Examination of Pavement Deterioration in the Presence of Automobile Traffic

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ABSTRACT

In recent years, and particularly in association with discussions of the federal highway cost-allocation study reported to Congress in 1982, a variety of statements and reports have surfaced alleging that automobile traffic, such as that on the Merritt Parkway in Connecticut and the Baltimore/Washington (B/W) Parkway in Maryland, causes as much overall pavement damage over the long term as does mixed truck and automobile traffic on highways of the same design in the same areas. A study was undertaken at the request of the Association of American Railroads to perform on-the-spot condition surveys of the Merritt Parkway, the B/W Parkway, and adjacent Interstate highways in both areas. In addition, intensive searches were made of records of the Connecticut Department of Transportation (which constructed and maintains the Merritt Parkway), FHWA (which built the B/W Parkway), and the U.S. Park Service (which maintains the B/W Parkway). The records of construction details and maintenance costs associated with the pavements under consideration were incomplete; nevertheless, a significant amount of information was obtained on which certain conclusions could be made. Basically, the results of the study clearly demonstrate that under the weather conditions, environment, construction materials, and pavement design and time frame involved in these cases, the damaging effect of trucks on heavy-duty highways is indeed greater than the damaging effect of automobiles. The data available and the scope of the study did not make it possible to derive quantitative relationships from these findings; however, they clearly refute the assertions that pavements deteriorate as rapidly under automobile traffic alone as they do under mixed truck and automobile traffic.

In recent years increasing pressure has been exerted by the trucking industry on Congress to have legal load limits increased and truck user fees and taxes decreased. One of the arguments that has been used is that trucks are not significantly more damaging to highway pavements than automobiles. Examples of pavement performance that have been used to support this argument are the somewhat poor pavement conditions of two parkways that are used by automobiles only: the Baltimore/Washington (B/W) Parkway (between Washington, D.C., and Baltimore, Maryland) and the Merritt Parkway in southern Connecticut. Two papers by Reith (1,2) of the American Trucking Associations, which refer to the two parkways, essentially make the same argument and conclude that "the parkways, without heavy truck traffic, lasted about the same time as other roads."

Although the idea of comparing the performance of these parkways with that of other highways is certainly valid, a thorough examination of the facts is required before any statements regarding the subject of relative pavement damage can be made. Therefore a study was conducted of the Merritt and B/W parkways and nearby truck-trafficked highways to determine, insofar as possible, the current condition of those roads and the possible reasons for their condition.

The primary objective of the study was to perform on-site examinations and surveys and subsequently make reasonable comparisons of the condition and performance of the two types of facilities. While conducting the examinations at the two locations, condition and riding quality surveys were performed, interviews with knowledgeable individuals were conducted, and records pertaining to construction, maintenance, and traffic loads were examined. The information from the field trips and subsequent research is presented in this paper.

It should be recognized that this was a relatively small study. Obviously, it would have been desirable to have collected more detailed measurements and to have conducted a more complete study. Unfortunately, these were not possible within the limited scope, and no attempt is being made to claim absolutely conclusive results about these roadways. Conclusive findings would require considerably more expensive research efforts than those that were undertaken. Nevertheless, this study (which was based on a well-founded set of engineering observations) and other recent studies (3,4) support realistic conclusions regarding the effect of vehicle load on pavement damage.

DESCRIPTION AND RECENT OBSERVATIONS OF THE CONDITION OF THE B/W PARKWAY AND NEARBY PAVEMENTS

The purpose of this section is to summarize all pertinent information collected relative to the design, construction, and performance of the B/W Parkway. Additional information was also collected from one other roadway section on I-495 to help provide a basis for comparison.

The sources of the information collected were primarily from FHWA and the U.S. Park Service; however, some pertinent data were also obtained from the Maryland Department of Transportation (DOT).

B/W Parkway

The B/W Parkway is a segment of a four-lane divided highway between Washington, D.C., and Baltimore, Maryland. The parkway is approximately 19 miles long, extending from just east of Jessup, Maryland (near the intersection with MD-175), south to the Washington, D.C., line. By definition, the B/W Parkway is restricted against truck traffic, although buses and mail trucks are allowed to use it.

