Research Report

Assessment and Update of TIB Urban Program and Small City Preservation Program

Part 4: Recommended SCPP Treatment Scoping Process

by

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30 June 2015

Prepared for
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SCPP TREATMENT SCOPING PROCESS

TIB has identified six (6) potentially viable treatment options for TIB Small City programs including the Small City Arterial Program (SCAP) and the Small City Preservation Program (SCPP). This section outlines a recommended process for selecting appropriate treatments for a Small City project.

STEP 1: GET PCR & HISTORICAL DATA FOR THE EXISTING ROADWAY

Obtain the Pavement Condition Rating (PCR) for the existing roadway either from existing TIB data or from a new measurement that follows TIB protocol.

STEP 2: GATHER HISTORICAL INFORMATION ON THE EXISTING ROADWAY

Available information for an existing roadway can help determine the underlying causes of its current pavement condition. If available, the following information should be reviewed:

- **Original design information and/or as-built drawings**. Will likely provide original pavement structure and thicknesses/composition of individual layers.
- **Details of materials used to construct the existing pavement layers**. Will likely provide information on the load bearing capacity of individual pavement layers.
- **Construction testing data**. Construction quality can influence pavement performance.
- **Maintenance activity information/records**. May indicate recurring pavement issues that are likely to recur with a new pavement roadway unless corrected.
- **Typical traffic patterns (especially bus or heavy truck routes)**. May indicate patterns of use that have changed over time that may have contributed to the pavement's current condition.

Much, if not all, of this information may be unavailable or available only by recollection rather than official records.

STEP 3: PERFORM A VISUAL DISTRESS SURVEY

Perform a visual distress survey to identify all observed distress types as well as their severity and frequency as shown in Figure 3. While TIB pavement condition records catalog some of the distresses in Figure 3, they do not contain all these distresses. It is important to catalog all the distresses in Figure 3 in order to determine the most appropriate treatment. Ideally, the visual distress survey should be completed within the year prior to making the pavement treatment selection. Figure 4 gives basic examples of these distresses.

STEP 4: EXCLUDE ANY ISOLATED AREAS OF BASE FAILURE

It may be that there are isolated areas of base failure. These can often be identified by isolated areas of severe alligator cracking or base rutting (rutting of the base material that causes the pavement wheelpaths to crack and sink). If these areas comprise < 20% of the total pavement

area, they should be (1) excluded from the visual distress survey results, and (2) dug out to the depth of the failing base and replaced with a material of CBR ≥ 10. If these base failure areas are > 20% of the total pavement area it is likely less expensive to reconstruct or FDR the entire pavement.

STEP 4: COMPLETE ALL TREATMENT SELECTION FLOW CHARTS

Complete all four (4) treatment selection flow charts in Figure 1. This process is intended to determine which of the four basic treatment types (chip/cape seal, HMA overlay, FDR, reconstruction) are viable for the pavement in question. It may be that more than one treatment is viable. Use the following steps to score a pavement:

1. For each observed distress enter the appropriate columns in Figure 3 using the observed distress type and severity level from Step 3 and determine a point total for each treatment. Points are scored for each distress as follows:
   - ✪ = 2 points. Usually the best treatment for the listed conditions. Risk of failure is low if designed/constructed properly.
   - O = 1 point. The treatment can work, but there is some risk of failure, or the treatment is expensive for conditions.
   - ☒ = 0 points. Treatment is inappropriate because it does not address the underlying cause of failure, is too expensive for the given distress, or the risk of failure is high.
2. Sum the points for each treatment across all distresses.
3. Determine viable treatments. The treatment with the highest point total is considered viable along with any treatment that scores within one point of this highest total. Any treatment that was disqualified for any distress is not considered viable.

STEP 5: OTHER CONSIDERATIONS FOR VIABLE TREATMENTS

Consider other items such as lifecycle cost, initial construction cost, typical surface life, and other unique design, construction, and project features in determining which viable treatment is preferred. Use the “Treatment Guidance” pages as a quick reference for these considerations.

STEP 6: SELECT THE PREFERRED TREATMENT

Select the preferred treatment based on Steps 1-5.

FIGURE 1: TREATMENT SELECTION FLOW CHARTS

For each project complete all four flow charts to determine which treatment options are viable.

