New York State Thruway Use of Road Test Findings

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• It is a strange person who does not experience enormous satisfaction in being part of an important and successful undertaking. Satisfaction is especially stimulating when it relates to progress, the development of new ideas, things that have never been done before. That is the general feeling about the AASHO Test Road Project. It is such an active nucleus of new knowledge, the ultimate benefits cannot yet be fully comprehended or appreciated. But, already more refined formulas for the structural design of highways and their bridges can be seen.

Engineering experience and judgment, of course, cannot be set aside in the light of this new knowledge. That will always be a principal part of any design. However, the competent engineer now has a wealth of new information at his disposal to buttress his knowledge and to perfect his work.

Probably most were thinking in terms of new construction when the Test Road concept first developed. At least the possibility of using it for highway maintenance did not firmly enter the author's thinking until a little over a year ago. At that time, the author's firm undertook the development of a long-range heavy maintenance program for the New York State Thruway. The Authority realized that a pavement, always maintained in sound condition, is vital to continuance of efficient highway performance and project income. Without a smooth pavement, the 559 controlled access system could not successfully compete with toll-free roads, especially new Interstate routes and arterial highways.

It was decided, therefore, to peer into the future with the greatest degree of accuracy possible today and to develop both a long-range heavy maintenance program and parallel financing plan.

In undertaking this study, it was natural to turn to the wealth of information developed at the Road Test. If the data could be used successfully to design highways to carry a specific type of vehicle, a predicted number of times, under Ottawa environmental conditions and with a certain loss of serviceability, it seemed apparent that the same knowledge could be used to predict the effects of estimated traffic upon an existing highway. It appeared logical to measure the accumulation of damage that mixed traffic and environmental conditions had produced in the past and then in the light of that knowledge to predict the time and the character of work that would be required to maintain the highway properly.

As a consequence, a preliminary review of the AASHO Test Road results was undertaken with this thought in mind. The matter was discussed with Fred Burggraf, E. H. Holmes, W. N. Carey, Jr., W. B. McKendrick, Jr., and others. They were all confident that a new approach to estimating future required highway maintenance could be opened up in this way.

Consequently, this procedure was adopted and the firm is enthusiastic about the results. Of course, as more work in this area is undertaken, short cuts will be developed, and refinements will be discovered. That is progress. But, in the hope this recent study will assist others to undertake surveys required to meet their maintenance responsibilities, it is a pleasure to present the techniques followed in the Thruway survey.

PRESENT SERVICEABILITY INDEX

Of elementary, but vital importance, is a thorough understanding of the way to measure pavement surface condition, a function of accumulated pavement damage. It makes no difference whether one is surveying a lot, weighing a pound of coffee or measuring the accumulated damage of a highway, a scale of comparative measurement is required. Consequently, the AASHO Test Road staff developed the PSI, or present serviceability index. This is a scale which is used to specify the condition of a pavement surface. By knowing the changes in this index which take place from time to time, the damage which has been accumulated in a pavement can be easily computed.

Since development of the PSI scale itself has been reported elsewhere, only the conclusions reached by the Test Road staff and by the Thruway survey are summarized in Table 1.

TABLE 1

PSI SCALE

AASHO Test Road		N.Y. State Thruway Survey	
4–5	Very good	4–5	Very good
4.5	New rigid pavement average, before traffic	4.1	New estimated rigid pavement average, before traffic
3–4	Good	3–4	Good
2–3	Fair	2–3	Fair
1–2	Poor	1–2	Poor
0–1	Very poor	0–1	Very poor

Where 5.0 is the top part of the "very good" classification, it is in reality a perfect highway pavement. This value is seldom reached for appreciable lengths in practice. When it is secured, it is more by chance than by good management. Even the Test Road which was built to higher specifications and under greater engineering surveillance, than probably any other highway has ever been built, the PSI only averaged 4.5 for the rigid pavement.

