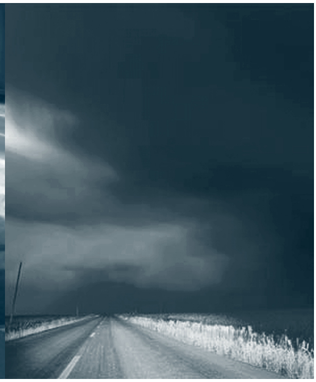

Hot Mix Paving in Adverse Weather

Manual 22

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CONTENTS

PREFACE

Driven by the wide variation of specification requirements for paving in windy, cold or wet conditions, Sabita held a seminar in November 1998 which focussed on the effects of weather and climate on hot mix asphalt paving. The outcome of this workshop was the formation of a combined working group of Sabita and the Southern Region of the Society for Asphalt Technology, which was tasked to produce a practical guideline for use by site staff when adverse weather conditions prevail or are likely to occur.

It was intended that this guideline should capture local and international experience to formulate practical recommendations applicable to southern African environmental and operating conditions.

The experiences of the broader southern Africa have been incorporated into these recommendations, and are offered as background and advice to improve practice and promote efficiency for the benefit of both client and contractor.

Readers should note that a significant portion of the content of this manual is based on selected National Asphalt Paving Association (NAPA) publications, and is therefore applicable to continuously graded asphalt. However, in conjunction with local experience, the range of applicability has been broadened, and the recommendations should therefore be considered valid for a wider spectrum of dense-graded mix types.

PA Myburgh
Chief Executive Officer
Sabita

INTRODUCTION

Most current specifications do not deal comprehensively with the complexity associated with the laying of hot mix asphalt in adverse weather conditions such as rain, wind and low temperatures in winter rainfall areas, or thunderstorms and low winter temperatures in summer rainfall areas.

Most specifications restrict paving to “favourable weather conditions”, leaving no specific boundaries between favourable and adverse weather conditions. Nor do they take into consideration different mat thicknesses or base layers. Procedures should be adopted to promote efficiency, decrease wasteful practice, and to reduce risk.

Purpose of this manual

To set out guidelines to assist resident engineers, clerks of works, main contractors, site agents, site foremen, paving contractors, paving foremen and asphalt suppliers in applying specifications judiciously.

Information and recommendations are provided on:

- Good paving practices;
- Risks involved;
- Limiting conditions for paving;
- Precautions required.

What are the major areas of concern and risk?

☹ RAPID COOLING
☹ RAPID COOLING and WET BASE
☹ RAPID COOLING and TRAPPED WATER

Rapid cooling due to loss of heat from the asphalt through the effects of wind, water and low ambient temperatures causes the available paving and compaction time window to shrink. Moisture in a granular base introduces weaknesses which make adequate compaction difficult to achieve. Trapped water in the asphalt can cause a loss in durability or stripping of the bitumen from the aggregate, leading to failures.

All these concerns increase the risk of inadequate compaction

This guideline is a revision of *Hot Mix Paving in Adverse Weather — Interim Recommendations*, published in 2000.

We express our sincere appreciation to Julian Wise for the refinements encapsulated in this revision.

1 IMPORTANT FACTORS AFFECTING THE COOLING OF ASPHALT

1.1 Mixing and Transport

- Mixing temperature at the plant and delivery temperature at site;
- Size of load;
- Length of haul;
- Use of tarpaulins (particularly important for long hauls in cold conditions).

1.2 Site conditions

Uncontrollable	Controllable
Temperature of base	Thickness of mat
Air temperature	Lay down temperature
Wind velocity	Water deposited by rollers
Other weather conditions (rain, cloud, shade from trees, buildings or bridges	

