aggregates, beach stone, sandstone, and limestone, were collected and prepared for testing in the laboratory.

Planned Program for Coming Year

Start laboratory testing of aggregate samples.

Salaries and Wages 1982: \$1,264

Title

82 D-43 - A Method of Determining the Angularity of Fine Aggregates and the Marshall Stability of Bituminous Concrete Mixtures

Purpose

To develop the capability of predicting bituminous mix stability on the basis of the gradation and angularity properties of the fine aggregate fraction of the mixture.

Scope

To develop a test procedure that can be used in the field or laboratory for the purpose of measuring the angularity properties of fine aggregates. And, to determine if fine aggregate angularity in combination with other commonly collected data can be used to predict the stability of bituminous mixtures.

Progress Past Year

Beach stone aggregate was collected, and prepared for laboratory testing. Testing procedures to be used were established.

Planned Program for Coming Year

To complete as much of the testing program as possible.

Salaries and Wages 1982: \$1,703

Title

57 E-15 - Sodium Chloride Stabilization, M 46 (M 82), from Newaygo-Montcalm County Line West

Purpose

To investigate why this test road, an experimental salt stabilization project constructed in 1960, is performing well after 23 years of service.

Scope

The test road will be investigated as follows: the pavement is to be condition surveyed to determine the cause of existing distress; the pavement is to be load tested to determine the pavement's load carrying capacity; a roughness survey will be conducted to determine the pavement's present Riding Quality Index; and, salt content of the pavement foundation is to be determined so that the previously established relationship between performance and salt content may be verified.

Progress Past Year

All field work has been completed except roughness surveys. All laboratory testing has been completed except that a small portion of salt content determination tests have to be completed.

Planned Program for Coming Year

Complete field and laboratory tests and prepare final report.

Salaries and Wages 1982: \$9,152

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

Implement a laboratory testing procedure for determining rheologic properties of each pavement layer. Develop computer capability for stress and strain analysis for five or more layer systems. Determine rheologic properties for typical materials used in Michigan for constructing pavements. Develop theoretical equivalencies of bituminous stabilized and granular bases. Theoretical design curves for determining the thickness of bituminous concrete, black base, and granular base will be included. Benkelman beam deflection and rut depth measurement data from I 75 will be analyzed. Environmental effects on cracking characteristics will be investigated.

Progress Past Year

Additional data were analyzed and recent deflection data studied. The black base area continues to show less deflection than does the aggregate base section.

Planned Program for Coming Year

Very little can be gained by continuing study of this project. Three reports have been prepared to date and similar work is being followed under Research Project 78 E-59. It is planned to finalize this project with a memorandum or a short summary report.

Salaries and Wages 1982: \$1,296

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 was used to replace a portion of the existing backfill material for the east abutment of a bridge structure. Annual visual and instrument surveys are conducted to observe performance.

Progress Past Year

No testing or inspections were made during the year.

Planned Program for Coming Year

Performance of the Elastizell project at St. Clair will be checked and a report prepared.

Salaries and Wages 1982: \$570

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 on this project was reviewed by the Aggregate Acceptance Committee and is in the process of being printed.

Planned Program for Coming Year

With publication of the final report this project will be completed.

Salaries and Wages 1982: \$4,336

Title

75 E-59 - Comparative Study on Performance of Bituminous Stabilized Bases and Aggregate 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 on M 20 and bituminous stabilized base on M 66.

Scope

Comparison of the strength of the two base layers will be made based on the elastic layer theory, the criteria of fatigue and rutting, and existing pavement condition surveys. The procedures will include the prediction of material characterization of the subgrade and bituminous concrete by using data from Benkelman deflection measurements, converted to 18 kip equivalent axle load repetitions. Remaining life expectancy of the pavements will be calculated based on future traffic projection and surface rut depth. Results will also be compared with Minnesota procedures.

Progress Past Year

A progress report was published describing conditions of the two test areas after six years of service. Both test areas are in excellent condition with a very slight advantage shown in favor of the black base section.

Planned Program for Coming Year

No work is planned for this project during 1983. Future testing will depend on visual observation of any change in surface conditions.

Salaries and Wages 1982: \$1,959

Title

75 E-60 - Use of Frost-Depth Indicators and Benkelman Beam 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 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

No work was done on this project during 1982.

Planned Program for Coming Year

Future work will depend on priority assignment and availability of District 1 personnel to continue deflection measurements at the seven test sites.

Salaries and Wages 1982: \$854

Title

81 E-62 - Evaluation of Enkamat as an Aid to Stabilize a Cut Slope

Purpose

The purpose of this study is to evaluate the effectiveness of "Enkamat" as a slope stabilization aid to prevent soil erosion and assist in the establishment of turf.