On the Thruway, study indicated that it probably averaged 4.1. Since the Thruway had no PSI readings taken prior to opening the highway, it was necessary to determine as accurately as possible what the PSI probably was at the beginning. To do this, readings were taken on other highways on the Interstate and arterial systems in the vicinity of the Thruway, built to the same specifications, having the same design standards, and which had not yet been opened to traffic. Although the results varied considerably, they averaged 4.1 and that value was adopted as the original PSI of the Thruway.

The importance of obtaining the initial serviceability index of the different Interstate Highways and other important roads prior to their being opened to traffic cannot be overemphasized. If that is not practical, it should be done as soon thereafter as possible. As time goes on, highway maintenance and need studies will become increasingly dependent upon these basic figures. They should be obtained as a construction job is finished. Then the necessary work can be done quickly, accurately, and cheaply.

Of equal importance is the serviceability index figure below which it is decided not to go because of inadequate pavement rideability. Therefore, a careful appraisal of PSI values in relation to pavement rideability and damage was made during the Thruway survey. This indicated that when an express highway reached an index of 2.2, the riding characteristics became noticeably unsatisfactory. Consequently, it was determined that resurfacing would be undertaken on the Thruway as close to the time as practicable when that terminal PSI value could be expected to be reached. The AASHO Test Road data revealed that when the PSI value reached 1.5, a road was completely unserviceable and would have to be rebuilt.

BASIC FORMULAS

One of the most important formulas developed at the Test Road is:

$$g = \frac{P_0 - P_t}{P_0 - 1.5} \qquad (1)$$

in which

g = accumulated damage;
P_0 = initial PSI; and
P_t = present PSI.

This formula relates a PSI to the accumulated damage which brought it about. The relationship is extremely important in maintenance forecasting.

Several other formulas and principles developed at the AASHO Test Road are also indispensable to a rigid pavement maintenance study. But since they have been presented by other authors, their derivation will not be described here. They are given in their final state only so that without unnecessary duplication, the formulas used in a maintenance study are available in one paper. The second equation of major importance is:

$$\log \rho = 5.85 + 7.35 \log (D_2 + 1) - 4.62 \log (L_1 + L_2) + 3.28 \log L_2 \qquad (2)$$

By definition, ρ is equal to the total number of axle applications that will reduce the PSI value of a highway of a specific type and design to 1.5. In Eq. 2, D_2 is a function of the design of the highway and is expressed in inches of thickness of the pavement. L_1 is the axle load expressed in kips, and L_2 represents the type of axle, the number 1 being used for L_2 in the case of a single axle and the number 2 for L_2 in case of tandem axles.

It has been found that when the total number of axles N are plotted against accumulated damage on a log log plot, for all practical purposes the trace is a straight line. The slope of this line is expressed by the following:

$$\beta = 1.00 + \frac{3.63 (L_1 + L_2)^{5.20}}{(D_2 + 1)^{8.46} L_2^{3.52}} \qquad (3)$$

The solid line in Figure 1 is the trace of a log log plot of N vs g values of a concrete pavement under environmental conditions identical to those of the AASHO Test Road. From this, it can be seen that the slope of the line is equal to,

$$\frac{\beta}{1} = \frac{-\log g}{\log \rho - \log N} \qquad (4a)$$

and that,

$$N = \rho g^{1/\beta} \qquad (4b)$$

This formula is used a great deal in a maintenance survey. Consequently, it is desirable to calculate the various log ρ and ρ values for each of the different single- and tandem-axle loads the highway under survey carries.

