# DEVELOPMENT AND USE OF A PAVEMENT DATA SYSTEM

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This paper details the development of a pavement data system that can be used in combination with other data systems to provide useful information to the Virginia Department of Highways for the purpose of planning maintenance resurfacing, skid resistance research studies, and pavement durability studies. The paper includes a general outline of the pavement data system, a discussion of the collection of historical data and the implementation of a data collection system for field personnel, and a discussion of the software development required to handle the data. A brief discussion is made of the integrated use of the pavement data with other data systems for the purpose stated above.

•THE CONSTRUCTION of the Interstate Highway System and the dual-laning of the arterial system have ushered in a new highway era in Virginia. This great upsurge in construction activity has generated thousands of pieces of data that have been collected and stored in the various offices of the highway department throughout the state. The original purposes for which the data were collected have been served well, but in the past few years difficulties have been encountered in retrieving these data for other applications. For example, planning for maintenance resurfacing is becoming an increasingly complex and important function. The increasing highway mileage and traffic volumes and the need to maintain a minimum skid resistance require that many variables be considered so that maintenance resurfacing funds are most efficiently allocated. Likewise, many variables must be considered in evaluating the skid resistance properties of various types of aggregates and mixes or in evaluating the performance of materials and pavement designs. Because of the large amounts and the complexity of the data required for various applications, the most feasible systems for handling the data are integrated, automated systems.

The purpose of this paper is to describe the development of a pavement data system that can be used in combination with other data systems to provide useful information to the Virginia Department of Highways for the purpose of planning maintenance resurfacing, skid-resistance studies, and pavement performance studies. In addition to describing the development of the pavement data system, the paper includes a brief discussion of the planned integrated use of the pavement data system with other systems. The paper covers only the work performed prior to August 31, 1973.

## PAVEMENT DATA SYSTEM DEVELOPMENT

The most specific uses in mind during the development of the pavement data system were those for maintenance resurfacing planning, skid resistance studies, and pavement durability studies including the evaluation of pavement designs. The total data required to meet these needs were determined by several committees composed of personnel from the Virginia Highway Department; the final judgment was made by a task group composed of top level personnel from the Materials, Maintenance, Construction, Traffic and Safety, and Data Processing Divisions, a district office, and the Research Council. The data agreed to be required are given in Table 1.

Columns 1, 2, and 3 in Table 1 comprise the data in the pavement data system de-

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veloped. The data shown in the remaining columns are contained in either existing automated systems or systems under development.

The pavement data system has 2 basic characteristics:

1. The basic unit in the new system is a surface mix section, which is defined as a length of roadway for which the surface mix type, age, materials data, and other descriptive data remain constant.

2. The locational method used in the system is the milepost as derived from the graphic logs maintained by the Traffic and Safety Division. The use of some locational method such as the milepost is the only effective way of correlating data from several computer systems, and the milepost is the most acceptable method used by the Virginia Department of Highways.

The desired location and descriptive data define the exact location of each surface mix section and provide a general description of the section. Highway system refers to the interstate, arterial, and primary systems and allows analysis of data for each system separately. District, residency, county, city, town, route, direction, lane, and beginning and ending mileposts define the location of the surface mix section and allow outputs to be generated by district, residency, county, city, or town. Descriptive beginning and descriptive ending are included to aid field personnel in their use of the output from the system. Maintenance section is the section used for the allocation of maintenance costs and is included so that projected resurfacing needs can be shown by the maintenance section. Highway type indicates the number of lanes and can be useful in several ways, particularly in determining how many surface mix sections exist across the highway at any point. For instance, the north-south, 4-lane, divided highway may require separate surface mix sections for the northbound and southbound lanes. Also, highway type permits data to be summarized by lane-mile rather than centerline-mile. Length and width are necessary for maintenance purposes to determine the area to be resurfaced (length, of course, can be determined from beginning and ending mileposts). Mix type indicates that the surface is portland cement concrete, surface treatment, slurry seal, mix-in-place, or bituminous concrete (for bituminous concrete the particular mix type such as S-5 is required). Special feature refers to particular characteristics about the surface such as grooved pavement and will be most useful in selecting data for future research studies. Age is required so that output can be provided by age or age and mix type and is determined by including the date of the last resurfacing.

The materials and construction data are desired so that estimations can be made about the useful life remaining for surface mix sections and to facilitate research work on the performance of materials. For instance, surfaces containing limestone aggregates likely will become slippery sooner than those containing other aggregate types and therefore require resurfacing sooner. Also, these data may show that aggregates from certain sources do not perform well from a structural standpoint. The aggregate information is required for each aggregate used in the surface mix.

