
PART 1 - GENERAL

1.1 SECTION INCLUDES

- .1 Materials and installation for asphalt concrete paving.

1.2 RELATED SECTIONS

- .1 Section 01 29 83 - Payment Procedures for Testing Laboratory Services.
- .2 Section 01 33 00 - Submittal Procedures.
- .3 Section 01 35 28 - Health and Safety.
- .4 Section 02 41 16 - Sitework, Demolition, and Removal.
- .5 Section 31 05 17 - Aggregate Materials.
- .6 Section 32 12 10 - Marshall Immerson Test for Bitumen.

1.3 REFERENCES

- .1 American Association of State Highway and Transportation Officials (AASHTO)
 - .1 AASHTO M320 latest edition, Standard Specification for Performance Graded Asphalt Binder.
 - .2 AASHTO R29 latest edition, Standard Specification for Grading or Verifying the Performance Graded of an Asphalt Binder.
 - .3 AASHTO T245 latest edition, Resistance to Plastic flow of Bituminous Mixtures Using Marshall Apparatus.
- .2 Asphalt Institute (AI)
 - .1 AI MS2-1994 Sixth Edition, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types.

- .3 American Society for Testing and Materials International, (ASTM)
 - .1 ASTM C88 latest edition, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate.
 - .2 ASTM C117 latest edition, Standard Test Method for Material Finer Than 0.075mm (No.200) Sieve in Mineral Aggregates by Washing.
 - .3 ASTM C123 latest edition, Standard Test Method for Lightweight Particles in Aggregate.
 - .4 ASTM C127 latest edition, Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.
 - .5 ASTM C128 latest edition, Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate.
 - .6 ASTM C131 latest edition, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - .7 ASTM C136 latest edition, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
 - .8 ASTM C207 latest edition, Standard Specification for Hydrated Lime for Masonry Purposes.
 - .9 ASTM D995 latest edition, Standard Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures.
 - .10 ASTM D2419 latest edition, Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
 - .11 ASTM D3203 latest edition, Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures.

.12 ASTM D4791 latest edition,
Standard Test Method for Flat
Particles, Elongated Particles, or
Flat and Elongated Particles in
Coarse Aggregate.

- .4 Canadian General Standards Board
(CGSB)
.1 CAN/CGSB-8.2 latest edition,
Sieves Testing, Woven Wire, Metric.
.2 CAN/CGSB-16.3 latest edition,
Asphalt Cements for Road Purposes.

1.4 PRODUCT DATA

- .1 Submittals in accordance with
Section 01 33 00 - Submittal
Procedures.
- .2 Submit viscosity-temperature chart
for asphalt cement to be supplied
showing either Saybolt Furol
viscosity in seconds or Kinematic
Viscosity in centistokes,
temperature range 105 to 175 degrees
C at least 2 weeks prior to
beginning Work.
- .3 Submit manufacturer's test data and
certification that asphalt cement
meets requirements of this Section.
- .4 Submit asphalt concrete mix design
and trial mix test results to
Departmental Representative for
review at least 2 weeks prior to
beginning Work.

1.5 SAMPLES

- .1 Submit samples in accordance with
Section 01 33 00 - Submittal
Procedures.
- .2 Inform Departmental Representative
of proposed source of aggregates and
provide access for sampling at least
2 weeks prior to beginning Work.

- .3 Submit samples of following materials proposed for use at least 2 weeks prior to beginning Work.
.1 One 5 L container of asphalt cement.
- .4 If materials have been tested by an independent testing laboratory within previous 6 months and have successfully passed tests equal to requirements of this specification, disregard above instructions and submit test certificates from testing laboratory showing suitability of materials for this project.
- 1.6 DELIVERY, STORAGE AND HANDLING
- .1 Deliver and stockpile aggregates in accordance with Section 31 05 17 - Aggregate Materials. Stockpile minimum 50% of total amount of aggregate required before beginning asphalt mixing operation.
- .2 When necessary to blend aggregates from one or more sources to produce required gradation, do not blend in stockpiles.
- .3 Stockpile fine aggregate separately from coarse aggregate, although separate stockpiles for more than two mix components are permitted.
- .4 Provide approved storage, heating tanks and pumping facilities for asphalt cement.
- 1.7 WASTE MANAGEMENT AND DISPOSAL
- .1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

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- .2 Remove from site and dispose of all packaging materials at appropriate recycling facilities.
 - .3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard and packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
 - .4 Divert unused aggregate materials from landfill to quarry facility for reuse as approved by Departmental Representative.
 - .5 Divert unused asphalt from landfill to facility capable of recycling materials.
 - .6 Fold up metal banding, flatten and place in designated area for recycling.

