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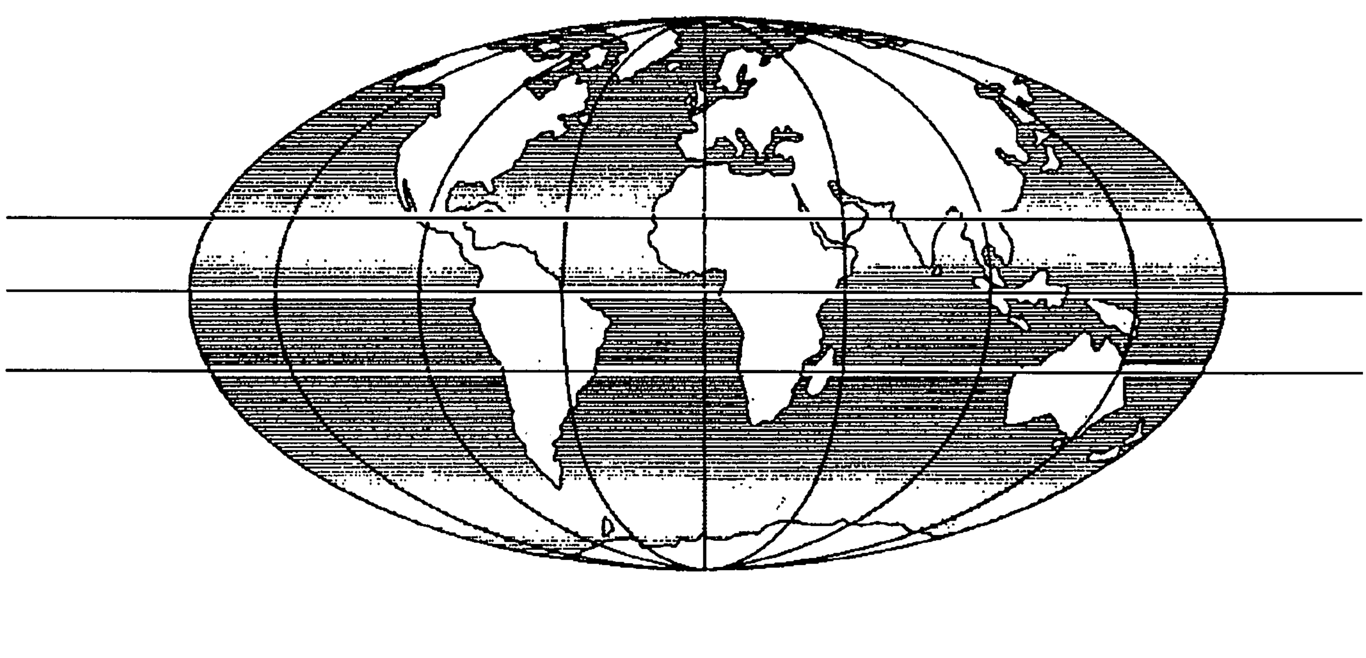

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SALT DAMAGE TO BITUMINOUS SURFACINGS : RESULTS FROM ROAD TRIALS IN BOTSWANA

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Abstract

The Paper discusses the results of research undertaken in Botswana to provide design criteria to avoid damage inflicted on thin bituminous surfaces by soluble salt. The damage, characteristic of warm arid or semi-arid regions of the World, occurs when the salt crystallizes within the pavement, physically disrupting the bituminous surfacing and causing premature deterioration of the road. The criteria were worked out from observations made on a road trial constructed in May 1990 in northern Botswana where the salt levels at which damage occurred and the nature and development of the damage were determined. Some preventative measures were incorporated in the trials to determine their efficacy in avoiding damage. The results from the trials have enabled a revision of the current Botswana road design standards with respect to salt limits in pavement materials to be proposed.

1 INTRODUCTION

During recent years the Government of Botswana has been undertaking an intensive programme of improving earth and gravel roads to bituminous standard. In the Kalahari region this work mainly involves the application of prime coats and surface dressing to natural gravel roadbases. Whilst the presence of salt is beneficial to earth and gravel roads because it retains water and helps bind the material during the prolonged dry season, comparatively thin (< 50mm) bituminous coatings can be damaged by soluble salts present in the pavement materials, including the compaction water, subgrade or groundwater. Soluble salt is defined (Netterberg & Maton, 1) as ' basically those minerals that are the most soluble, notably salts of magnesium and sodium. Gypsum, (calcium sulphate), an abundant salt is only slightly soluble and does not cause damage.

The damage is actually caused by the upward movement and crystallization of the salt in the top of the pavement, whereby the bituminous material is lifted and its adhesion to the roadbase destroyed. The disruption is essentially a physical process; no chemical effect is involved. Obika et al,(2) reviewed the reported incidence of salt damage, and concluded that it was restricted to the warm arid and semi-arid regions of the World with large diurnal ranges of temperature and relative humidity. These climatic conditions are typical in Botswana and with the extensive occurrence of salt pans and saline groundwater there was clear potential for salt damage. In 1990 severe salt damage occurred to the airstrip serving the Sua Pan salt factory: the airstrip consisted of a Cape seal covering a calcrete roadbase where saline water was apparently used for compaction. Within two months the surface had become extensively blistered, necessitating remedial measures (rolling) to be carried out regularly afterwards.

