Pavement Costs and Quality

by Robert G. Packard

When it comes time to build or rebuild a road or street, the owner-agency needs answers to several questions: what type of pavement; initial cost and cost of upkeep; quality of service; how long will it last? This "consumer's report" summarizes recent information and references on these topics.

Pavement service life

Many state highway agencies have recorded service lives for different types of pavement. The average age of pavements prior to resurfacing varies considerably, but for concrete, it may be as much as 25 to 40 years. As shown in Table 1, this is about 1½ to 2 times greater than the service life of asphalt pavements. When economic analyses are made, a longer service life with low maintenance cost reflects the long-term benefits of concrete performance.

In addition to the longer service life, it is important to recognize that concrete pavements carry considerably more traffic because concrete is often selected for higher-traffic routes. A national survey of heavily trafficked pavements showed that concrete carried an average of four times more daily truck traffic than asphalt.[8]

Pavement performance

Besides keeping records of the service lives, most state highway departments track the performance of pavements throughout their life. Many have developed performance curves or equations. This information is useful for predicting remaining pavement life for life-cycle cost analysis. The examples given here are typical:

Washington: Based on comprehensive surveys of pavement conditions, age, and traffic, the performance curves shown in Fig. 1 were developed. It was found that new asphalt pavements decrease in condition rating about 150 to 200 percent faster than concrete pavements, and that asphalt overlays decrease about 50 percent faster than new asphalt pavements.[9]

Oregon: All concrete pavements on the state system are performing well, with some in service for more than 30 years. Older concrete pavements have carried two to six times more traffic than designed for, yet maintain serviceability indexes greater than 3.0 (good condition).[10]

Kentucky: Based on surveys of pavements constructed since 1962, 41 percent of concrete pavements have been overlaid at an average age of 20 years; 59 percent are still exposed and, of these, about half are 23 to 31 years old. Ninety-four percent of asphalt pavements have been overlaid at an average age of 12 years.[3]

Illinois: Concrete pavements on the Illinois Interstate System have performed far better than they were designed to do, lasting an average of 20 years during which time they carried 2.7 to 4.0 times the design truck traffic.[11]

Louisiana: A study of pavements constructed between 1963 and 1967 showed that 14 percent of concrete pavements were overlaid at an average age of 18 years while 86 percent survive at an average age of 20. Seventy-seven percent of asphalt pavements were overlaid at 14 years.[12]

Service lives of overlays

Fig. 2, based on the Ohio DOT data,[13] shows the condition rating (PCR) of overlays over a seven-year period. Although none of the overlays has failed, asphalt's PCR is decreasing about 350 percent faster than concrete's. This loss is about the same as for the lower curve in Fig. 1, the performance prediction curve for asphalt overlays developed by the Washington SDOT.

Pavement costs

Due to the many variables involved, it is difficult to directly compare the costs of concrete and asphalt pavements. However, two notable examples of direct comparisons on the same stretch of roadways are available (same conditions of traffic, soils, climate, etc.).[14, 15] Although the cost data are dated, the comparison between concrete and asphalt is valid

Table 1 — Service life, years*

Agency (Refs. 1 - 7)	Concrete	Asphalt
Wisconsin	20 - 25†	12 - 14†
Minnesota	35	20 (12)‡
Kentucky	20+	12+
New York	20 - 25+	10 - 13
Colorado	27	6 - 12
FHWA (1985)	13 - 30	6 - 20
FHWA (1971)	25	15

* Heavy-duty highways.
† 25 percent longer if drained.
‡ 1½ in. overlay at 12 years; thick overlay at 20 years.

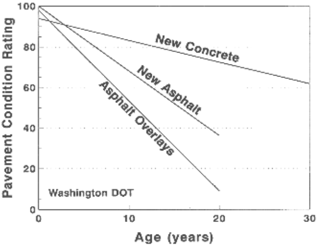

Fig. 1 — Washington's performance curves.