Data on mix type, depth and percentage of cement, lime, or asphalt for each layer under the surface, and 18-kip equivalent design volume are desirable for several reasons, but principally to indicate the maximum 18-kip equivalent volume the pavement was designed to carry, to aid in the evaluation of the performance of pavement designs, and to aid in deciding what type and rate of resurfacing to apply.

## GENERAL SYSTEM OUTLINE

A general outline of how the pavement data system works, independent of any interaction with other systems, is shown in Figure 1. Initially, the data forms should be filled out as explained in the code manual by either the inspector or project engineer assigned to the resurfacing or new construction job. Input form 1 (Fig. 2) is filled out for each job, and input form 2 (Fig. 3) is filled out whenever the job involves the placement of subsurface layers. If no code exists for certain data (for instance, a new quarry source), field personnel are instructed to submit the data in question in written form attached to the data form.

The forms are reviewed in the residency office and submitted with the contract or schedule finals to the district computer's office. The district materials engineer's

**Table 1. Data required for highway system.**

| Section Location and Descriptive Data | Surface Mix Materials and Construction Data | Subsurface Layers and Design Volumes for Each Layer | Dynaflect Data for Each Lane | Skid Data for Each Lane | Accident Data | Volume Data | Resident Engineers' Comments |
|---|---|---|---|---|---|---|---|
| Highway system | Application rate | Mix type | Spreadability mean | Mean PSDN | Total accidents | Average vehicles daily | Date of review |
| District | Aggregate size | Depth | Standard deviation | Standard deviation | Total fatal accidents | Trucks | Estimated remaining life |
| Residency | Aggregate type | Percentage of cement, lime, and asphalt | Sample size | Sample size | Wet accidents | 2 axle, 4 wheels | Reason for resurfacing |
| County | Aggregate source | 18-kip equivalent design volume | Date of test | Date of test | Wet fatal accidents | 2 axle, 6 wheels | |
| City and town | Aggregate percentage | | | Test vehicle | Percentage of wet accidents | 3 axle | |
| Route | | | | | Accident rate | Trailer trucks | |
| Maintenance section | | | | | | Buses | |
| Highway type | | | | | | | |
| Direction and lane | | | | | | | |
| Beginning milepost | | | | | | | |
| Descriptive beginning | | | | | | | |
| Ending milepost | | | | | | | |
| Descriptive ending | | | | | | | |
| Length | | | | | | | |
| Width | | | | | | | |
| Surface mix type | | | | | | | |
| Special feature | | | | | | | |
| Age | | | | | | | |