1.8 MEASUREMENT FOR
PAYMENT

- .1 Asphalt Paving: will be measured by the square metre (m²) of compacted surface coarse asphalt installed in the work within the limits indicated on the drawings. The square metre area includes asphalt thickness of 76mm thick compacted installed in two lifts of 38mm thick.
- .2 No separate payment will be made for any other ingredient or feature of the work and all factors, including asphalt bituminous tack coat, compaction, cold weather, asphalt, aggregates, saw cutting, and all plant, labour and materials is inclusive in the above price.

PART 2 - PRODUCTS

2.1 MATERIALS

.1 Performance graded asphalt cement:
to AASHTO M320, grade PG 58 - 28
when tested to AASHTO R29.

.2 Aggregates: in accordance with
Section 31 05 17 - Aggregate
Materials: General and following
requirements:

.1 Crushed stone or gravel.

.2 Gradations: within limits
specified when tested to ASTM C136
and ASTM C117. Sieve sizes to
CAN/CGSB-8.2.

.3 Table

<u>Sieve Designation</u>	<u>% Passing</u>	
	Lower Course	Surface Course
200 mm	-	-
75 mm	-	-
50 mm	-	-
38.1 mm	-	-
25 mm	100	-
19 mm	-	-
12.5 mm	70-85	100
9.5 mm	-	-
4.75 mm	40-65	55-75
2.00 mm	30-50	35-55
0.425 mm	15-30	15-30
0.180 mm	5-20	5-20
<u>0.075 mm</u>	<u>3-8</u>	<u>3-8</u>

.4 Coarse aggregate: aggregate
retained on 4.75mm sieve and fine
aggregate is aggregate passing
4.75mm sieve when tested to ASTM
C136.

.5 When dryer drum plant or plant
without hot screening is used,
process fine aggregate through
4.75mm sieve and stockpile
separately from coarse aggregate.

.6 Do not use aggregates having
known polishing characteristics in
mixes for surface courses.

- .7 Sand equivalent: ASTM D2419.
Min: 50.
- .8 Magnesium Sulphate soundness:
to ASTM C88. Max% loss by mass:
 - .1 Coarse aggregate surface
course: 12%.
 - .2 Coarse aggregate lower
course: 12%.
 - .3 Fine aggregate, surface
course: 16%.
 - .4 Fine aggregate, lower
course: 16%.
- .9 Los Angeles degradation:
Grading B, to ASTM C131. Max % loss
by mass:
 - .1 Coarse aggregate, surface
course: 25%.
 - .2 Coarse aggregate, lower
course: 35%.
- .10 Absorption: to ASTM C127. Max %
by mass:
 - .1 Coarse aggregate, surface
course: 1.75%.
 - .2 Coarse aggregate, lower
course: 2.00%.
- .11 Loss by washing: to ASTM C117.
Max % passing 0.075 mm sieve:
 - .1 Coarse aggregate, surface
course: 1.5%.
 - .2 Coarse aggregate, lower
course: 2.0%.
- .12 Lightweight particles: to ASTM
C123. Max % by mass less than 1.95
relative density:
 - .1 Surface course: 1.5%.
 - .2 Lower course: 3.0%.
- .13 Flat and elongated particles:
to ASTM D4791, (with length to
thickness ratio greater than 5): Max
% by mass:
 - .1 Coarse aggregate, surface
course: 15%.
 - .2 Coarse aggregate, lower
course: 15%.

.14 Crushed fragments: at least 60 % of particles by mass within each of following sieve designation ranges, to have at least 1 freshly fractured face. Material to be divided into ranges, using methods of ASTM C136.

