PERFORMANCE OF LABOUR BASED SURFACINGS

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ABSTRACT

The CSIR's Built Environment Unit, previously known as the Division of Roads and Transport Technology, Transportek, undertook a number of labour intensive/labour based roads projects to transfer the road maintenance technology to local and provincial government and community maintenance facilitators, engineering consultants, contractors and road maintenance units.

The performance of four different seals which have been constructed using labour intensive/labour based methods on five projects comprising eleven sections in different regions of South Africa will be discussed in this paper.

The evaluation of the performance of the different seals is based on the TRH 6 guidelines describing the conditions of asphalt pavements.

1. INTRODUCTION

The CSIR undertook five labour based projects over a period of eight years to transfer the technology of emulsion treated bases (ETB) and surfacing seals to provincial and local government departments, consultants, contractors and road maintenance teams. A total of eleven sections of surfacings were constructed, ranging from single seals, double seals, slurry seals and Cape seals. The performance of these surfacing seals is discussed using TRH 6 (Nomenclature and methods for describing the condition of asphalt pavements).

2. PROJECTS

2.1 Qwa Qwa Project

This project is situated in Phuthaditjaba in the North-Eastern Free State and was funded by Department of Transport and FHWA.

The object of this pilot project was to establish which surfacing would be the most economical and appropriate to be applied with hand labour for traffic volumes below 500 vehicles per day and less than ten percent of these being heavy vehicles. (Bergh…Ref SATC paper) Four streets were constructed to a 100 mm thick emulsion treated base using labour based methods and each street was surfaced with a different seal, namely:

- a single seal;
- a double seal;
- a Cape seal; and
- a slurry seal

2.1.1 Single seal
The single seal was constructed using a cationic emulsion as the binder for the tack and penetration coat and a 9.5 mm surfacing aggregate. A motorized hand sprayer was used to apply the binder at the required application rate. The aggregate was applied by hand. A pedestrian roller was used to roll the aggregate into the binder (LICT 7).

2.1.2 Double seal
The double seal was constructed using a cationic emulsion as the binder applied in three applications, namely, tack coat, penetration coat and a fog spray respectively and a 13.2 and 6.7 mm aggregate was used for the surfacing stone . The method used for applying the binder and aggregate was similar to the single seal. The aggregate was rolled into the binder using a pedestrian roller (LICT 7).

2.1.3 Cape seal
The Cape seal was constructed with a cationic emulsion as the binder for the tack and penetration coat using a 13.2 mm aggregate for the surfacing stone. A slurry was spread over the aggregate and dragged with a Hessian cloth. A pedestrian roller was used to roll the aggregate after the breaking of the emulsion of the slurry (LICT 7).

2.1.4 Slurry seal
The ten millimeter thick layer of slurry (wet) was constructed using a stable grade anionic emulsion and medium grading slurry aggregate. The slurry was placed between two ten millimeter steel guide rails and leveled with a straight edge (screed). The slurry was then rolled with a pedestrian roller after the emulsion in the slurry broke (LICT 7).

All four streets were completed in 1996.

2.2 Mandini (Natal)
The object of this project was to set up a training prgramme in Mandini, a small town immediately to the north of the Tugela River in KwaZulu-Natal, to train council employees and eligible members of the community in labour based construction and maintenance techniques for streets. The project started in February and was completed in November 1998. The project was funded by the Department of Transport and Mandini Local Municipality. The street provides access to a primary and high school.

The street is 250 m long and 4.5 m wide with a 1.5 m concrete side drain on the one side of the street edge and a concrete kerb and side walk which was constructed at a later stage by the local council on the opposite edge of the street.

The base layer of the top 150 m section of the street was sound accept for a few potholes which were repaired using emulsion treated material. A tack coat consisting of one part stable grade emulsion and six parts water was applied to the existing surfacing.

A medium graded slurry layer of ten millimeters (wet) was applied to this section of the street.

The base layer of the bottom 100 m section of the street was constructed using an emulsion treated base. The surface of the emulsion treated base was treated with a tack coat consisting of one part stable grade emulsion and six parts water, which was then surfaced with a Cape seal.

2.2.1 Slurry seal
The method is similar to the Qwa Qwa slurry seal.

2.2.2 Cape seal
The Cape seal was constructed using an anionic spray grade emulsion as a binder and a 13.2 mm aggregate. The rest of the process is similar to the construction of the Cape seal for the Qwa Qwa project.