The original pavement structure of the B/W Parkway was designed and built by the Bureau of Public Roads (now the FHWA) between 1951 and 1954. It con-

sists of an 8-in. jointed-concrete pavement reinforced with wire mesh. The spacing between each of the joints is 60 ft, and dowel bars were used to provide load transfer across these joints. The entire length of this portland cement concrete (PCC) pavement is supported by a minimum of 11 in. of granular subbase material. The course aggregate used in the concrete mix is what is known locally as "Prince George's aggregate," which has a high sulfate content and an apparent high coefficient of thermal expansion.

The B/W Parkway was originally designed to provide access to several federal agencies in the area (and not to provide access to Baltimore). The facility was not designed for truck traffic or for the average daily traffic (ADT) volumes now being carried.

Maintenance

The U.S. Park Service has always been responsible for carrying out maintenance on the B/W Parkway. Unfortunately, recent poor budgets have frequently resulted in a policy of deferring routine maintenance (i.e., joint and crack sealing). For example, the budget for 1983 was only $307,000, which must also be used for snow removal. (The 1982 cost for snow removal was approximately $50,000.)

Initial Performance

The personal recollections of several individuals interviewed indicated that problems with roughness and distress at many of the joints on the parkway began in the early 1960s, less than 10 years after initial construction. This observation was verified by the examination of a condition survey report prepared in 1965. This survey indicated that partial joint distress (an indication of future deterioration) was prevalent. The survey also indicated that more than 100 full 24-ft-width pavement blowups had occurred in the 36 miles of the two-lane pavement. A blowup (or joint compression failure) is primarily the result of temperature-change-related horizontal slab movements, which cause slabs to butt against each other with such force that joint crushing occurs. The likelihood of a blowup is increased by the use of an expansive-type coarse aggregate (such as the Prince George's type used in the concrete mix on the B/W Parkway). Favorable conditions for blowups will also develop when a loss of joint sealant occurs and incompressible materials (such as sand and dirt) fill the voids.

Traffic Estimates

Traffic on the B/W Parkway was about 24,000 vehicles per day in 1956 and has grown linearly to about 74,000 vehicles per day in 1980. This corresponds to an arithmetic growth rate of almost 9 percent per year.

HMAC Overlay Construction

Between 1976 and 1977 the entire length of the B/W Parkway (19 miles) was overlaid with hot-mix asphalt concrete (HMAC), which consisted of 2.5 in. of binder and 0.75 in. of an open-graded surface/wearing course. Personnel at the FHWA office that designed the overlay stated that it was placed to improve the riding quality of the road and not to provide structural rehabilitation. The thickness was selected based on economics and an effort to minimize subsequent reflection cracking.

Considerable maintenance and repair were carried out on the original pavement before placement of the overlay. According to overlay construction plans and the recollection of FHWA personnel, this maintenance was primarily joint repair in the form of full-depth hot-mix patching. However, some full-depth PCC patching and PCC slab replacement was also performed. Records on the frequency of these joint repairs were apparently not kept, but recollection indicates that it was extensive. The cause of this extensive maintenance and the reason for the overlay is primarily related to the choice of a poor aggregate coupled with the long joint spacing; it is not a direct function of traffic.

Condition and Performance of HMAC Overlay

The following observations and comments relative to the current condition and performance of the HMAC overlay constructed on the B/W Parkway in 1975-1976 are based on a recent inspection and condition survey of the facility.

1. Above every joint in the original pavement is a moderate to severe width (0.25- to 0.50-in.) reflection crack in the HMAC overlay. This is shown in Figure 1. In many cases excessive horizontal movements of the underlying slab have resulted in a