Scope

A 300-ft long section of cut slope (1 on 1-1/2 approximately) along an I 94 exit ramp (82021-18643C1) will be stabilized with Enkamat. This installation will involve approximately 840 sq yd of Enkamat. Construction procedures will be observed by Testing and Research personnel. The installation will be inspected periodically after construction for signs of erosion, wash-out, slippage, or other problems.

Progress Past Year

Enkamat was installed on a test section in Wayne County. Condition of the section was observed and photographed during construction and again several months later.

Planned Program for Coming Year

Final condition will be observed and photographed and a final report prepared.

Salaries and Wages 1982: \$89

Title

82 G-258 - Further Evaluation of Prewetted Salt for Ice Control

Purpose

The purpose of this study is to evaluate the concept of prewetting rock salt with calcium chloride brine prior to winter maintenance ice control application.

Scope

Applications of both wet salt and conventional salt will be made and compared during storms throughout the 1982-83 winter maintenance season. Equipment for prewetting the rock salt after it is loaded in the spreader trucks will be supplied and installed by the Dow Chemical Co. at the Saginaw East Side Maintenance Garage. Dow will also furnish the prewetting brine (the Department will pay for freight costs). The effectiveness of the treatments will be compared in terms of melting efficiency, amount of salt required, mechanical problems, and after-effects such as residual moisture and the resultant retention of blowing snow.

Progress Past Year

Test sections were established, materials and equipment installed and personnel were trained. No storms occurred to generate meaningful data during 1982.

Planned Program for Coming Year

Test applications will continue throughout the winter (1983) and a final report prepared.

Salaries and Wages 1982: \$2,000

Title

82 G-259 - Evaluation of CMA as an Ice Control Agent

Purpose

The purpose of this study is to evaluate the effectiveness of calcium magnesium acetate (CMA) as an ice control chemical during typical winter maintenance operations in Michigan.

Scope

Applications of both CMA and rock salt will be made and compared during winter storm conditions. Application rates will be varied but will be in the range normally used for rock salt applications. Effectiveness will be compared with rock salt and will be judged by considering ice melting ability, prevention of snow pack, pavement friction levels, and handling and storage characteristics.

Progress Past Year

Michigan's work plan was approved at the National Pooled-Fund Conference and the Department is to receive 100 tons of CMA for field evaluation.

Planned Program for Coming Year

Field evaluation of CMA as an ice control agent will be initiated. Laboratory tests for possible detrimental effects on reinforced concrete will be made.

Salaries and Wages 1982: - 0 -

RESEARCH SERVICES UNIT

Title

78 B-99 - Recycling of Concrete Pavement

Purpose

To investigate the feasibility of recycling portland cement concrete pavement into aggregate for producing new portland cement concrete pavement.

Scope

Because of severe financial constraints, projects selected for recycling have been postponed or a less expensive treatment chosen. If possible, new efficient methods for removing concrete will be required.

Progress Past Year

A one-mile length of two-lane pavement was successfully recycled on Garfield Rd in Macomb County. The Testing and Research Laboratories provided guidance and certain testing services for the county.

Planned Program for Coming Year

A 10-mile length of I 94 is to be recycled with the existing rigid pavement being crushed and used for coarse and fine aggregate.

Salaries and Wages 1982: \$3,035

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, and 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 bridge deck has been conventionally resurfaced and is no longer being observed. The pavement has served well for another year.

Planned Program for Coming Year

Close project with memo report.

Salaries and Wages 1982: - 0 -

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. of a distressed asphalt pavement.

Scope

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

Progress Past Year

Surveyed condition of pavement.

Planned Program for Coming Year

Prepare final report.

Salaries and Wages 1982: - 0 -

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

Nearly 1,900 lane miles of pavement were surveyed.

Planned Program for Coming Year

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

Salaries and Wages 1982: \$21,214

Title

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

Purpose

To evaluate the effects of studded tires on pavement.

Scope

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

Progress Past Year

Answered inquiries regarding the law.

Planned Program for Coming Year

Evaluate new studs, if any are submitted by industry, for compliance with the law.

Salaries and Wages 1982: \$56

Title

75 F-147 - Pavement Riding Quality

Purpose

Conduct surveys with the Rapid Travel Profilometer to measure 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. Also tested are several research projects and special requests as called for by other personnel within the Department.

Progress Past Year

A total of 2,300 lane miles of bituminous and concrete pavements were tested. This includes new construction, repeat testing, research projects, and special requests.