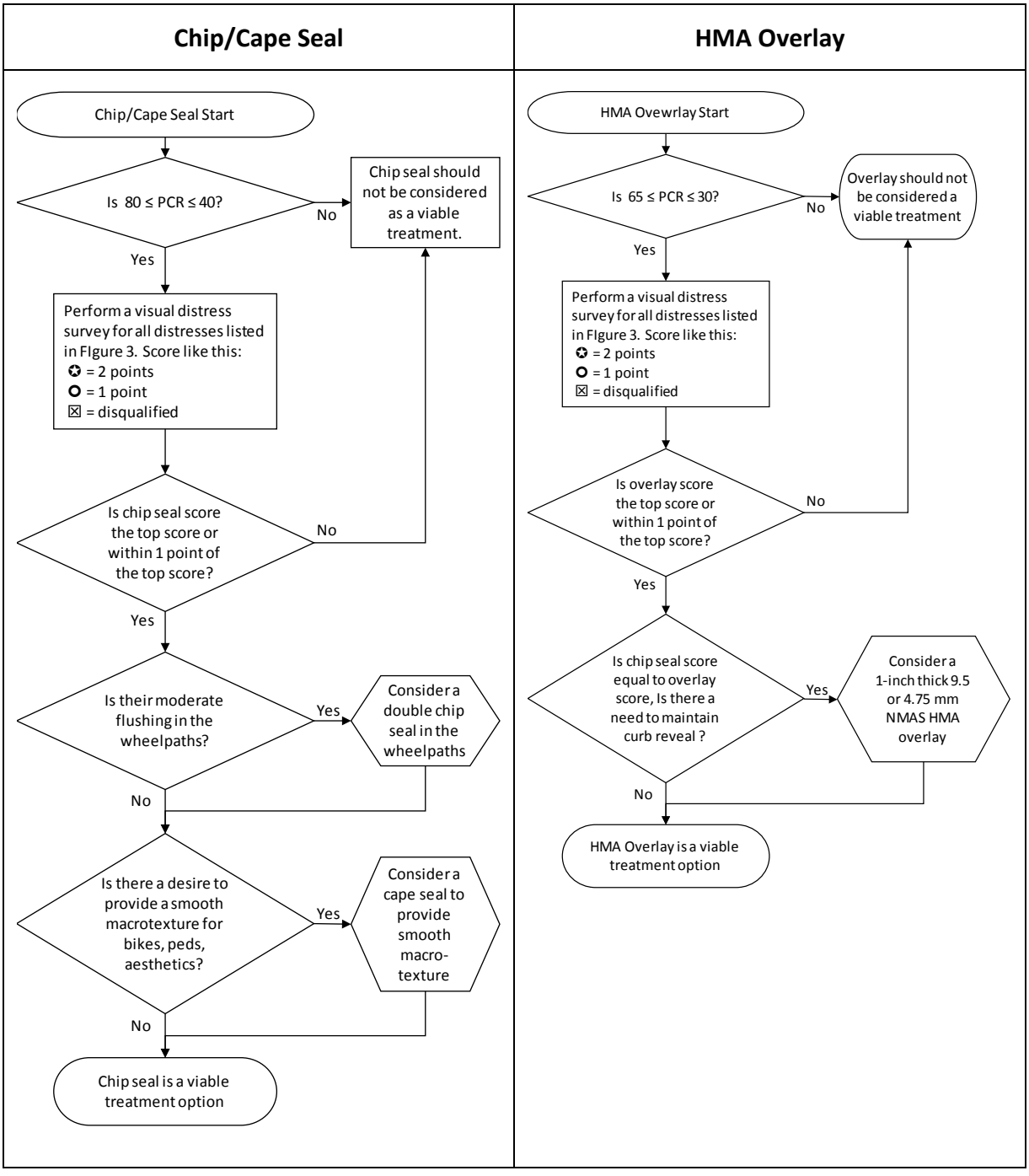


FIGURE 1 (CONT.): TREATMENT SELECTION FLOW CHARTS

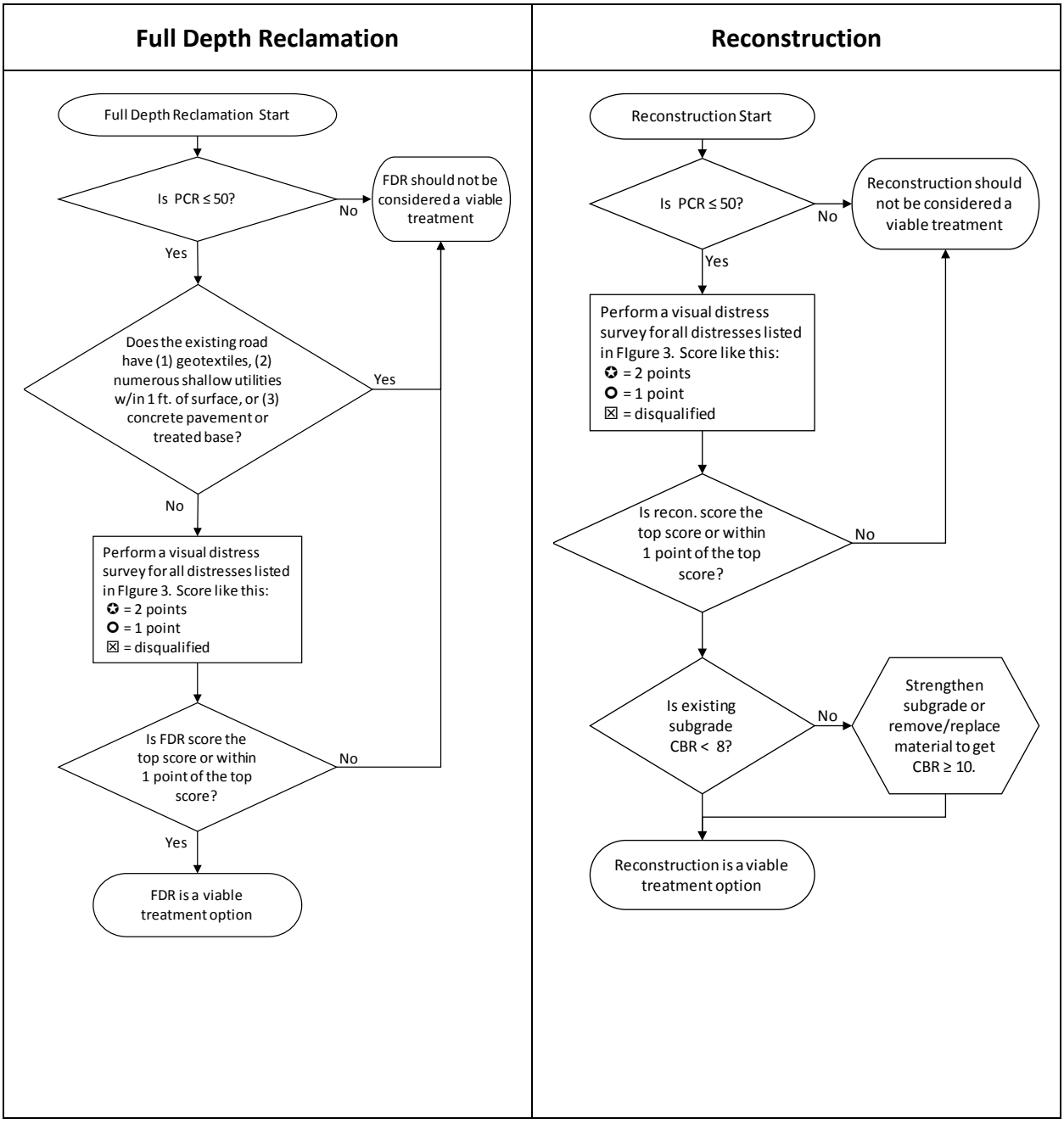


FIGURE 2: APPROPRIATE PAVEMENT TREATMENTS FOR PCR RANGES

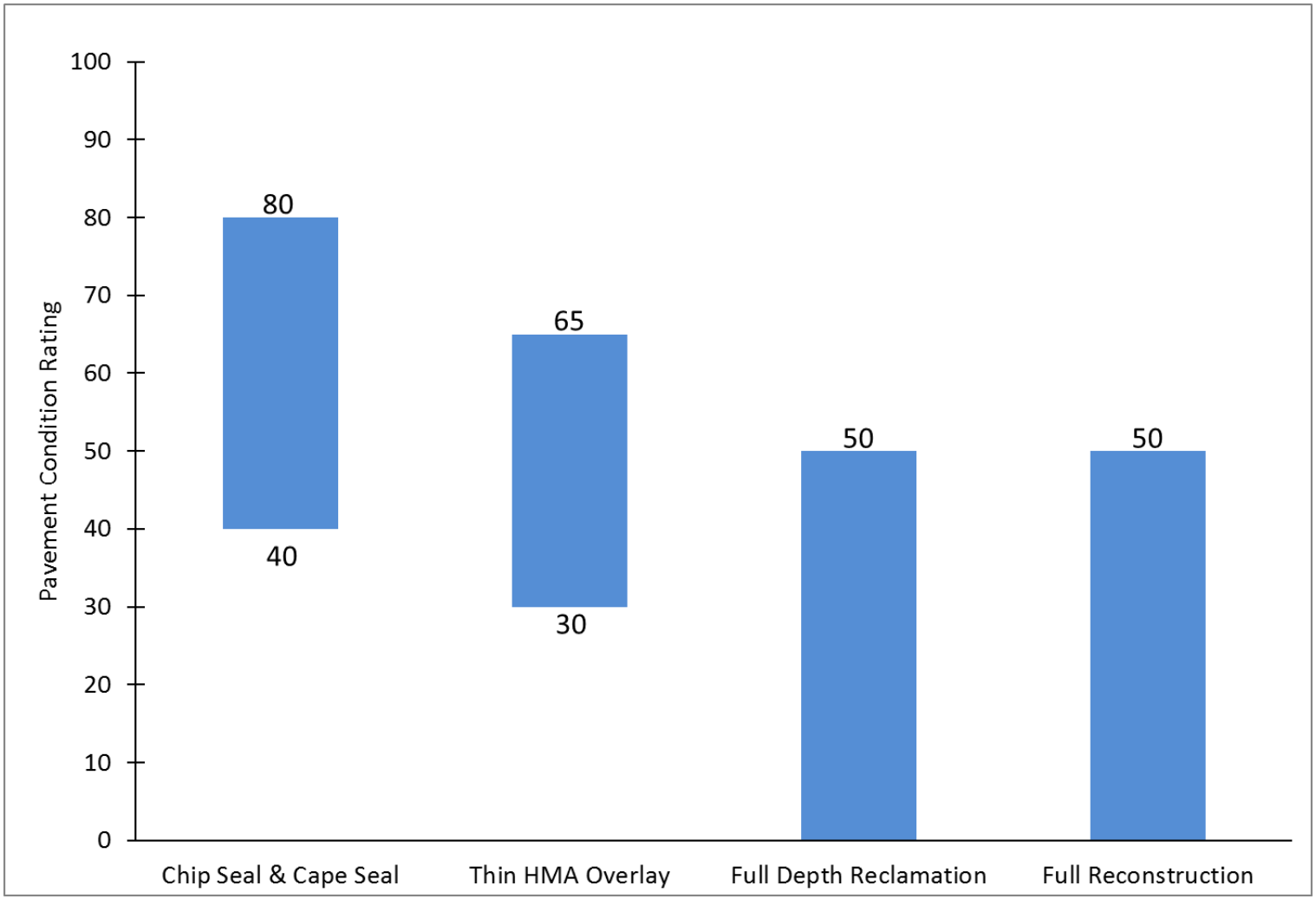


FIGURE 3: PAVEMENT TREATMENTS APPROPRIATE FOR OBSERVED PAVEMENT DISTRESSES

Preservation Treatment	Pavement Distress and Severity Levels (L=Low, M=Medium, H=High)							
	Ravel	**Bleed/Flush**	**Rutting**	**Patching**	**Alligator Cracking**	**Block Cracking**	**Transverse Cracking**	**Longitudinal Cracking**
	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
Chip Seal & Cape Seal	✪✪O	O O ☒	O ☒ ☒	O O ☒	✪ O ☒	✪ O O	✪ O O	✪ O O
Thin HMA Overlays	O O ✪	O O ☒	✪ O ☒	O O ☒	✪ ✪ ☒	O ✪ O	O ✪ O	O O ✪
Full Depth Reclamation	☒ ☒ ☒	☒ O ✪	☒ ✪ ✪	O O ✪	O O ✪	☒ ☒ O	☒ ☒ O	☒ ☒ O
Full Reconstruction	☒ ☒ ☒	☒ O ✪	☒ ✪ ✪	O O ✪	O O ✪	☒ ☒ O	☒ ☒ O	☒ ☒ O
Description of Severity Levels	L: Patchy areas, usually in wheelpaths M: Majority of wheelpaths affected H: Most of the lane is affected	L: Patchy areas, usually in wheelpaths M: Majority of wheelpaths affected H: Most of the lane is affected	L: Rut depth ≤ 1/4” M: Rut depth 1/4”to 3/4” H: Rut depth > 3/4”	L: ≤ 5% of surface area M: 6% to 25% of surface area H: > 25% of surface area	L: Hairline M: Spalling H: Spalling & Pumping	L: Cracks ≤ 1/4” wide M: Cracks over 1/4”with no spalling H: Cracks > 1/4” with spalling	L: 1 to 4 cracks per 100’ M: 5 to 9 cracks per 100’ H: 10 or more cracks per 100’	L: 1% to 99% of segment length M: 100% to 199% of segment length H: 200% or more of segment length

If more than one type of distress is present, select a treatment that addresses both distresses at least on a conditional level.

