EVALUATION OF EXPERIMENTAL FLEXIBLE PAVEMENTS
INTERIM REPORT No. 3
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Virginia Highway & Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia
Department of Highways & Transportation and the University of Virginia)

In Cooperation with the U. S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia
January 1978
VHTRC 78-R31
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SUMMARY AND RECOMMENDATIONS

A program of construction and performance evaluation of seven Virginia flexible pavements containing at least some experimental features is reported. The objective of the program is to evaluate the performance of the pavements incorporating new or timely design concepts and to assess the flexibility of these concepts for further use.

Among the major findings of the study to this point are the following.

1. Pavements having equivalent design thickness indices are not necessarily equivalent in construction cost or in early structural strength.

2. Very early deflection tests do not give good indications of the ultimate strength characteristics of pavements having cement stabilized layers.

3. Full-depth asphaltic concrete pavements can give excellent performance in very poor soil areas, especially when the design is modified through the provision of a cement stabilized subgrade.

4. An unstabilized sandwich layer placed between a cement stabilized layer and asphaltic concrete layers is effective in significantly delaying the reflection of transverse cracking from the cement stabilized layer through the asphaltic concrete layers. There is some evidence that reflective cracks may develop after many years under heavy truck traffic.

5. Such a sandwich layer is weaker than either of the two layers it contacts and can cause a net reduction in pavement strength as compared with the situation where the weaker layer is on the bottom.

6. Transverse shrinkage cracks reflect from a cement treated stone subbase through 3 inches (75 mm) of bituminous concrete in as little as 18 months and through 7 inches (175 mm) of bituminous concrete in less than 5 years.

7. Cement treatment of stone subbases can be omitted in passing lanes with no detriment to performance. (This may not be true with traffic volumes near capacity because of the change in distribution of truck usage as that point is approached.)

The two following recommendations for consideration by administrators of the Highway and Transportation Department seem appropriate at this time.
1. The Department is encouraged to consider the full-depth asphalt concept as a desirable alternative in flexible pavement design. In poor soil areas the designs should be modified to provide cement (or lime) stabilization of the native subgrade soil. Although full-depth design may be considerably more expensive than many alternatives, there is strong evidence reported herein that the full-depth pavements can provide performance somewhat better than most of these alternatives.

2. In cases where it is deemed appropriate to stabilize aggregate base materials on divided highways with four or more lanes where truck traffic is normally channeled into the outer lanes, it is structurally feasible to omit such stabilization from the inner or passing lanes. While in many cases there may be no economic advantage in such a practice because of construction difficulties, the concept is recommended for cases where it may be practically feasible.
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INTRODUCTION

For a number of years the Virginia Highway & Transportation Research Council and the Federal Highway Administration cooperated in comprehensive performance studies of highway pavements of all types located in all sections of Virginia. The studies, which at one time included nearly 200 projects, resulted either directly or indirectly in an almost total modification of the Virginia approach to flexible pavement design. As a result of the studies highway engineers in Virginia are much more cognizant of soil resiliency, the benefits of cement or lime stabilization, and of the value of thick bituminous concrete layers. (1, 2, 3, 4) In addition, Vaswani has utilized the results of the studies and those of the AASHTO road test in developing a strength coefficient design method for use in Virginia. (5)

The comprehensive studies were phased out at the end of calendar 1971, because most of the projects had reached the age where further study would not be profitable. On the other hand, recent innovations in pavement design are receiving attention so that occasionally new construction projects have features quite different from anything in the past. Examples are full-depth asphalt pavements and pavement systems in which the layers have been switched from their usual positions. Clearly, the evaluation of such projects is crucial to the determination of whether or not the experimental features should be adopted for routine pavement designs.

PURPOSE AND SCOPE

Since its conclusion, many highway agencies have been guided in their design practices by the results from the much publicized AASHTO road test of the late 1950's and early 1960's. The analysis of data from these tests has led to the gradual evolution of design practices involving strength coefficients of paving materials. (6) While the coefficients resulting directly from the road test are in wide use, there is general agreement that highway agencies should evaluate their
own materials and develop strength coefficients for them. The coefficients have been developed for Virginia materials and are in use for routine design purposes, but there is a need for continued evaluation to account for new concepts in pavement design. The evaluation of pavements wherein these concepts are applied is the thrust of the present study.

Specific objectives of the study are: (1) To evaluate the performance of pavements containing trial or experimental design features, and (2) to better define the strength coefficients of pavement components with respect to both materials and the location of those materials within the pavement structure.

Seven projects representing the Piedmont and Coastal Plains physiographic provinces are included in the study. Typical sections showing variations in types and locations of pavement elements are appended. The details of each project will be discussed later.

EVALUATION PROCEDURES

In general, the evaluation of experimental features begins when substantial portions of the subgrade for a given project have been prepared. At that time, dynaflect deflection tests are conducted on the subgrade. Similar tests follow the placement of subsequent pavement layers, including the final riding surface. Further steps in the evaluation of each project are as follows:

1. Procurement of final plans and cross sections, materials descriptions, construction costs, and date of acceptance from the contractor;

2. establishment of easily identified project limits by the use of roadside markers and written descriptions;

3. initial and periodic collection of data reflecting
   A. traffic characteristics,
   B. structural capability as indicated by deflection tests, and
   C. visual defects such as cracking, rutting, patching, and settlements; and

4. compilation of records of major maintenance operations (bituminous concrete overlays, for example) and their costs.

PROJECT NO. 1

U. S. ROUTE 29 BYPASS — ALTAVISTA

U. S. Route 29 Bypass at Altavista is a 4-lane roadway on an all new location. Completed in early 1974, the project is approximately
soil conditions

The nature of the embankment and subgrade soils on the Altavista project were determined during the preliminary engineering phase of the project. The details of these soil conditions are available in the project records. Briefly, the subgrade soils are predominately micaceous silts from A-2-4(0) through A-5(10) and with California bearing ratio (CBR) values of from 5 to 16. Since these soils are categorized as highly resilient with poor bearing capacity, where they are used as subgrades in Virginia it has been conventional to stabilize the top 6 inches (150 mm) with portland cement. As has been reported elsewhere this stabilization has been found to provide a good working platform for construction equipment and to enhance long-term pavement performance. As indicated in the cross sections such stabilization was provided on three of the experimental sections on the present project, while the fourth design specified compacted native subgrade without stabilization.

Project Objectives

Specific objectives of the Altavista project are:

1. To evaluate the original relative structural strengths of the four pavement designs,
2. to evaluate the relative long-term performance of the four designs, and
3. to evaluate the comparative construction and maintenance costs for the four designs.

Results and Discussion

Deflections

Deflection tests were conducted at regular time intervals from the beginning of subgrade preparation until the project was opened to traffic. The first tests were conducted on the raw subgrade of Section B and the cement stabilized subgrade of Section A on August 8, 1972. Tests were then run on each layer of each section as test locations became available. Final tests on the finished surfaces of all sections were conducted during the fall of 1973. A detailed discussion of these earlier tests may be found in Interim Report No. 1. Annual deflection tests have been conducted on the project since its completion.
Design A

Design A, shown in Figure A-1, is of the general type often considered as the standard for many areas of the state and for that reason was chosen as the standard of comparison for the present study.

