Experimental Composite Pavement in New Jersey

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An experimental composite pavement design was constructed in New Jersey in 1963. The terrain involved is essentially marshland. This route is one of New Jersey's most heavily traveled; presently carrying approximately 80,000 vehicles daily, of which 17 percent are in the heavy truck category.

A composite design was chosen as that which would most likely satisfy the requirements of a highway in this area. That is, a pavement that would provide inherent stability to carry the exceptionally heavy traffic, as well as surface continuity, for a relatively long period of time with a minimum of maintenance.

Over the 42-month period of operation thus far observed, the composite pavement has performed in accordance with design objectives. There has been an average total settlement of 0.06 ft in this period, most of which occurred within the first 18 months of service. Maintenance has been negligible thus far.

•THIS paper concerns a composite pavement design constructed on Route 3 in New Jersey. The subject pavement was designed in the latter part of 1961 and construction was completed in the middle of 1963. Because of the unique pavement design proposed for this project, the Bureau of Public Roads requested the New Jersey Department of Transportation to consider it as an experimental project. It was agreed that the State would study the behavior of the composite pavement design and report annually on the observations and collected data. The completed project has been reported on at periodic intervals of 1½, 2½, and 3½ years since construction.

The basic reporting methodology agreed on consists of: (a) traffic data including loadings, (b) determination of the serviceability index, (c) deflection measurements, (d) settlement determinations, (e) concrete base performance, and (f) bituminous concrete surface performance.

The composite pavement design was used on a portion of the projects in New Jersey involving the Route 3 and New Jersey Turnpike approach complex to the Lincoln Tunnel, connecting New Jersey with New York. Several factors influenced the use of a composite design rather than a conventional design in the approach section of the Route 3 crossing of the Hackensack River. The terrain over which this portion of the highway was constructed is meadowland; the subsoils consisted of thin varved layers of silt, clay, and sand. Approximately 12 feet of organic peat and muck overlaid the underlying soils.

Because of the urgency of the need for improvements to the overall approach complex, the following factors were involved in the design of the pavement section:

1. In 1961, Route 3 over the Hackensack River was carrying approximately 80,000 vehicles daily, and about 17 percent of these vehicles were in the heavy truck category. Therefore, it was imperative that the pavement section be of an unusually sturdy construction so that it remain virtually trouble-free and require an absolute minimum of maintenance over a relatively long period of time.

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2. A decrease in construction time was desirable and could be accomplished by removal and replacement of the organic peat and muck with Zone 2 material (open-graded quarried or bank-run material, 0 to 8 percent passing No. 200 mesh), placing a normal earth embankment and constructing a pavement thereon. However, this type of construction would not permit preconsolidation of the underlying compressible materials.

3. Serious doubts existed as to the advisability of employing New Jersey's standard design of reinforced concrete pavement (78 ft 2 in. slab length) because of the compressible nature of the underlying soil and the possibility of appreciable differential settlements causing serious cracking.

4. Investigations and studies, available at that time, of the performance of flexible pavements on major trucking routes in New Jersey, on the AASHO Road Test, and on sections of the New Jersey Turnpike in the area of this project, led to uncertainty as to the adequacy of any conventional flexible pavement under the extreme traffic conditions of this project.

5. Bituminous surfacing materials are apparently capable of satisfactorily carrying heavy truck traffic and remaining crack free, provided they are on a very stable foundation. This was borne out by the outstanding performance of the pavements on two rehabilitation projects which involved thick overlays placed on existing concrete pavement. In both instances, the existing pavement was badly cracked, depressed, and undergoing pumping. An overlay consisting of a 3-in. FA-BC-2 surfacing on 8 in. of macadam base, on 3 in. of essentially stone screenings, was constructed on US 22 between Somerville and Chimney Rock in 1952, and is still in satisfactory condition. In the northbound roadway of US 130, in the vicinity of Deans, an overlay was constructed in 1949 consisting of a 2-in. FA-BC-1 surfacing on 3 in. of penetration macadam, on 6 in. of macadam base, on 5 in. of bank-run gravel. This overlay, under considerable heavy truck traffic, is also still in satisfactory condition, whereas, a then-considered relatively high-type flexible section constructed in the northbound roadway is now very badly cracked, appreciably rutted, and exhibits numerous areas of localized settlement.