✪ = Recommended. Usually the best treatment for the listed conditions. Risk of failure is low if designed/constructed properly.

O = Conditional. Some risk of failure, or treatment is expensive for conditions. Usually requires further, more detailed, analysis.

☒ = Not Recommended. Treatment is inappropriate because it is too expensive for the given distress or the risk of failure is high.

Preservation Selection Table Guidance

Raveling

- Raveling is not a structural failure. If it is the only visible failure, then resurfacing is most appropriate.
- It is difficult to determine the severity of raveling in a given area. For this guide, severity is judged based on the area of raveling and not the amount of dislodged aggregate.

Bleeding/Flushing

- It is difficult to determine the amount of bleeding/flushing in a particular area from a moving vehicle. For this guide, severity is judged based on the area of bleeding/flushing and not the volume of asphalt binder showing on the pavement surface.
- Bleeding/flushing should be removed via milling if possible before resurfacing.

Rutting

- Rut depth should be measured from the deepest part of the rut to the normal pavement surface. This DOES NOT include the raised lip on one or both sides of the rut often caused by plastic deformation of the pavement surface.

Patching

- For the purposes of this guide patching is considered to be an inferior pavement surface done to lesser quality than a typical resurfacing. Therefore, it is assumed to have a shorter life. Also, patching can be an indication of an underlying uncorrected failure like base or subgrade failure.

Alligator cracking

- Alligator cracking is an indicator of structural failure (loads are greater than can be supported by the pavement structure), advanced cracking of another type (e.g., longitudinal cracking), or subgrade failure.
- Before selecting a treatment type, investigate the underlying cause of alligator cracking. If the base/subgrade is weak and deforming, a full-depth repair of the area is warranted rather than just a resurfacing.

Block Cracking

- Block cracking is indicative of surface aging and is NOT load related. A resurfacing should correct the issue unless it is severe.

Transverse Cracking

- Transverse cracking is the result of pavement volume contraction in cold weather. Usually they occur at regular intervals associated with the amount of contraction.

Longitudinal Cracking

- Can be the result of poor longitudinal joint construction or top-down cracking.
    - Poor joint construction: Cracks are usually very straight and occur on joint locations, often on lane markers.
    - Top-down cracking: Usually occurs on pavements with 5 inches or greater of HMA. Cracks are not as straight and can progress to alligator cracking.

Figure 4: Pavement Distress Types



Raveling



Bleeding/Flushing



Rutting (Severe)



Patching



Alligator Cracking (severe)



Block Cracking (severe)



Transverse Cracking



Longitudinal Cracking



Rutting/Cracking from Base Failure

TREATMENT GUIDANCE

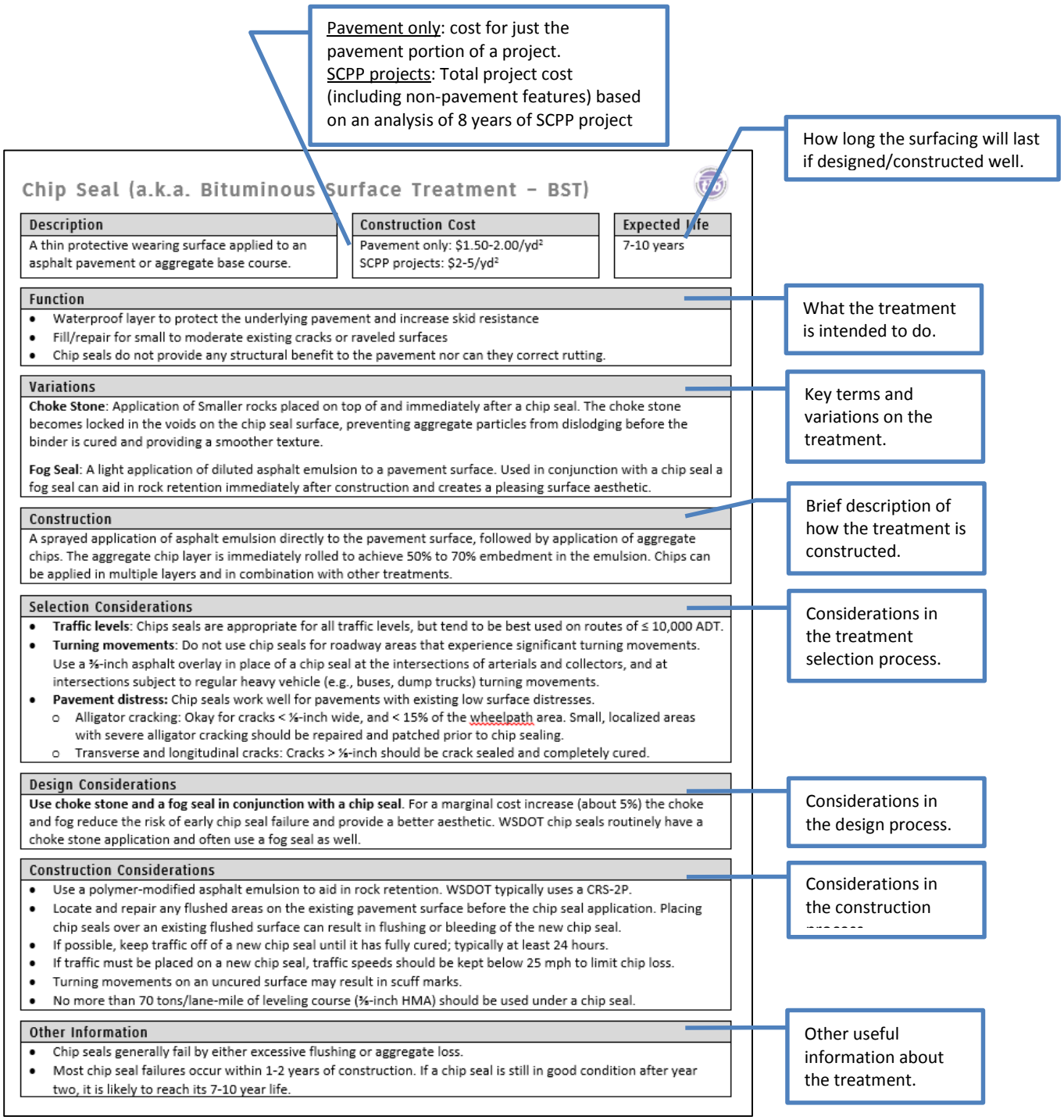
This section describes the six (6) potentially viable treatment options for TIB Small City programs including the Small City Arterial Program (SCAP) and the Small City Preservation Program (SCPP). The intention is to provide succinct one-page summaries of each type of pavement treatment to include description, cost, expected life, function, variations, construction, and various considerations for selection, design and construction. While these guidelines do not provide all relevant information regarding these treatments, they do provide a convenient reference when considering which treatment to select and how it is best designed, constructed, and maintained.