<u>Passing</u>		<u>Retained on</u>
25 mm	to	12.5 mm
12.5 mm	to	4.75 mm

.15 Regardless of compliance with specified physical requirements, fine aggregates may be accepted or rejected on basis of past field performance.

- .3 Mineral filler:
- .1 Finely ground particles of limestone, hydrated lime, Portland cement or other approved non-plastic mineral matter, thoroughly dry and free from lumps.
 - .2 Add mineral filler when necessary to meet job mix aggregate gradation or as directed to improve mix properties.
 - .3 Mineral filler to be dry and free flowing when added to aggregate.

2.2 EQUIPMENT

- .1 Pavers: mechanical grade controlled self-powered pavers capable of spreading mix within specified tolerances, true to line, grade and crown indicated.
- .2 Rollers: sufficient number of type and weight to obtain specified density of compacted mix.
- .3 Vibratory rollers:
 - .1 Minimum drum diameter: 1200mm.
 - .2 Maximum amplitude of vibration (machine setting): 0.5mm for lifts less than 40mm thick.

- .4 Haul trucks: sufficient number and of adequate size, speed and condition to ensure orderly and continuous operation and as follows:
 - .1 Boxes with tight metal bottoms.
 - .2 Covers of sufficient size and weight to completely cover and protect asphalt mix when truck fully loaded.
 - .3 In cool weather or for long hauls, insulate entire contact area of each truck box.

- .5 Hand tools:
 - .1 Lutes or rakes with covered teeth for spreading and finishing operations.
 - .2 Tamping irons having mass not less than 12 kg and bearing area not exceeding 310cm² for compacting material along curbs, gutters and other structures inaccessible to roller. Mechanical compaction equipment, when approved by Departmental Representative, may be used instead of tamping irons.
 - .3 Straight edges, 4.5m in length, to test finished surface.

2.3 MIX DESIGN

- .1 Mix design to be approved by Departmental Representative.

- .2 Mix design to be developed by testing laboratory approved by Departmental Representative.

- .3 Design of mix: by Marshall method to requirements below.
 - .1 Compaction blows on each face of test specimens: 75.
 - .2 Mix physical requirements:

<u>Property</u>	<u>Roads</u>
Marshall Stability at 60°C kN min	5.5 surface course 4.5 lower course
Flow Value mm	2-4
Air Voids in Mixture, %	3-5 surface course 2-6 lower course
Voids in Mineral Aggregate, % min	15 surface course 13 lower course
<u>Index of Retained Stability % minimum</u>	75

.3 Measure physical requirements
as follows:

.1 Marshall load and flow
value: to AASHTO T245.

.2 Compute void properties on
basis of bulk specific gravity
of aggregate to ASTM C127 and
ASTM C128. Make allowance for
volume of asphalt absorbed into
pores of aggregate.

.3 Air voids: to ASTM D3203.

.4 Voids in mineral
aggregates: to AI MS2, chapter
4.

.5 Index of Retained
Stability: measure in
accordance with Section 32 12
10 - Marshall Immersion Test
for Bitumen.

.4 Do not change job-mix without
prior approval of Departmental
Representative. When change in
material source proposed, new job-
mix formula will be provided to be
approved to be reviewed by
Departmental Representative.

.5 Return plant dust collected
during processing to mix in
quantities acceptable to
Departmental Representative.

PART 3 - EXECUTION

3.1 PLANT AND MIXING
REQUIREMENTS

- .1 Batch and continuous mixing plants:
 - .1 To ASTM D995.
 - .2 Feed aggregates from individual stockpiles through separate bins to cold elevator feeders. Do not load frozen materials into bins.
 - .3 Feed cold aggregates to plant in proportions to ensure continuous operations.
 - .4 Calibrate bin gate openings and conveyor speeds to ensure mix proportions are achieved.
 - .5 Before mixing, dry aggregates to moisture content not greater than 1% by mass or to lesser moisture content if required to meet mix design requirements.
 - .6 Immediately after drying, screen aggregates into hot storage bins in sizes to permit recombining into gradation meeting job-mix requirements.
 - .7 Store hot screened aggregates in manner to minimize segregation and temperature loss.
 - .8 Heat asphalt cement and aggregate to mixing temperature directed by Departmental Representative. Do not heat asphalt cement above maximum temperature indicated on temperature-viscosity chart.
 - .9 Make available current asphalt cement viscosity data at plant. With information relative to viscosity of asphalt being used, Departmental Representative to review temperature of completed mix at plant and at paver after considering hauling and placing conditions.
 - .10 Maintain temperature of materials within 5 degrees C of specified mix temperature during mixing.

