PERFORMANCE EVALUATION OF
TRINIDAD ASPHALT CEMENT FOR
BITUMINOUS CONCRETE RESURFACING

MICHIGAN

RESEARCH LABORATORY SECTION

**MICHIGAN DEPARTMENT OF
STATE HIGHWAYS AND TRANSPORTATION**

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The purpose of this study is to evaluate the relative performance of Trinidad asphalt – asphalt cement blend compared with conventional 85-100 penetration grade asphalt in bituminous concrete overlays. The study was divided into three major phases: First, preconstruction condition surveys were conducted showing all surface defects in the existing pavement. Measurements of skid resistance and riding quality of the test area were also recorded. Second, during construction, daily inspections of plant production and paving operations were conducted. Rolling temperature and nuclear density readings were also recorded at random locations in each test section. Third, post-construction seasonal surveys and field inspections have been continued, keeping records of progressive cracking, skid resistance, and riding quality for comparative evaluation.

The selected test area lies in Roscommon County and consists of 4.9 miles of four-lane divided highway on US 27 from Snowbowl Rd, northerly to the M 55 crossover. The resurfacing work in the test area began on June 13, 1974 and was completed August 2. Design characteristics, condition surveys, construction procedures, comparative costs, and results of initial field testing were presented in MDSHT Research Report R-962. Recent data from this project, and cost estimates, are discussed in detail in this report.

Skid Tests

Figure 1 summarizes the skid test results obtained in August 1974, after resurfacing and recent tests conducted September 1975. The skid data indicate the following:

Material	Coefficient of Wet Sliding Friction (wsf) Values						Increase in wsf, percent
	1974			1975			
	Low	High	Avg	Low	High	Avg	
Trinidad Asphalt (6.0%)	0.42	0.59	0.52	0.53	0.64	0.60	15
Trinidad Asphalt (6.5%)	0.48	0.63	0.54	0.55	0.65	0.60	11
Conventional Asphalt (6.0%)	0.51	0.62	0.54	0.55	0.66	0.60	11