The total pavement strength developed by Design A by the time construction was completed appears to be at least as high as required by design parameters, as evidenced by the thickness index of 15.0 determined from the deflection tests compared to a design index of 12.0. It should be noted here that the thickness index computed from deflection tests is only an approximation of the true index because the computations involve certain assumptions concerning the strength characteristics of the various materials used in the pavement structure. No appreciable changes in deflections or in thickness index were detected when the pavement was 1 year old. However, by the time this design was 3 years old there was a substantial increase in deflections and a corresponding reduction in the effective thickness index. While this change may have resulted from normal wear and tear there were some unusual weather conditions during the third and fourth years of the pavement's life. The third year was unusually wet and the fourth was unusually cold.

By the spring of 1977 some distress in the form of alligator cracking was becoming apparent in the Campbell County portion of the design type. Substantial differences in the performance between the Campbell and Pittsylvania County portions of the design suggest some differences in soils not detected in the design phase of the project. The two counties are separated by the Roanoke River such that soils of different characteristics would not be unusual. The soils data will be reexamined before the final report is issued.

Design B

Design B, sometimes referred to as a modified full-depth asphalt pavement because, except for the cement stabilized subgrade, the pavement is made up entirely of bituminous concrete, shows strength development under construction very much as would be expected. As can be seen in Figure A-2, the majority of the strength development can be attributed to the 8-inch (200 mm) bituminous concrete base course.

In this case, as with Design A, the thickness index data show that the completed pavement had a structural strength at least equivalent to design requirements. Again, the measured thickness index, 14.0, compared favorably with the design value, 11.9.

After approximately 1 year, the deflections on this section were substantially lower than when the pavement was first completed. It is speculated that this reduction in deflections was brought about by seasonal variations in subgrade moisture and in the stiffness of the thick asphaltic concrete. Vaswani has shown these variations to have a significant influence on both the deflections and indicated thickness index of typical
Virginia pavements. When the pavement was 3 and 4 years of age the deflections had increased to approximately the values measured immediately after construction and there were some small variations in the thickness index values.

Longitudinal and alligator cracking detected in the spring of 1977 in Campbell County suggest the possibility of variations in the soils on the project mentioned for Design A.

Design C

Experimental Design C (Figure A-3) is the only one of the four constructed with an unstabilized subgrade soil, and as a result a poorer working platform was provided for the contractor's equipment. This factor, together with extremely wet construction seasons and very poor soil conditions, resulted in some construction difficulties. These problems were evidenced (1) in the need to apply lime as a drying agent to certain saturated portions of the subgrade soil, (2) in the distortion of the prepared subgrade soils under construction traffic, and (3) primarily in the very early failure of one segment of the 4-inch (100 mm) cement treated crushed stone subbase under construction traffic. This subbase failure was corrected by the provision of 4% cement by weight to the previously unstabilized layer of crushed stone base.

Apparently because of the soil problems and construction difficulties discussed above, Design C had a completed average thickness index of 9.5, which did not compare well with the design index of 12.0. However, after about one year of service the pavement was significantly stronger, with an indicated thickness index of 13.0. Deflections for the third and fourth years suggest that this variation was a seasonal effect, as mentioned earlier, and not a permanent increase in pavement strength.

This design, as did Designs A and B, showed some longitudinal cracking by the spring of 1977.

Design D

Design D, which contains two cement layers, produced the strongest finished product of the four designs. The deflection data shown in Figure A-4 are self-explanatory, and it suffices to point out that the final deflections are the lowest and the final thickness index the highest of those measured for the four designs. Clearly, the final thickness index of 15+ compares very favorably with the design index of 11.9.

It is important to note here that while this particular design may perform extremely well, there will be reflection cracks from the cement treated crushed stone underlying the relatively thin bituminous concrete course. Furthermore, as has been reported earlier from a study of a similar pavement, the extreme rigidity of this
design coupled with the tendency of the cement treated stone to crack both transversely and longitudinally can result in behavior very much like that of a concrete pavement. Thus, if water becomes trapped under the stabilized stone a pumping action can occur to the detriment of pavement performance. The performance of this particular section will be watched closely for any evidence of this phenomenon. By the spring of 1977 some transverse and longitudinal cracks were evident in only the Campbell County portions of this design.

Conclusions

The following conclusions are based on tests conducted during construction and shortly after completion of the Altavista project. Because pavement characteristics may change with continued exposure to traffic and changing climatic conditions, no definite indications of ultimate pavement performance are offered in this report. Cost data supporting conclusion number 2 were given in Interim Report No. 1.(8)

1. Pavements having equivalent design thickness indices are not necessarily equivalent in early structural strength.

2. Pavements having equivalent design thickness indices are not necessarily equivalent in construction costs.

3. Very early deflection tests are not good indicators of the ultimate strength characteristics of pavements having cement stabilized layers.

4. Highly resilient soils, especially micaceous silts, must be stabilized to achieve a good working platform for pavement construction and to assure the early development of the design structural strength.

5. A design utilizing a cement stabilized subgrade overlaid with a cement stabilized stone base and bituminous concrete develops the design structural strength more rapidly and at a lower cost than do any of the other three designs.

6. Substantial differences in the performance of all four designs between the two counties the project traverses suggest that some variations in soil characteristics were not detected in the original design provisions.

PROJECT NO. 2

ROUTE 31 — WILLIAMSBURG

Project No. 2 (Figure A-5) was the first full-depth asphaltic concrete project built in the state. The pavement was completed in 1970, is 1 mile (1.6 km) long, and runs from the west corporate limits of
Williamsburg toward the downtown area. Because the project is part of the feeder road for the Jamestown ferry it does not carry a large volume of truck traffic. Even though traffic projections called for a design daily EAL-18 of 118 for the year 1978, traffic counts show that the actual daily EAL-18 has been only 4 to 7 for the first 7 years the project has been open to traffic.\(^7\)

**Soil Condition**

Soils encountered on the project were silty clays, sandy clays, and clays falling into AASHTO classifications A-2(4), A-6(2), and A-7-6(11). CBR values ranged from 1.3 to 11.7, with an average of 8.0.

**Typical Section**

The typical section for the Route 31 project, given in Figure A-5, consists of a 9-inch (225 mm) bituminous concrete base built on the native subgrade. This 9-inch (225 mm) base was constructed in one lift. The surface course is bituminous concrete type S-5 applied at a rate of 165 psy (89 kg/m\(^2\)).

The pavement is 4-lane undivided with a paved width of 48 feet (14.6 m). A crushed stone base was provided under the curb and gutter on either side of the roadway.

