R&T UPDATE
Concrete Pavement Research & Technology

FACTORS FOR PAVEMENT REHABILITATION STRATEGY SELECTION

The need for engineered rehabilitation of our highways, streets, and airports has never been greater. There is increasing demand to make better use of shrinking resources for rehabilitation and maintenance, and a variety of strategies are available to meet these demands. Selecting the most cost-effective strategy for pavement rehabilitation continues to be a significant challenge to the transportation professional.

This publication provides a framework and describes the information needed to create cost-effective rehabilitation strategies. An engineer can easily adapt the strategy selection framework for local materials, environment, project conditions and costs. Design and construction details for each of the rehabilitation techniques are available in other ACPA publications (1-9).

Pavement rehabilitation is a rapidly developing technology. Experience gained from past projects builds the foundation for advancing design and construction of future rehabilitation projects. Past projects also offer important lessons on proper timing of rehabilitation activities. Project-level pavement management combines this knowledge for systematic strategy selection.

SYSTEMATIC STRATEGY SELECTION

A systematic approach is the most effective way to evaluate and select pavement rehabilitation techniques. The process must account for all applicable parameters and their impacts on the choice between alternatives. These parameters may be both pavement and non-pavement related. Agency experience, initial cost of rehabilitation, anticipated maintenance, and future rehabilitation requirements also influence strategy selection (10). Figure 1 shows a systematic decision-making process for the selection of appropriate alternatives.

Policy decision-making that advocates applying the same standard fixes to every pavement does not produce successful pavement rehabilitation. This has led to poor performance and inefficient use of public funds (11). Successful rehabilitation depends on decisions that are based on the specific condition and design of an individual pavement.

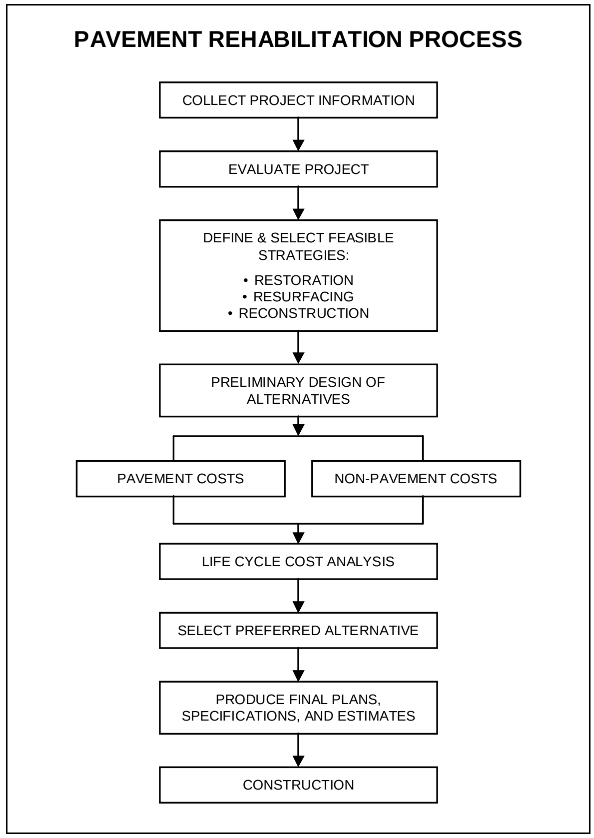

Figure 1. Systematic decision-making process for rehabilitation strategy selection.

Assessing the effectiveness of rehabilitation alternatives must include the examination of project conditions, life cycle costs, and constraints on strategy selection. Life cycle costs should include initial cost as well as yearly maintenance, future rehabilitation, user, and other costs.

PROJECT INFORMATION

Detailed project information is important for selection of the preferred rehabilitation strategy. Five basic types of information are necessary: design, construction, traffic, environmental, and pavement condition.

Design Data –

The first pieces of information an engineer needs are the design parameters for the existing pavement. This data includes the pavement type and thickness.

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Detailed information about the components of the pavement is also very helpful, including: layer materials and strengths, joint design, shoulder design, drainage system, and previous repair or maintenance activities.

Construction Data –
Investigation of the conditions during construction of the original pavement can often give insight into the causes of existing pavement distresses. Field books or daily log notes are excellent sources of construction information. Notes of problems or weather conditions are particularly helpful.

Traffic Data –
Strategy selection requires past, current and expected traffic growth. This helps determine the remaining effective structural capacity of the existing pavement. Knowing the structural capacity helps narrow the number of potentially effective rehabilitation options.