The particular design objectives for use of a composite pavement on this project were as follows:

1. To maintain the structural integrity of surface despite an anticipated differential settlement resulting from the deep fill and the compressible nature of the underlying soil.

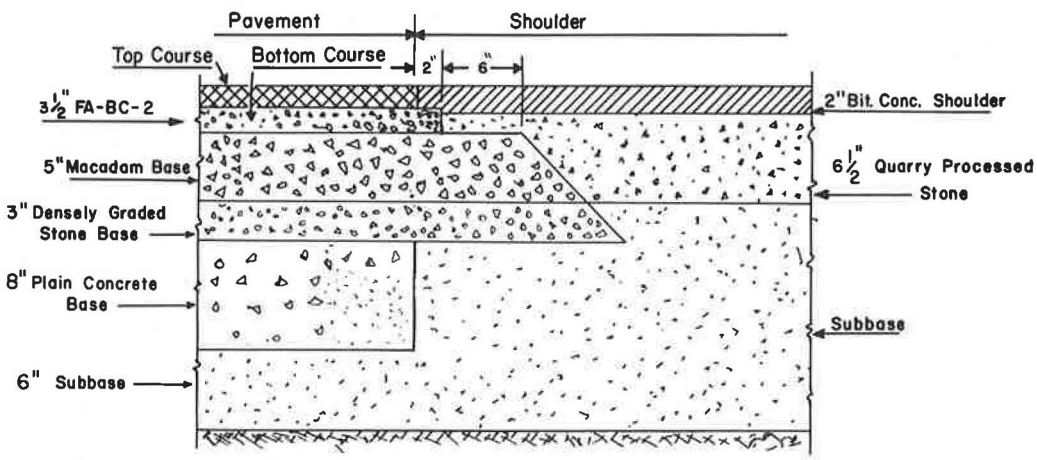

Figure 1. Experimental composite pavement section.

2. To achieve the high load-carrying capacity of a rigid pavement necessitated by the large volume of heavy truck traffic.
3. To achieve the continuity of surface of a flexible pavement.

The section of the mainline composite pavement and shoulder, designed on these principles, is shown in Figure 1.

Contraction joints, providing aggregate interlock load transfer, were constructed in the concrete base at intervals of 15 ft. A 3-in. base of densely graded stone was applied between the concrete base and the 5-in. macadam base. This was to act as a buffer to prevent the reflecting of cracks from the concrete base up into the 3 ½ in. of FA-BC-2 surface pavement.

Several construction contracts were associated with the approach complex to the Lincoln Tunnel. Reporting is limited to the Route 3 westbound roadway on the east side of the Hackensack River. The available initial data on the west side of the river and the eastbound roadway are not sufficient for analysis.

Construction cost of the pavement for the initial contract amounted to $12.39 per square yard. This cost, much higher than originally anticipated, was attributed to the inexperience of the contractor with this type of pavement. In subsequent contracts, the cost was reduced to $9.85 per square yard. A high-type bituminous concrete pavement or a reinforced portland cement concrete in New Jersey averages approximately $6.00 to $9.00 per square yard.

The two-way AADT experienced on this portion of Route 3 for the indicated periods were 1963—80, 400 vehicles; 1964—83, 890 vehicles; 1965—84, 730 vehicles; and 1966—83, 460 vehicles.

The truck percentage for westbound Route 3 was 19.0 percent (approximately constant for the 1964-1966 period) with an approximate lane distribution of: lane 4 (inside left)—6.0 percent, lane 3—32.0 percent, lane 2—43.0 percent, and lane 1 (outside right)—19.0 percent.

