CONCRETE PAVEMENT GUIDE

PART 1: GENERAL INFORMATION

CHAPTER 100 – PAVEMENT MANAGEMENT STRATEGIES

The Concrete Pavement Guide provides a comprehensive overview of current new concrete pavement construction/ reconstruction, preservation, and rehabilitation strategies used by the Department. The information in this guide applies to all concrete pavements and composite pavements (concrete overlayed with nonstructural hot mix asphalt) that were not previously cracked and seated. Included is a description of the effectiveness, limitations, material, design, and specification considerations for the individual strategies. Some limited information about construction is also included, but refer to the Construction Manual for more details about construction procedures.

The guide is divided into topical chapters organized into 4 parts: Part 1 provides general information and an overview of concrete pavement strategies and evaluation; Part 2 covers new concrete pavement and reconstruction strategies; Part 3 preservation strategies; and Part 4 rehabilitation strategies.

Chapter 100 introduces an overview of concrete pavement management strategies and concepts as well as a discussion of pavement strategy selection and funding programs.

100.1 PAVEMENT MANAGEMENT CONCEPTS

All pavement deteriorates over time. Effectively managing the roadway network requires optimizing new construction, preservation, maintenance, rehabilitation, and reconstruction pavement needs statewide with multiple constraints, including finite budget requirements, worker safety, user impacts, and regional issues. Preservation is the preferable network-level pavement management strategy: a long-term, proactive maintenance program intended to maintain pavements in good condition by applying cost effective project strategies at the optimal time to enhance pavement performance, extend pavement life, and conserve resources.

To be effective, a pavement preservation program must employ the right project-level engineering strategies before the onset of severe distress over an extensive area. The cumulative effect of a systematic, integrated preservation program is to postpone costly corrective maintenance, rehabilitation, or reconstruction projects (see Figure 100-1). Performing a series of successive pavement preservation strategies (HM or CAPM) during the life of a pavement is also less disruptive to uniform traffic flow than the longer closures normally required for rehabilitation (2R or RRR) and reconstruction projects. The frequency of application depends on the strategy selected (see Section 100.2), design life, performance over the anticipated service life (see Section 110.3), and future pavement management practices.

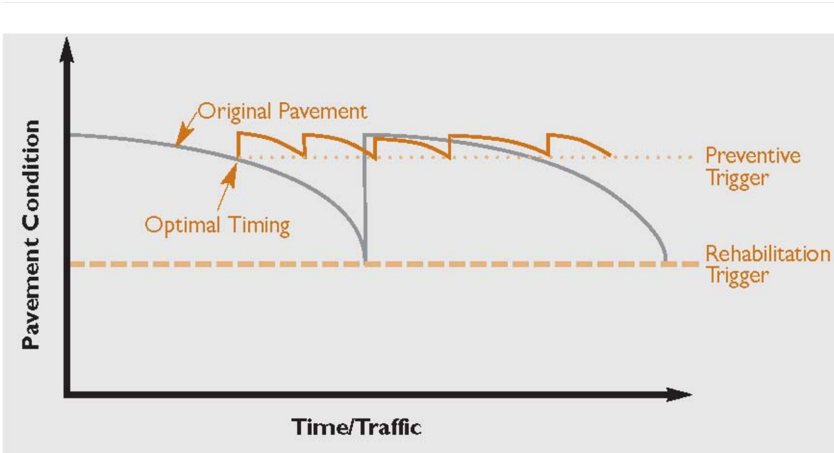

Figure 100–1: Pavement preservation concept (Galehouse et al, 2003)

100.1.1 Network-level Pavement Management

New construction, widening, and reconstruction are used for new alignments, to increase existing route capacity, or to replace obsolete roadway segments, respectively. Capacity improvement projects are typically funded by the State Transportation Improvement Program (STIP), local tax measure funds, bonds, or private developers. Current design standards require at least a 20-year design life for new construction and reconstruction. A minimum design life of 40 years is common for most concrete pavement given the cost effectiveness for higher traffic volumes typical on many routes (see HDM Topic 612).

