LIFE-CYCLE PERFORMANCE

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The Asphalt Institute's life-cycle performance program now has and is developing a database to store and analyze life-cycle performance data and make it available to user agencies. So far, survey results show that asphalt pavements are performing better than previously reported.

Five Climatic Conditions

The program uses five climatic conditions—wet freeze, wet no-freeze, dry freeze, dry no-freeze, or all climatic conditions. The traffic, or functional, classification is divided into six different classes. Class 1 represents the basic residential street. The classification progresses upward to Class VI, which is heavy interstate. The construction level is composed of new, rehabilitation, or both. Fifty-four service life equations can be developed from the data using the various traffic, construction and climatic conditions for a PCR of 70.

Initial service life equations show that asphalt pavements are not only performing according to design life, which is normally 20 years, but can be maintained longer with routine maintenance, which may include crack pouring, surface treatments, milling and overlays of nominal aggregate size. Maintenance is not normally thought to add structural value to the pavement, but merely to restore surface for rideability, safety and environmental protection from the elements.

Performance Difference

Preliminary data also indicates a significant difference in pavement performance for various climatic conditions. The rehabilitation, or second phase performance, is also out-performing estimated design periods, which are normally 15 years. For major rehabilitation, often referred to as reconstruction, pavements are also lasting beyond their planned design life. A much longer life than that anticipated by the estimate of design life is seen for the total range of rehab projects.

As additional pavement sections are added to the database, including Superpave concepts and new quality control specs, asphalt pavements are expected to show even longer performance periods with less maintenance. The data will be available for further analysis not only by this program, but also by other procedures as well. By the end of 1998 more than 800 pavement sections were logged in the database. Ultimately, there will be several thousand pavement sections for the complete analysis of all criteria with respect to time.

Design Variables Follow AASHTO Lead

Over 35 state agencies use the American Association of State Highway and Transportation Officials (AASHTO) pavement design procedures, or some modification of them. Many larger city and county agencies also use this design procedure, or a standard section, for various streets and roadways based on it. All formal procedures, regardless of the source, attempt to address the common issues of design variables. Since the AASHTO procedure is used the most, it is a common reference on some of the major issues.

One of the first considerations in design is "design reliability," a statistically based factor that indicates how valid the design is for the input values. AASHTO provides a range of reliability factors based on traffic, as do other formal design procedures (See Table 1).

When higher reliability factors are used, the pavement design is proportionately thicker. Most agencies will select the 85 to 90 percent reliability for the higher traffic levels. A reliability factor of 87.5 percent is fairly common for most high-traffic designs. Having heavier traffic than expected in the design period often negates the design more than any other factor. Designing at 95 percent reliability or above is prohibited by cost for most agencies. Lower volume roads and streets typically specified by ordinance or standard sections fall into a 50 to 70 percent range of design reliability.

The preliminary data from the performance program shows a wider variation in the performance life of Classes I to III than for Classes IV to VI. The level of maintenance may not be as high for the lower volume roads, which

Table 1. Design Reliability Factors for Functional Classifications

Functional Classification	*Percent Recommended Level of Reliability* Urban	Rural
Interstate & Freeways	85 to 99.9	80 to 99.9
Principal Arterials	80 to 90	75 to 95
Collectors	80 to 95	75 to 95
Local (Low Volume)	50 to 80	50 to 80

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could contribute to a wider band in the performance curve. The Institute's traffic classifications are presented in Table 2. All facilities were placed into the appropriate traffic classification based on equivalent single axle load (ESAL) design zone.

Environment Affects Pavement Performance

Environmental factors can and do affect pavement performance, and extreme moisture and temperature variations appear to be the most common factors. When both are present, this combination can affect the strength and durability, as well as the load carrying capacity, of the structure. Prolonged exposure to these extreme conditions destroys the structural capacity of the roadway.

Aging effects under the various environmental conditions are normally degrading to the structural coefficients that are originally assigned to the materials. This has to be taken into consideration in long-term pavement performance. Level of maintenance is extremely important as environmental factors are considered, and may be an issue in the spread of performance on lower-volume roadways.

Timely Maintenance

The loss of serviceability, or a decrease in present condition rating, can be the result of both traffic and environmental factors. Appropriate and timely maintenance, which may include crack sealing, cross-slope, shoulder and general drainage improvements in conjunction with some surface restoration, can retard environmental effects on the loss of PCR.