**Project Objectives**

Objectives of the project were to evaluate the performance of a full-depth bituminous concrete pavement on an untreated subgrade and to assess the strength coefficient of the full-depth base. As has been noted earlier, it is customary in Virginia to use cement stabilization in the silty subgrade soils such as those found on this project. However, in an effort to expedite construction in an urban area and to provide a more severe test for the full-depth bituminous concrete, such stabilization was omitted from this project.

**Results and Discussion**

Placing the full-depth bituminous concrete base in a single lift on the unstabilized subgrade soil presented some construction problems. The absence of a good working platform made it difficult to maintain an accurate grade as the weight of the paving machine was enough to significantly deform the subgrade in weak areas. The 1 1/2-inch (38 mm) surface course was insufficient to iron out these irregularities so that a rough riding surface resulted. The rough condition was aggravated by the fact that the paving contractor was unable to furnish materials to the paving machine with any degree of continuity, because project personnel simply were not accustomed to placing 9 inches (225 mm) of bituminous concrete in one lift and adequate trucking arrangements were not available. Hughes and Maupin have discussed the construction and materials aspects of this project in an earlier report.\(^11\)
Deflection tests on the project initiated soon after its completion in the summer of 1970 (Figure A-5) showed a marked decrease in deflections during the first 9 months the pavement was in service. Then, the deflections appeared to level off for the subsequent 3 years. It should be noted that the early deflections were in warm weather while the latter were for the cooler weather of spring. Tests at other times on the same project showed that deflections on the full-depth pavement were extremely sensitive to changes in pavement temperature. Thus, it could be expected that summer and spring deflections would differ significantly.

The application of a subgrade evaluation method suggested by Vaswani(12) shows that the subgrade conditions under the full-depth asphalt have not varied to any appreciable degree since the project was constructed. For this reason, it is surmised that changes in deflection are due to changes in the stiffness of the asphalt layer caused by temperature changes.

It should be noted that the thickness index of this project determined from deflection tests is very much as predicted from design parameters, which suggests that an asphaltic concrete strength coefficient of 1.0 is applicable to full-depth asphalt pavements within the depth limitations found in the current project. Virginia designers have sometimes used a reduced coefficient for full-depth asphalt under the assumption that the material deep in the pavement structure contributes less to the total pavement strength than that close to the surface.

Only one minor problem was noted on the 7-year-old full-depth pavement. This consisted of longitudinal cracking on a fill near the north end of the project and is attributed to fill settlement rather than to a pavement deficiency.

Conclusions

Based on 7 years of tests and observations, the following conclusions appear applicable to the first full-depth asphalt pavement built in the state. These conclusions are somewhat tempered by the fact that actual truck traffic using the pavement is nowhere near that for which the pavement was designed.

1. Full-depth asphaltic concrete pavements in a poor soil area can give excellent performance.

2. A reduction in strength coefficient for full-depth asphalt may not be justified when the total pavement thickness is no more than the 10 1/2 inches (265 mm) on the project reported herein.
PROJECT NO. 3

ROUTES 3 AND 33 — MIDDLESEX COUNTY

Project No. 3 is included in the study as an example of pavement performance when the positions of pavement layers are altered within the pavement structure. In this case, a cement stabilized sand and gravel subbase layer was used in two different positions. As originally designed, the stabilized subbase material was to be located directly under the asphaltic concrete layer. However, in an effort to reduce the reflection of transverse cracks from the stabilized layer through the asphaltic concrete layers the Research Council provided impetus to the construction of a 1-mile section of the pavement with an unstabilized subbase layer sandwiched between the asphaltic concrete and the stabilized subbase. In suggesting this test section it was envisioned that the unstabilized subbase layer would function as a cushioning layer to prevent the reflection of the transverse cracks. The design traffic for the project was 115 daily EAL-18.

Soil Conditions

Soils encountered on the project were sands and sandy clays falling into AASHTO classifications A-2-4(0) to A-6(7). CBR values ranged from 15 to 65, with an average of 28.

Typical Sections

Typical pavement sections for Project No. 3 are given in Figures A-6 and A-7, where it may be seen that the layers described above consist of 6 inches (150 mm) of select borrow having a minimum CBR value of 25. In each case the stabilized layer contains 8% portland cement by volume. Actual construction consisted of the provision of 12 inches (300 mm) of the select borrow with either the top or bottom one-half stabilized as required.

Both the experimental and the standard sections are overlaid by a 3 inch (75 mm) asphaltic concrete base course and a 1 1/2 inch (38 mm) asphaltic concrete surface course.

Project Objectives

The primary objective of the project was to assess the effectiveness of the cushioning layer of unstabilized material in preventing the reflection of transverse cracks through the asphaltic concrete layers. Secondary objectives were to assess the effects on the pavement structure of switching the positions of the stabilized and unstabilized select borrow layers and to assess the overall performance of the two designs, which were of equivalent cost but of different structural properties.
Results and Discussion

Studies of the two pavement designs included in this project for the first 7 years in service have shown that the provision of the unstabilized cushion layer has been effective in preventing the development of reflection cracks in the asphaltic concrete layers. However, such cracking has not been as severe as anticipated, even in the sections where the stabilized material is directly under the asphaltic concrete. In this section, the first reflection cracks were noted at 3 years, but present no significant performance problem even after 7 years. At 7 years of age a small amount of transverse cracking has been detected in the section containing the cushioning layer.

While the cushioning layer has served its purpose of preventing reflection cracks, deflection tests on the two test sections have shown that this layer has also served to weaken the pavement structure. As can be seen in Figures A-6 and A-7, tests conducted on both sections on the same dates show deflections on the section with the cushion layer to be significantly higher than those on the other section. At the same time, differences in spreadability values indicate that the pavement with the stabilized subbase close to the surface is much stiffer than the one with the sandwich, or cushion, layer. The end result is that the thickness index as determined from deflection tests is much lower for the pavement with the sandwich layer, as would be predicted from the design index, which gives consideration to a material's location within the pavement structure. Vaswani has investigated the effects of a sandwich layer more fully in another study. By the spring of 1977, the design with the sandwich layer showed a substantial amount of longitudinal cracking.

It should be noted that truck traffic volumes on these pavements are so low (20-30 daily EAL-18) that the weaker sandwich layer has not been a serious detriment to pavement performance for the first 7 years. While small differences in performance seem to be developing they are unlikely to be serious unless there is a substantial increase in truck traffic, which may never reach the 115 daily EAL-18 design value.

Conclusions

As with some of previous pavements discussed, the conclusions drawn from Project No. 3 must be tempered with the knowledge that truck volumes (EAL-18) are low so that such conclusions could not necessarily apply to similar pavements under more severe conditions. With this provision, the following conclusions appear reasonable.

1. An unstabilized sandwich layer placed between a cement stabilized subbase and asphaltic concrete layer is effective in preventing the reflection of transverse cracks from the cement stabilized layer through the asphaltic concrete layers.