Both Trinidad and conventional resurfacings showed improved friction levels to an average wsf value of 0.60 which is categorized as satisfactory.
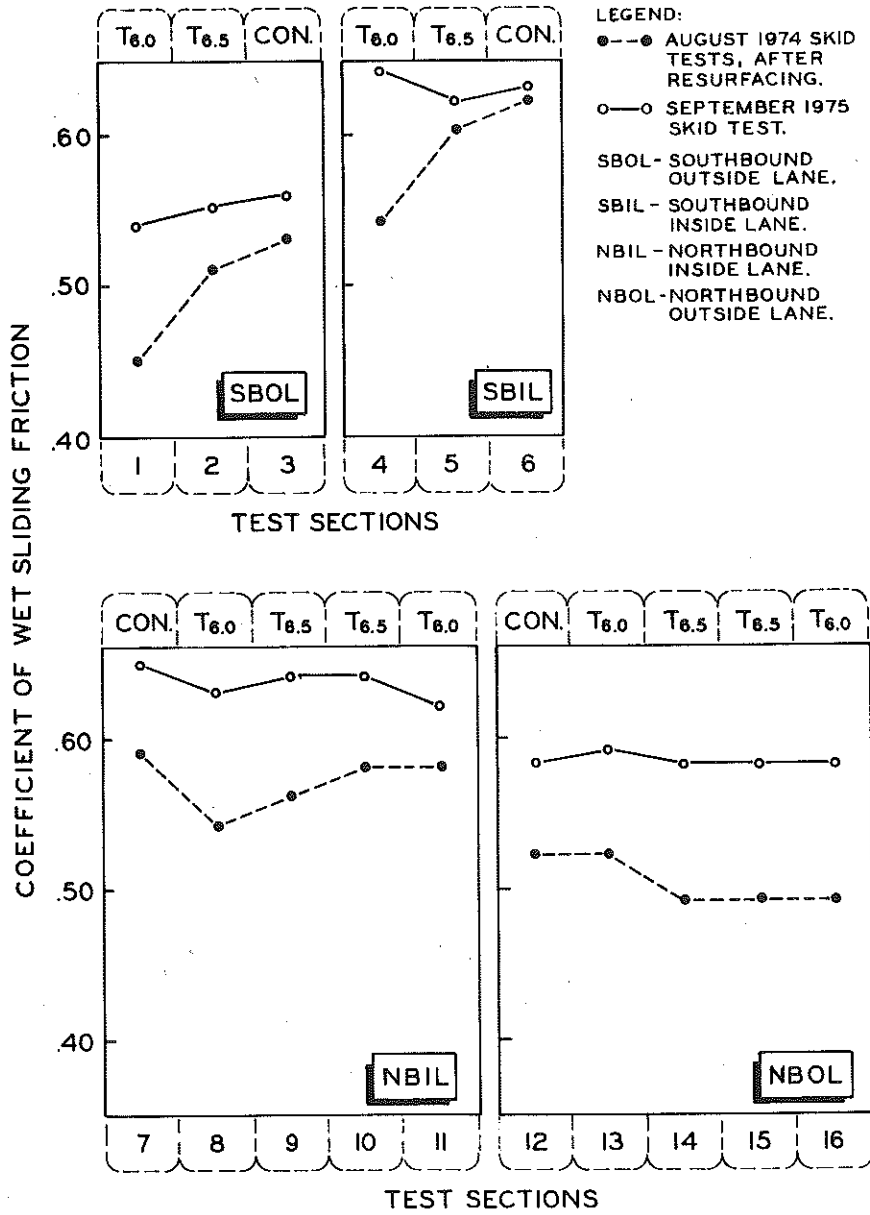
Figure 1. Summary of skid resistance data. Construction Project Mb 72013/06140A. Each test point represents the average of three tests per section.

Riding Quality

Riding quality results in terms of accumulated vertical inches of displacement per mile of pavement (surface roughness) are summarized in Figures 2 and 3. These data obtained in August 1974, after resurfacing the test area, and later in September 1975, were recorded over pavement segments, each about 1,000 ft long. The data indicate the following:

Material	Roughness, inches per mile						Increase in Roughness, percent
	1974			1975			
	Low	High	Avg	Low	High	Avg	
Trinidad Asphalt (6.0%)	127	153	134	130	164	141	5
Trinidad Asphalt (6.5%)	125	149	136	131	153	140	3
Conventional Asphalt (6.0%)	125	162	135	129	155	140	4

Both Trinidad and conventional resurfacings showed an increase in surface roughness, averaging 140 accumulated inches per mile; this average roughness is still within the limits of satisfactory quality.

Progressive Cracking

Figure 4 summarizes the results of transverse cracks reflected through the asphaltic concrete overlay during a two-year service period. The charts show how the test sections compare in percent of cracking and in rate of crack growth. Thus, for resurfacing with wearing course only, reflection cracking increased at an annual rate ranging from 3.5 to 22.0 percent for Trinidad sections, and 8.0 to 12.5 percent for conventional sections. This suggests better crack control in the conventional than in the Trinidad sections. On the other hand, for resurfacing with both leveling and wearing courses, reflection cracking increased at an annual rate ranging from 1.5 to 5.5 percent for Trinidad, and 3.5 to 14.5 percent for conventional sections. This suggests better crack control in the Trinidad than in the conventional sections.