Route 3 westbound was constructed on new alignment and completed in mid-1963. While existing Route 3 was being rehabilitated to accommodate eastbound traffic, from July 2, 1963, to May 27, 1964, the completed Route 3 westbound was divided into five lanes, each 10 ft wide, and was utilized for both eastbound and westbound traffic. During this period, it was subjected to approximately 3,505,056 eighteen-kip equivalent axle repetitions. Since May 28, 1964, the roadway has been used exclusively as four lanes for westbound traffic. The accumulated by-lane 18-kip equivalent axle repetitions since May 28, 1964, up to November 29, 1966, the date of the latest surveys, are lane 4 (inside left)—276,059, lane 3—1,472,311, lane 2—1,979,230, and lane 1 (outside right)—874,188—making a total of 4,601,788 eighteen-kip equivalent axle repetitions.

The relatively high traffic-load condition for the initial period up to May 1964 is due to the fact that the route carried traffic in both directions.

Roughometer surveys were conducted periodically on all lanes of the approach section of the Route 3 crossing of the Hackensack River from July 1963 (prior to opening to traffic) to November 1966 (latest survey). The first three surveys were conducted by personnel of the Structural Research Division of the Bureau of Public Roads. The latest survey was conducted with the assistance of the Port of New York Authority. Although no acceptable roughness levels have been established for New Jersey using a BPR-type roughometer, limited roughness data are available for both the reinforced portland cement concrete and bituminous concrete pavement types. The measured values obtained for the subject composite pavement are within the limits of the available data. Virtually no change was found in the pavement roughness and the serviceability index since construction.

TABLE 1

AVERAGE PERIODIC DEFLECTION MEASUREMENTS

Date	Deflections (thousandths of an inch)	
	Joints	Midpoints
Dec. 1963*	5	5
May 1965*	8	7
Oct. 1965	7	7
June 1966	7	7
Nov. 1966	7	6

*7,500-lb wheel load.

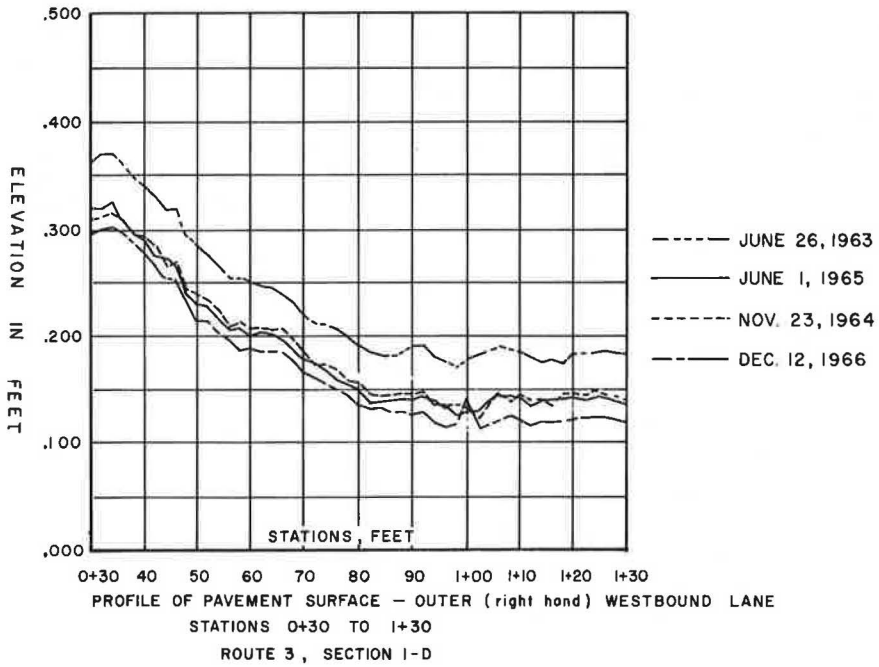

Figure 2.