2. Such a sandwich layer is weaker than either of the two layers it contacts and causes a net reduction in pavement strength when compared with the situation where the weaker layer is on the bottom.
Project No. 4 was included in the study to provide an opportunity to evaluate the performance of a pavement in which a cement stabilized, commercial crushed stone subbase was used in lieu of cement treatment of a micaceous, highly resilient subgrade soil. While the project is very similar to No. 1-C it was built earlier (1968), and is in a lighter traffic corridor. A design daily average EAL-18 of 25 has been approximated very closely by actual values of from 19-23 for the first 9 years the pavement has been in service.

The project is also similar to No. 3 in that a cushioning layer is expected to prevent reflection cracking from the lower cement stabilized layer. The difference in this case is that a commercial crushed stone is used rather than a local select borrow.

Soil Conditions

Soils encountered on the project were micaceous silts and silty clays characteristic of the Piedmont Province. These soils ranged in CBR value from 0.6 to 7.2, with an average of 4.7.

Typical Section

The typical section for the project given in Figure A-8 shows two layers of aggregate base, the lower of which is stabilized with portland cement at a rate of 4% by weight. Both layers were constructed of a commercial crushed stone meeting the requirements of Virginia specifications in effect in 1968. The stone layers are overlaid by 5 1/4 inches (132 mm) of asphaltic concrete comprising 3 inches (75 mm) of base, 1 1/4 inches (31 mm) of binder, and a 1 inch (25 mm) surface course.

Project Objectives

Objectives of the project were (1) to assess the ability of the untreated stone layer to prevent the reflection of cracks in the stabilized stone through the asphaltic concrete layers, and (2) to evaluate the performance of the design in which a cement treated crushed aggregate subbase was used in lieu of the usual practice of stabilizing the highly resilient subgrade soil.

Results and Discussion

Observations and deflection tests on the project for the first 9 years it has been in service show that it has performed extremely well. Most instances of observed distress are related to fill settlements and embankment slides rather than to defects in the pavement structure. Again, it should be recalled that the pavement is subject to a low volume of truck traffic. This volume has been accounted for in the design of the pavement structure as evidenced by the design thickness index of 9.1.
Thickness indices determined from deflection tests show that the design index has been realized in service. Measured indices range from 8.5 to 14.0 and reflect the seasonal variations mentioned on other projects.

The unstabilized layer has been successful in preventing the reflection of transverse cracks through the asphaltic concrete layers. After 7 years in service the project shows only a small amount of transverse cracking. Longitudinal cracking began to develop during the eighth year and was becoming substantial by the spring of 1977.

Conclusions

The following conclusions appear reasonable for this relatively low traffic road in which a sandwich layer of crushed stone is provided.

1. The sandwich layer is effective in preventing reflection cracks.
2. The pavement develops adequate structural strength to give excellent performance under the prevailing conditions.

PROJECTS NO. 5 AND 6

ROUTE 207, CAROLINE COUNTY

Projects No. 5 and 6 were incorporated in the study to provide a comparison of a full-depth asphalt design with a more conventional design. While the two projects were built at different times, they are adjoining and both serve the same heavy truck traffic, having a design EAL-18 projection of 919 per day for the year 1978. The projects provide trucking access from U. S. 301 near Bowling Green to Interstate 95. Traffic for the first few years the pavements have been in service does not approach the design projections, but does exceed 300 daily EAL-18, making the road one of the heavier trucked primary highways in the state. The similarity of both soil and traffic conditions should provide a good comparison of the two pavement designs.

Soil Conditions

The soils encountered on the two projects are typical Piedmont — Coastal Plains transitional soils consisting of silts, clays, and sands. CBR values range from 5 to over 100, with an average of 18. AASHTO soil classifications on both projects range from A-1-a(0) to A-7-6(9), with A-2-4(0) predominant.

Typical sections for Projects 5 and 6 are given in Figures A-9 and A-10, respectively. As shown in these sketches the lower 6-inches (150 mm) of subgrade soils on both projects were stabilized with 8% portland cement by volume. The standard design (Project 5) has a 6-inch (150 mm) layer of subbase material consisting of a commercial crushed stone size 21-A. The asphaltic concrete layers comprise 6-inches (150 mm) of base, 1 1/2-inches (38 mm) of binder, and 1-inch (25 mm) of surface.
The full-depth asphalt on Project 6 consists of 9 inches (225 mm) of base, 1 1/2 inches (38 mm) of binder, and 1 inch (25 mm) of surface. Notwithstanding the similarities in soils and anticipated traffic conditions, a modification in design procedure between the times the two projects were designed resulted in design thickness indices of 13 and 15 for Projects 5 and 6, respectively.

Objective

The objective of the two projects was to contrast the performances of the full-depth asphalt and standard pavement designs under similar soil and traffic conditions.

Results and Discussion

Performance studies have been conducted on Project 5 since its completion in late 1971 and on Project 6 from the beginning of construction.

The performance of Project 5, the standard design, has been highly disappointing in that after only 3 1/2 years of service the asphaltic concrete surface was extensively cracked longitudinally and had occasional areas of alligator, or "map," cracking that were close to the pothole stage. The project was resurfaced with 150 psy (81 kg/m²) of bituminous concrete type S-5 in October 1977. The overlay was applied after only about 700,000 18-kip axle load repetitions as opposed to an expected 2.5 million repetitions before an overlay would be necessary.

The cause of the poor performance of this pavement is not immediately evident although the deflection tests show that the design thickness index has never been developed by the pavement structure. The 1976 and 1977 deflection tests reflect the observed deterioration of this pavement as shown by the increased deflection and declining effective thickness index. The early indicated index of 11.0 should, however, have been adequate for the traffic the pavement has experienced to date. This lower than expected effective thickness index coupled with the observation that moisture is present on the surface of the pavement at least a day after precipitation led to speculation that a subsurface drainage problem existed. The "trench" construction and densely graded subbase material used on this project compare well with several similar projects where exploratory diggings had shown the subbase to be saturated and water to be trapped in the asphaltic concrete layers. In such cases, failure of the asphaltic concrete layers can be extremely rapid. In an effort to determine the subdrainage conditions of this pavement, in June 1977 two sites in the outer wheel path of the traffic lane were opened to the soil cement treated subgrade. One site is shown in Figure 1; the other was in somewhat better condition. At both sites it was found that the bituminous concrete base material was moist and had stripped so badly that in the wheel paths the material was removable with a hand shovel. The condition of this base material is indicated in Figure 2.

The aggregate subbase was damp at both sites, even though the project was located in an area experiencing a severe drought. Gradations and Atterburg limits on samples of the aggregate showed that the material
Figure 1. Surface condition of section analyzed.

Figure 2. Condition of bituminous concrete base.
was nonplastic with approximately 6% minus 200. Experience in
Virginia has shown that such materials will drain adequately, if
slowly, as long as there is an outlet for the water. In the case
of the two sites examined on this pavement the shoulders were built
of a clayey sand which would doubtless be of very low permeability as
compared to the subbase material. Thus, it is likely that the shoulder
material forms an impervious dam at the pavement edge such that surface
water is held in the lower pavement layers and results in stripping
and loss of integrity of the bituminous layers. Any potential concerns
about the condition of the cement stabilized subgrade soil were allayed
when the aggregate base was removed to reveal the hard, dense material
indicated in Figure 3.

