R&T UPDATE
Concrete Pavement Research & Technology

The New Concrete Pavement Preservation (CP^2) Approach
"A Technical Editorial"

The Pavement Preservation Concept

"Pavement preservation, as defined by the FHWA, is a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations (FHWA, 2005)" [1]. This definition divides preservation into three distinct outcomes: (1) pavement life extension, (2) improved safety and (3) motorist satisfaction. It also states that, by definition, the process can only be accomplished through a long-term, network level approach and using integrated, cost-effective practices. The FHWA clearly had the wisdom and foresight to realize the importance of defining not only the processes involved, but also the outcome.

By defining terms that "extend pavement life", the FHWA acknowledges a difference between treatment life and pavement-life extension. It is not uncommon to refer to pavement preservation strategies in terms of treatment life (i.e. 3-5 years). However, unless the treatment extends the service life of the pavement, the life of the treatment is inconsequential and insignificant. This is a very important concept to embrace, particularly during times of funding shortfalls.

Did You Know?

- CP^2 costs less and lasts longer than alternative preservation techniques.
- CP^2 is quicker and causes less traffic disruption than alternative preservation techniques.
- CP^2 can be used to repair a concrete pavement that has been overlaid with asphalt previously.
- CP^2 activities consist of slab stabilization, partial or full-depth repairs, dowel bar retrofit, cross-stitching of longitudinal cracks or joints, diamond grinding, & joint and crack resealing.

It is often thought that safety is improved by addressing pot holes or spalls in the pavement surface. Safety improvements, however, need to be much more comprehensive. Motorists place their trust in agencies to provide safe and comfortable roadways. When a motorist begins a journey, they expect that the pavement will provide a safe surface to travel on for all possible environmental and operational situations. This expectation can only be assured when an agency manages safety as a distinct portion of all pavement preservation activities.

Motorist satisfaction is best achieved through smooth roadways with minimized construction delays and maintenance. Traditionally, road roughness has been the measurement of choice for assessing roadway conditions because it correlates well with motorist satisfaction. Few motorists can relate to pavement distresses such as rutting or cracking. Furthermore, such surface defects are relatively indiscernible to the typical driver at highway speeds; typical drivers can, however, easily gauge overall roughness at highway speeds.

In addition to requiring an outcome-based result, the FHWA also defines the minimal process necessary to adequately provide a functional preservation system. Since most agencies have independent processes addressing the cradle to grave activities of a pavement network, it is critical that these processes be integrated into the pavement preservation system, a practice that involves long term network level assessment and feedback. For example, an agency might have one group design a roadway, another construct the roadway, another test the materials and project details for acceptance, and yet another maintain the project over time. This example leaves all the responsibility for collecting/assessing pavement performance data and deciding when to allocate funding for preservation treatments in the hands of others. All of these functions, however, can oftentimes be accomplished by fewer groups, resulting in a more integrated process that relies on actual pavement performance data collected on the network from cradle to grave. Only through this type of integrated

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approach can long-term, cost-effective preservation treatments be developed and applied.

Also included in the FHWA's Pavement Preservation definition are the terms "long-term" and "cost-effective", both of which allude to life cycle cost analysis (LCCA) approaches. LCCA is the only reasonable approach to ensuring that resources are utilized properly and roadway investments are managed adequately. However, to conduct an accurate LCCA, an agency needs to have construction costs, as-built data and performance data so they can evaluate the actual performance of the various preservation strategies and their associated costs. If this data is not readily available, then the LCCA approach is relegated to no more than a cosmetically improved anecdotal approach.

The traditional pavement preservation approach oftentimes uses the advertising slogan of "Pay me now or pay me later" to emphasize the preservation concept. This approach is regularly linked to the classic performance/investment curve as shown in Figure 1. It is generally accepted that investments made during the pavement preservation portion of the performance curve are more cost effective than investments made at later times during the curve.