Pavement Preservation includes preventive maintenance (HM) and CApital Preventive Maintenance (CAPM) pavement strategies (see Part 3) used to maintain or repair an existing pavement management segment that is still structurally sound overall. The District Maintenance Engineer typically initiates the projects and determines the preventive strategy, which can be funded as either preventive maintenance (HM) or CAPM projects depending on the existing pavement condition and budget constraints:

- Preventive Maintenance projects are typically done by the Department's Maintenance forces or through the Major Maintenance (HM) Program to preserve existing pavement in good condition. Preventive maintenance projects are not engineered for a minimum design life and typically do not include safety, geometric, or operational improvements.

- CAPM projects are funded through the State Highway Operation and Protection Program (SHOPP) but CAPM is considered a pavement preservation program because the strategies are more closely related to non-structural maintenance improvements than rehabilitation, which is designed to meet future long-term traffic loading.

  CAPM is intended to extend the pavement service life at least 5 years by making minor repairs to segments with limited distress, delaying further short-term deterioration that would require major roadway rehabilitation. Only cost-effective, easily implemented traffic safety and operational improvements such as signing and delineation are included in CAPM projects pending a review by District traffic personnel. More information about the CAPM program is in HDM Topics 603, 624, 644, and Design Information Bulletin 81 "Capital Preventive Maintenance Guidelines".

Roadway Rehabilitation is major engineered work intended to restore and extend the pavement service life when extensive structural distress occurs. Rehabilitation is funded through the SHOPP as a 2R or RRR project. A design life of at least 20 years is required and 40 years is likely for higher traffic volume projects pending life cycle cost analysis (LCCA). For more information, see HDM Topic 612 and the LCCA Procedures Manual. Upgrades to enhance safety, geometric design features, traffic operations, drainage, and structures are included in rehabilitation projects where needed. Additional discussion about roadway rehabilitation can be found in HDM Topics 603, 625, 645, and Design Information Bulletin 79 "Design Guidance and Standards for Roadway Rehabilitation Projects". CPG Section 100.2.3 and Part 4 have more information about rehabilitation strategies.

100.1.2 Optimal Project Timing

Optimizing selection of the best engineering strategies and the timing of project construction with the existing pavement condition is critical to long-term performance. The pavement management system (PaveM) uses models based on pavement structure, climate, and traffic loading to establish deterioration rates and predict future performance. By anticipating future distress conditions, preservation projects can be proactively initiated and developed through the design and construction process before deterioration progresses and more expensive repair is necessary. Eventually, pavement will age until preservation strategies are no longer effective and the pavement management system can help determine when more expensive rehabilitation or reconstruction is warranted.

Pavement management tools and engineering judgment are used to select specific strategies and optimum project timing, which are a function of many factors, including: overall pavement condition, distress types, deterioration rates, remaining service life, traffic, constructability, and economics. If pavement is not maintained effectively with timely, well-engineered strategies, it will prematurely deteriorate until reconstruction is required: the most expensive and least desirable resource management option. Figure 100-2 shows a generic pavement performance model with traffic and time. The optimal timing and relative cost of various pavement management strategies are superimposed.