The content of soluble salt required to cause damage is low. The current specifications for Botswana, (3) quote maxima of 0.2% and 0.3% Total Soluble Salt (TSS) for the roadbase and sub-base respectively. These limits are originally derived from Netterberg et al (in Weinert, 4) but, in the light of subsequent work, require qualification. Numerous workers since, eg Horta (5), Overby (6), (Spottiswoode et al, 7), (Januszke & Booth, 8), and more recently Netterberg (9) and Pers Comm re Swartklip trial, report on instances where much higher salt contents in the road pavement materials have not led subsequently to damage to the bituminous surfacing.

The research was a collaborative venture between the Transport Research Laboratory (TRL), the School of Civil Engineering, University of Birmingham and the Ministry of Works, Botswana. A programme of laboratory work, (Obika, 10) preceded a field trial that was carried out during the construction of a new road from Maun to Nata. The field trial was constructed on a part of the old, gravel-surfaced road, thereby allowing full control of the civil works . The new road followed a close but separate alignment to the old road and skirted the northern fringe of the Makgadigadi Pans, a vast inland draining depression characterised by high salt levels. A notable feature of the region is the natural occurrence of two very soluble salts, sodium bicarbonate and sodium chloride, combined together in the natural materials.

2 OBJECTIVES

The laboratory work carried out in advance of the field work indicated that the prime coats were particularly sensitive to low contents of salt in the pavement materials. The surface dressings, however, were resistant to much higher levels of salt for the limited duration of the experiment. It was to confirm these relationships in the conditions in Botswana that the field trial was constructed. In so doing it was hoped to define suitable design criteria for thin bituminous surfacings, i.e prime coats and surface dressings, in order that they would better resist damage from soluble salts. At the same time the opportunity was taken to investigate the effectiveness of several preventative treatments.

3 EXPERIMENTAL DESIGN

The key variables influencing damage to the bituminous surfacings identified in the laboratory work were, perhaps obviously, the salt content of the roadbase and also that of the water used in the compaction of the roadbase. A further source of salt, very important in the longer term, was that derived from the lower levels of the pavement. Other important variables considered were the type of prime coat applied to the roadbase and the time delay between the completion of the construction of the roadbase and the application of the prime. The further delay between the completion of priming and the application of the surface dressing was also considered important and included in the field trial, as were single and double surface dressings. Although the rate of application of the bituminous material (ie its thickness) influences whether or not damage occurs, it was not possible to include this variable without unduly complicating the experimental matrix.

The design of the field trial is shown in Fig 1. A location was chosen near the village of Zoroga, 50km west of Nata, in northern Botswana. Two separate sites 2.5 km distant from one another on the old gravel road were selected. At Site 1 the road was constructed on a hard calcrete roadbed: at Site 2 the road had been built up with sand above the level of the surrounding salt pan. Thus at Site 1 the road was built on a non-saline subgrade and at Site 2 on a saline subgrade.

At each site six trial roadbase sections were constructed, plus an additional control section at Site 1. The roadbases consisted of calcrete natural gravel (a partly indurated material derived by cementation of the Kalahari sand), designed to contain 0.07%, 0.60% and 1.34% TSS; these salt contents span the current Botswana specifications. Water of two different salinities was used in the compaction of the calcrete; thus roadbases with six different salt levels were obtained. Trial roadbase sections were constructed at the two sites, thus giving twelve sections. The control section 3 was non-saline calcrete compacted with non-saline water at Site 1.

Each trial section was subdivided into subsections depending on the type of prime used and the delay between the construction of the section and the application of the prime. The effect of different delays between the priming and surface dressing was also evaluated by staggering the application of the first surface dressing in two stages. The second surface dressing was applied universally. The road carriageway (6m wide) was double surface dressed and the shoulders (1.5m wide) were single surface dressed, according to normal construction practice.

To assess the effectiveness of preventative measures, two impermeable membranes, one comprising a thick bitumen layer and the other a polyethylene sheet, were incorporated at the bottom of part of Section 8 at Site 2.

The field trial was trafficked for 18 months, after which traffic was diverted on to the new road which had been completed by this time. Thereafter the trial sections received no traffic. This enabled the effects of no traffic on the condition of the sections to be assessed.

4 CONSTRUCTION

Sites 1 and 2 were each about 130m long with individual sections varying from 12 to 25m in length. The non-saline calcrete was obtained from a nearby borrow pit (which also served as a preparation site) and the saline calcrete was obtained from the gravel-wearing course of the old road where it crossed the salt pan. Fresh and saline water (for compaction) were obtained from local sources.

Each section was subdivided into subsections of 3m length and either cutback or emulsion prime applied. The cutback prime was MC30, a low viscosity medium-curing type and the emulsion was a medium-setting cationic type. Individual sections were separated from one another by 3m long transition zones.

The primes were sprayed on the roadbases, which had been previously swept and sprinkled with water to suppress dust, in 3 metre wide strips across the whole road width, using a hand-operated, motorised lance. The achieved prime application rate ranged from 0.7 to 1.4 litres/sq m (equivalent to 0.5 to 0.9 litres/sq m residual bitumen). Each section also included a subsection with no prime coat.