**Figure 1. Pavement Data System.**

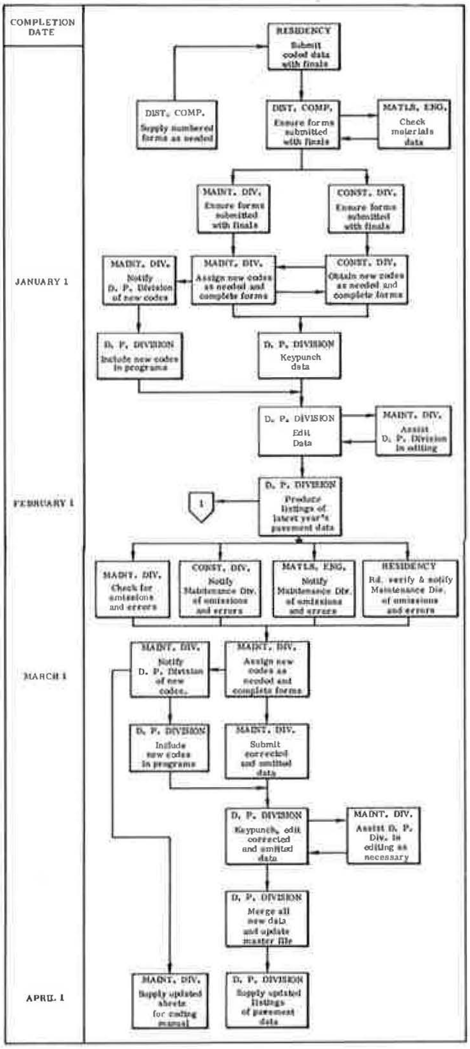


**Figure 2. Pavement descriptive information, input form 1.**

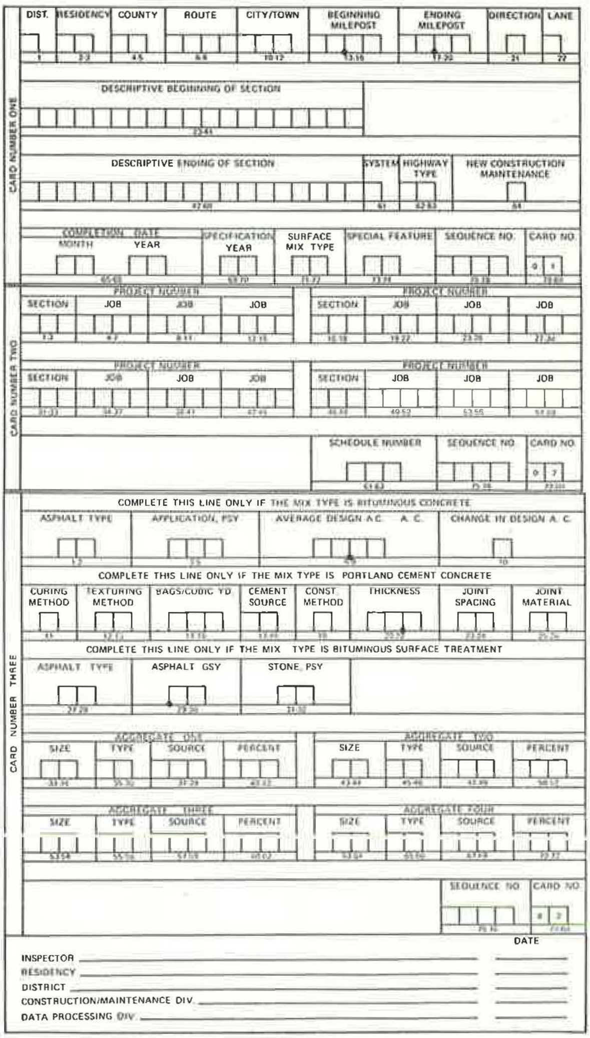
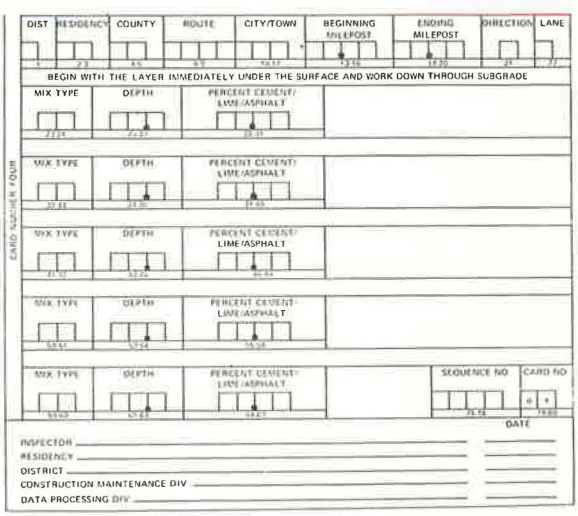



**Figure 3. Pavement descriptive information for subsurface layers, input form 2.**



office checks the forms for the accuracy of the materials and construction data. The forms are then submitted with the finals to the Maintenance Division or Construction Division, depending on whether the work is maintenance resurfacing or new construction. These divisions check to ensure that the correct number of forms are submitted with the finals and then forward them to the Data Processing Division for keypunching.

In addition to checking to ensure that the correct number of forms are submitted, the Maintenance and Construction Divisions assign new codes as necessary. If the work is new construction, the Construction Division obtains a code from the Maintenance Division and completes the form. If the work is maintenance, the Maintenance Division assigns the new code and completes the form. The Maintenance Division is responsible for notifying the Data Processing Division of new codes so that they may be included in the computer programs developed to handle the pavement data.

The reason for including the forms with the finals for a project or schedule is to ensure that forms are submitted when work is completed. A major weakness in previous manual systems was that there was no way to ensure that forms were submitted as work was completed, and consequently much work was completed without any data of the type discussed thus far ever being submitted.

The work described thus far involves all resurfacing and new construction completed from December 1 of one year to December 1 of the following year. A 1-month period (until January 1) is allowed each year to complete forms for work completed prior to December 1 and to submit them to the Data Processing Division. Between January 1 and February 1, the Data Processing Division edits and produces listings of the latest year's data (Fig. 4).