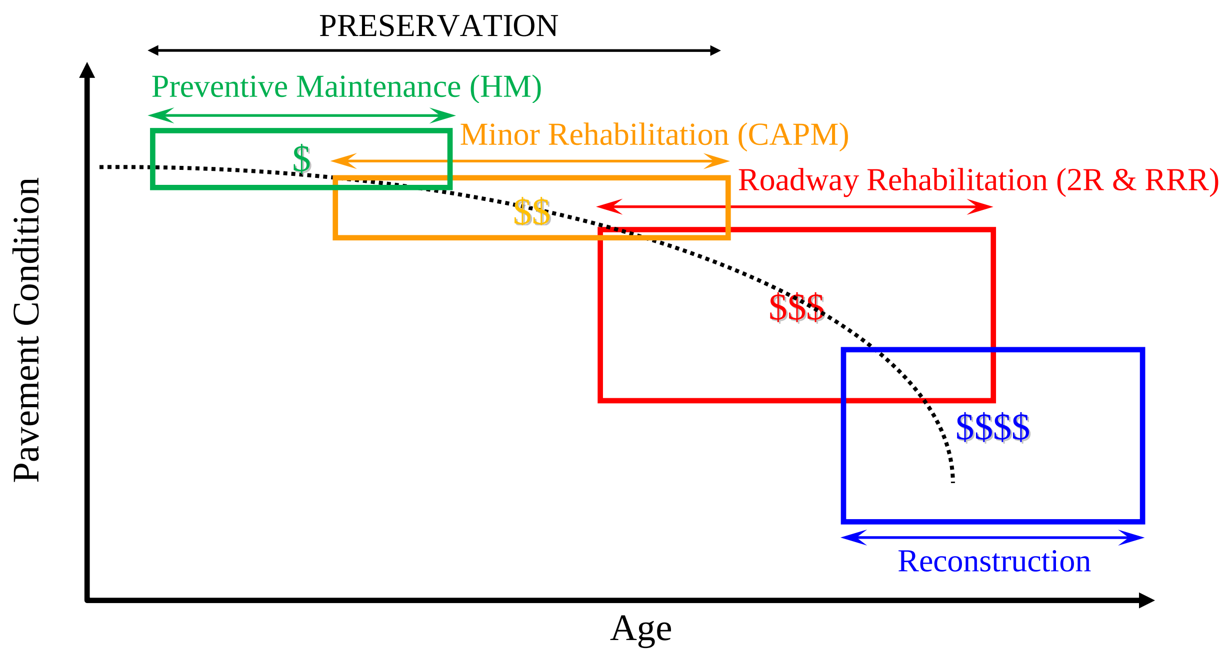

Figure 100–2: Typical pavement performance model and management strategies

100.2 PROJECT-LEVEL CONCRETE PAVEMENT STRATEGIES

Individual concrete pavement engineering strategies used by the Department are introduced below. Other strategies have been used nationally but are not currently used by the Department due to various reasons and limitations. Refer to the applicable Concrete Pavement Guide chapter of the individual strategy for more complete information. Chapter 110 contains more detailed discussion of the project-level pavement evaluation and selection process for engineering effective strategies.

100.2.1 New Design Strategies

Existing rigid pavement in California is generally non-doweled jointed plain concrete pavement (JPCP), although there are some limited areas of continuously reinforced concrete pavement (CRCP) and precast panel concrete pavement (PPCP). Although JPCP is more common, CRCP is currently favored by the Department for high traffic new construction, reconstruction, overlays, and some widening projects due to better long-term performance and reduced maintenance requirements. Pavement type selection for roadways should be determined by LCCA. More complete information about new concrete pavement design strategies currently used by the Department can be found in Part 2 of the Concrete Pavement Guide, introduced here:

- CRCP (Ch. 200) uses longitudinal joints and continuous reinforcement in the upper 1/3 of the concrete surface to control vertical and horizontal movement of transverse cracking in cast-in-place concrete. Tight cracks should occur randomly spaced in 3.5'– 8' intervals.

- JPCP (Ch.210) is unreinforced, cast-in-place concrete pavement designed with doweled transverse joints and tied longitudinal joints to control cracking as well as vertical and horizontal movement. Transverse and longitudinal joints are cut to a 1/8" width and not sealed except in desert and mountain climate regions.

- PPCP (Ch. 220) uses concrete panels that are precast off-site under controlled conditions and trucked to the project location. The panels must be placed on a smooth, finely leveled base and linked by dowel and tie bars. PPCP is an expensive nonstandard strategy that is currently used only on an experimental basis where extreme lane closure restrictions limit construction time.