- .11 Mixing time:
 - .1 In batch plants, both dry and wet mixing times as directed by Departmental Representative. Continue wet mixing as long as necessary to obtain thoroughly blended mix but not less than 30s or more than 75s.
 - .2 In continuous mixing plants, mixing time as directed by Departmental Representative but not less than 45s.
 - .3 Do not alter mixing time unless directed by Departmental Representative.

- .2 Dryer drum mixing plant:
 - .1 To ASTM D995.
 - .2 Load aggregates from individual stockpiles to separate cold feed bins. Do not load frozen materials into bins.
 - .3 Feed aggregates to burner end of dryer drum by means of multi-bin cold feed unit and blend to meet job-mix requirements by adjustments of variable speed feed belts and gates on each bin.
 - .4 Meter total flow of aggregate by an electronic weigh belt system with indicator that can be monitored by plant operator and which is interlocked with asphalt pump so that proportions of aggregate and asphalt entering mixer remain constant.
 - .5 Provide for easy calibration of weighing systems for aggregates without having material enter mixer.
 - .6 Calibrate bin gate openings and conveyor speeds to ensure mix proportions are achieved. Calibrate weigh bridge on charging conveyor by weighing amount of aggregate passing

over weigh bridge in set amount of time. Difference between this value and amount shown by plant computer system to differ by not more than plus or minus 2%.

.7 Make provision for conveniently sampling full flow of materials from cold feed.

.8 Provide screens or other suitable devices to reject oversize particles or lumps of aggregate from cold feed prior to entering drum.

.9 Provide system interlock stop on feed components if either asphalt or aggregate from bin stops flowing.

.10 Accomplish heating and mixing of asphalt mix in approved parallel flow dryer-mixer in which aggregate enters drum at burner end and travels parallel to flame and exhaust gas stream. Control heating to prevent fracture of aggregate or excessive oxidation of asphalt. Equip system with automatic burner controls and provide for continuous temperature sensing of asphalt mixture at discharge, with printing recorder that can be monitored by plant operator. Submit printed record of mix temperatures at end of each day.

.11 Mixing period and temperature to produce uniform mixture in which particles are thoroughly coated, and moisture content of material as it leaves mixer to be less than 2%.

.3 Temporary storage of hot mix:

.1 Provide mix storage of sufficient capacity to permit continuous operation and designed to prevent segregation.

.2 Do not store asphalt mix in storage bins in excess of 3 hours.

- .4 Mixing tolerances:
 - .1 Permissible variation in aggregate gradation from job mix (percent of total mass).

4.75 mm sieve and larger	5.0
2.00 mm sieve	4.0
0.425 mm sieve	3.0
0.180 mm sieve	2.0
0.075 mm sieve	1.0
 - .2 Permissible variation of asphalt cement from job mix: 0.25%.
 - .3 Permissible variation of mix temperature at discharge from plant: 5 degrees C.

3.2 PREPARATION

- .1 Prepare and clean existing expansion joints, control joints, and existing concrete deck of all foreign debris and granular materials prior to asphalt bitumen tack coat and asphalt placement.
- .2 Patch all holes, voids, expansion and control joints with new compacted asphalt prior to final surface coarse asphalt placement.

3.3 TRANSPORTATION OF MIX

- .1 Transport mix to job site in vehicles cleaned of foreign material.
- .2 Paint or spray truck beds with limewater, soap or detergent solution, or non petroleum based commercial product, at least daily or as required. Elevate truck bed and thoroughly drain. No excess solution to remain in truck bed.
- .3 Schedule delivery of material for placing in daylight, unless Departmental Representative approves artificial light.