More Information

The following resources are some of the best ones for obtaining more information about the treatment methods discussed in this document:

- *Pavement Interactive* (2014). http://www.pavementinteractive.org.
    - An online pavement Wiki with over 600 articles and accessed by over 350,000 people per year. Contains articles on most pavement topics including overlays, chip seals, construction, design, pavement distresses, and maintenance.
- Gransberg, D. and James, D.M.B. (2005). *NCHRP Synthesis 342: Chip Seal Best Practices*. Transportation Research Board, Washington, D.C. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_342.pdf
    - Best national reference on chip seals and cape seals. Provides details on common practices, distresses, mix design, and more.
- Peshkin, D.; Smith, K.L.; Wolters, A.; Krstulovich, J.; Moulthrop, J. and Alvarado, C. (2011). Preservation Approaches for High-Traffic-Volume Roadways. SHRP 2 Report S2-R26-RR-1, Transportation Research Board, Washington, D.C. http://www.trb.org/Publications/Blurbs/165280.aspx
    - National reference on preservation treatments for high volume roads. While small city programs do not address high volume roads, much of the guidance relating to treatment function, selection, performance, and cost remains relevant.
- Button, J. and Lytton, R. (2003). *Guidelines for Using Geosynthetics with HMA Overlays to Reduce Reflective Cracking*. Texas DOT Report 1777-P2, Texas Transportation Institute (TTI), Texas A&M University, College Station, TX. http://www.utexas.edu/research/tppc/pubs/button_geosynthetics.pdf
    - Best reference on how to effectively use geotextiles in pavements. Most such references do not include potential risks as well as this one.
- Caltrans. (2013). *Flexible Pavement Rehabilitation Using Pulverization*. California DOT (Caltrans), Sacramento, CA. http://www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/PDF/pulv_guide-Jan_2013_update_Final.pdf.
    - Best summary reference for FDR. While the guidance is specific for Caltrans, general practices, risks, advantages, etc. are describe well and remain relevant to Washington for the most part.
- Interlocking Concrete Paving Institute (2014). *Website*. ICPI, Chantilly, VA. https://www.icpi.org.
    - Best source of proper design, installation and care of concrete block pavers.

Key


Pavement only: cost for just the pavement portion of a project.
SCPP projects: Total project cost (including non-pavement features) based on an analysis of 8 years of SCPP project
How long the surfacing will last if designed/constructed well.
Chip Seal (a.k.a. Bituminous Surface Treatment – BST)
Description
A thin protective wearing surface applied to an asphalt pavement or aggregate base course.
Construction Cost
Pavement only: $1.50-2.00/yd²
SCPP projects: $2-5/yd²
Expected Life
7-10 years
What the treatment is intended to do.
Function
Waterproof layer to protect the underlying pavement and increase skid resistance
Fill/repair for small to moderate existing cracks or raveled surfaces
Chip seals do not provide any structural benefit to the pavement nor can they correct rutting.
Key terms and variations on the treatment.
Variations
Choke Stone: Application of Smaller rocks placed on top of and immediately after a chip seal. The choke stone becomes locked in the voids on the chip seal surface, preventing aggregate particles from dislodging before the binder is cured and providing a smoother texture.
Fog Seal: A light application of diluted asphalt emulsion to a pavement surface. Used in conjunction with a chip seal a fog seal can aid in rock retention immediately after construction and creates a pleasing surface aesthetic.
Brief description of how the treatment is constructed.
Construction
A sprayed application of asphalt emulsion directly to the pavement surface, followed by application of aggregate chips. The aggregate chip layer is immediately rolled to achieve 50% to 70% embedment in the emulsion. Chips can be applied in multiple layers and in combination with other treatments.
Considerations in the treatment selection process.
Selection Considerations
Traffic levels: Chips seals are appropriate for all traffic levels, but tend to be best used on routes of ≤ 10,000 ADT.
Turning movements: Do not use chip seals for roadway areas that experience significant turning movements. Use a ¾-inch asphalt overlay in place of a chip seal at the intersections of arterials and collectors, and at intersections subject to regular heavy vehicle (e.g., buses, dump trucks) turning movements.
Pavement distress: Chip seals work well for pavements with existing low surface distresses.
Alligator cracking: Okay for cracks < ⅛-inch wide, and < 15% of the wheelpath area. Small, localized areas with severe alligator cracking should be repaired and patched prior to chip sealing.
Transverse and longitudinal cracks: Cracks > ⅛-inch should be crack sealed and completely cured.
Considerations in the design process.
Design Considerations
Use choke stone and a fog seal in conjunction with a chip seal. For a marginal cost increase (about 5%) the choke and fog reduce the risk of early chip seal failure and provide a better aesthetic. WSDOT chip seals routinely have a choke stone application and often use a fog seal as well.
Considerations in the construction process
Construction Considerations
Use a polymer-modified asphalt emulsion to aid in rock retention. WSDOT typically uses a CRS-2P.
Locate and repair any flushed areas on the existing pavement surface before the chip seal application. Placing chip seals over an existing flushed surface can result in flushing or bleeding of the new chip seal.
If possible, keep traffic off of a new chip seal until it has fully cured; typically at least 24 hours.
If traffic must be placed on a new chip seal, traffic speeds should be kept below 25 mph to limit chip loss.
Turning movements on an uncured surface may result in scuff marks.
No more than 70 tons/lane-mile of leveling course (¾-inch HMA) should be used under a chip seal.
Other useful information about the treatment.
Other Information
Chip seals generally fail by either excessive flushing or aggregate loss.
Most chip seal failures occur within 1-2 years of construction. If a chip seal is still in good condition after year two, it is likely to reach its 7-10 year life.