Because results of the Test Road were produced by a single type of vehicle acting on a specific test section, it was obviously necessary to develop an equation which would make it possible to use the Road Test data under varying types of traffic. This is called the "mixed traffic theory" and was developed by F. H. Scrivner of the Test Road staff. Without the development of this theory, it would not be practical, without further research, to apply the Road Test principles to a highway maintenance sur-

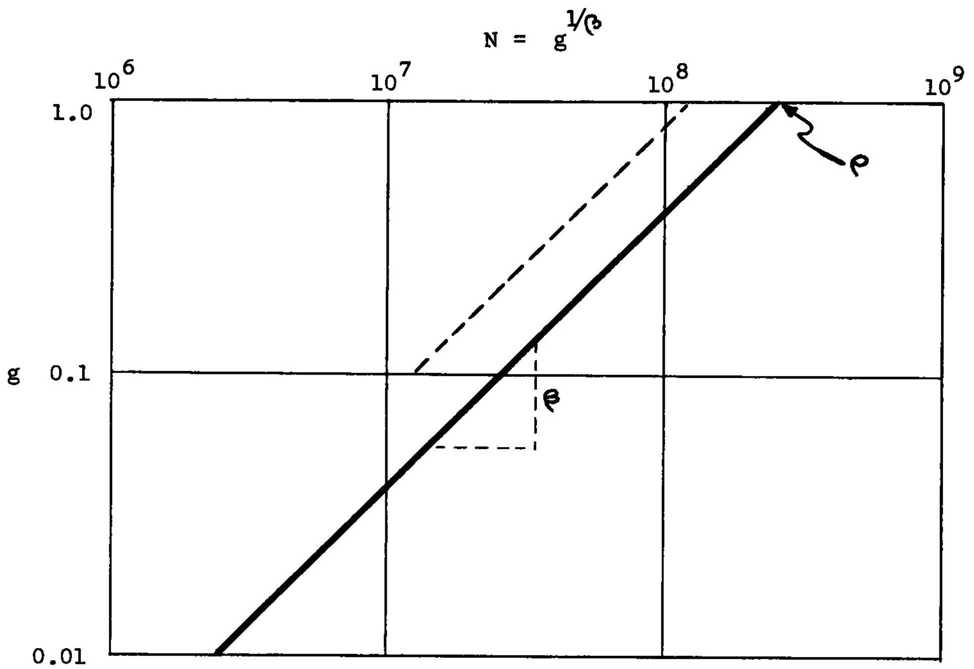

Figure 1.

vey. Scrivner's theory is a most valuable contribution and his formulas have been presented in great detail in other papers. Consequently, only the most essential to an understanding of the theory are presented here. The first is as follows:

$$dg = C_1 \frac{\partial g}{\partial N_1} dN + C_2 \frac{\partial g}{\partial N_2} dN + \cdots + C_i \frac{\partial g}{\partial N_i} dN + \cdots + C_k \frac{\partial g}{\partial N_k} dN \qquad (5)$$

which reduces to

$$N = \int \frac{dg}{\sum_{i=1}^{k} C_i \frac{\beta_i}{\rho_i} g^{1-1/\beta_i}} + \text{Constant} \qquad (6)$$

In these equations N_1, N_2, etc., represent the number of axle applications of a specific type and weight, N is the total number of all axles and C_1, C_2, etc., represent the ratio of the corresponding number of axles to the total number of all axles. The other symbols are as indicated previously. Under the traffic distribution pattern prevailing on the Thruway, the value of β as computed by Eq. 3 varied from 1.0 to 1.01. For all practical purposes, this is a constant and by making that assumption and integrating the previous equation, the value of N is shown to be:

$$N = \frac{1}{\sum_{i=1}^{k} \frac{C_i}{\rho_i}} g^{1/\beta} \qquad (7)$$

This equation is identical in form to $N = \rho g^{1/\beta}$ which was derived previously. Consequently, it can be seen that

$$\rho = \frac{1}{\sum_{i=1}^{k} \frac{C_i}{\rho_i}} \qquad (8)$$

TRAFFIC DENSITY AND ANALYSIS

These are two extremely important formulas. Before their use, however, it is necessary to determine the past and expected future traffic density for sections of a route under study having substantially the same traffic characteristics. The Thruway Authority had divided its traffic between interchanges into a number of classes which were in turn consolidated into three principal ones. For example, Class 7 is composed of 5-axle and 4-axle tractor-trailer units. Class 6 is composed of 3-axle tractor-trailers and the Class "All Others" as the name implies, includes passenger cars and miscellaneous types of trucks and buses. Figure 2 shows the past and expected future traffic density of these principal classifications for a specific Thruway section.