100.2.2 Preservation Strategies

Many preservation strategies can be used individually or in combination with each other. Some can be funded as either preventive maintenance HM projects or CAPM projects. More comprehensive information about concrete pavement preservation strategies currently used by the Department can be found in Part 3 of this guide. Briefly summarized:

- Subsealing and Jacking (Ch. 300) slabs are preventive maintenance strategies used for isolated locations of settlement or loss of underlying support from base erosion. Subsealing can also be referred to as undersealing or slab stabilization. Slab candidates for subsealing or jacking should have signs of pumping or rocking but limited or no cracking. For jacking, some faulting should be evident.

- Spall Repair (Ch. 310) requires partial depth removal of deteriorated concrete pavement and patching with fast-setting, high-strength material. The rectangular limits of the damaged or defective areas should be determined by striking the pavement with a hammer or similar tool to detect hollow sounding concrete. The defective area is then marked beyond the outer limits of unsound concrete for removal by sawing and chipping with a jack hammer.

- Individual Slab Replacement (Ch. 320) is a preservation strategy used to replace individual failed slabs with rapid strength concrete (RSC) when much of the remaining pavement segment is still in good condition. Replaced slabs match the existing concrete pavement thickness and replacement of the underlying base may also be required. This strategy is typically cost effective when ≤ 20% of the slabs in a lane have severe cracking, but is most cost effective when 3 to 10% slabs require replacement.

- Dowel Bar Retrofit (DBR) [Ch. 330] is a preservation strategy used in combination with grinding to restore lost load transfer capability at transverse joints or cracks in existing, non-doweled JPCP with significant remaining structural service life. DBR candidate pavements should have few joints with spalling related to poor concrete durability or fatigue cracking. DBR can treat some low severity joint faulting ≤ ½" or loss of underlying support from base erosion.

- Grinding and Grooving (Ch. 340) can be used as individual preservation strategies (HM or CAPM) or in combination with other pavement strategies. Grinding enhances surface friction safety characteristics and removes faulting, roughness, rutting, and surface irregularities resulting from chains, snow removal activities, or other factors causing surface attrition. Gang-mounted diamond saw blades are used to shave a thin portion (0.06-0.75 inches) off the existing concrete surface layer. Grooving is used to address poor skid resistance and hydroplaning by using diamond blades to cut 1/8" to 1/4" deep longitudinal grooves spaced at ¾".

- Specialized Surface Treatments (Ch. 350) include high-molecular-weight methacrylate (HMWM), concrete surface hardener, and polyester concrete overlays.

  - HMWM is used to treat minor partial depth cracking in the upper concrete surface of relatively new pavements in very good condition.
  - Concrete surface hardener is a nonstandard preventive maintenance strategy used in snowy climates to reduce rutting and wear due to abrasion from tire chains, studded tires, and snow plows. The existing pavement surface is prepared by grinding or shot blasting and liquid lithium silicate is applied by spraying. The treatment penetrates and seals the concrete surface, increasing hardness and abrasion resistance to the treatment depth. Concrete hardener is being used on an experimental basis while its performance is evaluated for cost effectiveness, but a 3 to 5-year service life increase is anticipated.
  - Polyester concrete overlays are considered a nonstandard CAPM strategy for concrete pavement. Typically used for bridge decks, polyester concrete could be used to treat short areas of increased wear and deterioration, such as near chain areas or weigh stations.

- Joint and Crack Sealing (Ch. 360) inhibits water and incompressible materials from entering the pavement structure, thus slowing the rate of spalling and cracking deterioration. Joint faces must be in good condition with little to no spalling to seal effectively. Pavement that exhibits a slow rate of deterioration should have a high priority for crack sealing, which is currently a nonstandard strategy.

- Thin HMA Overlays (HMAOL) [Ch. 370] provide a wearing surface ≤ 0.25' thick that protects the existing concrete from deterioration and can improve aesthetics when traffic lanes are realigned. HMA overlays on concrete pavement are susceptible to reflective cracking and contribute to ongoing maintenance and rehabilitation expenses. Depending on the existing roughness, surface irregularities, and overlay thickness, a leveling course and reflective cracking control measures such as RHMA and a stress absorbing membrane interlayer (SAMI) should be considered.