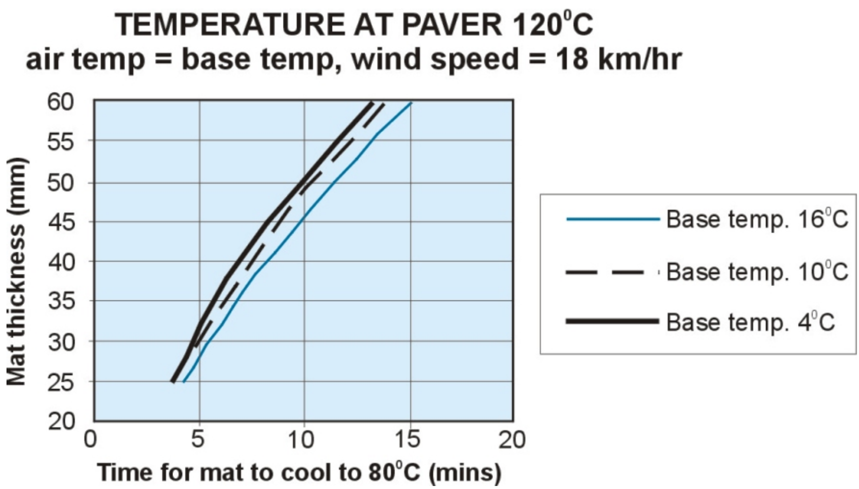
2 INFORMATION ABOUT THESE FACTORS

In general, mat thickness, air and base temperatures, wind speed, amount of rain, effect of rain on base and speed of attaining initial compaction, should all be considered.

2.1 Asphalt layer or mat

- Mat thickness and temperature act together in providing the total heat reservoir. These two plus the initial base temperature largely determine the rate at which the mat will cool (See Figure 1 and Appendix #1 for typical South African conditions);
- For thin mats (40mm and less), rapid cooling occurs through the entire thickness;
- More rapid cooling occurs at the bottom (in contact with the cold base) regardless of thickness.

Figure 1: Cooling rate curves - Compaction of Asphalt Pavements, NCHRP: Synthesis of Highway Practice 152.



2.2 Wind

- Wind cools the surface, and as the speed increases, so does its cooling influence;
- At wind speeds of >15 km/hr, the upper surface of the mat may cool more rapidly than the lower. Cold and wind have a far greater cooling effect on the mat than rain alone.

For example: It may be very risky to pave 25mm mats in windy conditions at ambient temperatures of say 15^{0}C.

If the surface and the underside cool rapidly (say 10mm combined) only the middle 15mm of the mat is at a temperature suitable for normal compaction.

On the other hand, there is much less risk to a 60mm mat under the same conditions.

2.3 Water

- Rain, apart from its cooling effect, may become a problem if excessive amounts of water enter the mat;
- Paving over standing water will cause rapid cooling and may allow the water to enter the new mat if not swept away;
- Drum sprinklers spray up to an equivalent of approximately 0.5mm/hour onto the mat (classified as a drizzle). The first roller cools the surface of the mat by approximately 25% after six passes, but only as measured at the surface. Thin mats are more affected by roller water than thicker mats.

2.4 Trapped water

- Water trapped in the mat may cause loss of adhesion and stripping, as well as excessive movement under the rollers. This may further result in shear cracks in the mat, making it more permeable and less dense.
- Thin mats are more vulnerable to rain and standing water than thicker mats.

2.5 Wet granular base

- Excessive moisture in a granular base makes compaction of the asphalt difficult.
- Trapping water in or on the base may affect its stability under traffic, causing heaving and/or crocodile cracking.
- Thin mats are more susceptible to moving on the wet base than thicker mats.

2.6 Transport

- The purpose of covering loads with tarpaulins is to obtain better temperature uniformity and reduce ”crust" thickness, but does not significantly contribute to an increase in the compaction window.
- On long hauls in cold weather, a crust will form not only on top but all around where the load is in contact with the truck body. Double skin trucks with canopies that close fully are used in Europe, but are seldom required under South African conditions.

3 RECOMMENDATIONS FOR ADVERSE PAVING CONDITIONS

3.1 Ground rules

The following rules should be considered and agreed between the resident engineer, main contractor, supplier and paving contractor before paving starts:

3.1.1 Working in adverse weather conditions requires close cooperation, good planning and a well organised site team to ensure that quality standards are maintained.

3.1.2 When the weather report indicates risk of adverse weather, parties should discuss the day's paving operation to reach consensus on achieving the required end product without compromising the specification.

3.1.3 Due consideration should be given to the specification and relevant factors affecting the cooling of asphalt (see chapters 1 and 2).