A 150/200 Penetration grade bitumen was used for the binder for the first surface dressing at an average application rate of 1.5 litres per sq m. A quick-setting cationic bitumen emulsion (KRS 60), was used as the second surface dressing, at a residual bitumen application rate of 1.2 to 1.3 litres per sq m. Nominal aggregate sizes were 19mm and 9.5mm with average least dimensions of 10mm and 4.5mm respectively.

The impermeable membranes were applied in Section 8 of Site 2. In subsection 6 a 0.55mm thick clear polyethylene sheet was laid on the saline embankment sand below the roadbase and in Subsection 7 bitumen emulsion at a residual bitumen application rate of 2.5 litres/sq m was similarly applied. The emulsion was the same as that used for the prime coat.

Soon after the second surface dressing had been applied in May 1990 the sites were opened to traffic, estimated to be 150 vehicles per day per lane, of which 40% were commercial (i.e with unladen weight of at least 1.5 tonnes). The traffic was diverted on to the new road in December 1991.

5 MEASUREMENT TECHNIQUES

The resistance of the bituminous surfacing to salt damage, whether prime coat or surface dressing, was assessed by visual observation. In the laboratory testing a 'severity rating' was established, summarised in Table 1 below; it was somewhat subjective owing to the nature and development of the damage.

Table 1: Severity of Damage to Bituminous Surface

Rating	Description of Damage
0	No damage to surface
1	< 10% of surface damaged
2	11 to 25% of surface damaged
3	26 to 50% of surface damaged
4	51 to 75 % of surface damaged
5	> 75% of surface damaged

Together with the visual evaluation, the trial roadbases were sampled for determination of soluble salt content, discussed in more detail below. Generally three samples were taken at each sampling point, representing 0 to 50mm, 50 to 100mm and 100 to 150mm of the roadbase. From the standpoint of damage to the bituminous surfacing, the 0 to 50mm sample was of most interest. Previous work had shown that whilst it could be assumed that the salt was evenly distributed in the roadbase at the time of construction, it eventually became concentrated in the upper part of the roadbase due to the movement of moisture through the roadbase layer. However it was important to check if the concentration in the top of the roadbase was matched by a depletion in the bottom.

5.1 Determination of Salt Content

Most of the analytical techniques available to determine salt contents are time-consuming and some require a considerable degree of skill. For this reason methods have been developed whereby the electrical conductivity (EC) of an aqueous solution of the material is measured, using a standardised procedure, and the values related to the Total Soluble Salt of the sample. The absolute relation of EC to salt content is complex and although it is not possible to obtain a correlation on a global basis it has been proposed on a regional basis, eg Doornkamp et al (11) in the Middle East.

The standardised method of determination of EC is based on the US Bureau of Soils paste method, subsequently adapted by the Southern African Roads Authorities and described in Method A21T of TMH 1:1986 (12). However, for this project, because of the large number of samples a quicker and more field-adaptable method was used. It has been extensively used in agricultural practice and has been adopted by UNESCO (13). Since each EC method requires the preparation of solutions of quite different salt concentration (containing 67% water in the 'rapid' method and about 28% water in the TMH 1:1986 method) the EC of 65 samples was determined by both methods. It was found that the EC determined by the TMH method gave results 30% higher than the 'rapid' method. This relationship had an R^2 value of 99%, within the range of conductivities tested, indicating a systematic difference.

To establish the correlation between the rapid EC and TSS measurements were determined on 70 samples. The method of determination of the EC is described above: the TSS was measured according to the method given in BS 1377:Part 3:1990 (14). The correlation between these components specific to the Nata-Maun materials was:

$$TSS = 0.04 + 0.16EC$$

A correlation coefficient of 0.9 was obtained for this relationship. The EC is measured in milliSiemens per cm (a Siemen is the reciprocal of the electrical resistance in ohms) at 25°C; and the TSS content is measured in mass percent. All determinations were carried out on the passing 20mm fraction only of the samples, corresponding to about 75% by mass of the borrow pit material: it is generally recognised that the major proportion of the salt is contained in the fines.

It was of interest to determine the nature of the soluble salt and it was confirmed by further chemical analysis that it comprised a combination of sodium chloride and sodium bicarbonate, with roughly 67% of the former and 33% of the latter.

6 ROAD TRIAL RESULTS

6.1 Climate

Meteorological data for 1991 for Maun, Francistown and Gaborone indicated that during the summer months (November through April) the typical daily temperature ranged from 40 to 15°C and relative humidity from 90 to 40%; in the winter months conditions were generally much cooler (25 to 5°C) and drier with the relative humidity below 75% for most of the day.

The equilibrium vapour pressure of a saturated sodium chloride solution is achieved at a relative humidity of 76%. This means that for sodium chloride to be precipitated relative humidities of less than 76% must prevail in the atmosphere. Both summer and winter conditions therefore favour the precipitation of salts; possibly the higher temperatures of summer are more favourable since they increase the rate of evaporation.