Furthermore, the crack surveys conducted in July 1976 showed longitudinal cracks developed as follows: 216 lin ft over Trinidad (6.0 percent), 34 lin ft over Trinidad (6.5 percent), and 66 lin ft over conventional; both Trinidad and conventional showed less than 1 percent of the total longitudinal cracking before resurfacing. Alligator or map cracking have not yet developed over the test area. Crack propagation as a function of time (rate
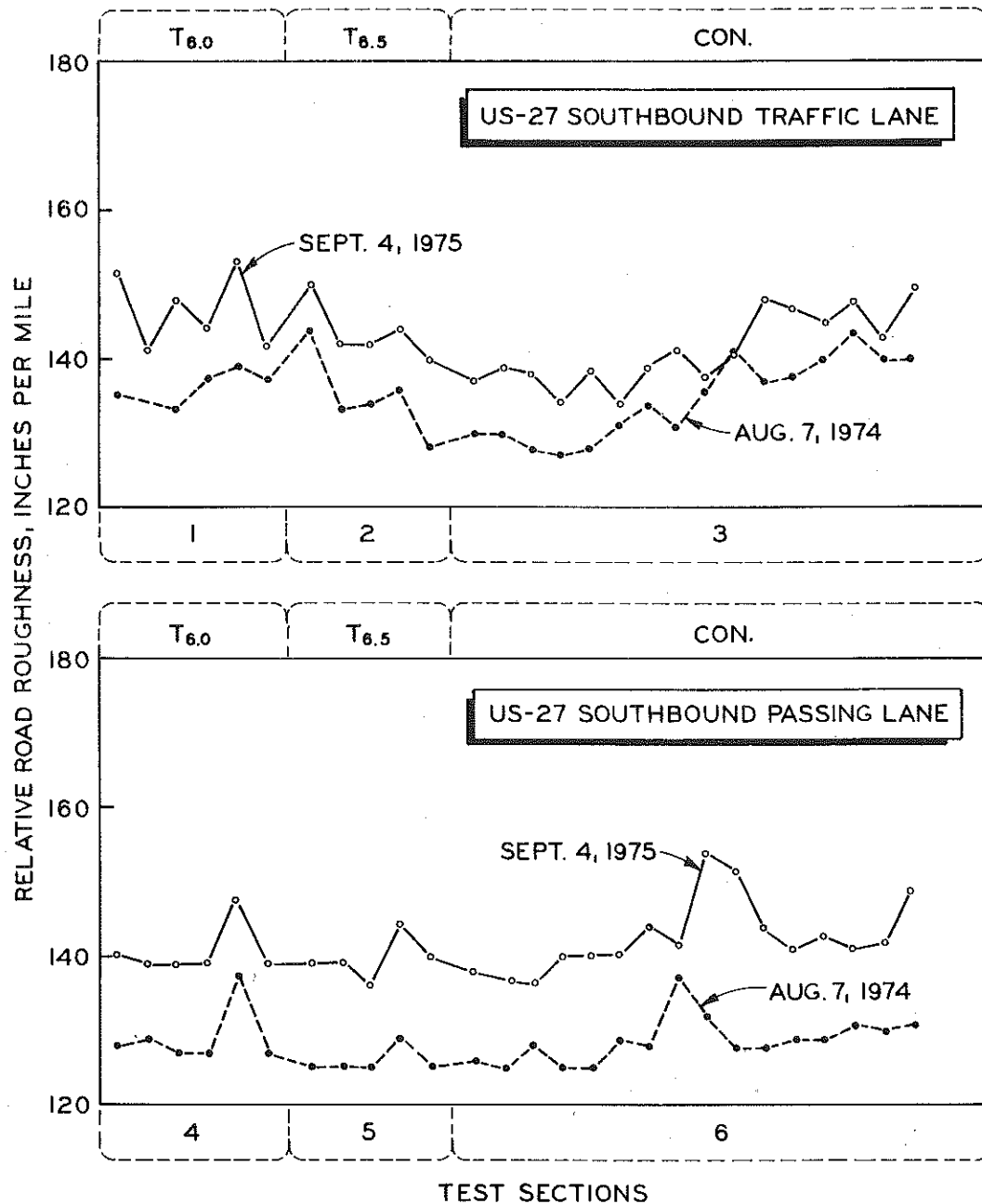
Figure 2. Summary of roughness data. Construction Project Mb 72013/06140A. Each test point represents approximately 1,000 lin ft of pavement.
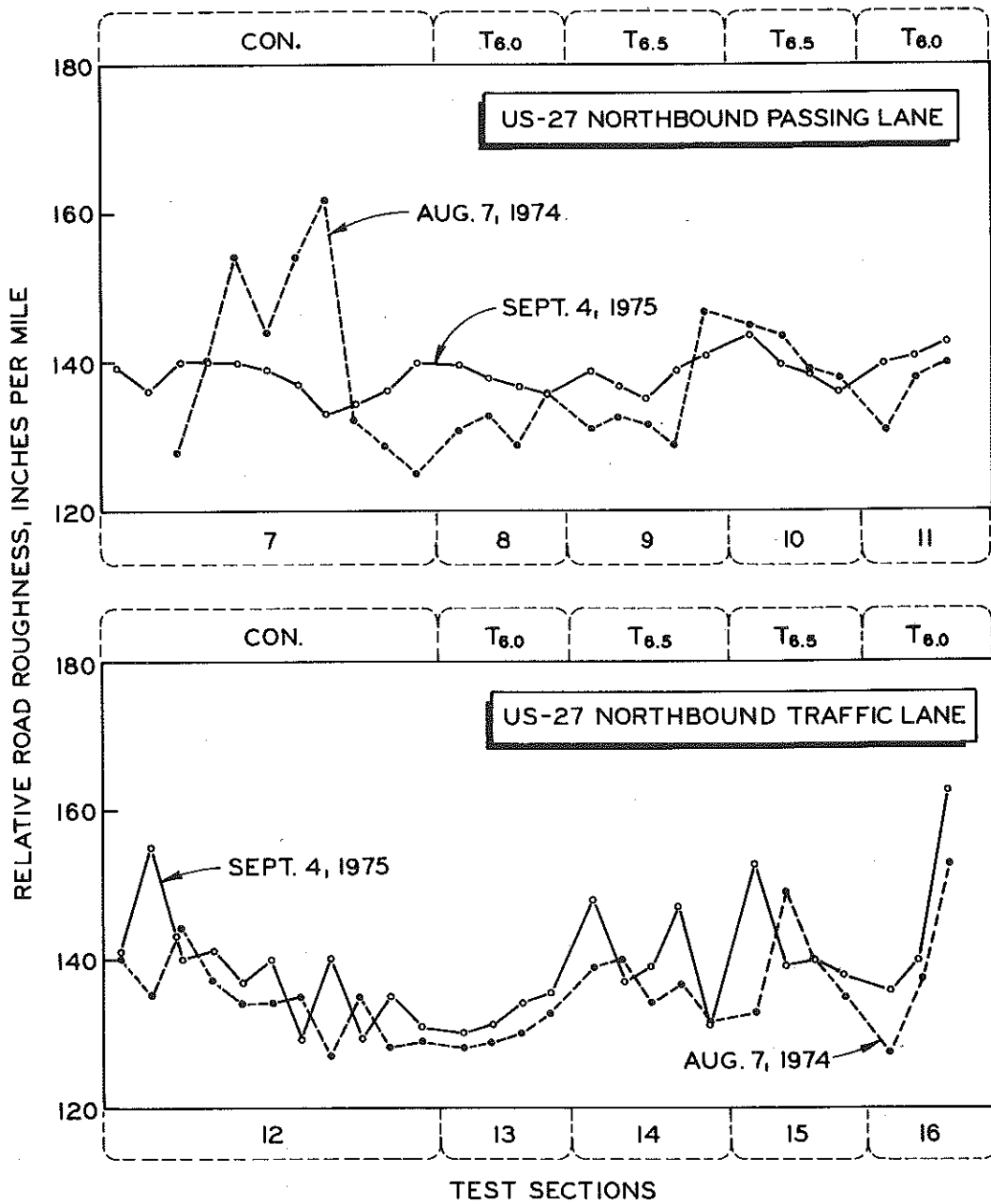
Figure 3. Summary of roughness data. Construction Project