3.1.4 The layers below the aphalt should be fully compacted and have a low enough moisture content so that the mat will not heave during compaction of the asphalt.

3.1.5 No paving should be started on:

- a granular base showing signs of sponginess;
- bases with a loose wet surface;
- existing asphalt containing trapped water.

3.1.6 There must be sufficient working time available to make paving and compaction commercially viable for the day (see 3.4.2).

3.1.7 If possible, increase mat thickness to increase the heat reservoir.

3.1.8 Ensure an uninterrupted supply to the paver.

3.1.9 Plan and agree times for the first and last trucks to arrive on site.

3.1.10 Endeavour to use large trucks (12 tons and greater) to ensure high heat retention.

3.1.11 All trucks to have full, thick, impervious tarpaulins (such as Sterkolite, not hessian) which should remain in place during tipping.

3.2 Prime, tack, bitumen and mixing temperatures

3.2.1 Typical prime types: cutback and emulsion primes (see 3.3.8).

3.2.2 Tack coats for wearing courses are recommended at all times — even on "fresh" primes — to ensure adequate adhesion.

Typical tack type: Stablemix emulsion (60%) mixed 50/50 with water, applied evenly at a rate of 0.2 to 0.4 ℓ/m^2 of the diluted emulsion.

3.2.3 The tack should be applied before the rain. If tack is not down and "broken" before any rain, paving should be delayed.

3.2.4 To ensure compactibility in cold conditions, check the (60/70-pen) bitumen test results to ensure that the viscosity (after RTFOT) at 135^{0}C is not more than 0.7 Pa.s, preferably 0.6 Pa.s.

3.2.5 For 60/70 pen bitumen a mixing temperature range of 155^{0}C-165^{0}C is usually required to ensure the minimum lay-down temperatures shown in Table 2.

3.2.6 For 40/50-pen bitumen, mixing and minimum lay-down temperatures should be 10^{0}C higher than for 60/70-pen.

3.2.7 Modified binders can be more sensitive to temperature and are placed at different temperatures: Consult the supplier.

3.3 Managing the effects of rain on granular bases

3.3.1 Moisture in the base layer should be less than 50% OMC before priming or paving commences.

3.3.2 Check for spongy areas with a pneumatic roller (or loaded truck). Repair before paving, using e.g. BTB, or accept the delay for evaporation to take place. This should be done before the paving contractor establishes to avoid costly delays.

3.3.3 A wet granular base with very low PI may result in a soft,loose surface, causing traction problems for the paver and compaction problems (the paving contractor may have to wait for the surface to dry).

3.3.4 Drainage of the base must be good (minimum 1% fall in a direction that will take water off the surface). This is a design requirement.

3.3.5 Protect the base from water damage by allowing drainage into catchpits by forming outlets in the kerbs or channels as often as necessary.

3.3.6 Sweep water away from in front of the paver before paving.

3.3.7 Where possible, pave downhill so that any rain will drain away from the mat.

3.3.8 Tack coat, in addition to a properly applied and well cured prime coat (which acts as a temporary protection from rain), is essential for good adhesion.

3.4 Minimum base and air temperatures

Table 1: Minimum base and air temperatures and related wind strength for continuously graded wearing courses and asphalt bases

Wind Speed	Mat thickness	25mm	40 - 60mm	> 60mm
	Base temp.	18°C	10°C	4°C
0 — 10 km/h	Air temperature	15°C	10°C	4°C
> 10 km/h	Air temperature	18°C	13°C	10°C

3.4.1 In windless, sheltered conditions, paving at ambient temperatures lower than 10°C can still be practicable for 40-60mm mats. The cooling effect at the surface is reduced and does not adversely affect the high temperature of the mat. This allows enough time for compaction to be achieved (see Table 2). However, harsh, hard to compact mixes must be avoided in these conditions.

3.4.2 At least 4 — 5 hrs of paving time per day is necessary to ensure cost effectiveness.

3.5 Minimum lay-down temperatures

Table 2: Minimum lay-down temperatures (related to Table 1)

Mat thickness (mm)	25	40	50	>75
Minimum truck temperature at tipping (°C)	150	145	140	130
Minimum mat temperature when rolling starts (°C)	130	130	125	120

3.5.1 It is vital to insist on at least the minimum truck temperatures at tipping.

3.5.2 Target a higher average temperature than these minimums.

3.5.3 These temperatures could be adjusted for highly flexible mixes (more workable) which compact more easily at lower temperatures.