6.2 Permeability

Evaporation is an essential process in the salt crystallization cycle and the permeability of the roadbases, primed and unprimed, was estimated using a simple field method whereby the time taken for a column of water to dissipate through a known area was measured. It was found that, for reasonably fresh materials, the unprimed base was approximately ten times more permeable than the primed bases, and the cutback-primed base was slightly more permeable than the emulsion-primed base. Both single and double surface dressings appeared to be virtually impermeable using this method.

6.3 Damage to Prime Coats

6.3.1 Visual Evaluation

Reference is made to Tables 2 and 3 which summarise the findings of the investigation into the use of different prime types and different delays to application of prime for Sites 1 (non-saline subgrade) and 2 (saline subgrade) respectively. Results for only some of the sections of Sites 1 and 2 are shown but are representative of the trial as a whole. The initial salinities refer to the whole of the roadbase and for these the % TSS was determined directly, whereas in subsequent samples the % TSS was derived from the EC.

Most bituminous prime coats became salt-damaged to some extent: the only exceptions were those applied to the non-saline roadbase sections (nos. 1, 3 and 8) and the emulsion primed subsections of the slightly saline roadbase section(no 9).

Damage to the primes usually occurred within a few days of their application. The cutback primes became discoloured to brown, followed by a progressive development of a crumbly or spongy texture with the eventual separation of the prime from the roadbase. Small blisters appeared on the emulsion primes which became larger and more numerous with increased salt and/or increased time delays. The underside of these blisters were coated with salt crystals, in a characteristic whisker-type form.

Although the less permeable emulsion prime was more resistant to salt attack than the cutback prime it did not soak into the roadbase and bind it for subsequent surfacing; rather it formed a skin on the surface.The cutback prime was also easier to treat after it had been damaged by salt. Brooming was used to restore a lightly damaged surface, leaving the roughened surface underneath as a key on to which the surface dressing bitumen could be applied. The emulsion, however, was delicate and prone to detachment from the surface of the base, especially in the warmer parts of the day.

Table 2: Site 1 (non-saline subgrade): results

Section	Section 2	Section 4	Section 6
Subsection	1 2 3 4 5 6	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7
Prime Type	C C C E E E	N C C C E C E E	N C C C E E E
Initial Salinity of roadbase, %TSS	0.70	0.62	1.16
Time (days) bet cons. & priming	4 6 14 5 7 14	- 1 2 3 5 12 4 13	- 2 2 5 3 12 1
Pre-priming Salinity, % TSS, (0 to 50mm)	0.7 to 1.2	0.7 to 1.3	1.3 to 2.1
Severity Rating	3 3 0 2 3 1	- 2 2 2 1 0 2 1	- 3 3 4 2 3 2

Notes: C = Cutback Prime
E = Emulsion Prime
N = No Prime

Table 3: Site 2 (saline subgrade): results

Section	Section 8	Section 10	Section 12
Subsection	1 2 3 4 5 6 7	1 2 3 4 5 6 7 8	1 2 3 4 5 6 7
Prime Type	E C C E E C C	E C N C C C E E	C C N C E E E
Initial Salinity of roadbase, %TSS	0.07	0.60	1.32
Time (days) bet cons. & priming	9 9 14 9 14 14 14	3 3 - 6 12 1 1 11	1 2 - 7 2 7 12
Pre-priming Salinity, % TSS, (0 to 50mm)	0.08 to 0.2	0.7 to 1.3	1.5 to 1.9
Severity Rating	0 0 0 0 0 0 0	3 4 3 1 4 3 1 3	4 4 - 5 4 5 1

In the subsections where surface dressing bitumen was applied without priming it was observed that there was poor adhesion of the surface dressing to the roadbase. However, these subsections remained in place throughout the duration of the trial.

6.3.2 Salt Content of Roadbases

Significant increases in salinity were measured in the upper 50mm of the trial roadbases prior to priming. The greater the construction salinity, the greater the rate of increase in salinity prior to priming; this relationship is shown in Fig 2. A maximum interval of 14 days was allowed between completion of construction and application of prime.

The increasing concentration of salt at the surface of the roadbases constructed on a non-saline subgrade (Site 1) generally resulted in salt depletion at the bottom. The same trend was initially observed for the roadbases constructed on a saline subgrade (Site 2) but, after a longer period (about 7 days), salt increases at the bottom of the roadbases were observed due presumably to replenishment from the saline sand fill. It is estimated that the rate of salt rise was about 5mm per day.

In the interval between application of the prime and surface dressing (maximum interval, 17 days), the cutback-primed roadbases showed less rapid increases in salinity than if no priming at all had been carried out; whereas the emulsion-primed roadbases showed virtually no changes in salinity after priming. This confirmed that the emulsion prime was less permeable than the cutback prime, as indicated in Section 4.2.

The effects of priming some subsections earlier than others in the same section generally resulted in reducing the rate of salt increase in the upper part of the roadbase but did not necessarily prevent damage to the prime coats if they were not then surface dressed within a short time period (approximately three days). This is well exemplified in Tables 2 and 3. The occurrence and degree of damage suffered by the prime coats primarily depended on the initial salt content.

6.4 Damage to Surface Dressing

6.4.1 Visual Evaluation

Visits to evaluate the condition of the surface dressing were initially made at six monthly, but eventually at yearly intervals.