Mb 72013/06140A. Each test point represents approximately
1,000 lin ft of pavement.
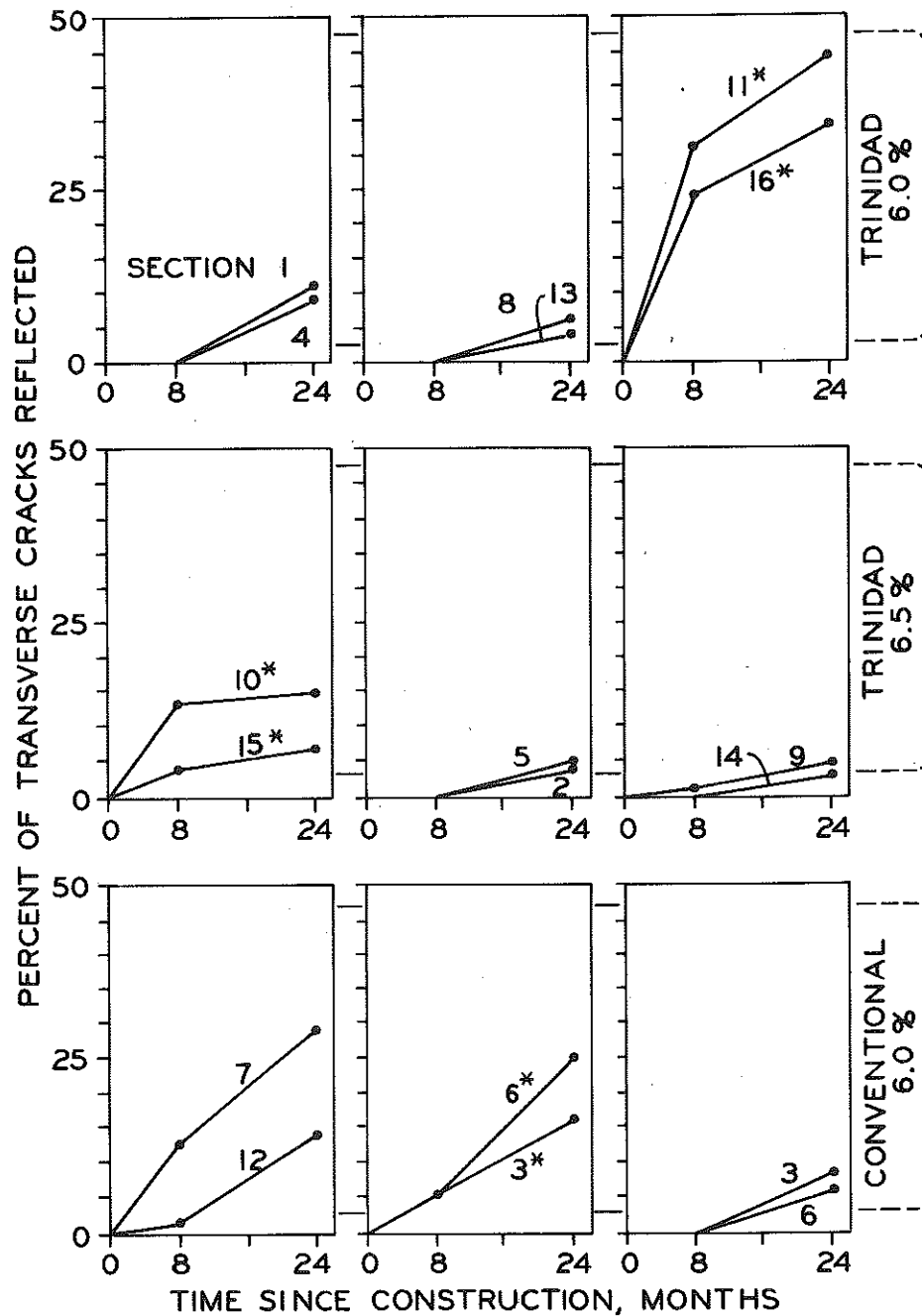
RESURFACING CONSISTED OF WEARING COURSE ONLY. ALL OTHER
SECTIONS CONSISTED OF BOTH LEVELING AND WEARING COURSES.
SECTIONS 3 AND 6 CONSISTED OF BOTH SINGLE-COURSE (40 PERCENT
OF LENGTH) AND TWO COURSE (60 PERCENT OF LENGTH) RESURFACING.