Figure 3. Condition of soil cement subgrade.

The full-depth asphalt pavement (Project 6) has performed
extremely well for its 3 years under traffic. One isolated problem
consists of what appears to be a saturated area where water occasionally
flows from the pavement surface. This condition may be caused by a
spring that was undetected during construction. Several saturated areas
that were detected during construction have not become evident in the
completed pavement. While this project is still too new to provide
definite conclusions, it is evident from the deflection tests that the
design thickness index of 15 is being realized in the pavement in
service.
Conclusions

The extremely poor performance of the standard design appears related to the "trench" construction method which prohibits proper drainage of lower pavement layers.

PROJECT NO. 7
ROUTE 7360 — KEYSVILLE BYPASS

Project No. 7 is the only one carried over from a previous study of experimental flexible pavements. The project was completed in December 1965 and has generally performed well under heavy truck traffic for over 12 years. The construction features and early performance history of the project were reported in detail earlier.(3,10)

Traffic projections on the project called for a design daily EAL-18 of 977. While this volume has not been reached, there was a steady increase from 1966 through 1971 to a peak of 577 daily EAL-18. The truck volume decreased to 464 daily EAL-18 in 1972, increased to 518 in 1974, and dropped to 424 in 1976.

Soil Condition

The soils native to the project are micaceous silts and silty clays of the A-4 to A-7-5 classification. CBR values range from 3.0 to 11.5.

Typical Section

The typical sections for Project No. 7 are given in Figures A-11 through A-14, designated Sections A through D. Section A represents the more or less standard design Virginia has used in the Piedmont area for some years. Sections B through D include design variables in the subbase, base, and asphaltic concrete layers. All sections were considered to be structurally equivalent at the time of construction. The only feature common to all four designs is the cement stabilization of the upper 6 inches (150 mm) of the native subgrade soil.

In this project, for the first time in the experimental studies, advantage was taken of the much lower truck traffic in the passing lanes. Since the additional strength was deemed unnecessary, the cement stabilization was omitted from the crushed stone used in the westernmost eastbound sections of Designs B and C. The feeling was that the somewhat objectionable transverse shrinkage cracks could be avoided with no loss in performance.

Among the structural features indicated earlier are three designs (A, B, and C) having thick bituminous concrete surface and base courses. Seven inches (175 mm) of bituminous concrete in these designs were considered equivalent to 3 inches (75 mm) of bituminous concrete and 4 inches (100 mm) of cement treated stone. Similarly, in the subbase 4 inches (100 mm) of bituminous concrete, 4 inches (100 mm) of cement treated stone, and 6 inches (150 mm) of untreated crushed stone all were considered equivalent.
Thus, also for the first time in the experimental projects, some consideration was given to the thickness index concept developed at the AASHTO road test and reported for Virginia materials by Vaswani. Note that the total pavement thickness is 17 inches (425 mm) for Designs B, C, and D, while Design A, with only a crushed stone subbase, is 19 inches (475 mm) thick. Thickness indices are 11.5, 10.8, 13.4, and 13.4 for Designs A, B, C, and D, respectively.

**Project Objective**

The objective of the project was to continue the evaluation on older major experimental projects where some definite indications of differences in performance had been detected earlier.

The comparisons to be made from the designs were given by Hughes as:

1. "Base — compares 4 inches (100 mm) of cement treated aggregate base (Design B) with 4 inches (100 mm) of asphaltic concrete base (Design C). (The additional 1 1/2 inches (38 mm) of asphaltic concrete base plus the 1 1/2 inch (38 mm) surface are assumed to be equivalent to the 3 inch (75 mm) surface of Design B.)

2. Subbase — compares 4 inches (100 mm) of lean mix asphaltic concrete (Design D) with 4 inches (100 mm) of cement treated aggregate base (Design C).

3. Subbase — compares 4 inches (100 mm) of lean mix asphaltic concrete (Design D) with 6 inches (150 mm) of untreated aggregate base (Design A).

4. Subbase — compares 4 inches (100 mm) of cement treated aggregate (Design C) with 6 inches (150 mm) of untreated aggregate base (Design A).

5. Compares EBPL to EBTL of S. Section of Design B and Design C to determine effect of omitting cement from lightly traveled passing lane."

**Results and Discussions**

**Visual Defects**

The first visually apparent defects on this project were transverse shrinkage cracks found in Design B. These were reported by Hughes when the project was about 2 years old and had sustained about 0.3 million EAL-18 (one direction). The report indicated that these cracks had reflected through 3 inches (75 mm) of bituminous concrete within the first 1 1/2 years. At the same time one transverse crack was reported in Design C (7 1/2 inches [188 mm] of bituminous overlying cement treated stone).
Later studies showed more fully developed crack patterns after 5 years under traffic (about 0.8 million EAL-18 in one direction). The average spacing of transverse reflection cracks was approximately 25 (8 m) and 75 feet (23 m) for Designs B and C, respectively. As expected, no cracks were present in the westerly sections of Designs B and C, where the cement was omitted from the stone subbase. It is clear that given enough time the cracks will reflect through even 7 1/2 inches (188 mm) of bituminous concrete.

In the thin overlay sections (Design B) the reflective cracking seemed in 1971 to have proceeded beyond a mere visual nuisance. Several sections had developed longitudinal cracks which, combined with the transverse cracks, created slab-like portions of pavement. Slab action was apparent to the extent of horizontal shifting, faulting, and pumping. The sections seriously affected were fairly limited in extent and did not lead to a significant reduction in the service life of this design since the rate of progression was relatively slow. Hughes reported some construction difficulties in a nearby area where an unstable subgrade was undercut and backfilled. (3)

Possibly the most significant finding from the transverse cracking studies is the confirmation of an earlier Route 360 project finding; i.e., that cement treated stone subbases should not be used very close to the surface of bituminous pavements. (10)

Recent studies of the project after some 12 years under traffic (approximately 1.8 million EAL-18) have shown that earlier indicated differences in performance have become more pronounced. Section A now has general rutting and extreme alligator cracking throughout. Surprisingly, a pattern of transverse cracking occurring at approximately 25 foot (8 m) intervals has developed. This finding was not expected because the 6 inch (150 mm) layer of crushed stone between the cement stabilized subgrade and the asphaltic concrete layers was expected to prevent the reflection of shrinkage cracks. It is expected that exploratory diggings will be conducted on this section to determine whether or not the transverse cracks are indeed of the reflection type.

Design B, with the cement treated aggregate base close to the surface, has now developed an intensive transverse cracking pattern with a spacing of 15 to 20 feet (5 to 6 m) in the traffic lanes. An example of severe transverse cracking on this design is illustrated in Figure 4. Occasional longitudinal cracking has also developed in these traffic lanes. However, the sections showing slab-like behavior earlier have not become significantly worse over the last 7 years. The areas of the passing lanes where the cement stabilization was omitted are still in good shape. It is apparent from this finding that from a performance standpoint it is feasible to omit such stabilization from the passing lanes. Portions of this design were resurfaced in 1976.