The trafficked, double sealed carriageway of both trial sites remained in good condition (although most of the smaller chippings of the second seal coat were lost from either an underapplication of binder or by trafficking too early). Since the diversion of traffic on to the new road, all the double surface dressed sections at Site 2 (with the saline subgrade) have shown progressively greater signs of salt damage, except for the subsection underlain by polyethylene sheet. However, no damage had occurred to the carriageway of Site 1 (with the non-saline subgrade) by March 1994, the latest visit.

Regarding the untrafficked, single sealed road shoulders at Site 2, most sections showed salt damage (salt-filled blisters and domes) within six months, especially at the junction of the road shoulders and carriageway. These became progressively worse, ultimately with lenses of salt up to 1 cm thick within the roadbase. Again the subsection protected by polyethylene sheet was undamaged. Only very minor damage possibly attributable to salt has occurred at Site 1.

Staggered delays, with a maximum difference of 14 days, between the application of prime coats and surface dressing were incorporated in the trial design. However, there has been no significant effect on the surface dressing over the four years since it was applied.

6.4.2 Salt Contents of Roadbases

The salt levels of the upper 50mm of the roadbases under the carriageway where the salt concentrated are shown in Fig 3. The values showed considerable variation, especially where the initial salt content was high, but the main trends are summarised below:

i) salt levels in the roadbases constructed on the non-saline subgrade (Site 1) have either undergone little change or experienced a slight decrease since the application of the surface dressing: this includes the control, Section 3, which is not shown in Fig 3.

ii) salt levels in the roadbases constructed on the saline subgrade (Site 2) have generally increased, except for Sections 12 and 13 where there is no increase: the reason for this is not understood

iii) the polyethylene sheet placed at the bottom of the roadbase in Subsection 8/6 had, up to the fourth year of observation, resisted the upward movement of salt from the saline fill and visually was still in good condition, whereas the bitumen layer laid at a similar level in the adjacent Subsection 8/7 had not.

iv) the difference in damage between the sections of Site 1 and Site 2 is not reflected in the salt levels: the salt contents of the most saline sections of Site 1, nos. 6 & 7, are about 1% TSS, only slightly lower than those of Site 2, Sections 8 & 9, which suffered damage soon after trafficking ceased.

Results for the road shoulders are omitted because of the physical disruption of the single seal.

6.4.3 Moisture Movements in the Pavement

The additional salt that has accumulated in the trial roadbases constructed on the saline subgrade has clearly been transported in rising moisture. Although the position of the water table has not been determined, the periodic occurrence of standing water in the rainy season (summer) indicates that it is close to the surface.

The importance of the permeability of the bituminous surfacing as a means of retarding the upward rise of salt was mentioned earlier. However, the gradual increase in salt levels beneath the surface dressings of the trial sections at Site 2 (constructed on the saline subgrade) implies that retardation has not occurred. As the surface dressing was virtually impermeable, the upward movement of moisture should not have occurred. However, salt rise beneath impervious pavements has been noted before, eg Netterberg (15), Tomlinson (16), Horta (5).

7 DISCUSSION

The results from the field trial have confirmed the indications from the laboratory work in that the surface dressings are significantly more resistant to salt damage than the prime coats. In the light of this and the work of other researchers it would appear reasonable to relax the current Botswana specifications regarding salt limits for roadbases constructed with surface dressings on non-saline subgrades.

Bituminous prime coats are, however, very sensitive to salt attack. The results indicate that they are affected at very low salt levels, of the order of 0.2% to 0.3% TSS, (contained in the whole of the roadbase) with the emulsion primes being more resistant than the cutback primes. Results from this field trial did not show that the early (ie within three days) application of the prime coat to the roadbase gave significant protection against salt damage because the salt still accumulated beneath the prime; this was a surprising result.The benefits of early application of prime are widely reported in the literature. The degree of salt damage suffered by the prime was severe (ie greater than 50% of the surface affected) when salt levels exceeded about 0.5% TSS (in the roadbase as a whole). The degree of salt damage suffered by the prime was greater on the roadbases constructed on the saline subgrade than the non-saline subgrade, although the reason for this was not clear. The only way to avoid damage to the prime coats in situations where salt levels are high is to apply the surface dressing quickly, ie within three days, but this may be impractical in some construction contracts.

Although the surface dressings were much more resistant to salt attack than the prime coats, the degree of resistance varied between the trial sections constructed on the non-saline subgrade (Site 1) and those constructed on the saline subgrade (Site 2). Additional salt, derived from the upward rise of saline groundwater, accumulated in the Site 2 sections despite the presence of the double surface dressing. For some reason, as yet unclear, more salt deposition occurred in the less saline roadbase sections of Site 2 than the more saline sections. Salt accumulation carried out continuously in the road shoulders and the single surface dressing was soon disrupted. Eventually,large salt lenses developed in the surface of the roadbase. There has been little or no change in salt levels in the trial roadbase sections constructed on the non-saline subgrade (Site 1). The hard calcrete subgrade has prevented any significant rise of moisture.