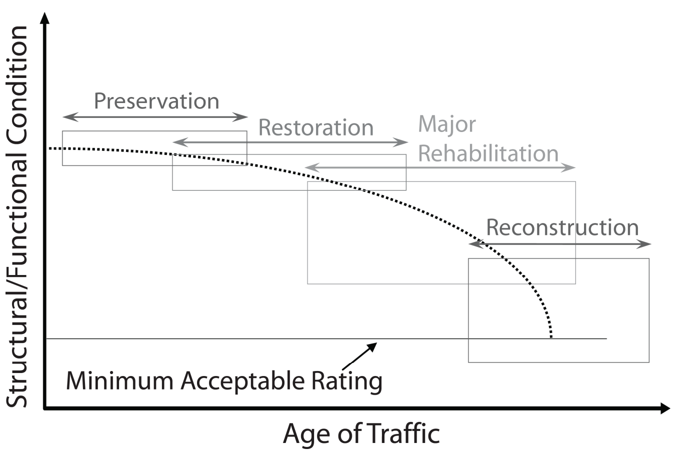

Figure 1: Typical Pavement Performance Curve and Maintenance/Rehabilitation with Time [1]

This approach, albeit conceptual, infers that all pavement types and strategies will perform similarly. Unfortunately, this is an oversimplification and leads to anecdotal approaches in the absence of adequate engineering data/analysis.

One additional implication of the FHWA requirement of "long-term strategies" is the selection of preservation strategies apriori. That is, for the designated life cycle analysis period, an agency or owner must designate the respective treatments from cradle to grave to define the "expected" performance/investment curve shown in Figure 1. However, except in very few instances, once the LCCA analysis is completed and the strategy selection made, no future funding is programmed to accomplish the "planned" preservation strategies; the agency or owner simply defers the funding, strategy selection, and decision making to future organizations and conditions.

All things considered, the traditional pavement preservation approach is inherently disconnected, making it difficult to link design, maintenance, and performance variables. This makes it practically impossible to accurately predict future pavement preservation schemes for any specific pavement type/configuration.

Summary of Current Practice

Traditionally, concrete pavement has been utilized on roadways which sustain heavy traffic loadings due to commercial vehicles or in urban areas where long life pavements are warranted to reduce delays and congestion associated with construction and maintenance activities.

CP^2 is a series of engineered techniques developed over the past 40 years to manage the rate of pavement deterioration in concrete streets, highways and airports. CP^2 is a non-overlay option used to rehabilitate areas of distress in concrete pavement, without changing its surface grade appreciably. This rational, preventive procedure restores pavement to a condition close to or better than original, and reduces major and more costly repairs later in the life of the pavement. Benefits of CP^2 include:

- **CP^2 addresses the causes of pavement distress, minimizing further deterioration.** Covering a distress with an overlay does not correct the root cause of the distress. Eventually the distress manifests itself again, usually as a larger, more expensive problem. This fundamental flaw makes CP^2 more effective and less costly than other overlay preservation techniques.

- **CP^2 costs less and lasts longer.** Georgia has used CP^2 extensively for nearly 40 years, sometimes as many as three times on a single roadway. They have found that CP^2 costs one-fourth to one-third as much as a 6-in. asphalt overlay.

- **CP^2 is quicker and causes less traffic disruption.** Since CP^2 maintains the existing grade, features such as curbs, gutters, bridge clearances, approach slabs and roadside appurtenances do not need adjustment. Furthermore, CP^2 repairs only those areas that need improvements, such as the heavily trafficked sections of roadways or runways. Such isolated repairs accelerate the preservation process, requiring fewer traffic control measures and causing less traffic disruption.

- **CP² preserves the safety of concrete pavement.** Concrete surfaces do not deform and they typically maintain their drainage characteristics for the life of the pavement. This is especially important at intersections and other locations where traffic is starting, stopping and/or turning. Furthermore, because of their color, concrete pavements reflect light better than most other pavement surfaces, improving vision and safety during nighttime and inclement-weather driving.

- **CP² can be used to repair a concrete pavement that has been overlaid with asphalt previously.** Agencies have overlaid many structurally sound concrete pavements due to roughness and/or lack of friction. Both of these surface characteristics are easily corrected by the use of diamond grinding.

True-to-Life CP² Curves

Classical pavement management or preservation curves are based on conceptual models like the one presented in Figure 1, with the same curve being used for both concrete and asphalt pavements. However, the two pavement types are designed and thus perform differently. Figure 2, another conceptual model used to promote optimum preservation strategies, is again an asphalt-based model so it does not lend itself to true CP². Newly constructed concrete pavements last longer than comparably designed asphalt pavements and pavement preservation techniques for concrete pavements generally last for longer intervals as well. Unlike asphalt pavements, many concrete pavements achieve and exceed their design life without pavement preservation assistance.