Design C, in which a cement treated aggregate base underlies 7 inches (175 mm) of asphaltic concrete, is still in good condition. Although it has a fully developed pattern of transverse cracking, no slab-like action has been detected. The occasional longitudinal cracking noted is to be expected under the prevailing condition.
Design D, which incorporates a modified full-depth concept (cement stabilized subgrade), is in good condition, having some longitudinal cracking in the outer wheel path of the traffic lanes. This design has performed markedly better than the other three. It is beginning to become somewhat rutted, probably due to densification of the thick bituminous layers.

![Severe transverse cracking (sealed) on section B of Project 7.](image)

**Deflections**

Deflections throughout the project have been generally satisfactory, but those for Design A have been significantly higher than those for the other three. The results of these deflection tests also show that Design A has never developed more than approximately one-half the effective thickness index found for the other three designs. Note that the indicated index for Design A has, with seasonal variations, ranged from 6.0 to 8.0, while in the other cases indices in excess of 15 are usually indicated. It is probably for this reason that Design A appears now to have performed worse than the other three.

**General Appraisal**

Based on the factors discussed above and recognizing that the project has served its expected design (before resurfacing) life of 8 to 10 years, it would have to be concluded that all four design types have performed adequately. However, when the four designs are contrasted
with each other, they can be classified as —

Design A — fair
Design B — fair
Design C — good
Design D — excellent.

It should be recalled that Design D, which shows excellent performance is essentially a full-depth asphalt pavement on an improved subgrade. Its initial construction cost was somewhat more than that of the other designs while its performance is considerably better. Based on recent cost increases in the highway industry it is likely that the cost differential would be even more if the experimental project were built in 1977. On the other hand, it is also apparent that the full-depth design may serve for much longer than the accepted 8 to 10 years before an overlay is required. In the judgment of the author, 15 or more years of service can be expected from Design D before an overlay will be necessary.

Conclusions

The following conclusions appear to be warranted from experimental Project No. 7.

1. Transverse shrinkage cracks reflect from a cement treated stone subbase through 3 inches (75 mm) of bituminous concrete in as little as 18 months and through 7 inches (175 mm) of bituminous concrete in less than 5 years.

2. Cement treatment of stone subbases can be omitted in passing lanes with no detriment to performance. (This may not be true with traffic volumes near capacity because of the change in distribution of truck usage as that point is approached.)

3. It has been reaffirmed that cement treated stone subbases should not be used in close proximity (3 inches or 75 mm, for example) to a bituminous pavement surface under heavy traffic conditions.

4. On the basis of over 12 years' exposure to heavy truck traffic, the pavement layers listed below give the indicated performance when overlaid by 7 inches (175 mm) of asphaltic concrete.

   4 inches (100 mm) of asphaltic concrete — excellent
   4 inches (100 mm) of cement treated aggregate base — good
   6 inches (150 mm) of untreated aggregate base — fair
ACKNOWLEDGEMENTS

The author gratefully acknowledges the excellent cooperation of the resident engineers and field maintenance personnel who have made essential contributions to the conduct of the study through their assistance in the collection of field data.

C. S. Hughes and Dr. N. K. Vaswani are acknowledged for their conduct of portions of the study and for their technical assistance in other portions. The interest and cooperation of R. W. Gunn and G. V. Leake in the collection and analysis of data are sincerely appreciated.

The work is being conducted under the general direction of Jack H. Dillard, head, Virginia Highway & Transportation Research Council, from HPR funds administered by the U. S. Federal Highway Administration.
REFERENCES


APPENDIX
Project: 6029-015-103, C501  
Study Project No.: 1-A  
County: Campbell-Pittsylvania  
Length: 9.70 mi

From: 5.239 mi, N, Campbell-Pittsylvania C.L.  
To: 4.651 mi, S, Campbell-Pittsylvania C.L.  
Design Traffic (EAL-18): 134  
Design Thickness Index: 12.0

Completion Date: April 1974

**PERFORMANCE SUMMARY SHEET**

- **Date**
- **Dynaflect Deflection (1/1000 in.)**
- **No. Tests**
- **Spreadability**
- **Thickness Index**
- **Avg. Daily EAL-18**
- **Cracking Factor**

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**Performance Rating:** Excellent  
**Cost per mi.:** $98,525

**Remarks:**  
Excellent condition 5-12-75, 4-5-76  
April 1977, small amount of alligator cracking in Campbell County only.

**Metric conversions:**  
1 ml = 1.6 km.  
1 ft = 0.3 m.  
1 in = 25 mm.

*Pavement elements listed in "date" column indicate pavement under construction.*
**PERFORMANCE SUMMARY SHEET**

**Project:** 6029-015-103, C501

**From:** 5.239 mi, N, Campbell-Pittsylvania C.L.

**To:** 4.651 mi, S, Campbell-Pittsylvania C.L.

**Completion Date:** April 1974

**Length:** 9.70 mi

**Design Traffic (EAL-18):** 134

**Design Thickness Index:** 11.9

---

**Diagram:**

- **Median:** 4' / 6'
- **165 psi Bit:**
- **Conc. Type S-5**
- **8" Base - Bit, Conc.**
- **Type B-3**
- **6" Cement Stabilized**
- **Subgrade (10% Vol.)**
- **12' fill**
- **10' cut**

---

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**Performance Rating:** Excellent

**Cost per mi.:** $87,965

**Remarks:** Excellent condition 5-12-75, 4-5-76

April 1977, some longitudinal and transverse cracking in Campbell County only.

---

**Metric conversions:**

- 1 mi. = 1.6 km.
- 1 ft. = 0.3 m.
- 1 in. = 25 mm.

---

* Pavement elements listed in "date" column indicate pavement under construction.
Performance Summary Sheet

Project: 6029-015-103, C501
From: 5,239 mi, N, Campbell-Pittsylvania C.L.
To: 4,651 mi, S, Campbell-Pittsylvania C.L.
Completion Date: April 1974

Study Project No.: 1-C
Length: 9.70 mi.
Design Traffic (EAL-18): 134
Design Thickness Index: 12.0

* Date | Dynaflect Deflection (1/1000 in.) | No. Tests | Spreadability | Thickness Index | Avg. Daily EAL-18 | Cracking Factor |
-------|-----------------------------------|-----------|---------------|-----------------|-------------------|----------------|
Subgrade | 2.737 | 104 | 38 | N/A | 0 | 0 |
C.S. Agg. Base | 2.533 | 168 | 43 | 2.8 | 0 | 0 |
Agg. Base | 1.691 | 95 | 53 | 5.0 | 0 | 0 |
B-3 | 0.894 | 296 | 59 | 7.4 | 0 | 0 |
S-5 | 0.750 | 90 | 64 | 9.5 | 0 | 0 |
3-25-74 | 0.524 | 47 | 69 | 13.0 | 246 | 0 |
4-5-76 | 0.787 | 33 | 66 | 9.5 | 293 | 0 |
3-23-77 | 0.679 | 45 | 59 | 8.5 | N/A | 13 |

Performance Rating: Excellent
Cost per mi.: $98,314

Remarks: Excellent condition 5-12-75, 4-5-76
April 1977, some longitudinal cracking in Campbell County only.