Planned Program for Coming Year

Continue with established program.

Salaries and Wages 1982: \$48,719

Title

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

Purpose

To conduct a program of pavement friction testing, interpretation, and research.

Scope

A systematic program of pavement friction 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

Nearly 15,300 pavement friction tests were conducted throughout the State.

Planned Program for Coming Year

Continue established pavement friction test program.

Salaries and Wages 1982: \$60,940

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

The noise barrier sites in the Minneapolis/St. Paul area of Minnesota were visited during the Transportation Research Board Committee meeting. The FHWA STAMINA 2.0/OPTIMA program was adapted to the Department's computer system for use by Testing and Research and other Divisions in the Department. Evaluation of the noise attenuation that exists at present barriers built by the Department was initiated.

Planned Program for Coming Year

Collect noise data from the field and analyze data on the evaluation of barrier noise attenuation.

Salaries and Wages 1982: \$17,482

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

Group II, approximately 12 sites have been selected for field review.

Planned Program for Coming Year

Final selection of Group II and write report to submit to the FHWA for funding approval.

Salaries and Wages 1982: \$6,507

Title

77 G-225 - Rubberized Asphalt Stress Relieving Membrane

Purpose

To evaluate the effectiveness of asphalt-ground rubber stress absorbing membranes used as an interlayer and seal coat in preventing reflection cracking.

Scope

This project is part of a continuing search for an effective method for preventing reflection cracking. This method was developed in Arizona and its performance on Michigan pavements under our climatic conditions will be evaluated.

Progress Past Year

Second annual condition survey was completed. Performance of the asphalt rubber interlayer continues to look promising.

Planned Program for Coming Year

Conduct annual survey and evaluate performance if possible.

Salaries and Wages 1982: \$191

Title

78 G-232 - A Study to Develop a Roughness Rating System for Highway Railroad Grade Crossings

Purpose

To develop a roughness rating system that will describe the roughness of a railroad crossing in quantitative terms.

Scope

Pavement profiles of approximately 50 railroad crossings selected at random will be obtained. Using this information, a single number index of pavement smoothness will be calculated.

Progress Past Year

There was no progress due to higher priority work.

Planned Program for Coming Year

Using recorded data and digital profile computation techniques, develop a procedure for ranking crossings. An index similar to that used for rating pavements is anticipated.

Salaries and Wages 1982: - 0 -

Title

78 G-237 - Feasibility of Solar Power Installation for Railroad Grade Crossing

Purpose

To determine the feasibility of using solar energy to supply electrical power for railroad crossings.

Scope

This project will be confined to the evaluation of one solar-powered crossing using 16, 30-watt photovoltaic panels which will charge a 12-volt battery supply.

Progress Past Year

The monitor system used to monitor energy flow has been in operation for three years. Data for the first two years have been compiled. Data collected include: energy from solar cells, energy stored, energy shunted to ground (batteries fully charged), energy consumed, battery temperature, and ambient temperature. Data collected during the third year are now being compiled.

Planned Program for Coming Year

Complete data analysis and prepare final report.

Salaries and Wages 1982: \$35

Title

78 G-240 - Evaluation of Shattering Existing Concrete Pavement Prior to Overlaying for Reducing Reflection Cracking

Purpose

This project is part of a continuing search for an effective method for preventing reflection cracking in bituminous overlays. This process has been used in Germany and on the Pennsylvania Turnpike.

Scope

To evaluate the effectiveness, in preventing reflection cracking, of creating structural discontinuities by shattering the existing concrete and adding a bituminous base course cushion to prevent transmission of movement from the underlying pavement into the overlay.

Progress Past Year

Construction has been completed on several projects using this concept; however, none have incorporated the necessary features required for full consideration as a research project. All the completed projects are being followed, however, to gather what information is available. A work plan was completed for a research project on US 23 in Monroe County.

Planned Program for Coming Year

Letting and construction of project on US 23.

Salaries and Wages 1982: \$2,899

Title

78 G-244 - Determination of Michigan Reference Energy Vehicle Noise Emission Levels and Validation of the FHWA Highway Traffic Noise Prediction Model

Purpose

Determine the vehicle noise emission levels for automobiles, light trucks, and heavy trucks as a function of speed. Also, develop a computer program for the FHWA Noise Prediction Model (Report No. FHWA-RD-78-138) for use on the Department's B7700 time-share computer.

Scope

The work will consist of three phases: 1) determine reference noise levels; 2) develop computer program; and, 3) validate the computer model for Michigan traffic noise. Field data will be obtained over a range of vehicle speeds, types, and traffic volumes to determine reference noise emission levels and sufficient data to validate the model.