Since the number of axles invariably changes within a particular classification, it was found desirable to express the vehicles having a certain number of axles in terms of percent of the total number of vehicles in the classification. For example, Table 2 gives the variations for the Thruway system.

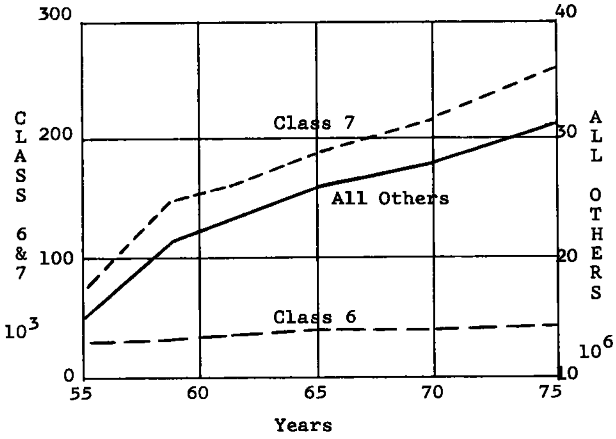

Figure 2. Traffic density, 1955-75, for an illustrative Thruway section.

TABLE 2

AVERAGE AXLE CLASSIFICATION IN PERCENT

Class 7	
4 Axle	97
5 Axle	3
Class 6	
3 Axle	100
All others	
Class 5	
3 Axle	1
Class 4	
2 Axle	4
Cars 2 Axle	95

Similarly, the weights of the vehicles both loaded and empty should be expressed in percentages of the total number of the particular axle classification, as well as class type. Table 3 gives the average percent weight classification for Classes 7, 6, 5 and 4 of the Thruway traffic.

TABLE 3

WEIGHT CLASSIFICATION

	(%)
Class 7	
4 Axles loaded	75
5 Axles loaded	100
4 Axles empty	25
Class 6 empty	25
loaded	75
Class 5 loaded	100
Class 4 loaded	75
empty	25

This type of distribution can be obtained from loadometer surveys. In the case of the Thruway, it was secured from surveys conducted by the State Department of Public Works in cooperation with the Bureau of Public Roads in 1959 and again in 1960.

Following the development of this information, load distribution curves are drawn, plotting the number of axles versus the magnitude of axle loads. Again in the case of Thruway traffic, they were determined for the conditions given in Table 4.

TABLE 4

- Class 7 Trucks (single-driving axle)
  - a. Loaded
    - Driving axle
    - Trailer axle (tandem)
  - b. Empty
    - Steering axle
    - Driving axle
    - Trailer axle (tandem)
- Class 7 Trucks (tandem-driving axle)
  - a. Loaded
    - Driving axle (tandem)
    - Trailer axle (tandem)
- Class 6 Trucks
  - a. Loaded
    - Driving axle
    - Trailer axle
  - b. Empty
    - Steering axle
    - Driving axle
    - Trailer axle
- Class 5 Trucks
  - a. Loaded
    - Driving axle (tandem)
- Class 4 Trucks
  - a. Loaded
    - Driving axle
  - b. Empty
    - Driving axle
    - Steering axle

Distribution curves were not plotted for unloaded Class 4 trucks since there was little distribution. Most of the axle loads fell within a very narrow range.

For each of the axle load distributions plotted, the value of $\sum \frac{C_i}{\rho_i}$ is determined and from this the magnitude of axle load L_1, that would give the same $\sum \frac{C_i}{\rho_i}$ as the mixed axle loads, is calculated as in Table 5 for a tandem trailer axle on empty Class 7 trucks. That is,

$$\rho = \frac{1}{\sum \frac{C_i}{\rho_i}} = \frac{1}{0.572596 \times 10^{-9}} = 1.74643 \times 10^9$$

From Eq. 2, substitution of $D_2 = 9$, $L_2 = 2$, and $\rho = 1.74643 \times 10^9$ gives

$$L_1 = 9.8^k$$

Similar calculations are made for each class of axle, and an axle load that would produce the same total is determined.