Table 2 — Life cycle cost analysis

Pavement type	Initial cost	Interim cost	Present worth, interim costs	Total life-cycle cost	Annual cost
Concrete (joint seal, 17.5 years)	$224,935	$6959	$3221	$228,156	$13,073
Asphalt, full depth (overlay, 20 years)	$212,378	$80,789	$33,503	$245,881	$14,087
Costs in dollars/mi., 4.5 percent discount rate, maintenance cost excluded.					

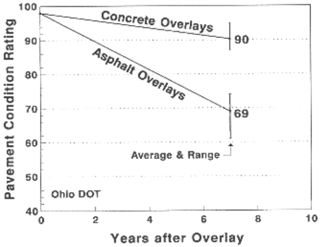

Fig. 2 — Ohio's overlay performance.

Table 3 — Rehabilitation costs

	Average life	Cost per mile	Cost per mile per year
Asphalt overlay (4 in.)	11.7 years	$62,790	$5367
Concrete overlay (6 in.)	23.2 years	$101,250	$4364

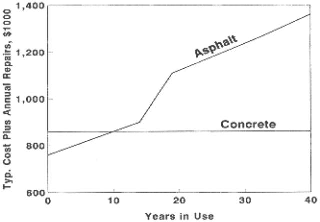

Fig. 3 — California cost data for streets (based on California State Controller's Office, Annual Reports on Local Streets and Roads).

in a relative way. On U.S. 77 in Oklahoma, concrete was initially more expensive than asphalt ($419,000 vs. $316,000 for 4 miles of each type); maintenance costs made up the difference. Asphalt maintenance for the 24-year period of the test totaled $128,000 including two resurfacings; concrete maintenance was $9545.

Indiana test results were similar. Asphalt was originally $3000 per mile cheaper than concrete, but maintenance brought the asphalt total to $79,835 per mile, while the total cost of concrete, including maintenance, was $71,315 per mile. These are actual costs without adjustments for interest and inflation.

Life cycle costs

The most effective method of comparing the costs of pavement types is by life-cycle cost analysis. This considers initial and future costs (maintenance and overlays) of each alternative by taking into account both the effects of inflation and interest rates over a specified pavement analysis period.

When concrete and asphalt pavements are both designed for the same conditions, concrete will usually, but not always, have a somewhat higher initial cost. However, on a life-cycle cost basis, the longer service life and low maintenance costs for concrete pavements usually result in an equal or lower present worth expenditure and annual cost for concrete. The example in Table 2 was developed by the highway department of a midwestern state.[16] This agency does not include routine maintenance costs which would have made a greater differential between concrete and asphalt.

Maintenance costs (routine annual costs excluding major rehabilitation) vary considerably depending on the pavement facility, age and condition of pavement, agency policy, availability of funds, and many other factors. They may vary from several hundred to several thousand dollars per mile depending on whether it is a road or street under local jurisdiction or a major roadway on a state's interstate system. In the latter case, the comparative cost between asphalt and concrete (average annual maintenance costs for the service life of pavement) may be about two or three to one.

For lower classifications, local agencies often spend very little on concrete maintenance so the ratio of costs rises to much higher values, perhaps as high as eight to one. Fig. 3 shows typical costs for California streets. Here, virtually no money was spent for concrete maintenance over a span of many years.

Rehabilitation costs

Table 3 shows the costs and service lives of asphalt and concrete overlays as reported in a 1989 survey of highway agencies.[17] Concrete did cost more initially, but with longer service life, the cost per year is less.

A similar situation exists for Iowa's county roads.[18] Five- or six-inch concrete overlays may cost up to 50 percent more than a 2 or 3 in. asphalt overlay, but the concrete would last at least twice as long. Based on publicly available information,[18] costs for whitetopping on Iowa county roads in 1993 average $36.40 per cubic yard of concrete plus $2.56 per square yard of pavement. This translates to $115,000 per mile for a 6 in. concrete overlay.