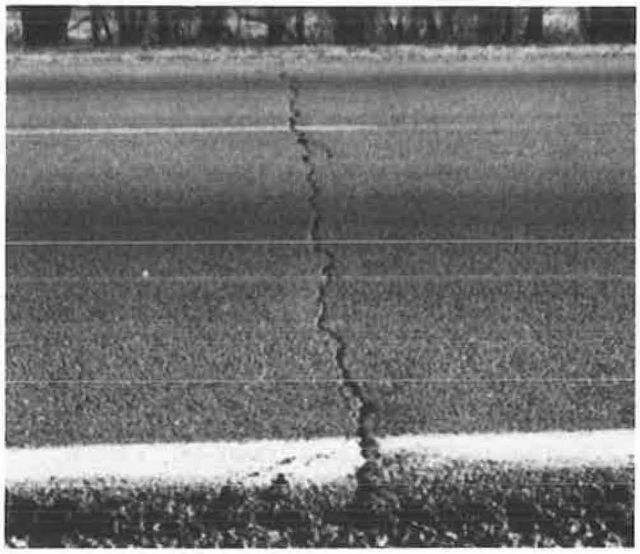

FIGURE 1 Reflection crack in HMAC overlay, B/W Parkway.

"hump" above the joint, as shown in Figure 2. The hump is probably the result of some type of joint distress in the underlying slab. It is difficult to detect this visually, but it can be easily felt when riding across it in an automobile. If not for the roughness generated by these humps, the riding quality of the pavement would be high [AASHO present serviceability index (PSI) estimated at 4.0].

2. In cases where there are likely underlying full-depth hot-mix patches in the original joint area, there are two cracks at the surface (Figure 3). Between these two cracks a heave of material will generally be found that is most likely the result of the shoving of the hot-mix patch, which occurs as the long PCC slabs expand during warm

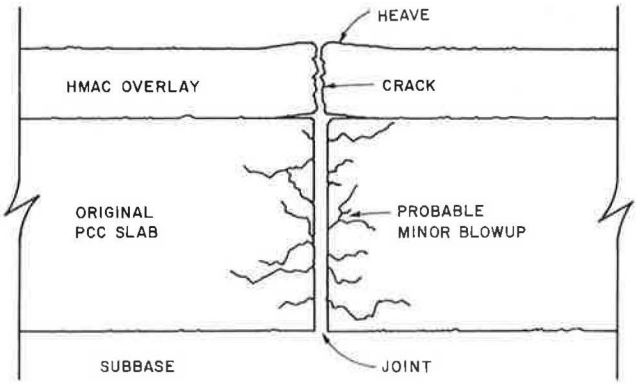

FIGURE 2 Illustration of probable joint condition beneath humps in overlay.

FIGURE 3 Heave of material above underlying hot-mix patch.

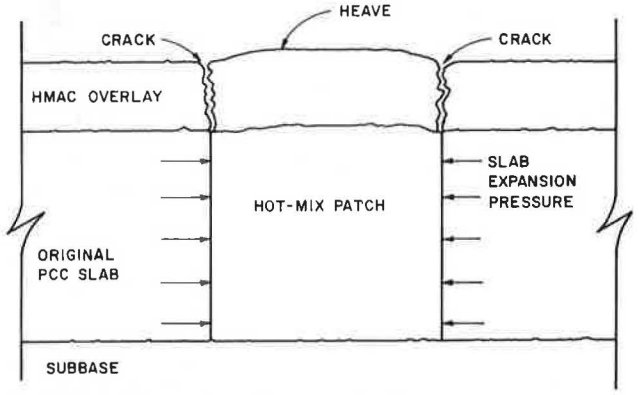

FIGURE 4 Illustration of heave mechanism.

weather (see Figure 4). Because of its width, this heave has an even greater detrimental effect on riding quality.

3. The roughness from these humps and heaves in the HMAC overlay occur throughout the length of the B/W Parkway; however, they are most severe in the sections close to the Capitol Beltway (I-495).

Capitol Beltway

To provide evidence of the relative poor quality Prince George's coarse aggregate used in the concrete mix on the B/W Parkway, the current condition of nearby portions of the Capitol Beltway (I-495) were examined, in which two different types of coarse aggregate were used--the Prince George's aggregate and a type of trap rock. Because of their difference in color, it was easy to distinguish between these two types of aggregate.