Progress Past Year

Field data have been analyzed and the report is in draft form.

Planned Program for Coming Year

Complete report and submit to the FHWA with a request to use results in the FHWA computer model.

Salaries and Wages 1982: \$412

Title

79 G-247 - Feasibility of Solar Energy for Hot Water Heating in Rest Areas

Purpose

Determine if solar hot water systems are practical for rest area buildings in Michigan. Determine the cost and energy savings associated with such systems and obtain experience on solar heating for use in other highway applications.

Scope

The Department is planning to modernize or expand approximately 12 rest area buildings. Solar hot water systems will be installed at each site where conflicts with trees or other structures are minimal. Installations will include different design concepts using liquid as well as air collectors. Three of the systems will include instrumentation to monitor the energy collected and resulting cost savings.

Progress Past Year

A solar hot water system was installed in the I 75 southbound rest area, Bay County. The recording of data began in June. Some revisions have been made to improve the validity of the data.

Planned Program for Coming Year

Data will be collected and analyzed.

Salaries and Wages 1982: \$2,459

Title

81 G-255 - Automatic Weighing of Trucks

Purpose

To automatically weigh and record truck weights to see if the percentage of overweight trucks increase during periods of time when an operator is not present in the scale house.

Scope

This project will be confined to installing this system in one scale house and monitoring freeway traffic in one direction to determine compliance.

Progress Past Year

All parts for the system have been purchased and assembly is in progress. Sensors and most necessary conduit have been installed.

Planned Program for Coming Year

Finish installation and begin collecting data.

Salaries and Wages 1982: \$8,669

Title

82 G-257 - Experimental Use of Ice Detection System on Bridge Decks

Purpose

To determine if the Scan system will provide a reliable means of predicting when slippery conditions will occur on bridge decks.

Scope

The project will be confined to evaluating the system at one freeway bridge deck for a period of two years.

Progress Past Year

Approvals received to go ahead with project and system installation were completed.

Planned Program for Coming Year

Bring system on line and begin collecting data.

Salaries and Wages 1982: \$5,818

STRUCTURAL RESEARCH UNIT

Title

77 B-96 - Experimental 'Econocrete' Shoulder Construction, M 14
Near Wayne County Line, and I 69 Near Lansing

Purpose

To evaluate the construction and performance of econocrete shoulders on M 14 near the Wayne County line and on I 69 near Lansing. The econocrete mix on I 69 contains a cheaper peastone aggregate. The econocrete mix on M 14 incorporated cement reductions intended to provide compressive strengths of 3,000, 2,500, and 2,000 psi at 28 days age. Construction of the M 14 job was completed in the fall of 1978.

Scope

Approximately six miles of the experimental shoulders were built on M 14, in half-mile sections. The sections consisted alternately of, grade 35P (3,500 psi compressive strength) concrete for control, along with 3,000, 2,500, and 2,000 psi grade 30E, 25E, and 20E econocrete, respectively. The econocrete mixes utilized a locally available 20AA aggregate containing about 68 percent sand.

The I 69 installation includes shoulders on approximately three miles of rural freeway. The mix utilizes a locally available peastone aggregate and is designed at 3,500 psi compressive strength. Construction of about 20 percent of the project was completed in 1981. The remainder was built during the summer of 1982. The Structural Research Unit is responsible for performance evaluations on these projects. Materials Research covered mix evaluation and strength of materials placed.

Progress Past Year

Semiannual measurements have been made on the M 14 installation. Early inspections showed that cracks were beginning to form on the mainline pavement near the shoulder joint locations, and now there is a crack in the pavement opposite nearly every shoulder joint. It is evident that the strong intermittent keyway that locks the shoulder to the mainline pavement on this project has increased the amount of commutative cracking in the pavement. Standard plans for future installations, including the I 69 job, have been revised to eliminate the keyway. No additional deterioration is evident at this time.

Reference points were established at selected joints on the I 69 project during construction this past summer. Initial readings were recorded at the time of construction, and the first set of readings was made during the summer. The project is in new condition, and has not yet been opened to traffic.

Planned Program for Coming Year

Monitoring of joint width variations, elevation changes, and general pavement condition will continue.

Salaries and Wages 1982: \$2,462

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 (I 69 south of Charlotte). 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

Winter and summer readings were completed and a condition survey made. Data were tabulated and are on file. Isolated problems at expansion joints in the concrete shoulders were noted previously. This past winter there was some frost heave at only one of these expansion joints. Inspection showed standard and full-depth bituminous shoulders deteriorating and sinking. The longitudinal shoulder-pavement joint in seal coated sections has been slurry-sealed by the Maintenance Division. Slurry sealing was not effective, deterioration is progressing. Several other bituminous locations have been wedged near the pavement edge. Some results from this

project were included in Research Report R-1169 that was presented at the International Conference on Concrete Pavement Design, at Indianapolis, in April 1981, and was published as a Departmental Report in September 1981.