2.3 Sebokeng
The Lekoa Vaal Metropolitan Council and the Community Based Public Works Programme of the Gauteng Department of Public Transport, Roads and Public Works funded the project.

The purpose of the project was to train three maintenance units to be incorporated into the Lekoa Vaal Metropolitan Council Maintenance Unit.

Two of the three street sections that were evaluated were constructed on a 100 mm thick emulsion treated base while the remaining section was constructed on a 100 mm thick Sasol ash rollcrete base. The street sections are referred to as:

- Neat Sasol Ash emulsion treated base
- Sasol Ash Rollcrete base stabilized with cement and reinforced with synthetic fibres
- Gravel (80%) with 20% slag emulsion treated base.

2.3.1 Slurry seal
All three street sections was surfaced with a 10 mm thick (wet) medium grading slurry using the same process as for the Qwa Qwa slurry. The streets were completed in 2001.

2.4 Botrivier and Elandsbaai Projects
The purpose of the project was to introduce the concept of labour based construction of roads and streets in the Western Cape to the officials of the Provincial Administration of the Western Cape, consultants responsible for the designs of the projects and the contractors who would construct these roads/streets who were involved in the Community Access Road Programme to assist with the poverty alleviation efforts in the province. Two projects were identified for pilot projects, Botrivier and Elandsbaai respectively. The Provincial Administration of the Western Cape funded the project which was completed in 2002.

2.5 Botrivier
The Botrivier street section consists of a street length of 90 m and 6 m wide which was constructed on a cement stabilized subbase and emulsion treated base using labour based methods. The local municipality provided a motor grader to blade the sand subgrade. There are no concrete side drains on either side of the street. The street provides access to a primary school and residential properties in the area.

A tack coat consisting of a diluted emulsion and water in the ratio of 1:6 was applied to the base. The Cape seal was then applied to the emulsion treated base.

2.5.1 Cape seal
The same process was followed as for the Qwa Qwa and Mandini Cape seal.

The labour used on the project was local residents, consisting of men and women who had no prior experience in the construction of road works and surfacing seals.

2.6 Elandsbaai

The Elandsbaai street section consists of a street length of 75 m and 3.2 m wide which was constructed on a sand subgrade and emulsion treated base using labour based methods. The street provides access to residents in the area and tractors removing refuse from the houses.

2.6.1 Cape seal

The surfacing consists of a Cape seal similar to the surfacing used on the Botrivier project.

The labour used on the project was local residents from the area who had no prior experience in the construction of road works and surfacing seals. The local municipality prepared the subgrade, supplied and laid the kerbs, channels and edging for this street.

3. PERFORMANCE OF SEALS

The performance of all the seals will be evaluated using the modes of distress (TRH 6), namely:

- Deformation;
- Cracking;
- Disintegration of surfacing
    - Ravelling;
    - Potholes;
    - Edge break
- Smoothing of surface
    - Bleeding
    - Polishing (excluded from study)

3.1 Single Seal (10 years old)

Qwa Qwa was the only project where a single seal was constructed. The seal was in a good condition after four years, but with no maintenance after ten years the seal needs urgent attention as it shows large areas of stone loss and exposure of the emulsion treated base (ETB).

There is no deformation of the street surface profile. Crocodile cracking appears on a very small area (Degree 3, 0.5% area) in the wheel path next to the stormwater side drain of the seal. There are two distinct areas of surfacing where stone loss has occurred, exposing the emulsion treated base and might cause potholes to develop over this area namely:

The first section (Degree 5), area 5 % and length 11% Spacing 700 mm.

The second section (Degree 5), area 1% and length 2%, spacing 700 mm.

There are random patches ranging from 50 - 300 mm diameter where stone loss occurred over the entire surface area.

There are two potholes which have been filled with large aggregate (Degree 5) and one pothole (Degree 4) next to the concrete stormwater drain. The edge break is minimal along this section of street as the grass on the verge grows up to the edge of the surfacing (Degree 2).

The surfacing shows no signs of bleeding.

3.2 Double Seal (10 years old)

Qwa Qwa was the only project where a double seal was constructed. There is no deformation in the street surface profile, accept where a pipe was installed across the street prior the construction of the ETB (Degree 5). There is only one longitudinal crack of 3 mm wide (Degree 4) along the centerline of the curve which could have been caused by the shrinkage of the fill material.