- CRCP Full-Depth Repairs (Ch. 380) require full-depth removal of deteriorated concrete pavement, replacement of longitudinal steel reinforcement, and patching with RSC material. Punchouts occur between 2 closely spaced transverse cracks when high deflections at the pavement edge or longitudinal joint pump base material from beneath the slab, causing loss of support. Crack movement cycles reduce aggregate interlock and continued traffic loading creates cantilever action that eventually ruptures the longitudinal bars at the crack faces, punching the broken concrete segment into the base. The rectangular repair limits should be at least 6’ long, extend at least 6” beyond the damaged or defective areas, and be at least 18” away from adjacent, non-deteriorated cracks.

100.2.3 Rehabilitation Strategies

Roadway rehabilitation design information is given in HDM Topic 625. More complete information about rehabilitation strategies currently used by the Department can be found in CPG Part 4 and condensed here:

- Lane replacement (Ch. 400) is used to replace individual lanes on multilane highways when other lanes have significant remaining service life. Lane replacement is cost effective when more than 20% of the slabs in a lane have severe cracking, but can also be cost effective from 10 to 20% compared to CAPM individual slab replacement depending on LCCA. The pavement structure is designed as new concrete pavement to accommodate future traffic loading, so replacement of the underlying base layers may be required according to the design catalogs in HDM Index 623.1.

- Crack, Seat, and (HMA) Overlay (CSOL) [Ch. 410] is used where multiple JPCP concrete pavement lanes have extensive severe third stage cracking over 10% or combined structural cracking and spalling deterioration exceeding 15% of the management segment. Heavy drop hammer equipment breaks slabs into 4’ by 6’ segments. The closely spaced pieces reduce vertical and horizontal movement and maintain aggregate interlock through full-depth hairline cracks with little loss of structural capacity, creating a strong, stable base for the overlay that retards reflective cracking. Cracked concrete is then seated using heavy rollers to create a relatively uniform grade to support paving operations and re-establish adequate support between the base and the cracked slab. CSOL. After cracking and seating, an HMA leveling course is placed, followed by a stress absorbing membrane interlayer (SAMI) and final HMA lift (see HDM Index 625.1).

- HMA Overlays (HMAOL) [Ch. 370] are used where CSOL application is limited and vertical clearance issues can be addressed. HMA overlays provide a wearing surface to protect the existing concrete but are more susceptible to reflective cracking since the concrete surface is not cracked and seated. Reflective cracking control measures such as use of thicker HMA, RHMA, and a SAMI should be considered. A leveling course may be justified depending on the existing roughness, surface irregularities, and overlay thickness.

- Unbonded Concrete Overlay (UBCO) [Ch. 420] consists of new concrete typically placed over existing concrete pavement and a thin HMA bond breaker interlayer at least 0.10’ thick. The HMA interlayer reduces reflective cracking and provides flexibility for concrete pavement curling from temperature differentials between the top and bottom of the concrete surface.

100.3 CONCRETE PAVEMENT PROJECT IMPLEMENTATION

Once any type of pavement is constructed, it inevitably begins deteriorating over time due to traffic loading and environmental exposure to a variety of climatic conditions. Eventually, a maintenance strategy or pavement project will be required to delay more rapid deterioration or restore acceptable structural and functional condition. Successful project implementation requires a comprehensive, accurate pavement condition evaluation analyzed within a sound pavement management policy framework.

Collecting accurate data using repeatable methods are goals of the biannual automated pavement condition survey (APCS), accessible through iVision and summarized in PaveM. The APCS quantifies existing distress by type, severity, and extent. Distress accumulation from exposure to traffic loading and environmental conditions is monitored by the APCS over time for individual pavement management segments. When thresholds established by performance models and decision criteria in the pavement management system are reached, a project is initiated by district maintenance or advance planning offices and the development process begins.