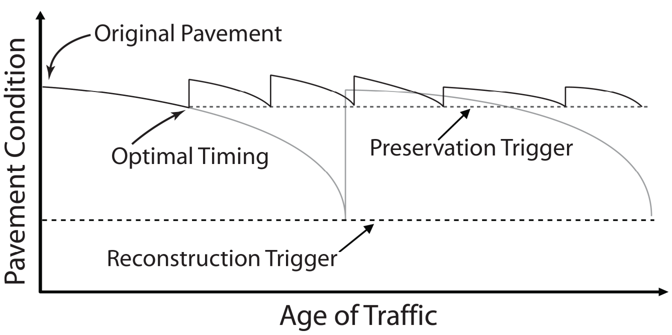

Figure 2: Optimum Timing for Pavement Preservation

For concrete pavements, a motorist is typically only aware of the ride quality or tonal characteristics. Seldom do they associate joint distress or cracking with anything but roughness. The performance model that best depicts this is a roughness curve. The roughness curves shown in Figure 3 illustrate the roughness progression for several projects studied in the Long Term Pavement Performance (LTPP) General Pavement Studies Experiments 3 (GPS-3) and 5 (GPS-5). The GPS-3 projects represent many jointed plain concrete pavements (JPCP) while the GPS-5 projects represent many continuously reinforced concrete pavements (CRCP). As shown in Figure 3, the roughness performance curves appear quite linear and often times flat, with little change in time. Therefore, to properly develop meaningful pavement preservation strategies, the agencies/owners need to develop realistic performance curves for both the original construction life and subsequent preservation strategies. It should also be noted that many of the pavements shown in Figure 3 are performing well beyond their 20 year design period. Good CP² requires developing models to represent the actual design strategy performance that will occur under the given loading and environmental conditions.

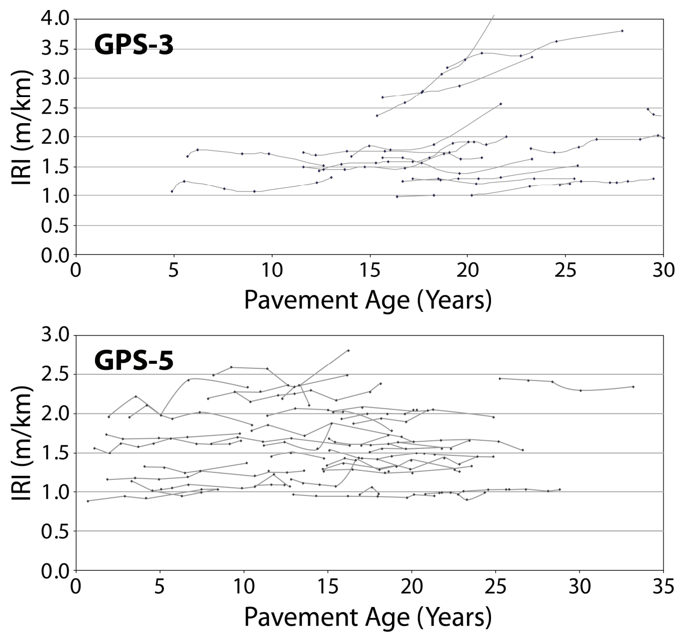

Figure 3 IRI Trends for GPS-3 and GPS-5 LTPP Test Sites [2]

Concrete Pavement Intervention Cycles

When funding is tight, concrete pavement preservation is often deferred. Most agencies recognize that concrete pavements last longer than their design lives so they understand deterioration is slow. This has allowed agencies to ignore CP² and expend preservation funds on asphalt pavements that deteriorate faster.

However, there is a need to shift the intervention cycle earlier in the life of a concrete pavement so that they can remain smooth and free from dynamic loading. This will both increase the ultimate serviceability of the pavement and improve motorist satisfaction. To accomplish this, the agency/owner needs to apply the data collection and analysis processes required by the FHWA preservation definition, as discussed earlier in this paper.