Periodic Benkelman beam surveys have been made on the outside (right) and inside (left) lanes of the Route 3 westbound roadway east of the Hackensack River since the inception of the study. Initially, a 7,500-lb wheel load was employed. The more recent surveys were made with a 9,000-lb wheel load. Deflections were obtained in the right wheelpath of the outside (right) lanes at contraction joints (aggregate interlock load transfer), construction joints (no load transfer), and midpoints of the concrete base slabs. Table 1 gives the average periodic deflection measurements.

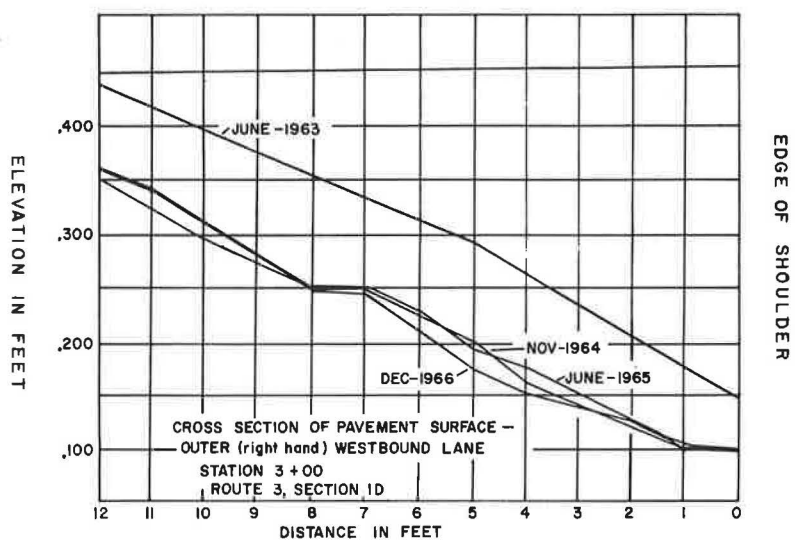

Figure 3.

Available limited data for other New Jersey pavements indicate deflection ranges of 0.01 to 0.03 in. and 0.006 to 0.010 in. for bituminous concrete and portland cement concrete pavements, respectively. The deflections observed thus far on Route 3 indicate they are well within acceptable limits.

Periodic close interval profile and cross-section readings have been taken on Route 3, Section 1 D—the section to which this report pertains. Figure 2 shows a portion of a typical profile as of June 1963 (as constructed), November 1964, June 1965, and December 1966. Figure 3 indicates a portion of a typical cross section taken on the above dates.

The settlement observed thus far has been approximately 0.06 ft. Most of this settlement took place during the first 18 months.

Visual inspections of Route 3, Section 1 D were made in November 1963, January 1966, and March 1967. These inspections revealed no significant defects in the composite pavement. Several very minor longitudinal cracks were observed. They are not considered as being detrimental to the overall performance of the composite pavement. No transverse cracking of the pavement has been observed, except immediately adjacent to the structure. This absence of transverse cracking in the surface indicates the buffer layers of densely graded stone and macadam are preventing the contraction joints of the concrete base from being reflected into the surface. Maintenance thus far has been negligible. Some minor patchwork was accomplished at the structure because of pavement settlement.

Profile surveys and visual inspections have shown no unusual conditions in the performance of the composite pavement. Therefore, no intimate study of the concrete base has been undertaken. All joint locations have been marked, however, and if necessary, excavations can be made to determine the condition of the joints and the performance of the base.

Over the 42-month period of operation thus far observed, the composite pavement has performed in accordance with the original design objectives, namely:

1. To maintain the structural integrity of surface despite an anticipated differential settlement resulting from the deep fill and the compressible nature of the underlying soil.
2. To achieve the high load-carrying capacity of a rigid pavement necessitated by the large volume of heavy truck traffic.
3. To achieve the continuity of surface of a flexible pavement.

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