Network-level policies and tools such as the APCS must be efficiently integrated with project-level support, analysis, and sound engineering judgment from the district project development team to engineer effective pavement strategies applied at the right time. The implementation process for concrete pavement project development is outlined by the flow chart in Figure 100-3. Ideally, as performance data accumulates, the process will evolve as individual elements are refined to maximize resources while collectively managing the entire 50,000 lane-mile roadway network statewide.

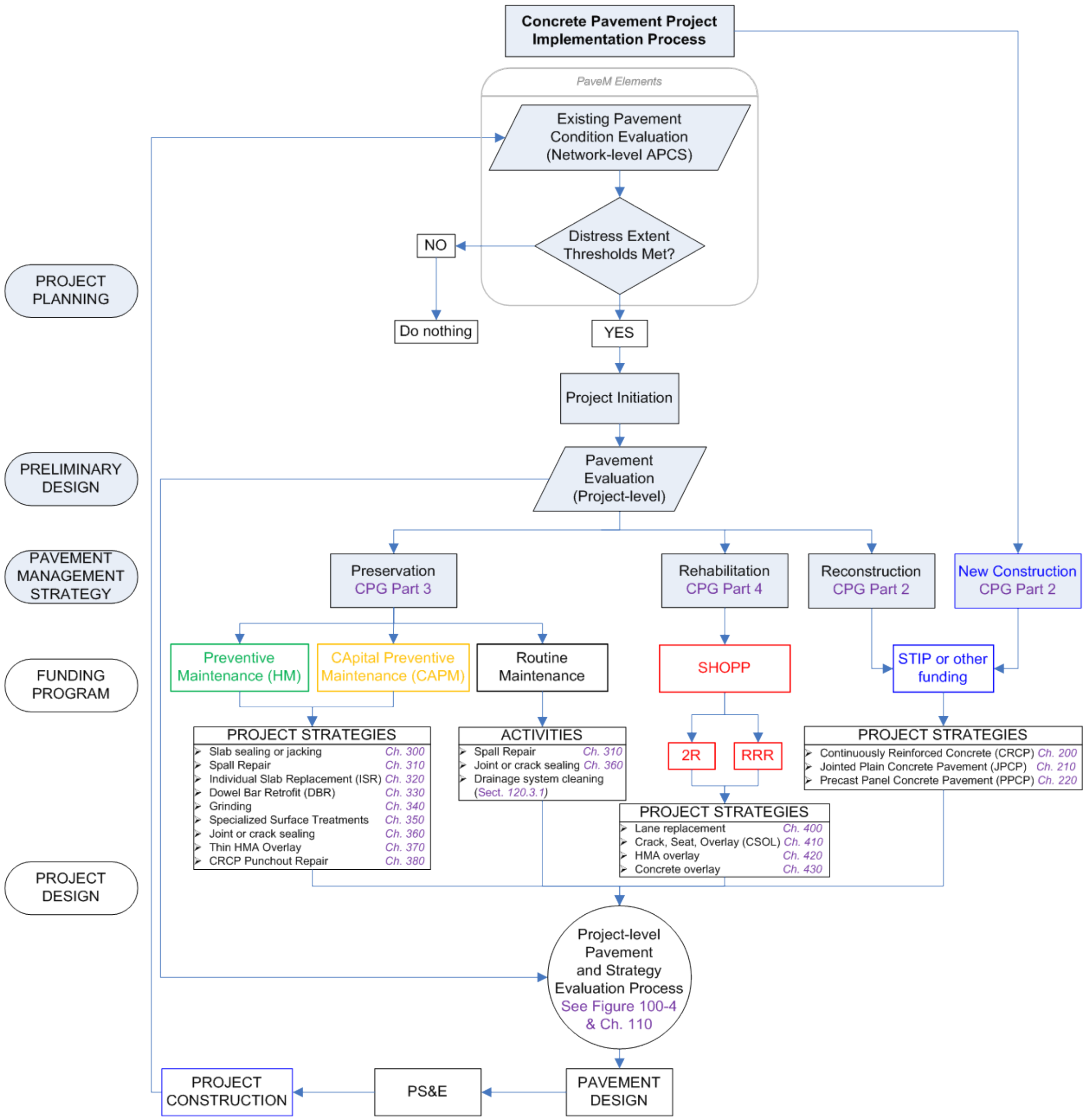

Figure 100–3: Concrete pavement management project development process

100.3.1 Pavement Strategy Recommendations

PaveM provides recommendations for project strategies to treat each individual distress. The strategies in Table 100-1 are network-level recommendations based on APCS structural and functional distress data and thresholds developed from pavement engineering principles and pavement management policy. Not all critical pavement distresses are quantified by the APCS, and failure mechanisms may not be