Potential Performance Enhancements Resulting from Improved Design/Construction Practices

CP² activities often are determined after a pavement has been in service for many years as opposed to apriori. The current approach assumes that what ever has occurred in the design, construction, and performance period will manifest itself and be arrested by the selected CP² strategy. Although this approach minimizes the risk involved in strategy selection (e.g. 20:20 hindsight), it affords no opportunity to prevent a reduced performance period caused by errors in the design/construction process. Figure 4 shows a plot of good and poorly performing projects from the GPS-3 LTPP sections. As is evident in the plot, there is a considerable difference in performance between the sampled pavements. Well-performing pavements have little change in IRI while poorly-performing pavements exhibit significant performance issues. Therefore, instead of just accepting the differences in performance levels and using CP² activities to mitigate their impact, there is a need to identify the features that cause these differences and to attempt to extend pavement performance at the onset (e.g. during design and construction processes). Such a preventative strategy is truly the most effective form of pavement preservation.

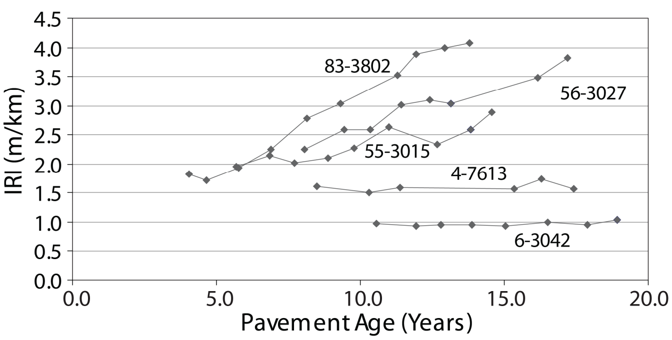

Figure 4: Good- and Poorly-Performing Non-Dowelled GPS-3 Sections [2]

Another example of how design can affect performance is indicated in Figure 5. For this example it is clear that the use of dowels reduces the performance variability and extends pavement life in many instances. Again, the point of the example is to reinforce the concept of applying a preservation strategy on actual performance data.

Incorporating Safety into CP² Strategy Selection Processes

Safety has generally been assessed in highway agencies through the use of the ASTM locked-wheel skid trailer. Discrete location tests are conducted at regular intervals, often at milepost locations, using either the ribbed or smooth ASTM test tire. Typically, these activities are conducted as part of the agency's pavement data collection effort. Many agencies/owners have trigger values that determine when corrective action is initiated to resolve any friction problems.

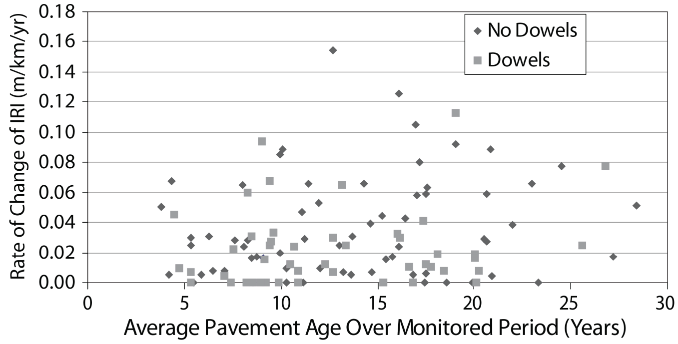

Figure 5: Relationship between Rate of Change of IRI and Pavement Age for GPS-3 Sections [2]

Often times, unless a deficient friction value exists, friction improvement is not a preservation activity and the effect of the selected activity on safety is not always properly considered. Since the FHWA preservation definition includes safety as one of the outcomes, there is a need to determine the best way to measure and manage roadway safety. When selecting preservation activities, their impact on safety should be considered.

The majority of the current vehicle fleet on the highway is equipped with anti-lock braking systems, which prevent locked-wheel skidding accidents. There is a need to improve the current system of safety measurement to a more relevant and technologically advanced measurement system that better relates the pavement condition to today's vehicles.

The Minnesota DOT is a good example of how an organization can improve safety through conscience actions. To improve the surface texture of their concrete pavements, they modified their mix design and provided incentives to contractors for lower water cement ratios. Both of these actions led to improved and longer lasting macro texture and subsequently safer roadways.

References

1. R.G. Hicks, et al, "Caltrans Concrete Pavement Maintenance Technical Advisory Guide", Caltrans, 2006
2. R.W. Perera, S.D. Kohn, "LTPP Data Analysis: Factors Affecting Pavement Smoothness", NCHRP, August 2001

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