The trap rock section is located between the University Boulevard and the New Hampshire Boulevard exits. The other two segments examined are located on either side of this middle trap rock section and were constructed using the Prince George's type concrete coarse aggregate. Other then some surface deterioration, such as aggregate polishing and wheel track wear, the trap rock section exhibited almost no signs of distress in either the eastbound or westbound lanes (see Figure 5). However, the sections on either side definitely showed the effects of the poor coarse aggregate used. The western segment exhibited considerable amounts of joint failures, cracking, and cold-mix patching at the joints (see Figure 6). The eastern section, which extends to the interchange at the B/W Parkway, exhibited the more costly full-depth PCC patching in all three outside lanes in both eastbound and westbound directions (see Figure 7). It should be noted that all three of these segments consist of eight lanes in which the inner lane was constructed more recently than the original structure.

FIGURE 5 Capitol Beltway (I-495), middle section constructed with Prince George's coarse aggregate.

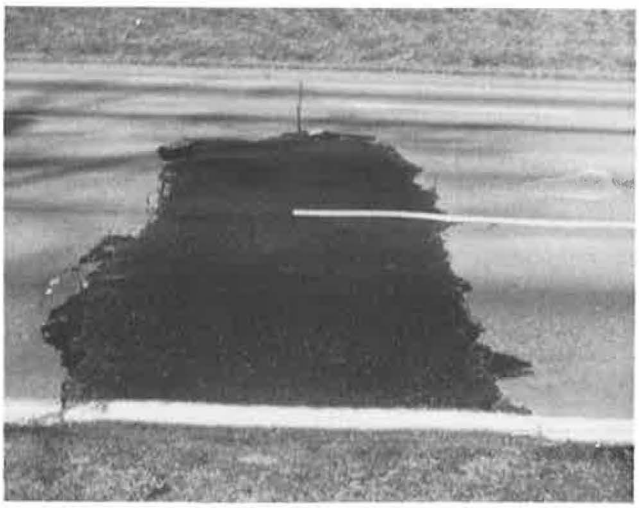

FIGURE 6 Capitol Beltway (I-495), western section constructed with Prince George's coarse aggregate.

FIGURE 7 Capitol Beltway (I-495), eastern section constructed with Prince George's coarse aggregate.

DESCRIPTION AND RECENT OBSERVATIONS OF THE CONDITION OF THE MERRITT PARKWAY AND NEARBY PAVEMENTS

The purpose of this section is to summarize all the pertinent information collected relative to the design, construction, and performance of the Merritt Parkway along Route 15 in Connecticut. To provide a basis for the evaluation and comparison of parkways (which only carry automobile traffic) and normal highways (which carry both automobile and truck traffic), pertinent information is also provided for sections of roadway adjacent or close to the Merritt Parkway. These additional highway sections include I-95 (between the New York State line and Housatonic River Bridge), I-91 (between Wallingford and Rocky Hill), and the Wilbur Cross Parkway (along Route 15, north of the Merritt Parkway). With the exception of the condition surveys performed by the authors, the primary sources of the data collected were from the Connecticut Department of Transportation (ConnDOT) and some records obtained from the American Trucking Associations.

Merritt Parkway

The Merritt Parkway is a section of four-lane highway located in Connecticut between the New York State line and the Housatonic River Bridge. Like most parkways, the Merritt Parkway has almost always had a restriction against truck traffic (although some truck traffic was allowed during World War II). The design, construction, and maintenance of the Merritt Parkway has always been the responsibility of ConnDOT. The facility is approximately 40 miles long.

The original pavement structure of the parkway consists of 8 in. of jointed reinforced-concrete pavement on top of from 12 to 24 in. of subbase (depending on whether in earth or rock cut). The original pavement was built in four different segments between 1938 and 1940.

Pavement Resurfacing

Actual historical construction records for the various resurfacing projects on the Merritt Parkway (as well as for every highway in the state) are buried in the archives of the different ConnDOT district offices. Because of the extensive effort that would have been required to piece it together, an actual overlay construction history of the Merritt Parkway could not be established as a part of this study. Suffice it to say that, with the exception of the pavement areas adjacent to toll booths, the entire parkway has been resurfaced at least once with HMAC overlays. According to available information and history obtained from the American Trucking Associations, the earliest HMAC resurfacing project was 4.5 miles long and occurred in 1956, 18 years after the original pavement had been opened to traffic. Scaling of the original PCC surface resulting from excessive use of salt (in de-icing operations) was identified as the reason for resurfacing.