Chip Seal (a.k.a. Bituminous Surface Treatment – BST)

Description	Construction Cost	Expected Life
A thin protective wearing surface applied to an asphalt pavement or aggregate base course.	Pavement only: $1.50-2.00/yd^2 SCPP projects: $2-5/yd^2	7-10 years

Function

- Waterproof layer to protect the underlying pavement and increase skid resistance
- Fill/repair for small to moderate existing cracks or raveled surfaces
- Chip seals do not provide any structural benefit to the pavement nor can they correct rutting.

Variations

Choke Stone: Application of Smaller rocks placed on top of and immediately after a chip seal. The choke stone becomes locked in the voids on the chip seal surface, preventing aggregate particles from dislodging before the binder is cured and providing a smoother texture.

Fog Seal: A light application of diluted asphalt emulsion to a pavement surface. Used in conjunction with a chip seal a fog seal can aid in rock retention immediately after construction and creates a pleasing surface aesthetic.

Construction

A sprayed application of asphalt emulsion directly to the pavement surface, followed by application of aggregate chips. The aggregate chip layer is immediately rolled to achieve 50% to 70% embedment in the emulsion. Chips can be applied in multiple layers and in combination with other treatments.

Selection Considerations

- **Traffic levels**: Chips seals are appropriate for all traffic levels, but tend to be best used on routes of ≤ 10,000 ADT.
- **Turning movements**: Do not use chip seals for roadway areas that experience significant turning movements. Use a ⅜-inch asphalt overlay in place of a chip seal at the intersections of arterials and collectors, and at intersections subject to regular heavy vehicle (e.g., buses, dump trucks) turning movements.
- **Pavement distress:** Chip seals work well for pavements with existing low surface distresses.
  - Alligator cracking: Okay for cracks < ⅛-inch wide, and < 15% of the wheelpath area. Small, localized areas with severe alligator cracking should be repaired and patched prior to chip sealing.
  - Transverse and longitudinal cracks: Cracks > ⅛-inch should be crack sealed and completely cured.

Design Considerations

Use choke stone and a fog seal in conjunction with a chip seal. For a marginal cost increase (about 5%) the choke and fog reduce the risk of early chip seal failure and provide a better aesthetic. WSDOT chip seals routinely have a choke stone application and often use a fog seal as well.

Construction Considerations

- Use a polymer-modified asphalt emulsion to aid in rock retention. WSDOT typically uses a CRS-2P.
- Locate and repair any flushed areas on the existing pavement surface before the chip seal application. Placing chip seals over an existing flushed surface can result in flushing or bleeding of the new chip seal.
- If possible, keep traffic off of a new chip seal until it has fully cured; typically at least 24 hours.
- If traffic must be placed on a new chip seal, traffic speeds should be kept below 25 mph to limit chip loss.
- Turning movements on an uncured surface may result in scuff marks.
- No more than 70 tons/lane-mile of leveling course (⅜-inch HMA) should be used under a chip seal.

Other Information

- Chip seals generally fail by either excessive flushing or aggregate loss.
- Most chip seal failures occur within 1-2 years of construction. If a chip seal is still in good condition after year two, it is likely to reach its 7-10 year life.

Cape Seal

Description	Construction Cost	Expected Life
A slurry seal placed over a chip seal. Usually done within 4-10 days after the chip seal is placed.	Pavement only: $2-3/yd^2 SCPP projects: unknown	7-15 years

Function

- Waterproof layer to protect the underlying pavement and increase skid resistance
- Fill/repair for small to moderate existing cracks or raveled surfaces
- Cape seals do not provide any structural benefit to the pavement nor can they correct rutting.

Components

Chip Seal: First step in a cape seal. No choke stone or fog seal is applied.

Slurry Seal: A mixture of emulsified asphalt, water, well-graded fine aggregate and mineral filler that has a creamy fluid-like appearance when applied. In a cape seal, the slurry seal is applied usually 4-10 days after the chip seal and is used to seal the aggregate chips in place and provide a smooth, skid-resistant surface.

Construction

A chip seal is applied to the existing pavement surface. After a 4-10 day waiting period to fully cure the chip seal, the surface is brushed off, and a slurry seal is placed over the top.

Selection Considerations

- **Traffic levels**: Cape seals are appropriate for all traffic levels, but tend to be best used on routes of ≤ 10,000 ADT.
- **Turning movements**: Do not use cape seals for roadway areas that experience significant turning movements. Use a ⅜-inch asphalt overlay in place of a cape seal at the intersections of arterials and collectors, and at intersections subject to regular heavy vehicle (e.g., buses, dump trucks) turning movements.
- **Pavement distress**: same as chip seal.

Design Considerations

- Cape seals can be used in any condition that would warrant a chip seal.
- Cape seals provide a smoother macrotexture (fine surface texture) than chip seals, which may be preferable for bicyclists, pedestrians, and more aesthetically appealing.
- Capes seals may last longer than chip seals.