Planned Program for Coming Year

Perform biannual joint movement and elevation measurements of concrete shoulder sections. Make annual condition and photographic surveys. Tabulate, enter, and analyze data through the computer.

Salaries and Wages 1982: \$971

Title

*68 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 by 4 ft by 7-1/2 in. were cast in the Laboratory and subjected to outdoor exposure with periodic applications of salt. A 30 ft by 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 twelfth winter. Routine maintenance was performed at the field exposure site. Specimens with uncoated bars still have about four times as much spalling above the rebars as do those with galvanized bars. Field inspections, 'corrosion cell' readings, and delamination detector surveys were completed on the five experimental decks that are now 10 years old. All data were tabulated and records updated. Quarterly reports on the project were prepared for the FHWA. The HP&R participation in this study has

been extended through 1987. The first small 'hollow areas' near uncoated bars were reported during the evaluation four years ago, and two small hollow areas were found over galvanized bars on the Grand River Ave Bridge two years ago. Last year's survey showed about 10 sq ft of hollow areas on the Grand River Ave Bridge, over both uncoated and galvanized bars. 1982 surveys show bridge decks in the same condition as last year. No further observable deterioration. Several field exposure slabs are showing severe deterioration. Salt analysis is continuing on specimens removed from the slabs.

Field exposure specimens having 1/2-in. cover over the bars were dismantled, and the rebar from the specimens is being cleaned of adherent concrete for evaluation of corrosive attack. The remaining specimens with 1-1/2 and 2-in. cover remain under treatment for future evaluation.

Planned Program for Coming Year

Bars from field exposure specimens with 1/2-in. cover will be cleaned and evaluated. Cores from the experimental decks will be removed and analyzed. Weekly treatment of the remaining field exposure specimens will continue through this winter as will yearly inspections of bridge decks. The project has been kept up to date and on schedule.

Salaries and Wages 1982: \$11,302

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. Black base was included at one site. Standard ramps were included for comparison.

Progress Past Year

A progress report was prepared for the FHWA. Faulting and joint opening measurements and profilometer surveys were completed. All data were reduced and tabulated. Poured joint seals have failed. Some faulting of joints has developed in the black base section of the I 475 interchange. General condition of the ramps is still good. No significant changes in rideability have occurred to date.

Planned Program for Coming Year

Next year's work will closely follow that of last year's, as this is a long-range evaluation type project, and the general deterioration of the experimental installations has not yet begun.

Salaries and Wages 1982: \$2,031

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 an experimental 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 uncoated 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. Roughness and condition surveys were completed and recorded. Repairs made shortly after construction are deteriorating. Concrete deterioration is present at the

bottoms of the joints in all slab lengths. First stages of surface deterioration are beginning to appear in the form of D-cracking and joint spalling. Rideability has not changed significantly.

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-term evaluation and design differences are slight; therefore, we expect several more years of observation before having sufficient information available to issue a final report.

Salaries and Wages 1982: \$1,048

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. Costs of all scheduled projects have been evaluated. No additional effort was made on this project due to higher priority work. (These projects are still in relatively good condition, analysis should await observable deterioration.)

Planned Program for Coming Year

At some time in the future qualitative performance condition surveys of some of the projects will be done. However, under present limitations on staff and budget, and the existence of other higher priority work, it is unlikely that any additional effort will be made on this project next year. Techniques of evaluation are being developed that will be useful in this project.

Salaries and Wages 1982: \$119

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 were prepared for the FHWA. Evaluation of laboratory specimens has been continued. Scheduled maintenance of field exposure specimens was completed. Yearly condition, delamination detector, and corrosion cell surveys were performed on three experimental bridge decks. Salt treatment of field exposure specimens is being performed for the ninth winter. All decks and experimental specimens still are in excellent condition. Computer programs have been completed to plot the corrosion data from the experimental decks.

Planned Program for Coming Year

Continue treatment and evaluation of the laboratory and field exposure specimens and experimental decks. Remove cores from the experimental bridge decks. Evaluate the cores for salt content and condition of the re-bars. Project is up to date and on schedule.