3.5.4 When being tipped, the last portion of the load is slightly cooler than the bulk of the load, and can come out behind the paver at a slightly lower temperature (say 10^{0}C).

3.6 Transporting the hot asphalt

3.6.1 Good communication between the paving contractor and the asphalt supplier should be maintained at all times so that allowance can be made for supply interruptions (see 3.7.7).

3.6.2 Normal transit time should ideally not exceed 2 hours; preferably 1½ hours (i.e. time from loading at plant to tipping on site).

3.6.3 Preferably arrange with the supplier to deliver in tons per hour, not in batches.

3.6.4 Mixing and transportation should be arranged to match the paving speed.

3.6.5 A transport fleet of large trucks (12 to 15 tons) should be available to ensure continuity of paving and good heat retention.

3.6.6 High standards for the type, size and use of tarpaulins must be maintained.

3.7. Compaction management

3.7.1 Choose a paving speed which ensures that the roller train remains close behind the paver.

3.7.2 Use wider rollers and/or pave narrower widths (e.g. cover mat in two roller widths instead of three), but ensure that longitudinal joints do not occur in the wheel tracks.

3.7.3 Use more or heavier rollers to increase the compactive effort.

In addition

3.7.4 First roller must roll immediately behind the paver; this helps seal in the heat and seal out water.

3.7.5 Roll longitudinal joints first.

3.7.6 Have a standby roller available in case of breakdowns or as an additional roller at the coldest time of day. Some circumstances may even require a standby paver. This has a cost implication for the contractor.

3.7.7 Empty the paver and form transverse joints when there is a supply delay to prevent the mat under and behind the paver (the area not yet reached by the rollers), cooling below the temperatures shown in Table 2.

3.8. Techniques for paving when caught in rainy conditions

3.8.1 Refer to 3.2 on tack coats and priming.
3.8.2 Surface must drain well.
3.8.3 Sweep away any standing water from in front of the paver.
3.8.4 Where possible, pave downhill (excluding steep hills) so that rain drains away from the asphalt. Rolling techniques must be adapted to prevent "shoving" when paving down slopes.
3.8.5 First roller must roll immediately behind the paver to seal the mat and prevent ingress of rain.
3.8.6 Reduce water on the roller drums to an absolute minimum (in some conditions it may be possible to cease all water application if "pick-up" does not occur).

3.9. Factors to be considered when assessing overall risk

3.9.1 **Type of rain:**
Is it light, a continuous drizzle, a sudden downpour or occasional showers?

3.9.2 **Amount of rain:**
Consider that drum sprinklers spray up to 50mℓ/m^2/hr without harm to the asphalt (equivalent to rain of 0.5 mm/hr.)

3.9.3 **Type of mix:**
Certain mixes such as base layers could possibly be paved in rain. However, this may not be possible with other mixes such as wearing courses.

3.9.4 **Mat thickness:**
The thicker the mat, the lower the risk of rapid cooling.

3.9.5 **Base condition and whether rain is affecting it:**
Opposites are asphalt bases and granular bases — there is less risk paving on asphalt bases than on granular bases in light rain. Coarsely graded base layers may trap water, which could take several days to dry.

3.9.6 **Prevailing temperatures:**
Extremes when rain occurs may vary from 25^{0}C in March to 10^{0}C in July.

3.9.7 **Prevailing winds:**
Extremes may range from no wind to a cold 40 km/hr wind.

3.9.8 **Temperature at which asphalt is delivered:**
See 3.1.10, 3.1.11 and 3.5.

3.9.9 **Need for high level supervision:**
When risk is high or medium, high level supervision linked to good paving experience (usually the responsibility of the site agent) should ensure that all precautions are taken and correct procedures followed at all times.

3.9.10 **Layer thickness, wind speed and base temperature:**
These parameters have the greatest influence on the mat cooling rate. Ambient temperature, rain and shade have less influence.