* Pavement elements listed in "date" column indicate pavement under construction.

Metric conversions:
1 mi. = 1.6 km.
1 ft. = 0.3 m.
1 in. = 25 mm.
**PERFORMANCE SUMMARY SHEET**

**Project:** 6029-015-103, C501  
6029-071-111, C501  

**From:** 5.239 mi, N. Campbell-Pittsylvania C.L.  
**To:** 4.651 mi, S. Campbell-Pittsylvania C.L.  
**Completion Date:** April 1974  

**Study Project No.: 1-D**  
**Length:** 9.70 mi.  
**Design Traffic (EAL-18):** 134  
**Design Thickness Index:** 11.9  

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*** Date | Dynaflect Deflection (1/1000 in.) | No. Tests | Spreadability | Thickness Index | Avg. Daily EAL-18 | Cracking Factor**
---|---|---|---|---|---|---
Subgrade | 1.768 | 104 | 45 | — | 0 | 0
C.S. Subgrade | 1.267 | 253 | 49 | 4.7 | 0 | 0
C.S. Agr. Base | 0.856 | 17 | 62 | 8.1 | 0 | 0
B-3 | 0.560 | 317 | 63 | 11.0 | 0 | 0
S-5 | 0.378 | 68 | 72 | 15+ | 0 | 0
3-26-74 | 0.343 | 43 | 75 | 15+ | 246 | 0
4-9-74 | | | | | | |
4-5-76 | 0.490 | 30 | 72 | 15.0 | 293 | 0
3-23-77 | 0.519 | 40 | 70 | 13.5 | N/A | 5

**Performance Rating:** Excellent  
**Cost per mi.:** $82,526

**Remarks:** Excellent condition 5-12-75, 4-5-76  
April 1977, some longitudinal and transverse cracking in Campbell County only.

---

*Pavement elements listed in "date" column indicate pavement under construction.*

---

**Metric conversions:**  
1 mi. = 1.6 km.  
1 ft. = 0.3 m.  
1 in. = 25 mm.
### PERFORMANCE SUMMARY SHEET

**Project:** 0031-137-102, C501  
**From:** WCL Williamsburg  
**To:** 1.0 mi. E. WCL Williamsburg  
**Completion Date:** Fall 1970  
**County:** City of Williamsburg  
**Study Project No.:** 2  
**Length:** 1.0 mi.  
**Design Traffic (EAL-18):** 118  
**Design Thickness Index:** 10.5

---

**Diagram Description:**
- Curb & Gutter: 24'  
- Base: 9" Bit. Conc.  
- Conc. Type S-5  
- Type B-3  
- Aggr. Base, Type II, Size 21 or 21A

---

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<th>No. Tests</th>
<th>Spreadability</th>
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**Performance Rating:** Excellent  
**Cost per mi.:** $136,910 (4 lanes)

**Remarks:**
- May 13, 1975 Poor cross-section (build in). Longitudinal cracking on fill at north end of project. Excellent otherwise.
- March 1977, longitudinal cracking. Project still in good condition except for very rough ride.

**Metric conversions:**
- 1 mi. = 1.6 km.
- 1 ft. = 0.3 m.
- 1 in. = 25 mm.

*Pavement elements listed in "date" column indicate pavement under construction.*
Performance Summary Sheet

Project: 0003-059-101, C501
0033-059-103, C501

From: 0.307 mi, E, Int, Rtes. 3 & 33 (Harmony)

To: 2.044 mi, E, Int, Rtes. 3 & 33 (Hartfield)

Completion Date: March 1970

County: Middlesex

Study Project No.: 3-A

Length: 5.2 mi

Design Traffic (EAL-18): 115

Design Thickness Index: 11.7

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Performance Rating: Excellent

Cost per mi.: $48,154

Remarks: First transverse cracking noted on 3-27-73. Occasional transverse cracking, not very pronounced on 5-13-75, April 1976, transverse cracking at 3 per mile. March 1977, transverse cracking at 13 per mile, some longitudinal cracking.

* Pavement elements listed in "date" column indicate pavement under construction.

Metric conversions:
1 mi. = 1.6 km.
1 ft. = 0.3 m.
1 in. = 25 mm.
**PERFORMANCE SUMMARY SHEET**

**Project:** 0003-059-101, C501  
0033-059-103, C501  

**From:** 0.307 mi., E. Int. Rtes. 3 & 33 (Harmony)  
**To:** 2.044 mi., E. Int. Rtes. 3 & 33 (Hartfield)  
**Study Project No.:** 3-B  
**Completion Date:** March 1970  

**County:** Middlesex  
**Length:** 5.2 mi.  
**Design Traffic (EAL-18):** 115  
**Design Thickness Index:** 9.0

---

**Diagram:**

- Median: 6'  
- 12'  
- 165 psi Bit. Conc.  
- Base: 3'' Bit. Conc.  
- Type S-4  
- Type B-1  
- CBR 25  
- 8% Cement by Vol.  
- 6'' Select Borrow  
- 4'' Sel. Bor.  
- 8% Cement Vol.

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**Performance Rating:** Excellent  
**Cost per mi.:** $48,154

**Remarks:**  
May 13, 1975 — No defects.  
April 1976, no transverse cracks. March 1977, transverse cracking, 4 per mile, considerable longitudinal cracking.

---

*Pavement elements listed in "date" column indicate pavement under construction.*

**Metric conversions:**  
1 mi. = 1.6 km.  
1 ft. = 0.3 m.  
1 in. = 25 mm.
**PERFORMANCE SUMMARY SHEET**

<table>
<thead>
<tr>
<th>Date</th>
<th>Dynaflect Deflection (1/1000 in.)</th>
<th>No. Tests</th>
<th>Spreadability</th>
<th>Thickness Index</th>
<th>Avg. Daily EAL-18</th>
<th>Cracking Factor</th>
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</table>

**Performance Rating:** Excellent  
**Cost per mi.:** $69,860

**Remarks:**
May 12, 1975 - Few minor settlements and cracks due to instability of fills. Pavement in excellent condition.
March 1976, some longitudinal cracking, transverse cracking at 4 per mile.
March 1977, considerable longitudinal cracking, transverse cracking at 4 per mile.

**Metric conversions:**
1 mi. = 1.6 km.
1 ft. = 0.3 m.
1 in. = 25 mm.

*Pavement elements listed in "date" column indicate pavement under construction.*
**PERFORMANCE SUMMARY SHEET**

- **Project:** 0207-016-102, C501
- **County:** Caroline
- **Study Project No.:** 5
- **Length:** 4.437 mi.
- **Design Traffic (EAL-18):** 919
- **Design Thickness Index:** 13

**Materials:**
- **Surface:** 100 psi Bit. Conc. Type B-3
- **Base:** 6" Bit. Conc. Type B-3
- **Subbase:** 6" Subbase
- **6" cement stab.