The listings are sent to the Maintenance Division, Construction Division, districts, and residencies for a final check for errors and omissions before the master pavement data file is updated. By March 1 the Maintenance Division is notified of corrections and omissions and submits them to the Data Processing Division along with any new codes assigned. The Maintenance Division is also responsible for supplying to the field updated sheets for the code manual as required by the assignment of new codes.

After receiving the corrections, the Data Processing Division keypunches and edits the data and updates the master pavement data file with the past year's data. Listings of the updated pavement file can then be issued to the field offices and divisions as desired. However, listings containing additional data from other files, as will be discussed later, are more useful for field and central office personnel.

Installations of computer terminals in the district offices may eventually effect a change in the system as described. At present, terminals are in 7 of the 8 districts and are used in a batch-operating mode, principally for design work. However, further work will involve studying the possibility of updating and accessing the pavement data system on a continual basis at the district level by the use of the terminals.

One important feature of the pavement data system not shown in Figure 1 is the periodic review of the system including evaluation by users of its overall usefulness and decisions to omit or add or both certain data elements. The Maintenance Division has the responsibility to ensure that this review is conducted at least each 2 years and more frequently if required.

Development and implementation of the pavement data system involved basically 3 separate functions: collection of historical data, implementation of a new data collection system for field personnel, and computer software development to handle the data. Progress on each of the functions is discussed below.

## Collection of Historical Data

The decision was made to collect historical data for the interstate and arterial systems only; data on the interstate, arterial, and primary systems were submitted from the field for new construction and maintenance resurfacing beginning in 1972. Collecting historical data about the subsurface and 18-kip equivalent design volume was impossible.

The collection of the historical data needed as original input for the pavement data system turned out to be a formidable task. Investigation revealed that several sources in the state contained information desired in the study: highway residencies, construction district offices, Research Council, and several divisions of the central office. The methodology selected for collecting the historical data was to compile the information obtained from the highway department's maintenance plant mix forms and construction forms. The collection and compilation involved the use of data contained at each of the offices mentioned above, none of which had complete information. Some of the records of surface mixes were excellent; others were very poor. An advantage of going to the field office was that when records were missing there was usually someone (an engineering clerk or inspector) with knowledge of when the road was surfaced. That knowledge made it possible to obtain information for sections for which records were missing. Information could not be obtained for considerable road mileage and was provided by the authors based on knowledge they obtained while collecting historical data. It may seem unusual that the source of materials can be verified from the road, but the familiarity gained during the study, the somewhat limited number of nonpolishing sources of aggregate in the state, the fact that aggregates can be clearly seen 3 months after the mix is placed, and the fact that one of the authors is a geologist all combined to make this possible.

When all of the information available had been collected, the data were put in order by milepost, and field verification was made in a car equipped with a special survey speedometer to check end-point locations of the sections and the authenticity of the recorded information.

To date, collection of historical data has been completed for the interstate and arterial systems with the exception of the subsurface data and 18-kip equivalent design volume as indicated above. Maintenance section and width also have not been collected for each section, but are readily available from the graphic log. The historical data were coded on the forms designed for input into the pavement data system (Figs. 2 and 3); the code manual designed for this purpose was used. The total effort required to collect and code the historical data was 30 person-months. The authors instructed field personnel in the correct methods of submitting data for the pavement data system.

## Implementation of Field Data Collection

Field implementation of the data collection procedures was accomplished by conducting schools in the department's 8 construction districts. All personnel who have a part in collecting, coding, or checking the data—inspectors, project engineers, maintenance supervisors, residency engineering clerks, district computers, and district materials engineers—were requested to attend. In addition, supervisory personnel such as resident engineers and their assistants and district engineers and their assistants were invited to attend. During the schools the use of the code manual and forms was explained, and several examples of both resurfacing and new construction were coded. In addition, an overview of how the pavement data system works was given. The district materials engineers, in conjunction with the Materials and Maintenance Divisions, have the responsibility of conducting refresher schools in coding as they are required.

The sessions were lively and resulted in much discussion of various items, and several suggestions were made and incorporated in the final version of the code form and manual. Setting up and teaching the schools required about 1 month of time of each of the authors, including the time required for several visits to various residency offices for the purpose of teaching a second school for some of the personnel.

A review of the forms submitted for work completed during 1972 indicates that, in general, a relatively low number of errors occurred. Also, most of the errors seem to be concentrated in 1 or 2 districts. The authors believe that with some limited amount of additional schooling in some districts the data collection will be very satisfactory.