It is clear that surface dressings are more resistant to disruption caused by salt crystallization. Based on the observations made at Site 1 in the three years since traffic was withdrawn, the double surface dressings have tolerated up to 1.0% TSS in the surface of the roadbases without being damaged. The single surface dressings appeared also to be in good condition but due to their reduced bitumen thickness (and permeability) compared to the double surface dressings may become damaged in the longer term. However, they should be able to withstand 0.5% TSS without damage. The bitumen application rate is important in this respect: in this field trial approximately 2.7 and 1.5 l/m^2 of bitumen were used in the double and single surface dressing respectively.

The effect of traffic was to oppose the upward force created by salt crystallization and maintain contact between the bitumen and the roadbase. It prevented damage to the double surface dressings applied to the carriageway at Site 2 even when surface salt levels reached 1.5% TSS, but the surface dressings were soon damaged when traffic was withdrawn, even in the least saline sections of Site 2, nos. 8 and 9, where salt levels in the top of the roadbase were about 1.2% TSS. From the standpoint of road construction the beneficial action of traffic must be regarded as a bonus and not as a design criterion; in situations where saline subgrades occur additional preventative measures must be adopted. In this respect the impermeable polyethylene sheet has been a success in the field trial up to the time of the last monitoring visit four years after construction. Black polyethylene sheeting, 0.25mm thick was used for the sections of the new road crossing the salt pan, altogether totalling 6km and costing approximately £0.3 per sq m. It was laid across the whole road width within a 50 to 100 mm thick layer of sand beneath the sub-base, and compacted with the sub-base. It was on average 350 to 400mm below the road surface. Three years after construction the condition of the road where the polyethylene had been laid was good, with no sign of salt in the roadbase.

Considering the sensitivity of the bituminous prime coats to saline conditions, it would be useful to carry out further tests where surface dressings were applied directly to the roadbase and the prime coat excluded. In this field trial an initial problem was experienced with the adhesion of the surface dressing to the roadbase but the evidence from this trial, and from elsewhere, indicates that it is improved by the passage of traffic.

8 CONCLUSIONS

1. In warm arid and semi-arid climates where evaporation exceeds precipitation, soluble salts accumulate in the upper layers of the road pavement and can damage thin bituminous surfacings such as prime coats and surface dressings.

2. The prime coats evaluated are very sensitive to this type of damage and can be affected if the soluble salt content, measured as percent Total Soluble Salt (TSS),is greater than about 0.3 % in the upper 50mm of the roadbase. Cutback prime is more sensitive than emulsion prime to this type of damage.

3. Surface dressings are more resistant than primes to salt damage. This trial indicated that single and double surface dressings would not be damaged by roadbase TSS contents up to 0.5 % and 1.0 % respectively within four years, provided the roadbases were

constructed on a non-saline subgrade. If these salt levels are expected a prime coat should be preferably be excluded but a trial would be advisable to determine the effectiveness of bonding the surface dressing directly on to the roadbase. Alternatively, the prime coat could be surface dressed within three days of application but this may be impractical in contract situations.

4. Trafficking increases the resistance of surface dressings to salt damage; the thresholds in conclusion 3. were exceeded by 50 % without damage whilst subjected to traffic. Surface dressed road shoulders are therefore especially vulnerable to salt attack.

5. In situations where saline subgrades occurred, the upward rise of salt continued despite the application of surface dressings, which were then eventually vulnerable to salt damage. In this field trial, an impermeable fabric (plastic) placed at the bottom of the roadbase prevented the upward rise of salt and protected the bituminous surfacing from salt damage, without compromising road performance. A thick bitumen layer placed in the same position was not successful in this respect.