Construction Considerations

- Locate and repair any flushed areas on the existing pavement surface before the initial chip seal application. Placing chip seals over an existing flushed surface can result in flushing or bleeding of the new chip seal.
- After completion of the chip seal, any aggregate loss should be repaired prior to placing the slurry seal. Flushing can occur if the slurry seal is placed over a chip seal area that has lost a significant amount of chips.
- If possible, keep traffic off of a new chip seal and new slurry seal until they have fully cured.
- If traffic must be placed on a new chip seal or new slurry seal, traffic speeds should be kept below 25 mph.
- Turning movements on an uncured surface (chip or slurry) may result in scuff marks.
- No more than 70 tons/lane-mile of leveling course (⅜-inch HMA) should be used under a chip seal.

Other Information

- Cape seals generally fail by either excessive flushing or aggregate loss. This may be caused by issues with the underlying chip seal or the surface slurry seal.
- Most cape seal failures occur within 1-2 years of construction. If a cape seal is still in good condition after year two, it is likely to reach its 7-15 year life.

Thin Hot Mix Asphalt (HMA) Overlay

Description	Construction Cost	Expected Life
A thin HMA wearing surface placed on top of an asphalt pavement. Usually 1 – 2 inches thick.	Pavement only: \$9-12/yd^2 SCPP projects: \$14-37/yd^2	10-20 years

Function

- Correct surface defects and improve ride smoothness
- Improve safety characteristics such as skid resistance and drainage
- Thin HMA overlays do not provide any structural benefit to the pavement

Variations

Milling: An existing surface can be milled to a depth equal to that of the overlay thickness. This removes existing surface defects that do not extend below the mill depth, and can maintain curb height.

Mix design: HMA mixtures are specified by their PG binder grade, nominal maximum aggregate size, and gradation.

- PG binder grade: a shorthand method of describing an asphalt binder specification. Standard WSDOT grades are PG 64-22 in Western Washington, and PG 64-28 in Eastern Washington.
- Nominal maximum aggregate size (NMAS): The largest sieve that retains some of the aggregate particles but generally not more than 10 percent by weight. Typical WSDOT specifications are ⅜-inch and ½-inch.
- Gradation: the distribution of aggregate particle sizes in the mix. Dense-graded mixtures are recommended.

Geosynthetics: Intended to control reflective cracking from existing pavement to the overlay and may also acts as a moisture barrier. Geosynthetic use can risk trapping moisture in the pavement. Geosynthetics are not effective in reducing reflection of thermal cracks. Not effective in areas of heavy rainfall or significant freeze-thaw cycles.

Construction

Asphalt binder and aggregate combined in a central mixing plant and placed with a paving machine. Rollers must compact the new HMA overlay before the mix cools to cessation temperature (the temperature at which no further compaction will occur). Cessation temperature varies between mixes but a rule-of-thumb is 150-170°F.

Selection Considerations

- **Traffic levels**: Thin HMA overlays are appropriate for all traffic levels.
- **Turning movements**: Use a ⅜-inch thin HMA overlay in place of a chip or cape seal at the intersections of arterials and collectors, and at intersections subject to regular heavy vehicle (e.g., buses, dump trucks) turning.

Design Considerations

- Use a ⅜-inch HMA mixture. Low traffic pavement benefits from the higher asphalt content offered by the smaller NMAS. This mix is also easier to place and less prone to segregation.
- For 1-inch overlays consider a 4.75 mm HMA mixture to aid in constructability and compaction.
- If high loading is expected (e.g., a regular bus or truck route) consider a ½-inch HMA mixture.
- Milling should only be done if at least 2-3 inches of undamaged HMA pavement will remain in place. Lesser remaining thicknesses risk breakage by the milling machine or damage by heavy construction equipment.

Construction Considerations

- Apply a layer of tack coat (asphalt emulsion) to the existing or milled pavement surface to enhance the bond between the overlay and the existing roadway. Amounts to inexpensive reduction of bond failure risk.
- Measure density of the finished thin HMA overlay. Core samples or nuclear gauge measurements are preferred.
- Overlay thickness should be at least 3 times the NMAS. Compaction can be difficult at ratios less than this.

Other Information

- Geosynthetics are not recommended: the risks generally outweigh the potential benefits.
- A thin HMA overlay alone cannot correct an excessively rough surface. Consider milling or leveling courses.

Full Depth Reclamation (FDR)

Description	Construction Cost	Expected Life
Existing pavement is pulverized and stabilized in place then covered with a chip seal or overlay.	FDR portion only: \$4-9/yd^2 SCPP projects: \$6-12/yd^2 plus surfacing cost	(Based on surfacing life) 7-10 years w/chip seal 10-20 years w/overlay

Function

- Provides an entirely new pavement structure and is an alternative to complete pavement reconstruction
- Alternative to preservation/repair involving dig-outs of more than about 20% of the paving area.
- Corrects major pavement defects such as: extensive alligator cracking of at least 30% of the wheelpath area, cracking wider than ¼-inch, rutting/shoving deeper than ¾-inch
- Corrects base failures
- Can be used to correct smoothness, profile and slope issues.

Variations

Stabilizing agent: different stabilizing agents can be used with the pulverized material. Typically either cement, or foamed asphalt with an active filler (portland cement or lime) are used depending upon the material being stabilized. Different filler types have different construction techniques and cautions.

Other types of in-place recycling:

- Hot in-place recycling: Used to correct minor surface defects. Heats and scarifies existing surface then adds a rejuvenator and sometimes additional material before the top layer is repaved in place.
- Cold in-place recycling: Similar to FDR but is limited to the existing pavement structure only.

Construction

A road reclaimer is used to pulverize the existing pavement to a predetermined depth. A stabilizing agent (cement, asphalt emulsion, or a combination) is added to stabilize the reclaimed layer. The reclaimed material is compacted using a roller then shaped with a grader. After a period of curing, a chip seal or thin HMA overlay is placed.

Selection Considerations

Traffic levels: FDR is appropriate for all traffic levels.

Limitations: The following situations are not recommended for FDR:

- Pavements with a geosynthetic interlayer, stabilized base, or concrete (may be difficult to pulverize).
- Extensive shallow utilities or drainage facilities within 6 inches of FDR depth (reclaimer may damage these).
- Saturated subgrade or base layers (saturated condition is likely to persist and cause future failure).