4 RISK ASSESSMENT

(Based on Western Cape experience in rainy conditions.
Other regions may interpret differently.)

4.1 Assumptions

- Base layer is well compacted, dry enough and primed;
- Tack has been applied and is ready for paving;
- Base and air temperatures conform to Table 1;
- Delivery temperatures are higher than the minimums in Table 2;
- Enough rollers are available to ensure speedy compaction.

4.2 Definitions

Rain type	Quantity
Drizzle	Up to 1mm/hr
Light	1mm — 2.5mm/hr
Moderate	2.5mm — 12.5mm/hr
Heavy	> 12.5mm/hr

(Courtesy of the Cape Town Weather Office)

4.3 Recommendations

Nil risk **(N)** – always use good paving practice;
Low risk **(L)** – take precautions to minimise the possibility of failure;
Medium risk **(M)** – avoid paving unless absolutely necessary, and then only if risk can be reduced to an acceptable level.;
High risk **(H)** – paving should not be considered.

4.4 Risk assessment

4.4.1 Condition A: Wearing course on an asphalt base or asphalt base on a cementitious subbase.

Table 3: Risk assessment for Condition A

Mat thickness		25mm mat		40mm mat		60mm mat/>	
Weather	Wind	Nil	> 10km/h	Nil	> 10km/h	Nil	> 10km/h
Air temp: > 24^{0}C							
Drizzle		N	L	N	N	N	N
Light rain		L	M	N	L	N	N
Moderate rain		M	H	L	M	L	L
Air temp: 18 - 23^{0}C							
Drizzle		L	M	N	L	N	N
Light rain		M	H	L	M	N	L
Moderate rain		H	H	M	H	L	M
Air temp: <18^{0}C							
Drizzle		M	H	L	M	N	L
Light rain		H	H	M	H	L	M
Moderate rain		H	H	H	H	M	H

4.4.2 **Condition B:** Wearing course or asphalt base on a sound, unstabilised granular base e.g. crushed stone.

Table 4: Risk assessment for Condition B:

Mat thickness		25mm mat		40mm mat		60mm mat/>	
Weather	Wind	Nil	> 10km/h	Nil	> 10km/h	Nil	> 10km/h
Air temp: > 24^{0}C							
Drizzle		L	M	L	L	L	L
Light rain		M	H	L	M	L	L
Moderate rain		H	H	M	H	M	M
Air temp: 18 - 23^{0}C							
Drizzle		M	H	L	M	L	L
Light rain		H	H	M	H	L	M
Moderate rain		H	H	H	H	M	H
Air temp: < 18^{0}C							
Drizzle		H	H	M	H	L	M
Light rain		H	H	H	H	M	H
Moderate rain		H	H	H	H	H	H

Note: Even if well primed and tacked, other granular bases with very low PI's and certain materials such as ferricrete, laterite, or calcrete, may increase the risks even more, depending on how their surfaces are affected by rain.

References

1. NCHRP: Synthesis of Highway Practice 152.
2. CAPSA 2004 Bulletin Paper: *A practical guide for estimating the compaction window time for thin layer hot mix asphalt* — Julian Wise.
3. National Asphalt Pavement Association (NAPA): *Hot mix paving handbook*, 2000 – PH-1.
4. National Asphalt Pavement Association (NAPA): *Cold weather compaction* – QIP-115.