Figure 4. Rate of increase of transverse cracks reflected
through asphaltic concrete resurfacing over a two-year
period since construction.

of crack growth) usually follows exponential trends characterized by a slow increase at first, then more rapidly to nearly its maximum value, eventually tapering off its growth with time (1, 2, 3, 4, ·5).

Since reflection cracking through the experimental overlays seems to be following such exponential trends (Fig. 4), monitoring this development should provide meaningful data in the evaluation of overlay performance. Experience shows that an accelerated progressive cracking might be expected after four to six years of pavement service since construction.

In summary, based on Departmental standards and on currently available methods of rating pavements (6, 7), none of the above performance characteristics (skid tests, riding quality, progressive cracking) nor other pavement distresses have yet exhibited any meaningful trends. Therefore, the superiority of one overlay over the other has not been established.

Cost Comparisons

An important consideration in this study is the economical solution to the problem of reflection cracking. Perhaps most important is a cost-benefit analysis based on the construction costs of materials in-place and on surface durability in resisting cracking, deformation, and other pavement failures.

The following paragraphs will explain briefly how construction costs, service life of bituminous overlays, and reflection cracking come together to provide a means of assessing the economic level of the two alternatives being investigated; Trinidad as compared with conventional asphaltic cement construction.

Table 1 summarizes the unit prices of the resurfacing work completed for this project, and also includes the service life required for Trinidad resurfacing to be economically equal to conventional construction. The basic economic analysis, assuming 10 years of service life for conventional asphalt, is shown in the Appendix.