## Software Development

The initial work in the development of the software was devoted to the code manual and data forms. The development of this material was handled by the Data Systems and Analysis Section at the Research Council, and the items were reviewed several times by representatives of the Data Processing Division. Care was taken to ensure that the

**igure 4. Pavement information for latest year.**

| SECTION LOCATION AND DESCRIPTION | | | | | |
|---|---|---|---|---|---|
| ROUTE | 0150 | DIRECTION/LANE | SOUTH BOUND-ALL LANES | PROJECT NUMBERS | 0150-020-104 C501,B612,B613 |
| DISTRICT | RICHMOND | BEGINNING MILE | 07.67 0.043 MI N INT 60 | | |
| RESIDENCY | CHESTERFIELD | ENDING MILE | 09.64 0.005 MI N WCL RICH | | |
| COUNTY | CHESTERFIELD | SURFACE MIX TYPE | S-5 | | |
| CITY | | SPECIAL FEATURE | NONE | SCHEDULE NUMBER | |
| SYSTEM | PRIMARY | COMPLETION DATE | OCTOBER-72 | SPEC. YEAR | 70 |
| HIGHWAY TYPE-FOUR LANE DIVIDED - FULL CONTROL OF ACCESS | | | | | |

| SURFACE MIX MATERIALS AND CONSTRUCTION DATA | | | | | | | |
|---|---|---|---|---|---|---|---|
| BITUMINOUS MIXES | | PORTLAND CEMENT CONCRETE MIXES | AGGREGATE INFORMATION | | | | |
| ASPHALT TYPE | AC-20 | CURING METHOD | | SIZE | TYPE | PERCENT | SOURCE |
| APPLICATION,PSY | 165 | TEXTURING METHOD | | TOP SIZE 1/2 | GRAVEL | 45 | WEST SAND AND GRAVEL CO. RICHMOND, VA. |
| AVG. DESIGN AC | 6.00 | BAGS/CUBIC YARD | | | | | |
| CHANGE IN AC | NO | CEMENT SOURCE | | SAND | SAND | 10 | WEST SAND AND GRAVEL CO. RICHMOND, VA. |
| ASPHALT, GSY | | CONST. METHOD | | 10 | GRAVEL | 45 | WEST SAND AND GRAVEL CO. RICHMOND, VA. |
| STONE, PSY | | THICKNESS | | | | | |
| | | JOINT SPACING | | | | | |
| | | JOINT MATERIAL | | | | | |

| SUBSURFACE LAYERS - BEGINNING WITH LAYER IMMEDIATELY UNDER THE SURFACE | | |
|---|---|---|
| MIX TYPE | DEPTH | PERCENT CEMENT/LIME/ASPHALT |
| B-3 | 4.0 | 4.40 |
| SUBBASE MATERIAL- STONE SIZE 21A | 6.0 | |
| SUBGRADE-NATIVE-CEMENT STABILIZED | 6.0 | 1.00 |