Salaries and Wages 1982: \$6,745

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

This project has seen no activity during the past year. It is being continued as a long term evaluation of the performance of the concrete glare screen, but since all concrete installations are relatively new, no planned series of activities exists. Performance of the concrete screens has been considerably better than the metal mesh screens, from a damage and durability standpoint. Many mesh installations have been replaced by concrete.

Planned Program for Coming Year

Survey condition of experimental glare screens, and issue a final report, if time and staff permit.

Salaries and Wages 1982: \$237

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 (US 10 relocation north of Clare). 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 course were placed on sand grade. All pavement sections are portland cement concrete, 9 in. thick.

Progress Past Year

Joint and fault measurements were recorded, and profilometer runs made. Black base sections with no drainage show increasing signs of aggregate discoloration along the centerline and at joint intersections, and

spalling at joint intersections is progressing. This type of deterioration is starting to occur in other sections as well. Cores from the joints in the black base sections showed concrete deterioration of the joint faces and the bottoms of the slabs to be proceeding rapidly. This is providing material which is being pumped under the leaving edges of the slabs and causing faulting which is now more than 3/4-in. at some locations. Sections on open graded drainage course are performing well as are the sections with load transfer on gravel base. Commercial traffic is light. Cores have been cut from this project and 40 other construction projects, for laboratory analysis related to durability or D-cracking. Approximately 333 cores have been taken, covering 13 different aggregate sources and ages of pavement ranging from 7 to 40 years. Laboratory work is in progress. Experimental edge drains were installed at several locations on the US 10 site. Rideability data show changes so small as to not be significant.

Planned Program for Coming Year

Continue all experimental measurements and evaluations in the field, and laboratory work as well. This project will continue for many years.

Salaries and Wages 1982: \$23,716

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-ups.

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

Yearly condition survey and biannual measurements were performed. Results of data tabulation are as follows:

It was obvious from earlier results that there were significant differences in the performance of the various construction contracts included within the limits of evaluation.

In general, the pressure relief joints have closed to near their capacity. Much of the expansion and contraction is occurring at open cracks, with some joints frozen. Pressure relief joints where filler was lost are inoperative as far as pressure relief is concerned. A final report for the project (R-1185) was prepared, published, and distributed during the first quarter of 1982.

After six years of service since preventive maintenance was done, some of the sections were badly in need of repair. However, no emergency repairs had been required. It was concluded that the type of deterioration is the same on all projects, although the amount is quite different. The cause is aggregate durability or D-crack deterioration. None of the aggregates used in this portion of I 75 performed excellently, some performed quite poorly.

Planned Program for Coming Year

The project is complete.

Salaries and Wages 1982: \$831

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 were determined. Fracture toughness was measured by both Charpy and fracture mechanics type evaluations. Cyclic loadings determined fatigue crack initiation and propagation. Specimens were prepared for outdoor exposure.

Progress Past Year

All experimental work for the HPR project was completed previously. However, the HPR completion date has been extended one year to allow for completion of the report. Initial work on crack propagation and fatigue was done during the past year, and additional non-destructive evaluation of specimens was done as well. Initial experiments with the acoustic emission crack detector were carried out. The initial set of exposure specimens was removed from the field after approximately five years exposure. The final report for the HPR phase of the project is in preparation.

Planned Program for Coming Year

The fatigue crack propagation studies will be continued during the coming year, along with chemical analysis work and some additional fracture toughness work as well, providing staff and equipment can be made available. Field investigations of existing bridges with electrosag weldments will continue if staff and funds permit. The HPR final report will be published and the remainder of the work is being carried on as a regular Michigan research project.

Salaries and Wages 1982: \$1,338

Title

75 F-150 - Experimental Project Concerning Joints in 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 (I 75 south of Flint), to compare the reaction and performance of slabs with various types of joints and seals.

Progress Past Year

Scheduled faulting and joint movement measurements were completed and surveys were performed. A condition survey of the entire project was

completed. Poured joint seals have come loose in places, some unsealed joints continue to fill and 'grow.' Many neoprene seals have been lost from expansion joints. Some faulting is developing, preliminary analysis of the data indicates that expansion and contraction repair joints perform equally poorly as far as faulting is concerned. Work on the report is in progress, a draft copy has been completed and is being revised for final review.

Planned Program for Coming Year

Publish the final report.

Salaries and Wages 1982: \$15,309

Title

77 F-153 - Static and Dynamic Properties of Anchor Bolts for Sign Supports

Purpose

To determine the effect of: 1) nut engagement on the static strength of typical anchor bolt assemblies; 2) closeness of fit of nut and bolt on the static strength of anchor bolt assemblies; and, 3) galvanizing on the fatigue strength of typical anchor bolts.