Actual loads for weight classification may be determined also from State Police records or other basic data. They were in the case of the Thruway survey, because the D.P.W. loadometer survey showed practically no overloaded trucks. Apparently, as a result of grapevine communication, truckers bypassed the locations of the temporary weighing stations if they were carrying near legal limit loads or they were overloaded.

TABLE 5

CLASS 7 TRUCKS (EMPTY) TRAILER AXLE

Axle Load (kips)	No.	C_i	Avg. Load (kips)	ρ_i	C_i/ρ_i
4–6	6	0.041	6	1.0354×10^{10}	3.9598×10^{-12}
6–8	56	0.384	7	6.0089×10^{9}	6.3905×10^{-11}
8–10	60	0.411	9	2.3777×10^{9}	17.2856×10^{-11}
10–12	13	0.089	11	1.0989×10^{9}	8.09901×10^{-11}
12–14	6	0.041	13	5.6734×10^{8}	7.2267×10^{-11}
14–20	5	0.034	17	1.9035×10^{8}	1.7862×10^{-10}
Total	146	1.000			$\sum \frac{C_i}{\rho_i} = 0.572596 \times 10^{-9}$

In the final calculations for the Thruway, it was assumed that 90 percent of the trucks weighed as indicated by the D.P.W. loadometer survey, 5 percent in accordance with the State Police findings which were generally overloaded and 5 percent at the maximum legal limit allowable.

With those values, the C_i for each axle load were then calculated as in Table 6.

TABLE 6

CALCULATION OF C_i VALUES

$$C_i = \frac{\text{Number of axles in the } i^{\text{th}} \text{ category}}{\text{Total number of axles in all categories}}$$

$$C^{T}\,9.8 = \frac{0.25 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{S}\,8.2 = \frac{0.25 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{S}\,7.2 = \frac{0.25 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{T}\,26.2 = \frac{0.90 \times 0.75 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{S}\,17.4 = \frac{0.90 \times 0.75 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{T}\,39.6 = \frac{0.05 \times 0.75 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{S}\,27.1 = \frac{0.05 \times 0.75 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{T}\,36.0 = \frac{0.05 \times 0.75 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{S}\,22.4 = \frac{0.05 \times 0.75 \times 0.97 \times \text{Class 7}}{\text{Total}}$$

$$C^{T}\,24.2 = \frac{0.90 \times 0.03 \times \text{Class 7}}{\text{Total}}$$

$$C^{T}\,20.8 = \frac{0.90 \times 0.03 \times \text{Class 7}}{\text{Total}}$$

$$C^{T}\,32.0 = \frac{2 \times 0.05 \times 0.03 \times \text{Class 7}}{\text{Total}}$$

$$C^{T}\,36.0 = \frac{2 \times 0.05 \times 0.03 \times \text{Class 7}}{\text{Total}}$$

$$C^{S}\,7.1 = \frac{0.25 \times \text{Class 6}}{\text{Total}}$$

$$C^{S}\,6.4 = \frac{0.25 \times \text{Class 6}}{\text{Total}}$$

$$C^{S}\,8.0 = \frac{0.25 \times \text{Class 6}}{\text{Total}}$$

$$C^{S}\,14.7 = \frac{0.90 \times 0.75 \times \text{Class 6}}{\text{Total}}$$

Etc.