Environmental Data –
Precipitation, temperature, and freeze-thaw conditions are important factors. Each of these factors acts on the materials and layers of a pavement system to influence material integrity, structural capacity, and rideability.

Understanding how these factors have affected the existing pavement can help a designer prevent potential problems in the performance of the rehabilitated pavement.

Distress/Condition Data –
A condition survey should report the type, severity and quantity of each distress. Isolating areas of distress can help pinpoint different solutions for different sections along a project. The distress should be characterized as load or climate related. Non-destructive testing (NDT) and destructive testing (i.e. cores and borings) can help determine the structural condition and material properties below the surface. A visual or photo log survey is also important. The main objective is to collect enough information to be able to characterize the type and extent of deterioration.

Not all rehabilitation options require the same level of survey for accurate analysis. Table 1 (below) recommends the data essential for determining feasibility and developing designs for most rehabilitation options.

Table 1. Data Required for Determining Feasibility and Developing Rehabilitation Strategies for Concrete Pavements (12).

Type of Data	Rehabilitation Method								
	Partial Depth Repairs	Full Depth Repairs	Dowel Bar Retrofit	Diamond Grinding	Joint Resealing	Slab Stabilization	Cross Stitching	Overlay (concrete or asphalt)	Recycling
Traffic Control Options	Required	Required	Required	Required	Required	Required	Required	Required	Required
Pavement Design	Required	Required	Required	Required	Required	Required	Required	Required	Required
Distress	Required	Required	Required	Required	Required	Required	Required	Required	Required
Traffic Load & Volume		Required	Required	Required	Desired	Desired	Desired	Required	Required
Age	Desired		Desired	Desired	Desired	Desired	Desired		Desired
Material Properties	Desired	Desired		Required		Desired	Desired	Required	Required
Previous Maintenance		Desired		Desired	Desired	Desired	Desired	Desired	Desired
Destructive Testing	Required	Required	Desired	Desired		Desired		Required	Required
Non-Destructive Testing	Desired	Desired				Required		Desired	
Original Constr. Data		Desired		Desired				Desired	Desired
Subgrade					Required	Desired		Required	Required
Drainage		Desired		Desired	Desired	Desired	Desired	Required	Required
Climate					Required	Required		Required	Desired
Skid Values				Required				Desired	Desired
Accidents				Desired				Desired	Desired
Roughness				Required					Desired
Surface Profile				Required					
Underground Utilities		Desired				Desired			Desired
Pushing of Bridges					Desired				
Vertical Clearances								Required	Required
Geometrics								Desired	Desired

EVALUATION

Pavement evaluation draws from all of the project information in order to determine the cause of pavement distress. The goal of rehabilitation is to fix the causes of the deterioration, not just the symptoms (12). Repairs which merely cover a problem do not provide effective solutions.

Whenever possible, an evaluation should not be done using assumed conditions or unknown material strengths. These factors are measurable from actual response to destructive and non-destructive testing methods. Using assumed values provides no insurance that the rehabilitation strategy will actually meet design expectations. An engineering evaluation must address several key issues such as functional & structural condition, materials condition, drainage conditions, and lane condition uniformity (12):

Functional & Structural Condition –

In evaluation, the engineer must determine the structural condition of the pavement. Structural deterioration is any condition that reduces the load-carrying capacity of a pavement (13). Corner breaks, pumping, faulted joints and shattered slabs are some examples of structure-related distresses for concrete pavement. Alligator cracking, transverse cracking, shoving and rutting are examples for asphalt pavements.

Many agencies trigger the need for rehabilitation work based on a serviceability index or rating, usually indicated with an IRI (International Roughness Index) number (14). Ride quality is the primary influence of serviceability values (15).

Lost in the subjectivity of serviceability values is the distinction between functional and structural distress. Functional distresses include problems which influence the ride quality, but are not necessarily signs of reduced structural capacity.

Figure 2 illustrates how time and traffic loadings reduce a pavement's ability to carry load, and how rehabilitation techniques can increase that ability (13). Pavements that have lost much of their structural capacity require treatment with either a thick resurfacing or reconstruction. Restoration is applicable only for pavements with substantial remaining structural capacity.

Evaluating the level of structural capacity requires thorough visual survey and material testing (13). Non-destructive testing is important to characterize both pavement stiffness and subgrade support.

Materials Condition –

Material problems such as alkali-silica reactivity (ASR) and D-cracking can significantly reduce the integrity of concrete. Stripping and raveling impact asphalt integrity. Most of these problems are easily identified from the surface of the pavement. The severity of material distresses may impact the number of possible candidate rehabilitation procedures. Petrographic analysis helps identify them when their cause is not obvious.