Scope

Two sizes of galvanized bolts are being evaluated at 0.25d, 0.50d, 0.75d, 1.0d, 1.5d, and 2.0d engagement where d is the nominal diameter of the bolt. Bolt diameters are 1-1/2 and 2 in. Anchor bolts are being evaluated statically and in fatigue, both plain and galvanized.

Progress Past Year

All scheduled tests were completed. Static tests showed the effects of inadequate nut engagement. In all cases, the fatigue life of the plain or 'stripped' (galvanizing removed) specimen has been at least twice as long as that of the corresponding galvanized specimens, with a 95 percent confidence level in the resulting data. Therefore, it appears evident that the galvanized coating increases fatigue cracking. The final report for the originally scheduled work (R-1197) was completed and published. A review of the report by the Engineering Operations Committee resulted in additional work being initiated on this same project. Anchor bolts for new large cantilever sign supports have been redesigned based on the results of the study

to date. Procedures for nondestructive evaluation of anchor bolts in the field have been developed as part of this project; specimens for calibration and training for inspectors also were provided. A new set of loading fixtures for the MTS machine has been designed and built, and a few additional dynamic tests have been completed. Arrangements have been made to add stainless clad bolts with rolled threads to the evaluation.

Planned Program for Coming Year

Obtain additional samples and conduct further fatigue evaluations.

Salaries and Wages 1982: \$3,490

Title

79 F-157 - Field Inspection of Electrosag Welded Bridges for Weldment Flaws

Purpose

On March 14, 1979, the Department received a notice on "Federal Participation in Electrosag Weldment Inspection and Retrofitting," that included main-load-carrying members that are redundant as well as those that are non-redundant. Michigan has more than 125 such bridges in the Interstate system. This project was established to segregate time spent on such inspections for the purpose of obtaining any available Federal funds.

Scope

It is intended to work on inspection of the 125+ bridges, as time and staff permit, to evaluate the condition of the structural integrity of the electrosag butt weldments subject to tensile stress. Applicable non-destructive evaluation techniques will be used.

Progress Past Year

No significant effort was made on this project during the year because of higher priority projects and reductions in staff.

Planned Program for Coming Year

This project is a very long range undertaking, and will be worked on only as staff, equipment, and travel funds are available. Due to current

restrictions, and reduced staff, it is questionable whether further work will be undertaken next year. However, an effort will be made to obtain preliminary data.

Salaries and Wages 1982: - 0 -

Title

82 F-160 - Stainless Steel Clad Reinforcing Bars in a Bridge Deck

Purpose

To gain some practical experience with supply, fabrication, and installation of stainless clad rebar in bridge decks, and to evaluate the performance of the decks in comparison with other decks having epoxy coated rebar.

Scope

A total of four single-span, urban Interstate bridges will be included in the evaluation. Two will have stainless clad rebar, and two will have epoxy coated rebar, in the decks and safety walls. Decks with epoxy coated rebar will have two-stage construction with latex modified overlay, while decks with stainless bars will be built with a single lift, 3-in. cover of standard bridge deck concrete.

Laboratory experimentation will cover tensile and fatigue evaluations of the bars, as well as limited flexural work with reinforced concrete beams.

Progress Past Year

The research proposal was prepared and approved by the Engineering Operations Committee and the Federal Highway Administration. Specifications were prepared, and the special requirements for the experiment were included in the plans for four structures by the Design Division. The structures are to be located at I 696 over the service road on the west side of I 75 (S01, S02 eastbound and westbound, and S03 of 63103). Contracts were awarded during the fall of 1982. Since that time, a steel supplier has requested and obtained approval to furnish solid stainless steel rebar in place of the stainless clad bar originally called for. Both stainless clad and solid stainless bars will be included in the laboratory phases of the work.

Bid prices for the job were as follows: uncoated rebar, \$.38/lb; epoxy coated rebar, \$.57/lb; and stainless rebar, \$2.00/lb.

Planned Program for Coming Year

Monitor progress on the construction project.

Observe and document the installation of the experimental decks. Sample steel from the site and begin experimental laboratory work.

Salaries and Wages 1982: \$1,234

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

Project evaluation work is complete. Awaiting final report from MSU.

Planned Program for Coming Year

Final report to be issued and reviewed.

Salaries and Wages 1982: - 0 -

Title

75 G-212 - Non-Discharge Recirculating Sewage System for Freeway Rest Areas

Purpose

To evaluate Aqua-Sans Recirculating Sewage System for use at rest areas.

Scope

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

Progress Past Year

Project completed, and publication of Research Report R-1138.

Planned Program for Coming Year

Project is completed.