According to ConnDOT personnel, however, most of the overlays on the Merritt Parkway (all of which were HMAC) were constructed in the early 1970s, some 30 years after initial construction. ConnDOT personnel pointed out that these overlays were required to alleviate the problems associated with surface deterioration and wheel track wear in the original concrete surface, and were not intended for structural rehabilitation. They further identified the use of studded snow tires (which began in the early 1960s) as the primary reason for the PCC surface deterioration problems. It was suggested that the use of studded tires, combined with the fact that the parkway does not have shoulders (which has resulted in a channeling effect on traffic), may explain why wheel track wear and distress have been such problems.

Studies and reports by ConnDOT (5,6) definitely demonstrate the deteriorating effect of studded snow tires on pavement surfaces. Field measurements in Connecticut indicated that PCC wear rates were 0.08 in. per million studded tire vehicle passes. (Data presented from Minnesota indicated that this rate was roughly twice as high for bituminous surface). Photographs (see Figure 8) taken in the toll booth areas (which have not been overlaid) illustrate the extent of this type of surface deterioration. [It is also useful to note that these and other photographs in this area (see Figure 9) indicate little other distress in the original PCC pavement, providing evidence that it is indeed still structurally sound.]

According to ConnDOT personnel, the policy for overlays on the parkway has been to place 2 in. of HMAC if the extent of surface deterioration dictated it. This is comparable to their policy of using 2.5 in. of HMAC on truck-trafficked roads if the ADT is less than 50,000 and 3.0 in. if the ADT is greater than 50,000.

Traffic Estimates

ADT estimates obtained from ConnDOT for the Merritt Parkway vary considerably, depending on the location along the facility. In 1980 the ADT at a point near

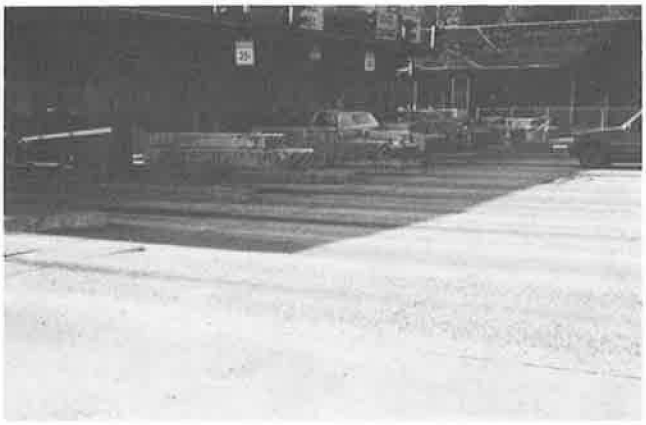

FIGURE 8 Wheel track wear and surface deterioration on Merritt Parkway, Greenwich toll station.

FIGURE 9 Structural condition of PCC pavement on Merritt Parkway at Greenwich toll station.

the New York State line was approximately 23,000 vehicles per day, whereas at a point on the opposite end (near Trumbull) it was 42,000 vehicles per day.

Most of the traffic on the Merritt Parkway has certainly been automobiles; however, the facility has not been completely free of truck traffic. According to ConnDOT personnel there has been at least one occasion (during World War II) when the truck restriction was lifted. They had no information, however, as to how long or how many trucks were carried, although they estimate that the number was probably small.

Condition and Performance Observations

Based on both a windshield survey and a study of the condition surveys of the Merritt Parkway, the following observations and comments can be made.

1. The roadway is completely overlaid (with the exception of the toll booth areas), and the older overlay sections do display significant amounts of distress and maintenance. All the longitudinal and transverse cracking observed, however, appeared to be related to the reflection of horizontal movements in the underlying joint. Some edge longitudinal cracking was also observed, which is probably related to the fact that the parkway has no shoulders.
2. In addition to environmentally induced reflection cracking, a considerable amount of distress in the HMAC overlays was observed, which is probably related to surface deterioration from studded tire use. The distress takes the form of slight to moderate rutting, raveling, pop-outs, and both large and small areas where skin patching had been accomplished to repair surface distress (see Figures 10 and 11). It was also evident that many of the overlaid bridge decks required considerable maintenance in the form of small skin patches.