**gure 5. Detailed output f proposed system.**

```
SECTION LOCATION AND DESCRIPTIVE INFORMATION:
**************************************************************************************************

SYSTEM          XXXXXXXXXX          BEGINNING MILE    XX,XX XXXXXXXXXXXXXXXXXX   PROJECT NUMBER  XXXX-XXX-XXX,XXXX,XXXX,XXXX,XXXX
DISTRICT        XXXXXXXXXXXXX       ENDING MILE       XX,XX XXXXXXXXXXXXXXXXXX                            XXX,XXXX,XXXX,XXXX,XXXX
RESIDENCY       XXXXXXXXXXXXXXX     LENGTH            XX,XX                                               XXX,XXXX,XXXX,XXXX,XXXX
COUNTY/CITY     XXXXXXXXXXXXXX      WIDTH             XX                                                  XXX,XXXX,XXXX,XXXX,XXXX
ROUTE           XXXX                SURFACE MIX TYPE  XXXXXXXX XXXXXX XXXXXXX                             XXX,XXXX,XXXX,XXXX,XXXX
MAINT. SEC.     XX                  SPECIAL FEATURE   XXXXXXXXXXX XXXXXXXXX                               XXX,XXXX,XXXX,XXXX,XXXX
HIGHWAY TYPE    XX                  COMPLETION DATE   XXXXXXXXX-XX               SCHEDULE NUMBER XXX-XX
DIRECTION/LANE  XXXXX XXXXX XXXXX   AGE               XX,X                       SPEC. YEAR      XX

REVIEW DATA:
**************************************************************************************************

DATE LAST REVIEW    XXXXXXXXX-XX       ESTIMATED REMAINING LIFE AT REVIEW:PAVEMENT  XX
                                       PRESENT REMAINING LIFE            :PAVEMENT  XX

SURFACE MIX MATERIALS AND CONSTRUCTION DATA:
**************************************************************************************************

     BITUMINOUS MIXES            PORTLAND CEMENT CONCRETE MIXES                          AGGREGATE INFORMATION
     ----------------            ------------------------------                          ---------------------
ASPHALT TYPE        XX-XX    CURING METHOD      XXXXXX XXXXXXXX                  SIZE        GEOLOGIC TYPE   SOURCE  PERCENT
                                                                             ------------  -------------   ------  -------
APPLICATION,PSY     XXX      TEXTURING METHOD   XXXXXXXX XXXXXX XXXX         XXX XXXX XXX  XXXXXXXX XXXXX   XXX     XXX
AVERAGE DESIGN AC   XX,XX    BAGS/CUBIC YARD    X,XX                         XX X          XXXXXXX          XXX      XX
CHANGE IN AC        XXX      CEMENT SOURCE      XX                           XX X          XXXXXXXXX        XXX      XX
ASPHALT,GSY         .XX      CONST. METHOD      XXXXXXXXXXX XXXXXXXXXX       XX XX         XXXX             XXX       X
STONE,PSY           XX       THICKNESS          XX,X
                             JOINT SPACING      XX
                             JOINT MATERIAL     X

SUBSURFACE LAYERS DATA BEGINNING WITH LAYER IMMEDIATELY UNDER THE SURFACE:
**************************************************************************************************

                MIX TYPE                          DEPTH        PERCENT CEMENT/LIME/ASPHALT
*******************************************       -----        ---------------------------
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX         XX,X                   XX,XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX         XX,X                    X,XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX          X,X                    X,XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX         XX,X                   XX,XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX         XX,X                   XX,XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX         XX,X                   XX,XX
 XXXXXXXX-XXXXXX XXXXXX-XXXXXXX XXXXXXXXX         XX,X                   XX,XX
 TRAFFIC VOLUME DATA:
 ************************************************************************************************

                              TOTAL      ONE DIRECTION     LANE 1(TRAFFIC)     LANE 2     LANE 3
                              -----      -------------     ---------------     ------     ------
  AVERAGE VEHICLES DAILY      XXXXXX     XXXXX             XXXXX               XXXXX      XXXXX
  2 AXLE -4 TIRES              XXXXX     XXXXX              XXXX                XXXX      XXXXX
  2 AXLE -6 TIRES              XXXXX     XXXXX              XXXX                XXXX      XXXXX
  3 AXLE                       XXXXX     XXXXX              XXXX                XXXX      XXXXX
  TRAILER TRUCKS               XXXXX     XXXXX              XXXX                XXXX      XXXXX
  BUSES                        XXXXX     XXXXX              XXXX                XXXX      XXXXX

  ACCUMULATED VEHICLE PASSES  XXXXXXXXX  XXXXXXXXX          XXXXXXXXX          XXXXXXXXX  XXXXXXXXX
  2 AXLE -4 TIRES             XXXXXXXXX  XXXXXXXXX          XXXXXXXXX          XXXXXXXXX  XXXXXXXXX
  2 AXLE -6 TIRES             XXXXXXXXX  XXXXXXXXX          XXXXXXXXX          XXXXXXXXX  XXXXXXXXX
  3 AXLE                      XXXXXXXXX  XXXXXXXXX          XXXXXXXXX          XXXXXXXXX  XXXXXXXXX
  TRAILER TRUCKS              XXXXXXXXX  XXXXXXXXX          XXXXXXXXX          XXXXXXXXX  XXXXXXXXX
  BUSES                       XXXXXXXXX  XXXXXXXXX          XXXXXXXXX          XXXXXXXXX  XXXXXXXXX

  EQUIVALENT PASSES           XXXXXXXXX  XXXXXXXXX          XXXXXXXX           XXXXXXXXX  XXXXXXXXX
  DESIGN 18 KIP  VOLUME       XXXXXXXXX  XXXXXXXXX          XXXXXXXX           XXXXXXXXX  XXXXXXXXX
  18K EQUIVALENT VOLUME       XXXXXXXXX  XXXXXXXXX          XXXXXXXX           XXXXXXXXX  XXXXXXXXX

                 DYNAFLECT DATA                                         SKID DATA                  ACCIDENT DATA
                 --------------                                         ---------                  -------------
  DIRECTION/                SPREADABILITY    MAXIMUM 18 KIP
    LANE        DATE       AVG.  S.D.  N        VOLUME              DATE   AVG.  S.D.  N                          19XX    19XX
  ---------    ------     ---------------   --------------         ------  ------------                          ----    ----
  XX XXXX X    XX-XX      .XX   .XX   XXX       XXXXXX              XX-XX   XX    XX   XX      TOTAL              XXX     XXX
  XX XXXX X    XX-XX      .XX   .XX   XXX       XXXXXX              XX-XX   XX    XX   XX      TOTAL FATALS        XX      XX
  XX XXXX X    XX-XX      .XX   .XX   XXX       XXXXXX              XX-XX   XX    XX   XX      WET                XXX     XXX
  XX XXXX X    XX-XX      .XX   .XX   XXX       XXXXXX              XX-XX   XX    XX   XX      WET FATALS          XX      XX
  XX XXXX X    XX-XX      .XX   .XX   XXX       XXXXXX              XX-XX   XX    XX   XX      PERCENT WET        XXX     XXX
  XX XXXX X    XX-XX      .XX   .XX   XXX       XXXXXX              XX-XX   XX    XX   XX      ACCIDENT RATE     XXXX    XXXX
```