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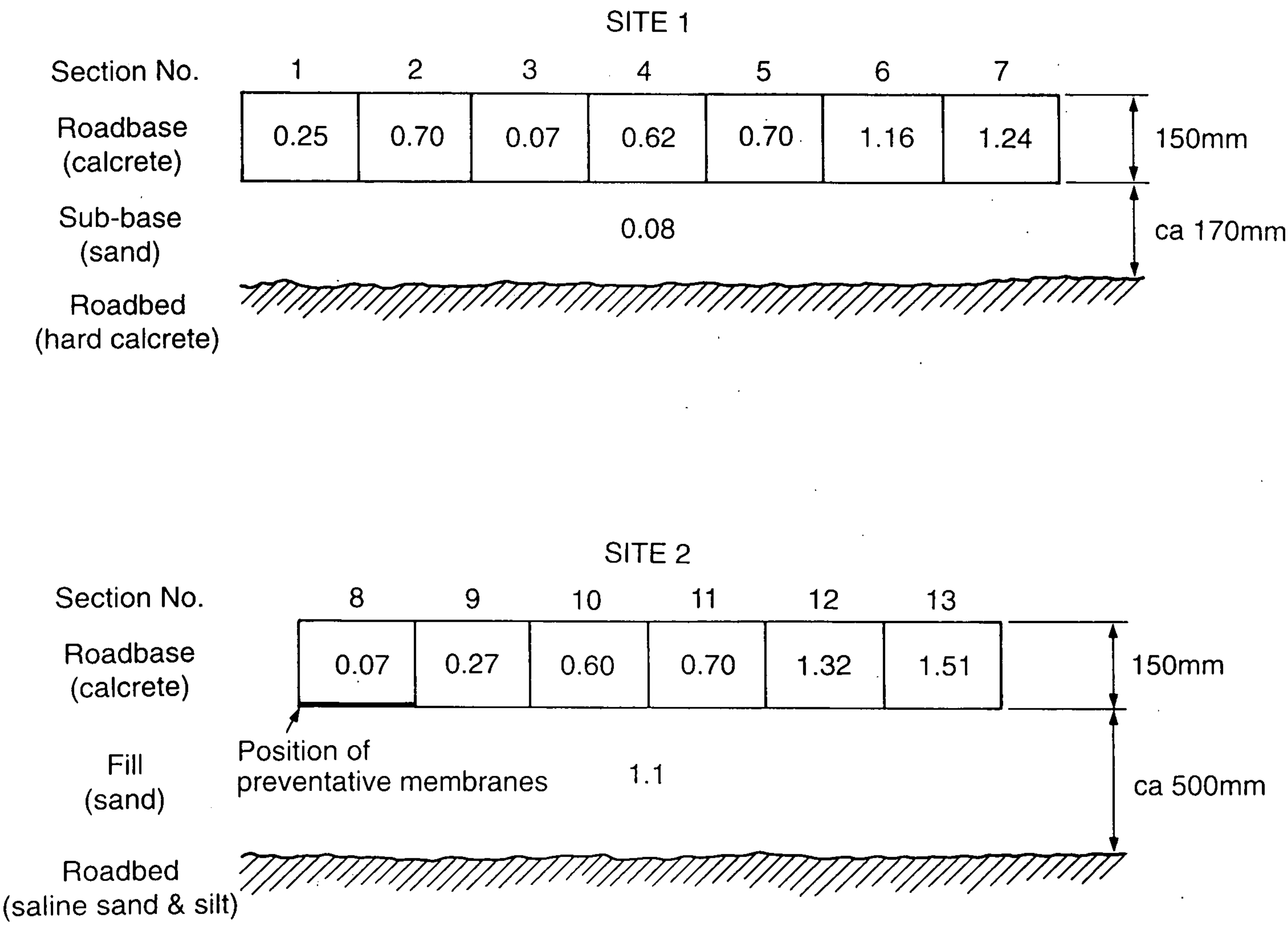

Note 1. Values given are percentages Total Soluble Salt in sections at construction

Fig. 1 Nata-Maun road salt damage trial: cross section and salt contents of trial sections