FIGURE 10 Surface deterioration and raveling on HMAC overlay, Merritt Parkway.

FIGURE 11 Full lane width skin patching to repair surface deterioration along Merritt Parkway.

3. The riding quality of the parkway was basically good (AASHO PSI estimated at 3.0 to 3.5). There were some areas of recent overlay construction in which the riding quality was excellent (PSI of 4.0 to 4.2). There were also those sections that had large areas of maintenance and skin patching, in which the riding quality was poor (PSI of 2.5). The riding quality was also poor at many of the bridge decks and approaches, where considerable amounts of level-up patching and surface repair had been accomplished.
4. As a final note about the condition of the parkway, no signs of faulting were observed. All the reflection cracking observed is most likely attributable to the horizontal rather than vertical movements of the underlying PCC slabs, because there were no signs of pumping or loss of support. This

was further demonstrated by the good transition in riding quality across the joints and examination of the joints in the concrete slabs around the toll booths.

Interstate 95

The segment of I-95 examined as a part of this study is south of and roughly parallel to the Merritt Parkway (between the New York State line and the Housatonic River Bridge). The original pavement structure basically consists of 10 in. of jointed reinforced-concrete pavement with a varying depth of subbase. The pavement was constructed mostly in 1958-1959; however, one short section was built in 1954.

Based on both a windshield survey and a study of the condition surveys of I-95 between the New York State line and West Haven, the following observations and comments can be made.

1. The pavement is largely overlaid with HMAC; however, there are some sections in both the eastbound and westbound lanes that consist only of the original PCC structure.
2. In areas where the original PCC surface has not been overlaid, several different types of distress were observed, including surface defects (such as polishing, wheel track wear, scaling, raveling, and potholes), faulting, joint deficiencies (such as spalling, creeping, and loss of sealant material), and cracking (primarily single transverse, but also some D-cracking and corner breaks). Some of these distress manifestations are shown in Figures 12 and 13. Some lane separation at longitudinal joints and sizable amounts of cold-mix patching and full-depth joint repair were also observed. Faulting (both at transverse cracks and joints), however, was identified as the primary distress problem in these nonoverlaid sections. Overall, the riding quality of these original PCC sections was poor (AASHO PSI estimated at 2.5).
3. Concerning the HMAC overlaid sections, the overall riding quality was relatively good (AASHO PSI estimated at 3.5). However, condition surveys did indicate some of the same signs of surface wear exhibited on the Merritt Parkway (i.e., wheel track wear, raveling, scaling, and skin patching) that were associated with the use of studded snow tires.
4. As part of its overall road inventory program, ConnDOT conducts pavement serviceability ratings to augment its yearly pavement serviceability log. The statewide summary of the log presents objective ratings (on a 1 to 9 scale) for five different categories of pavement condition: cracking, distortion, disintegration, drainage, and riding quality. For regions (such as the toll booth areas) that still exhibit the original PCC surface, this summary log provides the basis for an objective comparison between the performance of truck-trafficked roads and roads that carry only automobile traffic. The data in Table 1 represent an excerpt from the 1981 log in which the ratings were performed at three different toll stations, one on the Merritt Parkway and two on I-95. Obviously, there is a definite difference between the ratings for automobile-only versus mixed-traffic roads. With the exception of drainage, the scores for the parkway station are excellent compared with those on I-95.

FIGURE 12 Structural condition of PCC pavement along I-95, Norwalk toll station.

FIGURE 13 Severe faulting in outside lanes of PCC pavement along I-95, Housatonic River Bridge.

Wilbur Cross Parkway and Berlin Turnpike

Another case provided by ConnDOT, which illustrates the difference in performance between truck-loaded roads and those that carry automobile traffic only, are adjacent sections of Route 15 (the Berlin Turnpike) and the Wilbur Cross Parkway.