Salaries and Wages 1982: - 0 -

Title

78 G-241 - Effect of Corrosion on Bridges of Unpainted A588 Steel and Painted Steel Types

Purpose

To quantify the corrosion rates and total section loss due to corrosion on unpainted A588 steel bridges. To determine if any crevice corrosion is evident on steel bridge details and to investigate for possible corrosion-fatigue damage. To determine the integrity of paint systems applied over salt-contaminated steel.

Fatigue evaluation of specimens removed from bridges, also has been added to this project.

Scope

This investigation is aimed primarily at the nearly 500 bridges in Michigan that are constructed of unpainted A588 steel. Field investigations have revealed that salt leakage and spray from traffic have caused rapid deterioration of the unpainted steels.

The Department has terminated the use of unpainted steel.

A major problem is direct attack and crevice corrosion due to leakage of saltwater through the joints onto the beams. Spray from traffic below

has been determined to cause more severe deterioration than previously noted. Accumulation of debris on the beams, capillarity of the rust coating, and lack of washing and drying cycles, also add to the problem.

In areas directly wetted by salt solution, the rate of attack is several-fold greater than on the structure in general, and in crevices subject to drainage the rate can be several-fold greater still. Additional work this year has allowed better quantification of the various environments.

Preliminary work on evaluation of painted structures was done. Paint loss on lower web and flange occurs in eight to fifteen years depending on severity of exposure.

Progress Past Year

Work has continued on analysis of corrosion data, and preparation of a progress report. Preparation by machining of all fatigue specimens has been completed, and fatigue testing has continued in the Structures Laboratory. Specimen grips for the MTS machines were worn out by the testing and have been rebuilt. The fatigue program is about half done. The results to date indicate a significant decrease in fatigue life with increased pitting and surface attack due to corrosion.

Planned Program for Coming Year

Experimental work on fatigue life will continue on the plates removed from the bridges in Detroit.

Data gathering and analysis will be continued. The progress report will be submitted for review and will be published.

Salaries and Wages 1982: \$15,709

Title

81 G-252 - Thetford Corporation "Cycle-Let" Recirculating Sanitary System

Purpose

To evaluate the performance of the Cycle-Let Recirculating Sanitary System for rest areas.

Scope

A Cycle-Let Model HU 1500 sanitary system, having a maximum capacity equivalent to 15,000 gallons per day of waste water, will be installed in the new rest area on I 96 eastbound, west of Jordan Lake Rd in Ionia County. Performance, effectiveness, operation, and maintenance costs will be evaluated.

Progress Past Year

Specifications for the installation are ready for bids. The project letting has been delayed until spring of 1984.

Planned Program for Coming Year

Project delayed. Installation procedures to be monitored and evaluated during construction.

Salaries and Wages 1982: - 0 -

Title

81 G-256 - Evaluation of Strength and Durability of Guardrail Posts

Purpose

To document the condition of some older installations of wooden and steel guardrail posts; and periodically to evaluate the appearance and strength of unauthorized wood species posts in comparison with approved species.

Scope

The condition of posts was checked on 35 field locations of wooden posts 15 to 24 years of age treated with three different types of preservatives, and about 50 field locations of painted and galvanized steel posts about 20 years of age.

Posts of approved and unauthorized species were identified by the Soils and Materials staff in the Metro and Kalamazoo Districts, and samples are removed for strength testing in the Laboratory at intervals of approximately one year. Unauthorized species under consideration are of poplar. Pine posts are used as control, since they are of approved species.

Periodic condition surveys will be made by District Testing and Research staff on the unauthorized and control species.

Progress Past Year

A rating system for the laboratory-conducted condition surveys of older wooden posts has been developed and field inspections were completed. A limited field inspection was conducted for steel posts.

Posts of unauthorized and control species were removed from the Metro and Kalamazoo Districts and sent in to the laboratory. Evaluations of strength in static bending, loss of cross-section due to deterioration, moisture content, specific gravity, penetration of preservatives, and species determination were completed. Samples also have been obtained of wooden posts that had been removed from service due to deterioration, in the Grand Rapids District; and from steel posts in the Jackson District.

Inspection tools, methods, and training were furnished to Maintenance and Construction personnel for use in field inspection of wooden posts.

Planned Program for Coming Year

Conduct bend-to-failure tests on posts submitted to the Laboratory.

Continue condition surveys of the various installations of wooden and steel posts in the field.

Purchase and evaluate a sonic pole tester similar to that used by Detroit Edison for measuring deterioration of their wooden telephone posts.

Compile and evaluate data.

Write progress report.

Salaries and Wages 1982: \$35,024