Equivalent designs

Initial costs, service lives, and rehabilitation costs all depend on the structural adequacy (thickness) of the pavement and subsequent overlays. Obviously, a pavement of inadequate design will have a lower first cost, but it will wear out faster and cost more to fix. Thus, when different pavement types are compared, it is vital that realistic and equitable designs be used. Design methods such as those provided in the 1993 AASHTO Guide[19] are a sound basis for making side-by-side comparisons using the same design inputs for both pavement types. This is conveniently done with the Pavement Analysis Software (PAS)[20] which computes thicknesses based on the 1993 AASHTO Guide. PAS is also used to make life-cycle cost comparisons.

Summary

The true value of any pavement, whether a major highway, city street, or local road, is determined by assessing several factors. As shown in this report, the best decision between pavement types of equivalent design is based not solely on initial pavement cost, but is almost always dependent on subsequent costs and length of service life.

References

1. "The Pavement Type Selection Process," Wisconsin Department of Transportation, Division of Highways, Nov. 1993.

2. "Method of Pavement Type Selection," Engineering Standards, Minnesota Department of Transportation, 1983 (current as of Jan. 1994).

3. Kentucky Bureau of Highways, Pavement Conditions Evaluation Form Sheets dated through 1993.

4. Vyce, John M., "A Life-Cycle Cost Analysis for Asphalt and Concrete Pavements," Special Report 82, Engineering and Development Bureau, New York State Department of Transportation, Feb. 1985.

5. Information from Colorado Department of Transportation, 1994.

6. Noel, L. M., "What Do Pavements Cost?," *Civil Engineering*, American Society of Civil Engineers, Nov. 1985.

7. Corvi and Houghton, "Service Lives of Highway Pavements — A Reappraisal," *Public Roads*, Federal Highway Administration, Aug. 1971.

8. Darter, M. I. and Barenberg, E. J., "Zero-Maintenance Pavements: Results of Field Studies on the Performance Requirements and Capabilities of Conventional Pavement Systems," FHWA-RD-76-105, Interim Report, Federal Highway Administration, April 1976.

9. Bednar, James, "Pavement Performance Curves: Four Case Studies," *Public Roads*, Federal Highway Administration, Dec. 1989.

10. Lundy, James R., "Rigid Pavement Performance Data," Oregon Department of Transportation, Nov. 1993.

11. Hall, K. T.; Darter, M. I.; and Rexroad, W. M.; "Performance of Bare and Resurfaced JRCP and CRCP on the Illinois Interstate Highway System — 1991 Update," Research Report 532-1, Illinois Department of Transportation, Oct. 1993.

12. Temple, W. H. and Boleware, D. A., "Life Cycle Cost and Loading Characteristics of AASHTO Designed Rigid and Flexible Pavements in Louisiana," TRR 1215, Transportation Research Board, 1989.

13. Ohio Department of Transportation, Pavement Condition Ratings 1984-1992.

14. Oklahoma Legislative Test Road, Oklahoma Highway Department Report to the Legislature, 1979.

15. "Indiana Test Road Progress Report Number 10," Indiana State Highway Commission, Jan. 1971.

16. Ofstead, E. E., "Applications of Life Cycle Cost Analysis; MNDOT Process for Pavement Surface Type Determination," Symposium on the Economics and Engineering of Concrete Pavements, University of New Brunswick, May 1989.

17. "The Cost of It All," *Better Roads*, Dec. 1989.

18. Smith, Gordon, "Whitetopping Spells Relief in Iowa," *Concrete Construction*, Nov. 1993.

19. *Guide for Design of Pavement Structures*, American Association of Highway and Transportation Officials, 1993.

20. "Pavement Analysis Software," American Concrete Pavement Association, MC016P, 1993.

Selected for reader interest by the editors.

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