**Performance Rating:** Poor

**Cost per mi.:** $78,552

**Remarks:**

**Metric conversions:**
- 1 mi. = 1.6 km.
- 1 ft. = 0.3 m.
- 1 in. = 25 mm.

* Pavement elements listed in "date" column indicate pavement under construction.
<table>
<thead>
<tr>
<th>Date</th>
<th>Dyna Deflection (1/1000 in.)</th>
<th>No. Tests</th>
<th>Spreadability</th>
<th>Thickness Index</th>
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<th>Cracking Factor</th>
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<td>15+</td>
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</table>

**Notes:**
- Performance Rating: Excellent
- May 13, 1975 - Cracking and water seepage from one saturated area in passing lane. Otherwise in excellent condition.
- March 1976, a few longitudinal cracks.

**Remarks:**
- Pavement elements listed in "date" column indicate pavement under construction.

**Conversion:**
- 1 ml. = 1.6 km.
- 1 ft. = 0.3 m.
- 1 in. = 25 mm.

**Cost per ml.:** $89.707
**PERFORMANCE SUMMARY SHEET**

Project: 7360-019-102, C501  
Study Project No.: 7A  
County: Charlotte  
Length: 4,486 mi.  
Design Traffic (EAL-18): 977  
Design Thickness Index: 11.5

From: 2.014 mi, S. Int, Rte. 40  
To: 1.263 mi, W. Prince Edward C.L.  
Completion Date: Dec. 1965

![Diagram of road cross-section with layers labeled: Surface, Base, Subbase, 6'' Sel., 6'' cement stab, subgrade.](image)

<table>
<thead>
<tr>
<th>Date</th>
<th>Dynaplect Deflection (1/1000 in.)</th>
<th>No. Tests</th>
<th>Spreadability</th>
<th>Thickness Index</th>
<th>Avg. Daily EAL-18</th>
<th>Cracking Factor</th>
<th>Cost per mi.</th>
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<td>0.899</td>
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<td>—</td>
<td>—</td>
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</table>

Performance Rating: Fair  
Cost per mi.: $70,752

Remarks: May 12, 1975 - General rutting, longitudinal and alligator cracking throughout, frequent tranverse cracking at about 25' intervals.  
October 1977, some rutting is evident.

* Pavement elements listed in "date" column indicate pavement under construction.

Metric conversions:  
1 mi. = 1.6 km.  
1 ft. = 0.3 m.  
1 in. = 25 mm.  

---
**PERFORMANCE SUMMARY SHEET**

**Project:** 7360-019-102, C501  
**County:** Charlotte  
**Study Project No.:** 71B  
**Length:** 4,486 mi.  
**Design Traffic (EAL-18):** 977  
**Design Thickness Index:** 13.4

**From:** 2,014 mi, S, Int, Rte, 40  
**To:** 1,263 mi, W, Prince Edward C.L.  
**Completion Date:** Dec. 1965

---

**Surface** 1/2" Blt.  
**Binder** 2" Blt. Conc.  
**Base** - 4" cr. agg. Cement  
**Subbase** - 4" subbase mat'l  
**6" Cement Stab., Subbase**

---

<table>
<thead>
<tr>
<th>Date</th>
<th>Dynafect Deflection (1/1000 in.)</th>
<th>No. Tests</th>
<th>Spreadability</th>
<th>Thickness Index</th>
<th>Avg. Daily EAL-18</th>
<th>Cracking Factor</th>
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</table>

**Performance Rating:** Fair  
**Cost per mi.:** $73,075

**Remarks:** May 12, 1975 - Transverse cracking at 15'-20' intervals throughout traffic lanes. No cracking in passing lanes.  
Occasional longitudinal cracking in traffic lanes. Pumping location detected in 1971 seems to have gotten very little worse. This design partially overlaid in 1976.

---

* Pavement elements listed in "date" column indicate pavement under construction.  
** Passing lane (no cement in 4" subbase layer of crushed aggregate).
Project: 7360-019-102, C501
From: 2.014 mi, S, Int, Rte, 40
To: 1,263 mi, W, Prince Edward C, L,
Completion Date: Dec, 1965

PERFORMANCE SUMMARY SHEET
County: Charlotte
Study Project No.: 7C
Length: 4.486 mi.
Design Traffic (EAL-18): 977
Design Thickness Index: 13.4

* Date | Dynaflect Deflection(1/1000 in.) | No. Tests | Spreadability | Thickness Index | Avg. Daily EAL-18 | Cracking Factor |
--- | --- | --- | --- | --- | --- | --- |
4-5-66 | 0.432 | 20 | | | | |
4-11-67 | 0.486 | 20 | 70 | 15+ | 385 | 373 |
5-6-68 | 0.436 | 20 | 79 | 15+ | 383 | |
4-21-69 | 0.608 | 20 | 77 | 15+ | 415 | 16 |
4-20-71 | 0.545 | 20 | 79 | 15+ | 577 | 22 |
5-15-72 | 0.387 | 20 | 78 | 15+ | 464 | |
3-28-73 | 0.497 | 20 | 82 | 15+ | 467 | — |
3-13-74 | 0.387 | 20 | 80 | 15+ | 518 | — |
4-11-67** | 0.687 | 20 | 63 | 9.5 | — | — |
4-21-69** | 1.050 | 20 | 65 | 8.5 | — | — |
3-15-76 | 0.535 | 20 | 79 | 15+ | 427 | 15 |
3-8-77 | 0.489 | 20 | 76 | 15+ | N/A | 35 |

Performance Rating: Good
Cost per mi.: $72,230

Remarks: May 12, 1975 - Transverse cracking throughout traffic lanes.
Occasional longitudinal cracking in traffic lanes. No cracking in passing lanes.

Metric conversions:
1 mi. = 1.6 km.
1 ft. = 0.3 m.
1 in. = 25 mm.

* Pavement elements listed in "date" column indicate pavement under construction.
** Passing lane (no cement in 4" layer of crushed aggregate).
PERFORMANCE SUMMARY SHEET

Study Project No.: 7-D

Length: 4.486 mi.

Design Traffic (EAL-18): 977

Design Thickness Index: 13.4

Completion Date: Dec. 1965

County: Charlotte

From: 2.014 mi. S. Int. Rte. 40

To: 1.263 mi. W. Prince Edward C.L.

<table>
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<tr>
<th>Date</th>
<th>Dynaflect Deflection (1/1000 in.)</th>
<th>No. Tests</th>
<th>Spreadability</th>
<th>Thickness Index</th>
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Performance Rating: Excellent

Cost per mi.: $77,141

Remarks: May 12, 1975 - Trace longitudinal cracking in outer wheel paths of traffic lanes. Excellent condition otherwise.

Metric conversions:
1 mi. = 1.6 km.
1 ft. = 0.3 m.
1 in. = 25 mm.

* Pavement elements listed in "date" column indicate pavement under construction.