codes developed corresponded to those that exist in other automated systems, which eventually will be used in an integrated manner with the pavement data system. Development of this material required about 2 person-months of time and was completed prior to implementing a final data collecting system in the field or coding historical data.

After work was completed on the code manual and forms, work was begun on the development of computer programs to edit and produce listings of the pavement data. The programming work was handled by the Data Processing Division staff, who had frequent discussions with the authors concerning the requirements to be met in these programs. The programs were written in assembly language and ANSI COBOL languages to be run on the IBM 370-155 computer operated by the Data Processing Division.

A sample of the output produced by these programs is shown in Figure 4. No codes are printed as part of the output. The authors were insistent that coded output not be allowed, for they felt it would greatly diminish the use of the output. Blank spaces occur on the output when a particular data item is not applicable to the section, such as those items shown in Figure 4 under portland cement concrete mixes. To date the programs have been used to provide initial listings of all historical data as well as separate listings of data submitted by the field for work completed during 1972.

Work is under way by the Data Systems and Analysis Section to develop programs for data corrections and updating. Initially these programs will be used to make corrections to the historical data and 1972 data and then to update the master file (historical data) with the 1972 data. These programs are being written in IBM compatible FORTRAN IV and ANSI COBOL. The installation in the near future of a terminal at the Research Council will permit access to the IBM 370 operated by the Data Processing Division and will facilitate the implementation of these programs.

Thus far the program for corrections has been completed and tested and is being used to enter corrections of the 1972 and historical data in preparation for the initial update.

The update program represents a major programming effort for several reasons. First, on occasion the update record will not correspond to the beginning and ending points of an existing section, but instead will overlap 2 or more existing sections or be within an existing section. In addition, the update information may refer to all lanes in both directions or any group of lanes in either direction. For all of these reasons, an update at times is likely to have the effect of creating several new sections. The procedure may be complicated even further if the update reflects new construction that could be the replacement of existing roadway or completely new roadway. A further complication is that historical data are retained for each section of the surface.

The programming effort expended thus far has amounted to 5 or 6 person-months. Additional software is under development for the integrated applications.

## INTEGRATED USES OF PAVEMENT DATA SYSTEM

Some of the anticipated uses of the pavement data system are for maintenance planning, skid resistance research studies, and pavement durability studies. Each use will require that pavement data be integrated with the other types of data given in the last 5 columns of Table 1. These data can be divided into the 5 categories of Dynaflect data, skid data, accident data, traffic volume data, and resident engineers' comments. Before discussing the intended uses, we should first discuss what data bases exist for these 5 categories and what work will be done to further develop these data bases.

At present, all Dynaflect data are collected by the Pavement Section of the Research Council. These data are collected on particular construction projects for research purposes and, at times, on pavements requiring resurfacing to gain an indication of what type and thickness of resurfacing to apply. There is no automated system to handle Dynaflect data, but plans are to develop and implement one suitable to the requirements of maintenance planning and pavement evaluation.