Design Considerations

- Core samples from the existing pavement structure should be obtained to determine subgrade characteristics such as soil classification, gradation, unconfined compressive strength, and CBR. These subgrade characteristics are used to determine the type of stabilization as well as the depth of reclamation.
- A pavement engineer should be consulted to determine stabilizer type and quantity and pavement design.

Construction Considerations

- An FDR surface can be temporarily opened to traffic before the chip seal or thin HMA overlay is placed. High-volume traffic may cause raveling. A fog seal over the top may reduce raveling.
- Broom the surface of the FDR roadway prior to opening to traffic

Other Information

- FDR is an alternative to a full pavement reconstruction. If selection criteria are met it can save 30-60% because it uses less material (existing material is reused in-place), which saves on material and hauling costs.
- Excessive FDR stabilizer content (i.e., more than 5% cement) may cause cracking of the FDR layer that will reflect through to the surfacing. Reducing stabilizer content is preferable to reinforcing with geosynthetics.

Full Hot Mix Asphalt (HMA) Reconstruction

Description	Construction Cost	Expected Life
The existing pavement structure is removed and replaced with a new pavement structure.	Pavement only: $24-53/yd^2 (5"HMA over 6" CSBC). SCPP projects: Cost varies depending upon other project features included.	Surface: 10-20 years Structure: 40+ years

Function

- Provides an entirely new pavement structure
- Addresses severe pavement distress types by replacing the entire pavement structure with equal or enhanced subbase, base course, and surface course layers.

Variations

Mix design: HMA mixtures are specified by their PG binder grade, nominal maximum aggregate size, and gradation.

- PG binder grade: a shorthand method of describing an asphalt binder specification. Standard WSDOT grades are PG 64-22 in Western Washington, and PG 64-28 in Eastern Washington.
- Nominal maximum aggregate size (NMAS): The largest sieve that retains some of the aggregate particles but generally not more than 10 percent by weight. Typical WSDOT specifications are ⅜-inch and ½-inch.
- Gradation: the distribution of aggregate particle sizes in the mix. Dense-graded mixtures are recommended.

Construction

The existing asphalt pavement and the underlying base course is removed. Crushed stone base course is applied over the prepared subgrade surface. Asphalt binder and aggregate combined in a central mixing plant and placed with a paving machine over the base course layer. Rollers must compact the new HMA overlay before the mix cools to cessation temperature (the temperature at which no further compaction will occur). Cessation temperature varies between mixes but a rule-of-thumb is 150-170°F.

Selection Considerations

- **Traffic levels**: Full reconstruction is appropriate for all traffic levels.
- **Maintenance**: Perform preservation maintenance as needed to maximize the life of the pavement structure.

Design Considerations

- New pavement design should be a minimum of 5 inches of HMA over 6 inches of crushed stone base.
  - Crushed stone base: Should be at least 6-inches thick for constructability purposes.
  - HMA layer: Should be at least 5 inches thick. This thickness (1) allows for subsequent mill-and-inlay rehabilitation, and (2) provides assurance that failure will be from the top-down rather than bottom-up.
- The pavement structure must have adequate thickness to account for frost protection. If not specified, the pavement structural thickness at least 50 % of design freeze depth is acceptable. Increasing the crushed stone base course layer is the most economical way to meet this recommendation.

Construction Considerations

- Compaction of subgrade and base layers are critical to minimize settlement of the pavement. For both subgrade and base, compaction should be at least 98% of modified proctor density (ASTM D1557).
- A minimum density of 92% is recommended for the HMA surface course layer. Density measurements should be made on the new pavement. Core samples or nuclear gauge measurements are preferred.
- The HMA layer should be paved in 2 lifts to improve compaction and smoothness.

Other Information

- Use a ⅜-inch HMA mixture. Low traffic pavement benefits from the higher asphalt content offered by the smaller NMAS. This mix is also easier to place and less prone to segregation.
- If high loading is expected (e.g., a regular bus or truck route) use a ½-inch HMA mixture.
- If spotted early-on, top-down cracking can be corrected via mill-and-fill to at least the crack depth

Interlocking Concrete Block Pavement Reconstruction

Description	Construction Cost	Expected Life
Precast interlocking concrete blocks placed on a layer of bedding sand.	Pavement only: $30-40/yd^2 SCPP projects: unknown (not done)	40+ years

Function

- Provides an entirely new pavement structure
- Can be designed as part of a porous pavement drainage solution if a permeable structure is used
- Can provide a range of aesthetic treatments including multiple colors, sizes, shapes, etc.

Variations

Permeable interlocking concrete pavement: Similar in nature to standard concrete block pavement, but have small openings that create permeable joints. Openings constitute about 5-15% of the surface area and are filled with a permeable small-sized aggregates.

Non-road applications: concrete block pavements can and have frequently been used for patios and walkways, driveways.

Construction

The subgrade is compacted and a base layer is placed and compacted. Concrete blocks are placed on a layer of bedding sand and a vibratory plate compactor is used to spread sand into the joint spaces. Excess sand is swept away from the surface.

Selection Considerations

Maintenance: Interlocking concrete block pavers can be readily removed and replaced throughout their life. Maintenance under the paver layer can be performed by removing, then when finished, replacing the pavers. Stains or other aesthetic concerns can be dealt with by replacing only the affected pavers.

Design Considerations

- Paving blocks should have a length-to-thickness ratio of 3:1 or less.
- Use concrete edge restrainers to provide lateral support.

Construction Considerations

- Compaction of subgrade and base layers are critical to minimize settlement of the pavement. For both subgrade and base, compaction should be at least 98% of modified proctor density (ASTM D1557).
- Use concrete sand (ASTM C33) for the bedding sand layer. Other sands (masonry sand, limestone, screenings, stone dust) do not compact uniformly.
- Use a 45° or 90° herringbone pattern layout in order to provide maximum interlock and structural performance.
- Can be installed in wet weather conditions

Other Information

- Can be used for traffic speeds up to 45 mph
- Settlement and the resulting uneven surface is a risk.