Since the sum of all the C_1 values equals 1, the sum of all the numerators equals the total number of axles or N. For the Thruway distribution of vehicles, the above summation equaled:

$$N = 2.243\ (\text{Class 7}) + 2.25\ (\text{Class 6}) + 1.96\ (\text{All Others}) \qquad (9)$$

was reduced

$$N = 2.25\ (\text{Class 7} + \text{Class 6}) + 1.96\ (\text{All Others}) \qquad (10)$$

Similarly, the calculation of C_i/ρ_i is performed, and in the case of Thruway traffic distribution, the summation reduced to

$$\sum_{i=1}^{k} \frac{C_i}{\rho_i} = [(8.052\ \text{Class 7} + 5.2346\ \text{Class 6} + 0.1620\ \text{All Others}) \times 10^{-8}] \div \text{Total} \qquad (11)$$

ACCUMULATED DAMAGE AND PSI SURVEY

The next logical step in a maintenance survey is the determination of the accumulated pavement damage from the time of opening to traffic to the time of the survey. This figure may then be plotted on log-log paper versus the total number of axle loads that have occurred during that time interval.

Since accumulated damage is a function of the PSI, that figure, for the different sections of a route under study, having different traffic volumes, must be determined. In doing this, a two part field survey of pavement characteristics is performed. The initial part consists of a visual survey of pavement conditions and the second involves a survey of the pavement's slope variance by means of a profilometer, an instrument which measures, records, and partially computes,

$$\overline{SV} = 8.46\left[\frac{\Sigma Y^2}{N} - \left(\frac{\Sigma Y}{N}\right)^2\right] - 3 \qquad (12)$$

where $\overline{SV}$ is the slope variance, Y the slope taken in 6-in. increments, and N in this case equals the number of slope measurements taken in a given distance.

For the visual survey, a truck proceeds along the outside shoulder of the road, at a slow rate of speed, from which position recorders in the vehicle are able to observe and evaluate visual pavement damage on all lanes of the roadway simultaneously. A back-up truck is deployed about 300 ft behind the inspection vehicle in order to caution passing motorists and give maximum protection to the survey team.

Upon previously compiled forms, observations of cracking, patching, scaling, transverse joints, longitudinal joints and edging, shoulders and drainage are made of a rigid pavement. Faulting, spalling and pumping observations are made in a three-phase system varying in degrees of severity from phase 1 to phase 3, inclusive.

The observation of substantial pavement cracking is especially important. It is a major factor in the serviceability index equation. In accordance with AASHO Road Test procedure, a "one-half" rule is applied. Road Test experience indicated that if a crack had spalled for more than one-half of its length, the remainder would spall in a short period of time. Therefore, cracks which are spalled or opened to one-half or more of their total crack length are recorded as totally spalled. Cracks spalled more than 3 ft but less than one-half their length are also classified as substantial cracks for their spalled length. Cracks having less than 3 ft of spalling are not considered to be substantial cracks. The minimum width of spalling or opening of substantial cracks is ¼ in. for classification purposes. These substantial cracks are recorded in lineal feet of projected length. They are measured, either parallel or perpendicular to the pavement edge, whichever gives the greater distance.

Patching, in accordance with the AASHO Road Test procedure, refers to bituminous concrete patching, or badly cracked areas with crack densities greater than ½ ft per sq ft of pavement area; this factor applies to the patching term of the serviceability index equation and is measured in square feet of patching per 1,000 sq ft of pavement area.

In making the Thruway survey, the other factors such as pumping, faulting, spalling, shoulder and drainage conditions were recorded even though not a part of the PSI formula. They were later used in averaging PSI results for practical lengths of pavement requiring maintenance work.

The second part of a pavement field survey consists of taking measurements relating to the pavement's slope variance by means of a profilometer. The pavement's slope variance is a function of the rideability of the pavement and is a vital part of the serviceability index formula.

A profilometer survey team consists of an engineer, computer operator, and a driver. The engineer is given charge of the team and designates the various segments of pavement to be sampled. The readings are recorded by the engineer. Spot checks of these readings are computed in the field to insure the equipment is operating satisfactorily. The computer operator is responsible for operation of the electronic equipment, and relaying the panel board data to the engineer. The driver of the towing vehicle is responsible for the correct positioning of the recording wheels and calling off increments of a mile.