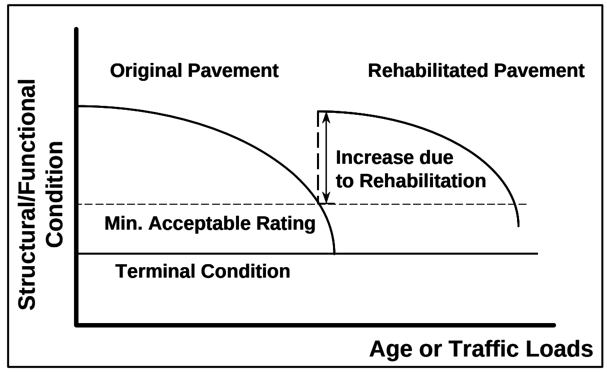

Figure 2. Increase in pavement life due to rehabilitation

Drainage Condition –

Evaluating the drainage conditions is relatively simple. Drainage problems usually manifest into noticeable pavement distress. Any presence of pumping joints or severe asphalt rutting indicate drainage deficiencies. The condition of ditches and drain system outlets are also important indicators.

Lane Condition Uniformity –

On many four-lane routes, the outer truck lane deteriorates at more rapid pace than the inner lane or shoulders. This condition is important to note during an evaluation. Significant savings may result by repairing only the pavement lane that requires treatment.

REHABILITATION CHOICES

Restoration –

Concrete Pavement Restoration, or CPR, refers to a set of engineered techniques that bring the functional or structural condition of a pavement to an acceptable level (16). CPR techniques include:

- partial-depth repair
- full-depth repair
- dowel bar retrofit
- diamond grinding
- joint & cracking resealing
- cross stitching
- slab stabilization

Most projects will require several of these techniques to correct existing distresses and prevent their occurrence. Each technique has unique design details and construction procedures, more details of which can be found in ACPA publications (1,2,5,7,17,18,19).

Resurfacing –

Resurfacing alternatives, or overlays, provide two important functions. Through the provision of a new wearing course, overlays improve rideability, safety, and skid resistance. The new surface also allows correction of cross-section and surface defects. A thick overlay can also increase the structural capacity of a pavement. Resurfacing techniques include the following:

Overlays of concrete pavements:

- Bonded concrete
- Unbonded (separated) concrete
- Asphalt concrete

Overlays of asphalt pavements:

- Whitetopping
- Ultra-Thin Whitetopping (UTW)
- Asphalt concrete

Repair work is almost always necessary before placing an overlay on an existing pavement. The quantity of repair before overlay may affect the required thickness of an overlay. In some situations, better and more extensive pre-overlay repair permits a reduction in overlay thickness.

The necessary quantity of pre-overlay repair also depends on the overlay type. For instance, unbonded (separated) concrete overlays and whitetopping overlays usually require little or no pre-overlay repair.

Reconstruction –
Reconstruction involves complete removal of the pavement structure, typically but not always including the base layer(s). The structure is replaced as a new pavement or inlay. Reconstruction techniques offer the choice of selecting virgin or recycled materials. Use of recycled material can often lower project costs (9).

TIMING REHABILITATION ACTIVITIES
Rehabilitation timing is a fundamentally important ingredient in pavement rehabilitation. As a pavement deteriorates, the type of rehabilitation which is most appropriate changes. Figure 3 shows that each strategy has its most appropriate application during a certain portion of the pavement life. Proper timing of rehabilitation techniques, along with proper design and construction, is essential for good performance.

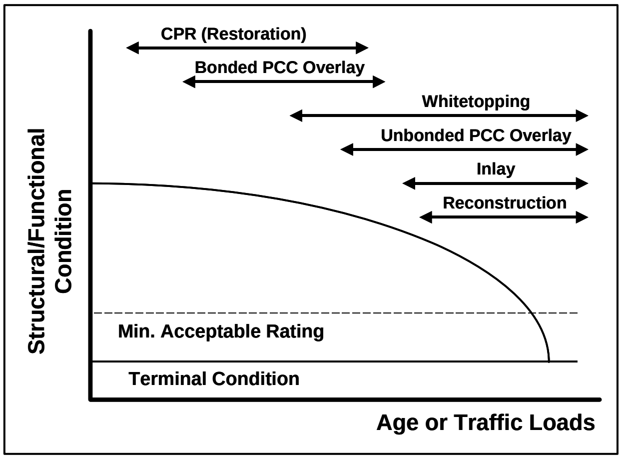

Figure 3. Life-cycle diagram showing how rehabilitation strategies relate to pavement condition.

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