1. Both sections have the same cross section (8 in. of jointed reinforced-concrete pavement). The Wilbur Cross Parkway was constructed in 1946-1947 and the Berlin Turnpike was constructed in 1942.
2. The Wilbur Cross Parkway has carried no truck traffic, but the Berlin Turnpike has.
3. According to ConnDOT personnel, the Berlin Turnpike has had considerable problems associated with higher edge deflections (i.e., pumping, corner breaks). In fact, one 0.8-mile section of the turnpike had to be reconstructed in 1954 because of its deteriorated condition. Since then the entire length of the turnpike has been overlaid and has also required a considerable amount of ConnDOT's "skid-box" skin patch maintenance treatment.
4. Conversely, the adjacent section of the Wilbur Cross Parkway has performed extremely well. In fact, at an age of 35 years, parts of it have yet to be rehabilitated.

Interstate 91

In examining the condition of I-91 between New Haven and Hartford, a marked difference between the condi-

TABLE 1 ConnDOT Ratings for Original PCC Pavement Structures

	Cracking		Distortion		Disintigration		Drainage		Riding Quality	
	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
Merritt Parkway, Greenwich toll station	8	8	8	8	8	8	8	8	8	8
I-95										
Greenwich toll station	4	4	4	4	4	4	6	7	5	5
Norwalk toll station	4	5	5	4	4	4	7	7	5	6

Note: EB = eastbound and WB = westbound.

tion and performance of the northbound and southbound lanes was observed in areas that had not been overlaid. The northbound lanes exhibited a considerable amount of concrete patching, faulting, and roughness (especially in the outside lane), whereas the southbound lanes exhibited almost none. Furthermore, a much greater percentage of the northbound lanes had been overlaid. Not surprisingly, W-4 loadometer tables from ConnDOT indicate that in 1979 the split between 18-kip equivalent single-axle loads was 61 to 39 percent (northbound over southbound). Figures from 1981 indicated a 65 to 35 percent split (northbound over southbound).

DISCUSSION AND COMPARISON OF RESULTS

In the previous sections detailed observations on the parkways and nearby Interstate highways in the Baltimore/Washington area and in Connecticut were presented. It should be noted that these were not designed experiments, and detailed follow-up investigations have not been carried out. However, significant comparative information does emerge that sheds light on the question of damage caused by truck loading versus damage caused by automobile loading.

Connecticut Highways

1. The primary difference observed between the condition of the Merritt Parkway and the parallel section of I-95 is that the I-95 section exhibited considerable amounts of faulting, particularly in the outside lane, whereas none could be detected on the Merritt Parkway. Faulting is a severe form of pavement damage characterized by rough rides and accelerated pavement deterioration. The difference in this condition between the two facilities was particularly apparent in comparisons between unoverlaid sections (primarily around toll booth areas where faulting, cracking, and patching were more prominent on I-95).

2. The primary reason for overlays on the Merritt Parkway was identified by ConnDOT personnel as the presence of excessive wheel track wear and surface deterioration. The use of studded tires combined with channelized parkway traffic because of a lack of shoulders was identified as the primary cause of this deterioration. These same personnel also noted that the reason for overlays on I-95 was primarily to provide structural rehabilitation and increased load-carrying capacity for a worn-out pavement exhibiting both moderate and severe distress manifestations.

3. A comparison of adjacent sections of the Wilbur Cross Parkway (no trucks) and the Berlin Turnpike (normal truck traffic) provides more information relative to the effects of truck traffic. Portions of the Berlin Turnpike (constructed in 1942) had to be reconstructed in 1954 because of serious deterioration. Furthermore, the turnpike has since been completely overlaid. Conversely, adjacent sections of the Wilbur Cross Parkway [which have the same cross section and were constructed only 4 to 5 years later (1946 and 1947)] have performed extremely well, with portions still consisting of only the original structure.

4. The ConnDOT policy for parkway overlays is 2 in. of HMAC, which has historically only been required to remedy surface deterioration. This compares with a typical 2.5- to 3-in. HMAC overlay policy that has been used to provide structural rehabilitation on roads carrying truck traffic. This indicates that practical engineering experience dictates more significant repairs for roads subjected to truck traffic.