The profilometer caravan proceeds along the outside driving lane at about 5 to 6 mph. The arrangement includes two back-up trucks and a police vehicle to give maximum protection to the profilometer survey crew and advanced warning to passing motorists. The warning vehicles are equipped with appropriate signs and flashing lights. The first truck is stationed about 150 ft behind the profilometer in the outside driving lane. The police car and second warning truck are deployed on the outside shoulder of the roadway approximately 500 ft apart.

Profilometer recordings taken for two segments in each mile have been satisfactorily taken, generally between the 0.3 to 0.4 and 0.8 to 0.9 mile posts, except, of course, when these sections were not truly representative.

Upon the completion of the visual and profilometer surveys, the PSI values for each ½ mi of the Thruway were calculated in accordance with the formula,

$$\text{PSI} = 5.41 - 1.80 \log(1 + \overline{SV}) - 0.09 \sqrt{C + P} \tag{13}$$

C represents the length of substantial cracking, whether sealed or not, expressed in feet per 1,000 sq ft of pavement area, the patching factor P is expressed in square feet per 1,000 sq ft of pavement area.

In the case of the Thruway survey (Fig. 3), the actual PSI values were averaged into Thruway sections one mile or greater in length. It will usually be necessary to combine a number of short pieces of a highway having different PSI values in order to make a practical length for resurfacing or other major highway maintenance treatment work. These sections are delineated for further consideration by observing the PSI concurrently with pavement rehabilitation work that has been determined to be required during the course of the maintenance survey. For example, where pumping exists in a rigid pavement, it should be corrected. Where serious faulting or cracking exists, the pavement should be releveled by jacking, and the cracks filled. Where excessive accumulation of damage is brought about by lack of proper

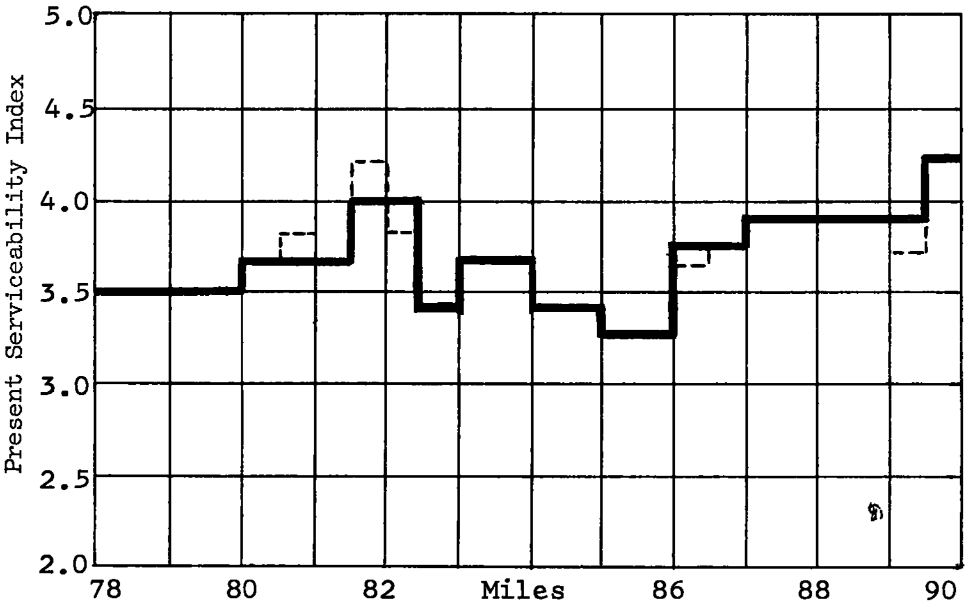

Figure 3.

under drainage, it should be provided. Many other things may become evident during the course of the survey which will require prompt correction. All of this work is usually classified as pavement rehabilitation. By rehabilitating the pavement, the PSI value will be increased. Consequently, when determining the average PSI value for a section, these factors must be considered. For example, one mile of pavement with a PSI value of 2.7 may be sandwiched between sections having a PSI of 3.4. When called for rehabilitation work is done on the low valued section, it will be brought close to the PSI value of the adjacent sections. Therefore, the entire piece should have a PSI value approximately equal to the 3.4 sections of highway.