Figure 5 shows the relationship between reflection cracking and required service life for both overlays to be economically equal.
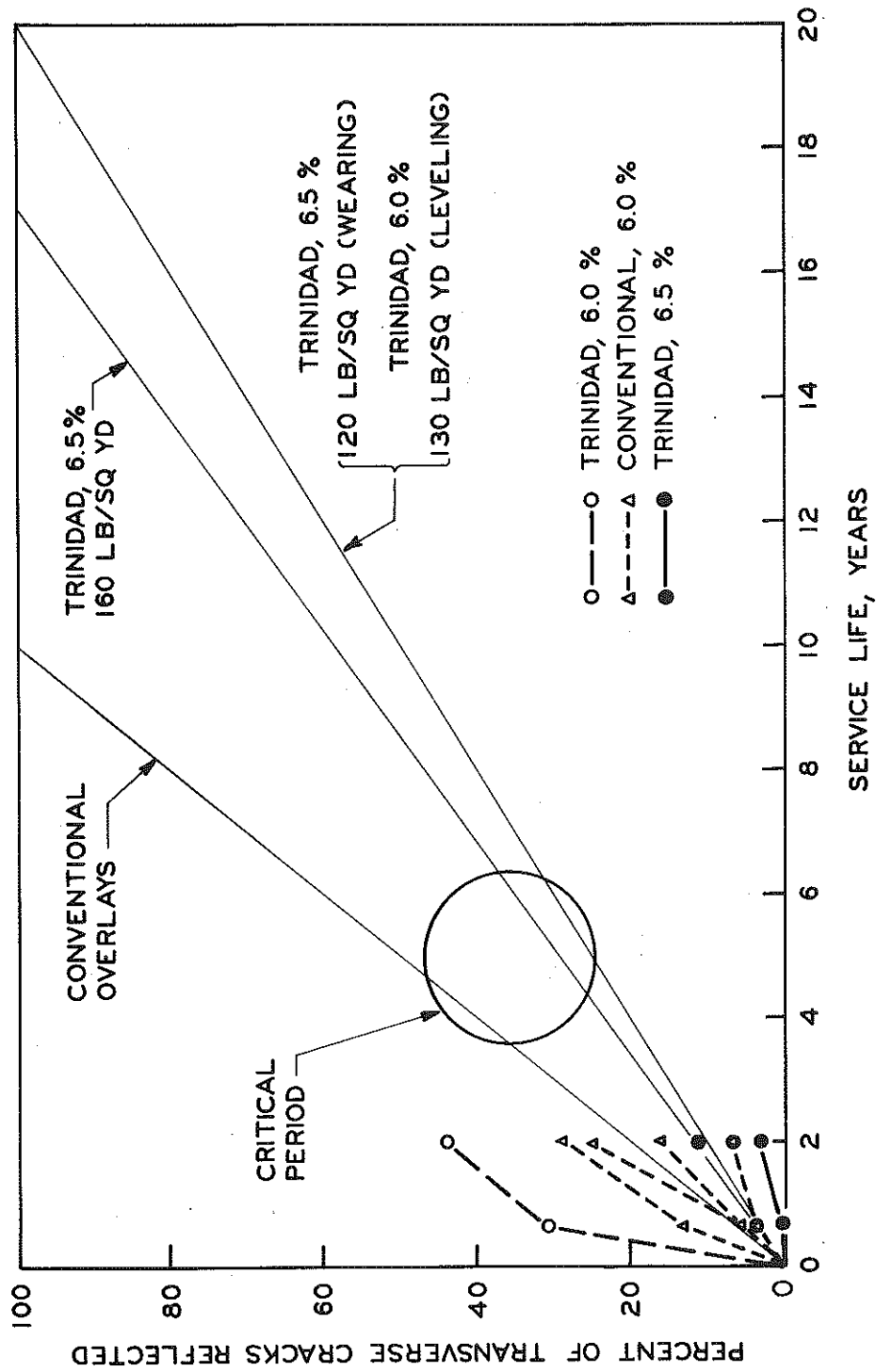
Figure 5. Relationship between reflection cracking and length of service in years for Conventional and Trinidad overlays to be economically equal as shown by the sloping lines for 10, 17, and 20 years, respectively.

TABLE 1
SUMMARY OF CONSTRUCTION COSTS USED TO ESTIMATE THE REQUIRED SERVICE LIFE OF TRINIDAD RESURFACING
(Construction Project Mb 72013)

Item	Unit Price, dollars/ton	dollars/ lane mile	Service Life, years [1]
Trinidad leveling course 25A 130 lb/sq yd	26.90	12,300	20
Trinidad wearing course Type M 120 lb/sq yd	27.20	11,500	
Conventional leveling course 25A 130 lb/sq yd	15.30	7,000	10 [2]
Conventional leveling course Type M 120 lb/sq yd	18.50	7,800	
Trinidad wearing course Type C 160 lb/sq yd	26.80	15,100	17
Conventional wearing course Type C 160 lb/sq yd	17.20	9,700	10 [2]

[1] Service life required for both Trinidad and conventional constructions to be economically equal. Basic economic analysis is shown in the Appendix.

[2] Service life of 10 years is assumed for conventional construction.

The relationship is based on the following assumptions:

1) Overlays are designed for a service life of a certain number of years during which a pavement is free from major maintenance. At the end of this period, pavement conditions have deteriorated so seriously (cracking, rutting, roughness, etc.) that some type of rehabilitation is needed.