5. Examination of loadometer data for I-91 (northbound versus southbound) indicate that the percentage of truck traffic split was 61 to 39 (in terms of equivalent axle loads) in 1979 and 65 to 35 in 1981. Correspondingly, observation of the pavement condition at this time clearly indicates that significantly more rehabilitation, full-depth patching, pavement distress, damage, and deterioration exists in the northbound lanes than in the southbound lanes. This is further accentuated by the fact that this distress and the maintenance observed was confined to the outside lane, where most trucks travel.

To summarize the observations in Connecticut, rehabilitation has been accomplished on all highways, regardless of traffic, but it appears that, both in terms of practical and engineering judgments, far more damage has been sustained by those highways carrying truck traffic than by the parkways. Furthermore, it appears apparent that the damage to the parkways has been significantly associated with studded tires, which are now banned and are no longer affecting the roads. Thus this type of damage has now decreased, and continued observation of the highway system might well reveal that damage in future years would be even more greatly associated with truck than with automobile traffic.

Baltimore/Washington Highways

An earlier section of this paper presented the description and recent condition survey observations of the B/W Parkway and the nearby Capitol Beltway. The findings may be summarized as follows.

1. The primary cause of damage on the B/W Parkway appears to be caused by the unfortunate combination of a 60-ft joint spacing and the use of an expansive concrete aggregate known locally as Prince George's aggregate. The effects of this combination are excess horizontal movements at slab ends that ultimately resulted in compression failures, blowups, full-depth patching at the joints during the life of the original structure, and severe reflec-

tion cracking and hot-mix patch heaving since overlay construction.

2. Because of the use of different types of concrete aggregate on adjacent sections of the nearby Capitol Beltway (I-495), a comparison of their performance was possible. The section between University Boulevard and New Hampshire Boulevard was constructed with a trap rock concrete aggregate, whereas the sections both east and west of this middle section were constructed with the same Prince George's type aggregate used on the B/W Parkway. The section with the trap rock aggregate exhibited little or no signs of distress, whereas the sections on either side exhibited significant effects of the poor aggregate in terms of pavement condition. Specifically, the western section exhibited considerable amounts of joint failures, cracking, and patching. The eastern section exhibited even more costly full-depth PCC patching. In both cases the poor condition of the joints appeared across all lanes, except for locations where there was a recently constructed inside lane.

In summary, although not as easy to sort out and as conclusive as the observations in Connecticut, the observations in the Baltimore/Washington area still indicate that pavement damage is greater when associated with mixed truck and automobile traffic than with automobile traffic alone. The relative effects of traffic on the pavements studied are certainly masked to some degree, however, by the poor materials involved in construction and a poor selection of joint spacing.

FINDINGS

As pointed out in the beginning of this paper, it was not possible within the budget for the study to make detailed engineering measurements of the pavements investigated. Furthermore, conclusive observations would require many years of measurement. Nevertheless, this study clearly provides substantive evidence against assertions that damage on parkways carrying automobile traffic alone is at least as great as that on nearby highways carrying normal traffic, including trucks. In the present study condition surveys were made of the Merritt Parkway, the B/W Parkway, and nearby parkways and Interstate highways in both areas to provide a basis for comparison.

Clearly, from an engineering and economic point of view, the damage observable on Interstate highways carrying mixed truck and automobile traffic is more severe and has required more rehabilitation and maintenance than that on comparable sections of the parkways carrying automobile traffic alone. Although quantitative statements of relative damage and relative costs are not possible within the limits of this study, the results are more than adequate to refute recent claims by industry representatives concerning the effects of truck traffic on the nation's highways.

ACKNOWLEDGMENTS

The results of a small engineering study that examined damage to pavements that have nominally been subjected to passenger car traffic only over their past service lives have been presented. This study was commissioned by the Association of American Railroads. The support of many people, too numerous to mention, in FHWA, the U.S. Park Service, and ConnDOT is gratefully acknowledged. Douglas L. Johnson, the sponsor's technical representative on the project, was helpful in providing information, locating sources, and making appointments with persons involved in this study.

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