Table 2. Traffic Classifications

Traffic	ESAL	Type of Class Street or Highway	Approximate Range-Number Of Heavy Trucks for Design Life
I	5×10^3	• Parking lots, driveways • Light traffic residential streets • Light traffic farm roads	<7,000
II	10^4	• Residential streets • Rural farm and residential roads	7,000 – 15,000
III	10^5	• Urban minor collector streets • Rural minor collector streets	70,000 – 150,000
IV	10^6	• Urban minor arterial and light industrial streets • Rural major collector and minor arterial highways	700,000 -–1,500,000
V	3×10^6	• Urban freeways, expressways and principal arterial highways • Rural interstate and other principal arterial highways	2,000,000 – 4,500,000
VI	10^7	• Urban interstate highways • Some industrial roads	7,000,000 – 15,000,000

Table 3. Projected Service Life of Hot Mix Asphalt[1]

Traffic Class	Type of Construction: New	Rehab	Both	Climatic Conditions: Wet Freeze	Wet No Freeze	Dry Freeze	Dry No Freeze	ALL
I	✓			X	X	X	X	24
I		✓		X	X	X	X	X
I			✓	X	X	X	X	18
II	✓			X	X	X	21	20
II		✓		X	9	X	17	13
II			✓	X	9	X	20	17
III	✓			9	X	47	27	23
III		✓		20	10	32	25	19
III			✓	16	11	39	27	21
IV	✓			18	X	36	X	34
IV		✓		41	34	X	35	46
IV			✓	30	X	43	33	39
V	✓			37	31	X	X	49
V		✓		24	38	27	X	29
V			✓	34	38	38	15	35
VI	✓			X	X	X	X	X
VI		✓		26	21	25	X	25
VI			✓	32	21	29	X	28

[1] Service life projected to a PCR of 70 indicates surface restoration be considered.
X = insufficient data

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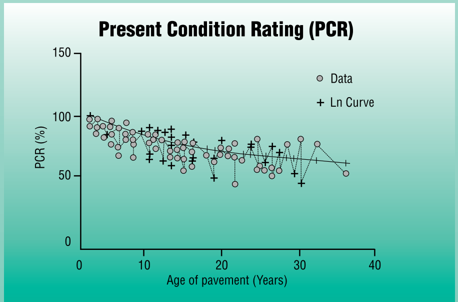
The pavement sections for climatic conditions of dry freeze and dry no-freeze appear to have the best overall service life, based on this preliminary data. Right now the study is short on projects from the dry no-freeze region. The projected service life for a PCR of 70 is presented for the classifications that have a significant amount of data (See Table 3). As more data is collected, current values are expected to change. Normally, as the R2 of the correlation equation increases, the projected service life decreases up to a given point. For some of the cells, there's not enough data to make a valid correlation. The categories of all climatic conditions and both categories for the construction level, should provide an overall estimate of the life expectancy of each roadway facility, before major rehabilitation or reconstruction will be required.

Figure 1. Typical Service Life Decay



Service Life Decay Curve

The typical and traditional polynomial curve often used to illustrate the decay or service life of pavements was not seen in the performance equations. A typical logarithmic decay curve was found to provide the best-fit curve (See Figure 1). The pavements do not drop by the purported 40 points of PCR in the 12 percent time remaining, as alleged. Perhaps this is due to timely maintenance by agencies.

Data Collection Methods Vary

All state DOTs have implemented some form of a pavement management system according to Federal Highway Administration (FHWA) directives. National Center for Highway Research Programs (NCHRP) Synthesis 203, Current Practices in Determining Pavement Condition, summarizes state agency procedures and shows what measurements are made in determining the pavement conditions. This data indicates most states use some measure of deducts combined with ride or roughness measurements.

It also shows that none of the states have rated their pavements in the same manner. As a result, the Asphalt Institute used a detailed rating form in existence for over 30 years and adopted by many agencies for use in determining PCR. The Asphalt Institute rating system, based on *A Pavement Rating System for Low Volume Asphalt Roads* (IS-169), contains practically all forms of asphalt pavement defects on a weighted scale with major load-associated defects assigned a deduct value of 10. Minor and environmental defects are assigned a deduct value of five.

This system has proven reliable because it offers a detailed breakdown of the defects. A summary of the deduct values are shown in Table 4. The rating is normally in a range of 40 to 100. The rating value is subjective, implying that the pavement is at this condition at the time and under the existing conditions of traffic and environmental factors. In a subjective rating, no attempt is made to project what any existing defect will have on future performance.

The form in Table 1 was used to correlate the data available from the state DOTs. The procedure entails a survey of the data available within a particular DOT's pavement management system, and subsequently, an on-site rating of specific sections of pavement. This procedure provides a standard for all pavement sections in the study. The states surveyed so far have been helpful and cooperative in providing existing, available data. Other states that do not have a rating system have provided project logs that can be used to establish the pavement's age. An Asphalt Institute District Engineer then rated the pavement.

Anyone can submit a project for this study. Projects submitted for inclusion will require verification by an Asphalt Institute District Engineer for pavement age and PCR. Many local agencies have data that can be added to the database directly because they are using this rating form in their current pavement management system. An update of this study should be made periodically, and the data can also be obtained from the Asphalt Institute's website as well as through written reports. This is an on-going study with no end-point currently established.▲

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Table 4. Summary of Maximum Pavement Deductions

Cracking	Distortion	Disintegration	Drainage	Roughness (Ride)
35	20	10	10	PCR = 100 - deducts