- .4 Deposit mix from surge or storage silo to trucks in multiple drops to reduce segregation. Do not dribble mix into trucks.
- .5 Deliver material to paver at uniform rate and in an amount within capacity of paving and compacting equipment.
- .6 Deliver loads continuously in covered vehicles and immediately spread and compact. Deliver and place mixes at temperature within range as directed by Departmental Representative, but not less than 135 degrees C.

3.4 PLACING

- .1 Obtain Departmental Representative's approval of existing concrete deck surface prior to placing asphalt bituminous tack coat.
- .2 Apply layer of asphalt bituminous tack coat over entire concrete deck surface prior to asphalt placement.
- .3 Place asphalt concrete to thicknesses, grades and lines as indicated. Bevel all perimeter edges of asphalt as indicated on drawings.
- .4 Placing conditions:
 - .1 Place asphalt mixtures only when air temperature is above 5 degrees C.
 - .2 When temperature of surface on which material is to be placed falls below 10 degrees C, provide extra rollers as necessary to obtain required compaction before cooling.
 - .3 Do not place hot-mix asphalt when pools of standing water exist on surface to be paved, during rain, or when surface is damp.

- .5 Place asphalt concrete in compacted lifts of thickness as indicated.
 - .1 Lower course in 1 layer of 38mm.
 - .2 Surface course in 1 layer of maximum 38mm.

- .6 Where possible do tapering and levelling where required in lower lifts. Overlap joints by not less than 300mm.

- .7 Spread and strike off mixture with self-propelled mechanical finisher.
 - .1 Construct longitudinal joints and edges true to line markings. Departmental Representative to establish lines for paver to follow parallel to centerline of proposed pavement. Position and operate paver to follow established line closely.
 - .2 When using pavers in echelon, have first paver follow marks or lines, and second paver follow edge of material placed by first paver. Work pavers as close together as possible and in no case permit them to be more than 30m apart.
 - .3 Maintain constant head of mix in auger chamber of paver during placing.
 - .4 If segregation occurs, immediately suspend spreading operation until cause is determined and corrected.
 - .5 Correct irregularities in alignment left by paver by trimming directly behind machine.
 - .6 Correct irregularities in surface of pavement course directly behind paver. Remove by shovel or lute excess material forming high spots. Fill and smooth indented areas with hot mix. Do not broadcast material over such areas.

- .7 Do not throw surplus material on freshly screeded surfaces.
- .8 When hand spreading is used:
 - .1 Distribute material uniformly. Do not broadcast material.
 - .2 During spreading operation, thoroughly loosen and uniformly distribute material by lutes or covered rakes. Reject material that has formed into lumps and does not break down readily.
 - .3 After placing and before rolling, check surface with templates and straightedges and correct irregularities.
 - .4 Provide heating equipment to keep hand tools free from asphalt. Control temperature to avoid burning material. Do not use tools at higher temperature than temperature of mix being placed.

3.5 COMPACTING

- .1 Do not change rolling pattern unless mix changes or lift thickness changes. Change rolling pattern only as directed by Departmental Representative.
- .2 Roll asphalt continuously to density not less than 98% of blow Marshall density to AASHTO T245.
- .3 General:
 - .1 Provide at least two rollers and as many additional rollers as necessary to achieve specified pavement density. When more than two rollers are required, one roller must be pneumatic tired type.
 - .2 Start rolling operations as soon as placed mix can bear weight of roller without excess

displacement of material or cracking of surface.

.3 Operate roller slowly initially to avoid displacement of material. Do not exceed 5km/h for breakdown and intermediate rolling for static steel-wheeled and pneumatic tired rollers. Do not exceed 9km/h for finish rolling.

.4 For lifts 50mm thick and greater, adjust speed and vibration frequency of vibratory rollers to produce minimum of 25 impacts per metre of travel. For lifts less than 50mm thick, impact spacing not to exceed compacted lift thickness.

.5 Overlap successive passes of roller by minimum of 200mm and vary pass lengths.

.6 Keep wheels of roller slightly moistened with water to prevent pick-up of material but do not over-water.