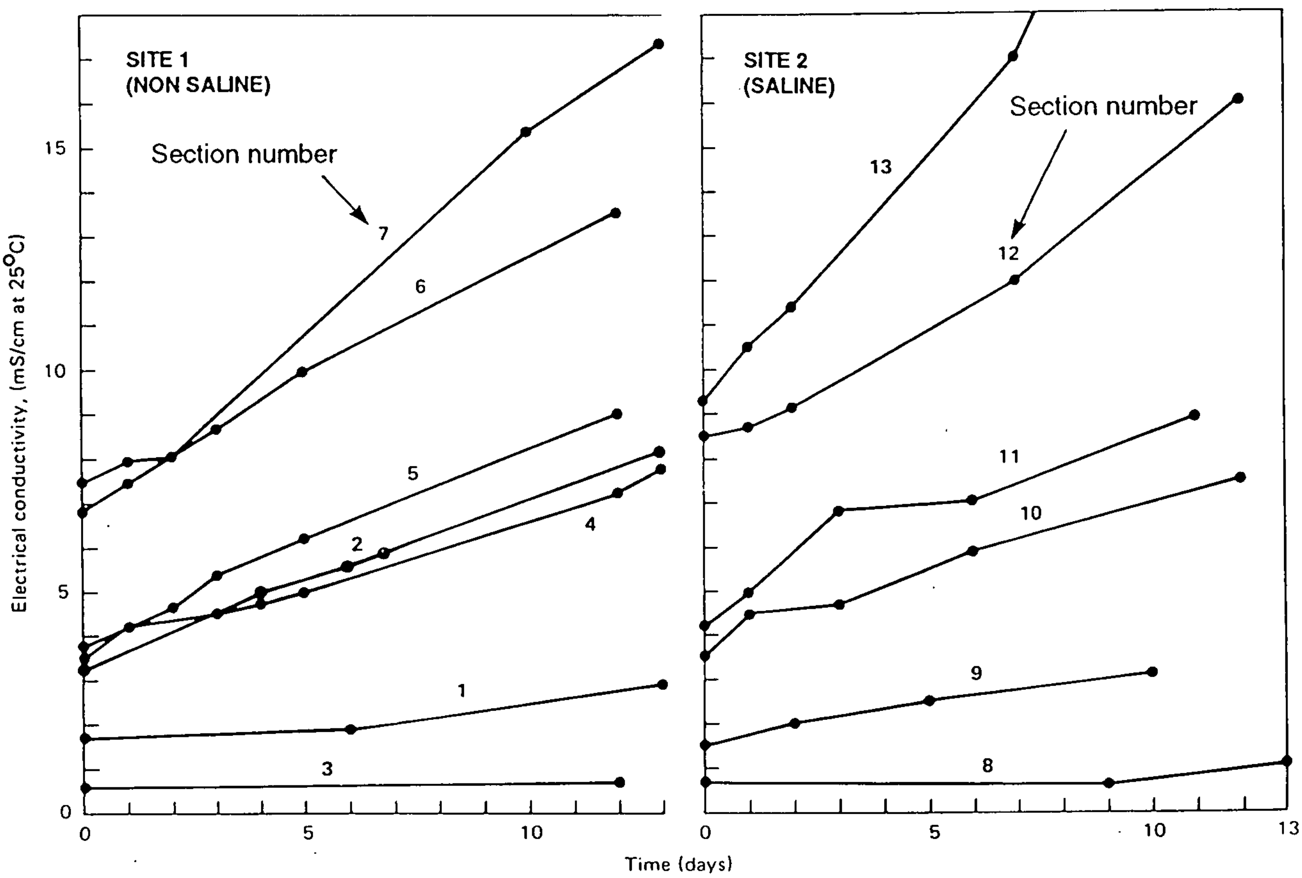

Fig. 2 Salt trends in top 50mm of road bases before priming

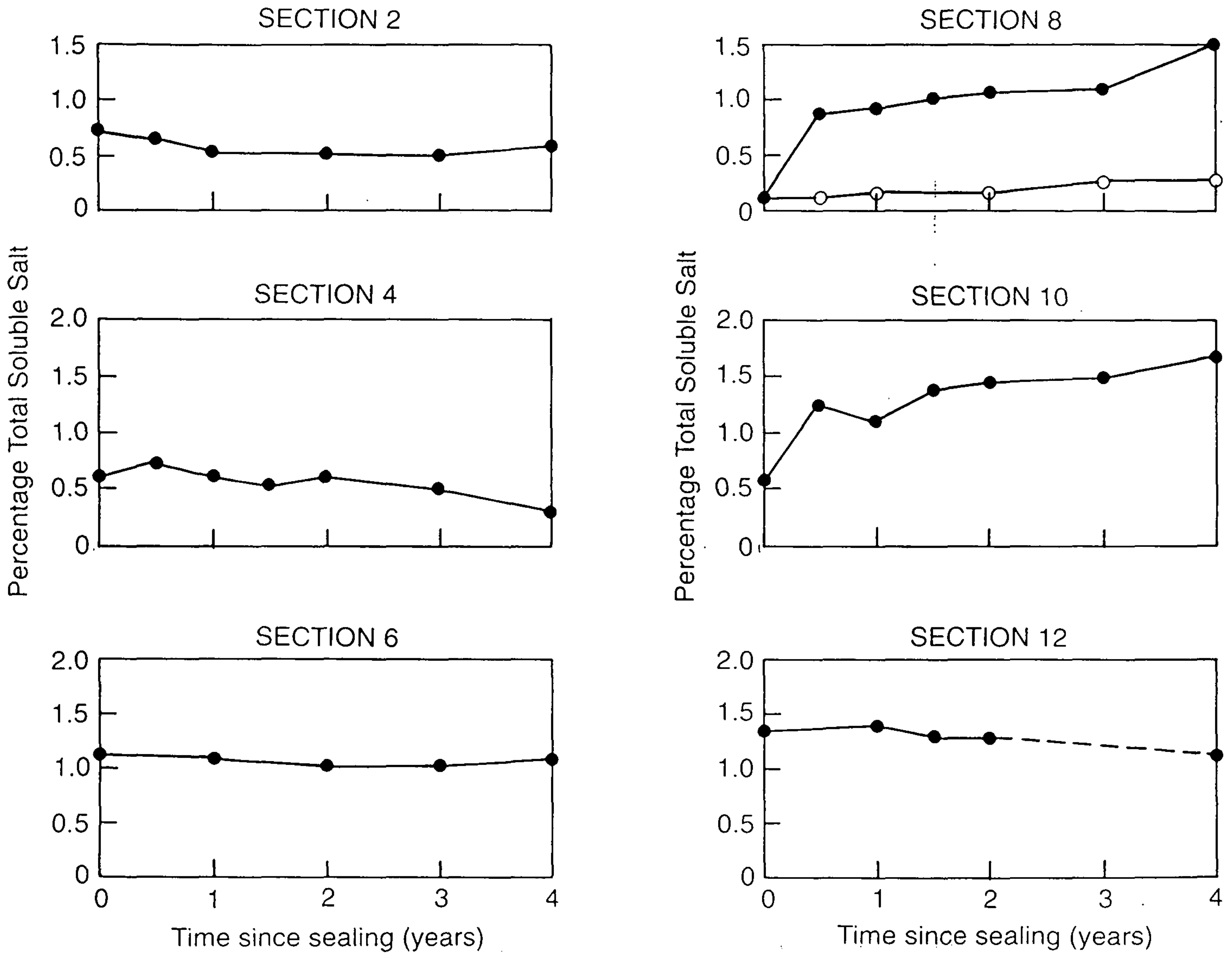

Fig. 3 Change in salt levels in roadbases under carriageway (0 - 50mm depth) after sealing