readily identified from available images and data for the network. All project strategies and locations should be verified using engineering judgment after a scoping field review by the project team, consisting of the HQ program advisor or pavement reviewer and qualified District maintenance, materials, and design personnel (see Section 110.2). During the field review, areas where multiple distresses or failure mechanisms require additional repairs or pavement strategy combinations should be identified (see Section 100.3.2). After the pavement is evaluated by field review, the project development team should analyze the feasible alternatives and document the strategy recommendations in the appropriate project development report (PSR, PR, PSSR).

Chapter 110 contains more details about the project-level pavement and strategy evaluation processes, which are outlined below in Figure 100-4:

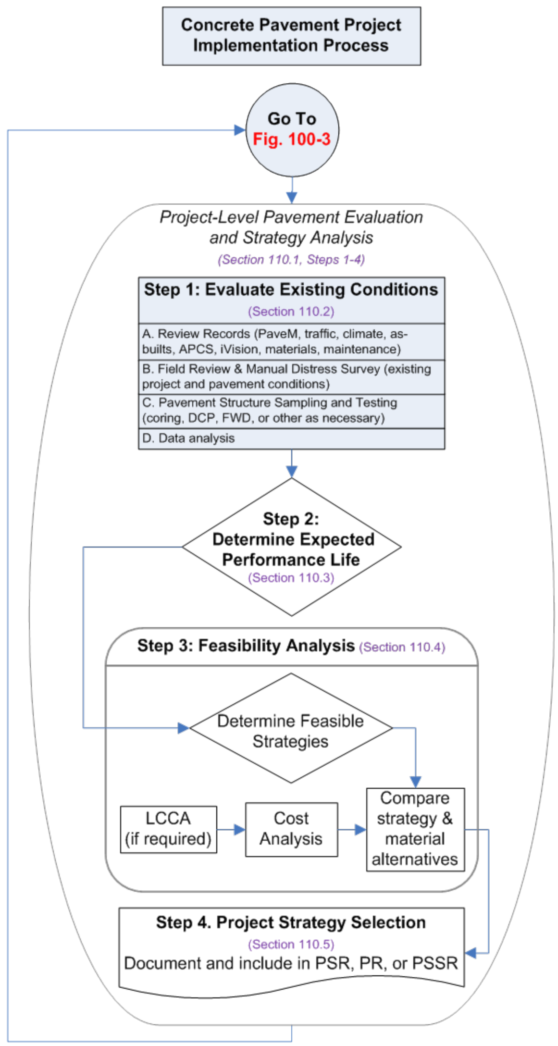

Figure 100–4: Concrete pavement strategy evaluation process

Table 100–1: Concrete Pavement Strategy Selection

Preventive Maintenance (HM)	CApital Preventive Maintenance (CAPM)	Rehabilitation (SHOPP)