APPENDIX #1

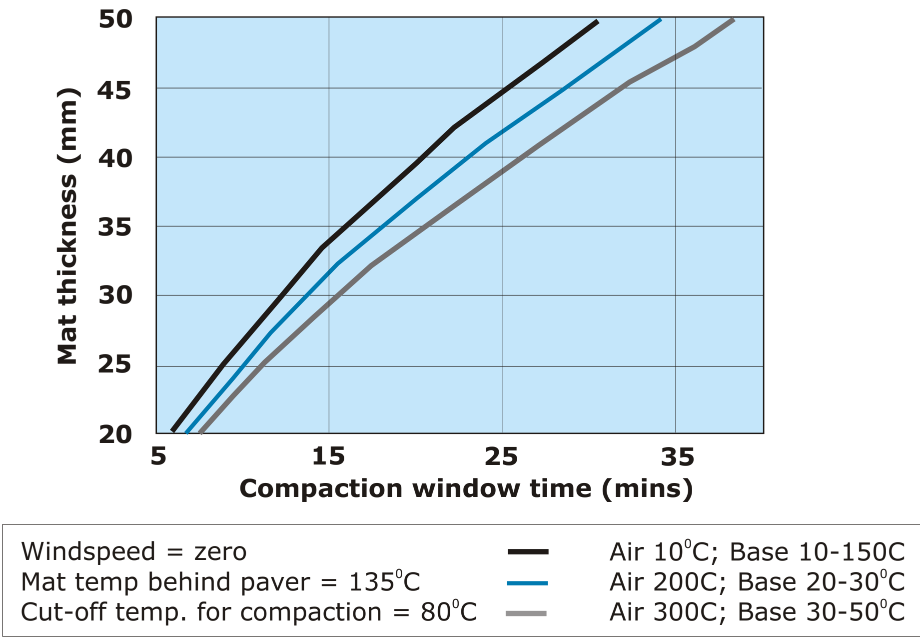
A GUIDE FOR ESTIMATING COMPACTION WINDOW TIME

The guide consists of three charts:

1. Mat thickness versus compaction window time for typical ambient and asphalt temperatures (Chart 1);
2. Reduction of this compaction window time due to differing wind speeds (Chart 2);
3. A guide to estimating wind speed.

Figure 1: Compaction time vs. mat thickness for windless conditions. *(Note the three assumptions below the chart).*

Figure 2: Effect of wind on compaction window time



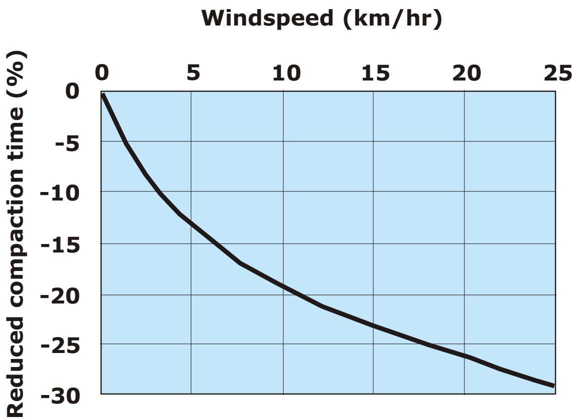


Table 1: Estimating windspeed

Wind speed km/hr	Description	Guide
0 - 2	Calm	Smoke rises vertically
2 - 4	Light air	Smoke drifts in direction of wind
4 - 7	Light breeze	Wind felt on face; leaves rustle
7 - 11	Gentle breeze	Wind extends a light flag; leaves in motion
11 - 18	Moderate breeze	Wind raises dust and light paper
18 - 25	Fresh breeze	Small trees sway, wavelets form on water
25 - 32	Strong breeze	Large branches sway; whistling in overhead wires
32 - 36	Near gale	Whole trees move; affects walking

Using the guide:

Example 1

Site conditions	Mat thickness	Compaction time from Chart 1	Correction for wind
Delivery temp. 150^{0}C Temp at screed 135^{0}C Base temp 16^{0}C Air temp 13^{0}C Windspeed 15km/hr	25mm	9 mins	7 mins
	40mm	21 mins	16 mins
	50mm	32 mins	24 mins

Example 2

Site conditions	Mat thickness	Compaction time from Chart 1	Correction for wind
Delivery temp. 150^{0}C Temp at screed 135^{0}C Base temp 45^{0}C Air temp 30^{0}C Windspeed: calm	25mm	11 mins	11 mins
	40mm	26 mins	25 mins
	50mm	38 mins	36 mins

Comments

1. A rule of thumb for compaction time is a minimum of 10 minutes, but this is for mixes that compact easily. Harsh mixes require more time (e.g. 12-14 minutes)

2. **For a 25mm mat:**
    - In **Example 1**, there is not enough time to achieve compaction;
    - In **Example 2**, however, there is enough time.

3. **For a 40mm mat**:
    - In **Example 1,** there is just enough time for, say, a harsh COLTO medium mix, as long as the rollers are close behind the paver;
    - In **Example 2**, there is plenty of time.