2) Based on construction costs of Table 1 and on an assumed service life of 10 years for conventional construction, the economic analysis shown in the Appendix requires that Trinidad overlays have 17 to 20 years of ser-

vice life. This means that if the overlay performance exceeds this period without pavement rehabilitation, then Trinidad would be more economical than conventional construction.

3) Total transverse cracks developed and recorded in the old pavement before resurfacing have completely reflected through the overlay during the design or estimated service life.

Graphically, the above assumptions suggest that 100 percent reflection cracking and service life in years represent a logical relationship that should be joined by an upper horizontal line (Fig. 5). Note also that respective service lives for conventional and Trinidad overlays are joined to the origin (0, 0) by sloping lines (growth lines); this was done to simplify the interpretation of progressive cracking as a function of time (growth rate). In addition, resultant trends from plotted data should aid in selecting the best economical alternative for the conditions being investigated. For example, cracking trends above the growth line suggest a reduced service life, whereas below the growth line suggest an extended service life.

Furthermore, when reflection cracking results are plotted on Figure 5, cracking trends for both Trinidad and conventional overlays run on both sides of their respective growth lines, suggesting that results are still inconclusive to date and that further condition surveys are warranted.

Conclusions

1) Skid resistance, riding quality, and progressive cracking results over a two-year period are at practically the same level for both Trinidad and conventional construction; none of the above performance characteristics have developed any trend indicating superiority of one overlay over the other.

2) Cost-benefit considerations indicate that required service life for the experimental Trinidad construction is 17 to 20 years if a 10-year service life is assumed for conventional construction. If Trinidad performance exceeds this period without pavement rehabilitation, then Trinidad construction would be the more economical investment.

Recommendations

Two major points are recommended: First, that seasonal survey and field inspections of the experimental project should continue for at least three more years to monitor the period of rapid crack growth expected to occur after four to six years of pavement service; second, since Trinidad overlays do not offer any practical advantage over conventional practice at the present time, the additional cost for this type of construction is not justified.

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APPENDIX

Highway Economics

The general method of estimating annual cost of highways involves the following basic Equations ($\underline{8}$, $\underline{9}$, $\underline{10}$).

$$C_a = H + T + M + C_R \tag{A}$$

$$C_R = (C - V_s) \left(\frac{i(1 + i)^n}{(1 + i)^n - 1} \right) + i V_s \tag{B}$$

$$M = \sum_{n=1}^{n} \frac{C_1 + (n - 1) C_2}{(1 + i)^{n - 1}} \tag{C}$$

where

C_a = annual cost of highway operation and ownership

H = annual cost of administration

T = annual cost of highway operation associated with services to the traffic

M = annual routine maintenance costs

C_R = capital recovery with return on capital

C_1 = maintenance cost during the first year after initial overlay construction

C_2 = incremental increase in routine maintenance cost per year

C = construction cost

V_s = salvage value at end of n years

i = interest rate applicable to highway funds

n = service life expected after overlay construction

Where cost comparisons of two alternatives (Trinidad vs. conventional) are based on annual costs, the procedure to follow is to equate the annual costs to determine the unknown service life of the Trinidad alternative. Annual costs for H and T are practically identical for both alternatives and can be excluded without affecting the cost comparison. If the salvage value V_s of both overlays is zero, the basic equation (A) becomes:

$$C_a = M + \frac{c}{a_n}$$

where $\dfrac{1}{a_n} = \dfrac{i}{1 - (1 + i)^{-n}}$ has been tabulated in standard Compound Interest and Annuity Tables (11). Based on construction costs shown in Table 1 and on annual maintenance costs $C_1 = \$50/$lane mile and $C_2 = \$10/$lane mile during the cost-analysis, $n = 10$ years for conventional overlay, the expected service life of Trinidad is estimated as 17 to 20 years for maintenance costs less than 50 percent of conventional construction and capital recovery at 5.0 percent interest rate.