When these average values are determined (Fig. 3), the theoretical accumulated damage for the individual sections is computed by Eq. 1.

The accumulated damaged figures are then plotted against the total number of axle applications N on log log paper as shown in Figure 1. The theoretical curve shown as a solid line is to the right of the actual PSI curve and it will probably be this way in almost all practical cases. In other words, the theory predicts less damage to a pavement than actually occurs. This results from a number of factors. For instance, the AASHO Road Test equations are based on conditions such as climate, soil, and construction practices which were peculiar to that locale and project. The use of these equations for another pavement in another part of the country is subject to variation dependent upon those factors.

The AASHO Road Test equations were developed for pavements subjected to one magnitude of load. The modification of these equations into a multiload relation is based on theory and has not yet been verified experimentally.

The AASHO Road Test pavements were subjected to known numbers of axle applications and known magnitude of loads. In other cases, since data are not usually available for determining exact numbers and magnitude of loads, assumptions by necessity must be made.

To predict future serviceability in actual practice, therefore, the theoretical curve is moved parallel to itself until it passed through the point representing the actual condition of the pavement at the time of the survey.

A terminal PSI of 2.2 was taken for the Thruway as the point below which pavement serviceability should not be permitted to go. The estimated number of axle loads required to produce that PSI value is given by the intersection of the practical line plotted on the log log graph and the horizontal line representing the g which a PSI of 2.2 will produce.

Knowing the number of axle loads at which a PSI of 2.2, or other terminal point will be reached, the year in which this number is estimated to occur is then calculated for each segment of the highway under study. Following this, it merely becomes a matter of estimating the cost of resurfacing or other work required, to establish a parallel long-range financing program. It is recommended, however, as time advances, because of the variables involved, that periodic surveys of pavement characteristics be conducted to determine the actual rate of accumulated damage and thus to adjust predicted serviceability index values. These surveys should be undertaken after pavement rehabilitive heavy maintenance has been accomplished, before scheduling major resurfacing to determine whether the terminal PSI has actually been reached, at other regular intervals to adjust for actual traffic densities and predictions, and after major resurfacings have been completed to ascertain the original PSI for future heavy maintenance requirements.

The AASHO Test Road has given the highway maintenance engineer these important new engineering methods. They are fundamental to preventative maintenance planning. They will help him to husband the enormous highway investment placed in his care. None of his work is more important.

DISCUSSION

H. E. **Diers**, *Illinois Division of Highways.*—Dr. Tallamy is to be congratulated on his work in adding a valuable budgeting tool to the field of maintenance operations.

As a member of the original panel which viewed the roads and rated them as to their adequacy (thus establishing guidelines for the AASHO road staff in developing the numerical PSI), and from a background of many years of experience in supervising the preparation of maintenance budgets, the writer wishes to emphasize certain points.

The Present Serviceability Index trend (performance as defined at the Road Test), as used by Dr. Tallamy, is well adapted to predicting long-term surface maintenance needs and determining the extent of surface damage in a large road system. The serviceability performance concept is not, nor was it ever considered to be, adapted to use for short-term budget planning on an individual section of road unless accompanied by visual observation by competent personnel of immediate maintenance needs. The report particularly notes that other factors such as pumping, faulting, spalling, shoulder and drainage conditions were considered even though not a part of the performance equations. It recognizes the need for observing the PSI of each section of highway concurrently with the pavement rehabilitation work determined to be required during the course of the maintenance survey.

The preparation of short-term (one or two year) maintenance budgets still requires observations by experienced personnel. Dr. Tallamy has adapted the AASHO Road Test performance concept to permit a more refined and accurate procedure for uniformly comparing long-term roadway surface needs in various sections. His work is a valuable contribution in a field neglected by planners and researchers.