APCS Distress Type	Severity	Quantity (per slab)	Management Segment Extent (%)	Recommended Primary Strategy*	Reference
Transverse, Longitudinal, or Corner Cracking (Count ≥ 1; Width: inches)	Low	< ¼”	100	None	APCS Manual
	Medium	¼ – ¾”	1–25	None	APCS Manual
			> 25	Crack sealing	Ch. 360
	High	> ¾”	1–15	▪ Individual slab replace ▪ HMAOL	▪ Ch. 320 ▪ Ch. 370
			> 15	▪ Lane replacement ▪ CSOL or HMAOL ▪ Unbonded concrete OL	▪ Ch. 400 ▪ Ch. 410 ▪ Ch. 420
3rd Stage Cracking (Width: inches)	Low	< ¼”	100	None	APCS Manual
	Medium	¼ – ¾”	1–20	None	APCS Manual
			> 20	Crack sealing	Ch. 360
	High	> ¾”	1–10	▪ Individual slab replace ▪ HMAOL	▪ Ch. 320 ▪ Ch. 370
			> 10	▪ Lane replacement ▪ CSOL or HMAOL ▪ Unbonded concrete OL	▪ Ch. 400 ▪ Ch. 410 ▪ Ch. 420
Spalling (ft^2)	Low	< 1	100	None	APCS Manual
	Medium	1–2	1–25	None	APCS Manual
			> 25	Spall repair	Ch. 310
	High	> 2	1–15	▪ Individual slab replace ▪ HMAOL	▪ Ch. 320 ▪ Ch. 370
			> 15	▪ Lane replacement ▪ CSOL ▪ Unbonded concrete OL	▪ Ch. 400 ▪ Ch. 410 ▪ Ch. 420
Roughness (IRI: inches/mile)	Low	< 95	100	None	APCS Manual
	Medium	95–170	100	None	APCS Manual
	High	> 170	1–50	None	APCS Manual
			> 50	Grinding	Ch. 340
Faulting (inches)	Low	< ¼”	100	None	APCS Manual
	Medium	¼ – 1”	1–50	None	APCS Manual
			> 50	▪ Grinding	▪ Ch. 340
				▪ DBR & Grinding	▪ Ch. 330 & 340
	High	> 1”	1–25	▪ Grinding	▪ Ch. 340
				▪ DBR & Grinding	▪ Ch. 330 & 340
			> 25	▪ Grinding, thin HMAOL	Ch. 340, 370
Rutting (inches)	Low	< ¼”	100	None	APCS Manual
	Medium	¼ – 1”	1–25	None	APCS Manual
			> 25	▪ Grinding, hardener	▪ Ch. 340 & 350
	High	> 1”	1–10	▪ Grinding, thin HMAOL	▪ Ch. 340 & 370
			> 10	▪ Grinding, thin HMAOL ▪ Unbonded concrete OL	▪ Ch. 340 & 370 ▪ Ch. 420
CRCP Punchouts (per mile)	Low	< 1		None	APCS Manual
	Medium	2–5		CRCP full-depth repair	Ch. 380
		6–9		CRCP full-depth repair, thin HMAOL	Ch. 380, 370
	High	> 10		▪ Lane replacement ▪ HMAOL ▪ Unbonded concrete OL	▪ Ch. 400 ▪ Ch. 370 ▪ Ch. 420

*The primary recommended strategy should be evaluated by a field review and pavement evaluation (see Ch. 110). Multiple distresses may require a combination of strategies for effective pavement performance.

100.3.2 Strategy Combinations and Preoverlay Repair

Performance of any pavement surface is dependent on uniform support from the underlying structure. Some distress combinations require multiple pavement strategies for effective repair or to address failure mechanisms. Medium and high severity spalling on slabs not identified for replacement should be repaired for all projects. If any type of overlay is recommended as the primary strategy, HDM Index 625.1 requires existing pavement distress to be repaired. Repair includes addressing the resulting distress and the mechanism causing the failure. Some repairs recommended for consideration are:

- Medium or high severity cracks should be sealed.
- JPCP slabs with severe 3rd stage cracking ≥ ½” may require replacement.
- JPCP slab medium severity settlement or faulting ≥ ½” may require base replacement.
- Medium severity roughness with an IRI from 95 to 170 inches/mile may require a leveling course or grinding prior to overlay.

Refer to the applicable Concrete Pavement Guide chapter of the recommended primary strategy for more information about identifying effective strategy combinations.