.7 Do not stop vibratory rollers on pavement that is being compacted with vibratory mechanism operating.

.8 Do not permit heavy equipment or rollers to stand on finished surface before it has been compacted and has thoroughly cooled.

.9 After traverse and longitudinal joints and outside edge have been compacted, start rolling longitudinally at low side and progress to high side. Ensure that all points across width of pavement receive essentially equal numbers of passes of compactors.

.10 When paving in echelon, leave unrolled 50 to 75mm of edge which second paver is following and roll when joint between lanes is rolled.

.11 Where rolling causes displacement of material, loosen affected areas at once with lutes or

shovels and restore to original grade of loose material before re-rolling.

- .4 Breakdown rolling:
 - .1 Begin breakdown rolling with static steel wheeled roller vibratory roller immediately following rolling of transverse and longitudinal joint and edges.
 - .2 Operate rollers as close to paver as necessary to obtain adequate density without causing undue displacement.
 - .3 Operate breakdown roller with drive roll or wheel nearest finishing machine. When working on steep slopes or super-elevated sections use operation approved by Departmental Representative.
 - .4 Use only experienced roller operators.

- .5 Intermediate rolling:
 - .1 Use pneumatic-tired, steel wheel or vibratory rollers and follow breakdown rolling as closely as possible and while paving mix temperature allows maximum density from this operation.
 - .2 Rolling to be continuous after initial rolling until mix placed has been thoroughly compacted.

- .6 Finish rolling:
 - .1 Accomplish finish rolling with two-axle or three-axle tandem steel wheeled rollers while material is still warm enough for removal of roller marks. If necessary to obtain desired surface finish, use pneumatic-tired rollers as directed by Departmental Representative.
 - .2 Conduct rolling operations in close sequence.

3.6 JOINTS

- .1 General:
 - .1 Remove surplus material from surface of previously laid strip. Do not deposit on surface of freshly laid strip.
 - .2 Paint contact surfaces of existing structures such as Portland cement concrete deck, manholes, curbs or gutters with bituminous material prior to placing adjacent pavement.
- .2 Transverse joints:
 - .1 Offset transverse joint in succeeding lifts by at least 600mm.
 - .2 Cut back to full depth vertical face and tack face with thin coat of hot asphalt prior to continuing paving.
 - .3 Compact transverse joints to provide smooth riding surface. Use methods to prevent rounding of compacted surface at joints.
- .3 Longitudinal joints:
 - .1 Offset longitudinal joints in succeeding lifts by at least 150mm.
 - .2 Cold joint is defined as joint where asphalt mix is placed, compacted and left to cool below 100 degrees C prior to paving of adjacent lane.
 - .1 If cold joint can not be avoided, cut back by saw cutting previously laid lane, by at least 150mm, to full depth vertical face, and tack face with thin coat of hot asphalt of adjacent lane.
 - .3 Overlap previously laid strip with spreader by 25 to 50mm.
 - .4 Before rolling, carefully remove and discard coarse aggregate in material overlapping joint with lute or rake.

.5 Roll longitudinal joints directly behind paving operation.
.6 When rolling with static or vibratory rollers, have most of drum width ride on newly placed lane with remaining 150 mm extending onto previously placed and compacted lane.

.4 Construct bevel joints so that thinner portion of joint contains fine graded material obtained by changed mix design or by raking out coarse aggregate in mix. Place and compact joint so that joint is smooth and without visible breaks in grade.

.5 Construct butt joints as directed by Departmental Representative.

3.7 FINISH TOLERANCES

.1 Finished asphalt surface to be within 5 mm of design elevation but not uniformly high or low.

.2 Finished asphalt surface not to have irregularities exceeding 5 mm when checked with 4.5 m straight edge placed in any direction.

3.8 DEFECTIVE WORK

.1 Correct irregularities which develop before completion of rolling by loosening surface mix and removing or adding material as required. If irregularities or defects remain after final compaction, remove surface course promptly and lay new material to form true and even surface and compact immediately to specified density.

.2 Repair areas showing checking, rippling, or segregation.

- .3 Adjust roller operation and screed settings on paver to prevent further defects such as rippling and checking of pavement.