Skid data are also collected by the Research Council. The Maintenance Section uses both a stopping distance car and skid trailer to obtain data and at present has more than 30,000 test results. An automated system has been developed by the Data Systems and Analysis Section to handle skid data. This system is compatible in all respects with the pavement data system. In addition, a new skid trailer is being purchased by the highway department to be operated by the Materials Division as a survey vehicle. Data obtained with this new trailer will be included in the skid data base.

Accident data are maintained in an automated system by the Data Processing Division. These data are located by county, route, and milepost and thus can be associated directly with pavement surface mix section and skid data.

Traffic volume data are also maintained in an automated system by the Data Processing Division. However, these data are located not by milepost but by traffic sections. A determination will be made of the most appropriate method of obtaining traffic volume data, including the consequences of assigning beginning and ending mileposts to the traffic sections or the possibility of building a separate file compatible with the other data files discussed thus far.

Resident engineers' review data do not yet exist, but will be collected on the basis of pavement surface mix sections. Development of the materials necessary to implement this system will involve further discussions with personnel from the Research Council, field offices, and divisions regarding what data are appropriate to collect.

Although data bases are not so complete as desired, we can make use of the data that are available and proceed with developing the integrated applications.

The integrated use of the pavement data with data from the other systems discussed above is best illustrated in terms of what output will be provided. Most of the work thus far has been to develop outputs for planning maintenance resurfacing. These outputs include a detailed output (Fig. 5), an exception output (Fig. 6), and a summary output (Fig. 7). Present plans are to provide each type of output annually to the residencies and districts for the counties they include and to the Maintenance Division for the entire state. The detailed output is intended primarily as a reference; the other 2 outputs are the primary maintenance resurfacing planning tools. The exception output is obtained

**Figure 6. Output by exceptions.**

DISTRICT CULPEPER
RESIDENCY CHARLOTTESVILLE

| SECTION IDENTIFICATION | | | | | | | | ATTENTION NEEDED BECAUSE OF | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY | ROUTE | HIGHWAY TYPE | DIRECTION AND LANE | BEGINNING MILEPOST | ENDING MILEPOST | LENGTH | MIX TYPE | AGE | PRESENT LIFE | 18 KIP VOLUME | LOW SKID RESISTANCE | WET ACCIDENTS |
| ALBEMARLE | 29 | 41 | ALL LANES | 21.00 | 23.60 | 2.60 | S-5 | | | | * | |
| ALBEMARLE | 29 | 41 | NB LANES | 26.45 | 28.45 | 2.50 | S-5 | * | * | * | * | * |
| ALBEMARLE | 29 | 41 | SB LANES | 26.45 | 31.52 | 5.07 | S-5 | | * | * | | * |

**Figure 7. Summary output in long-range planning.**

MIX TYPE XXXXXXXX XXXXXX XXXXXXXX

| | AGE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | '15 | TOTAL |
| TOTAL MILAGE | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX | XXXXX |
| PERCENT OF TOTAL MILAGE | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | 100 |
| MILES TESTED FOR SKID NUMBER | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| MILES WITH SKID NUMBER < 42 | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| PERCENT OF MILES TESTED < 42 | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | 100 |
| MILES ASSIGNED 18 KIP MAX. | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| MILES EXCEEDING 18 KIP MAX. | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| PERCENT EXCEEDING 18 KIP MAX. | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | 100 |
| MILES REVIEWED | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| MILES PRESENT LIFE <1 YR. | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| PERCENT PRESENT LIFE <1 YR. | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | 100 |
| MILES SN<42 EXCEEDING 18 KIP MAX. | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| MILES SN<42 PRESENT LIFE < 1 | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| MILES EXCEED 18 KIP LIFE < 1 | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |
| MILES EXCEEDING ALL CRITERIA | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

by determining when established criteria for resurfacing are met for one or more of the variables of age, present remaining life as determined by the resident engineers' review, accumulated 18-kip equivalent volume, skid resistance, or percentage of wet accidents. This output is intended to provide guidance regarding what specific sections may need resurfacing during the next resurfacing season. The summary output gives the lane-miles of pavement meeting one or more of the criteria discussed above.

With regard to skid resistance and pavement durability studies, detailed output will be particularly useful in determining what specific programs have been developed, yet it is anticipated that one of the initial programs written will be for the purpose of establishing curves of skid resistance versus accumulated traffic volume for each aggregate source (either solely or in combination with other aggregate sources). Another program anticipated is one to relate the design 18-kip accumulated volume to the actual 18-kip accumulated volume achieved before resurfacing is required. Many other programs will be developed to meet particular needs, especially as the data bases become more complete.

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