4. **For a 50mm mat:**
   There is always sufficient time, even if temperatures are near zero.

5. Note how the time almost doubles from a 25mm to a 40mm mat, and more than trebles from a 25mm to a 50mm mat.

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SUMMARISED FIELD GUIDE
WHAT ARE THE MAJOR AREAS OF CONCERN?

- ☹ RAPID COOLING
- ☹ RAPID COOLING and WET BASE
- ☹ RAPID COOLING and TRAPPED WATER

Rapid cooling due to the loss of heat from the asphalt through the effects of wind, water and low ambient temperatures causes the available paving and compaction time window to shrink.

Moisture in a granular base introduces weaknesses which make adequate compaction difficult to achieve.

Trapped water in the asphalt can cause a loss of durability or stripping of the bitumen from the aggregate, leading to failures.

Table 1: Minimum base and air temperatures and related wind strength for continuously graded wearing courses and asphalt bases.

Windspeed	Mat Thickness	25mm	40 - 60mm	> 60mm
	Base temperature	18^{0}C	10^{0}C	4^{0}C

0 — 10 km/hr > 10 km/hr	Air temperature Air temperature	15^0 18^0	10^0 13^0	4^0 10^0

Table 2: Minimum lay-down temperatures (related to **Table 1** above)

Mat thickness	25	40	50	> 75
Minimum truck temp. at tipping (^{0}C)	150	145	140	130
Minimum mat temp. when rolling starts (^{0}C)	130	130	125	120

Risk assessment

(Based on Western Cape experience. Other regions may interpret differently).

Assumptions

- Base layer is well compacted, dry enough and primed;
- Tack has been applied and is ready for paving.;
- Base and air temperatures conform to Table 1;
- Delivery temperatures are higher than minimums in Table 2;
- Enough rollers are available to ensure speedy compaction.

Definitions

Rain Type	Quantity
Drizzle	Up to 1mm/hr
Light	1mm - 2.5mm/hr
Moderate	2.5mm - 12.5 mm/hr
Heavy	> 12.5mm/hr

(*Courtesy of the Cape Town Weather Office*)

Recommendations

Nil risk **(N)** – always use good paving practice.
Low risk **(L)** – take precautions to minimise the possibility of failure.

Medium risk **(M)** – avoid paving unless absolutely necessary, and then only if risk can be reduced to an acceptable level.

High risk **(H)** – paving should not be considered.

Risk Assessment

CONDITION A: Wearing course on an asphalt base or asphalt base on a cementitious subbase.

Table 3: Risk assessment for Condition A

Mat thickness		25mm		40mm		60mm >	
Weather	**Wind**	**Nil**	**> 10 km/hr**	**Nil**	**> 10 km/hr**	**Nil**	**> 10 km/hr**
Air temp: > 24^{0}C							
Drizzle		N	L	N	N	N	N
Light rain		L	M	N	L	N	N
Moderate rain		M	H	L	M	L	L
Air temp: 18 - 23^{0}C							
Drizzle		L	M	N	L	N	N
Light rain		M	H	L	M	N	L
Moderate rain		H	H	M	H	L	M
Air temp: < 18^{0}C							
Drizzle		M	H	L	M	N	L
Light rain		H	H	M	H	L	M
Moderate rain		H	H	H	H	M	H

CONDITION B: Wearing course or asphalt base on a sound, unstabilised granular base, e.g. crushed stone.

Note: Even if well primed and tacked, other granular bases with very low PI's and certain materials such as ferricrete, laterite or calcrete, may increase the risks even more, depending on how their surfaces are affected by rain.

Table 4: Risk assessment for Condition B

Mat thickness		25mm		40mm		60mm >	
Weather	**Wind**	**Nil**	**> 10 km/hr**	**Nil**	**> 10 km/hr**	**Nil**	**> 10 km/hr**
Air temp: > 24°C Drizzle Light rain Moderate rain		L M H	M H H	L L M	L M H	L L M	L L M
Air temp: 18 - 23°C Drizzle Light rain Moderate rain		M H H	H H H	L M H	M H H	L L M	L M H
Air temp: < 18°C Drizzle Light rain Moderate rain		H H H	H H H	M H H	H H H	L M H	M H H