The loss of the 6.7 mm stone occurred soon after construction, but the rate of stone loss was significantly less after the initial stone loss. There was no loss of 13.2 mm aggregate. Thirty percent of the surfacing area was affected by the 6.7 mm stone loss affecting the appearance of the surfacing (Degree (5), area 30%, length 30% and spacing 750 mm).

The two curves were surfaced with the double chip and spray seal, but show no signs of deterioration, although the one curve is on a steep slope.

The double seal is the most difficult of the four seals to construct using labour based methods (Bergh et al 1998).

There is no development of potholes in this seal's surface (Degree 1). The levels of the properties fall from the street edge towards the houses, creating an edge between the surfacing and the verge which causes edge break. Edge break occurs where residents are accessing their property with vehicles (Degree 3). This can be prevented by installing concrete edging along the edge of the street.

No bleeding occurs, but there are a few areas which appears rich in binder.

3.3 Slurry Seal (10 years old)

The slurry surfacing shows no sign of deformation in the street surface profile. Crocodile cracks appear over most of the surfacing area, but these can be attributed to the shrinking of the slurry during the construction stage and probably caused by the ageing of the binder (Degree 3).

No discernable loss of binder occurs on the seal. There is isolated loss of surfacing (3 no.) caused by mechanical damage when the underside of vehicles hit the surface when crossing the concrete side drain to enter their property.

Two potholes of 300 mm diameter developed on this street (Degree 4). Edge break occurs along the length of street, but are worse at the section near the curve where vehicles used to cut across the curve instead of driving along the surfaced area inside the curve (Degree 5) and length 10%. Edge break also occurred on the remaining section of the street at a lower degree (Degree 4). There was no edge break at the intersection of a minor gravel street to the coarse slurry. The edge is intact, proving that the coarse aggregate slurry can withhold the abrasions of the gravel spilled onto the street at this intersection.

No bleeding occurs on this seal.

3.4 Slurry Seal (7.5 years)

On the slurry seal no failures have been recorded except for bicycle tyre marks left by local kids immediately after construction and tooth marks caused by a front end pay loader. Stone loss was noted in some areas (seal is becoming brittle). There are signs of cracks similar to block cracking on the whole area of the seal. The seal is in need of rejuvenation.

3.5 Slurry (5 years)

3.5.1 Neat Sasol Ash Emulsion Treated Base Section
There is a depression of 50 mm deep (Degree 5) in this section of the street which was caused by a leaking water main over a length of 7m along one half the width of the street.

The municipality repaired the water main but did not reinstate the surfacing. There are no surface defects along the rest of the street.

Longitudinal cracks, 3 mm wide, are evident along this section of the street and crocodile cracks have developed in this area where the street failed at the leaking water main.

A surface patch of 600 mm diameter within the failed section has lost slurry. There are three small areas (300 mm x 100 mm) next to the stormwater drain where the slurry stripped from the base (Degree 5).

Two potholes of 450 mm diameter have developed in this section of the street (Degree 5). Edge break is evident at the start of the street section (Degree 3) and is caused by the difference in level of the surfacing edge at the high end of the cross-section of the street and the surrounding ground level of the verge.

There is no bleeding on this seal.

3.6 Slurry Seal (5 years)

3.6.1 Sasol Rollcrete Section
There are no deformations in the road surface profile. Transverse cracking of the slurry seal appears, but no pumping from the basecourse layer. Transverse cracking of Degree 5 at 5 m spacing over 60 per cent of the area is evident on this section. Transverse cracking of Degree 4 at 2 m spacing over 40 % of the area appears on this section. The width of the cracks has a range between 2 mm and 8 mm.

There is a clean expansion crack 10 mm wide in the surfacing where the Sasol ash rollcrete joins the Sasol ash emulsion treated base. The transverse cracks are probably caused by the shrinkage of the cement stabilized base.

Transverse cracks develop along the joint where the surfacing joins the concrete which develops into spalling of the surfacing.

There is no discernable loss of slurry (Degree 1). There are no surfacing defects along this section of the street, accept for the indentations caused by a few pedestrians walking on the wet slurry immediately after construction.

There is no clear development of potholes in this section of the street (Degree 1). Although the surfacing is slightly higher than the gravel on the verge, minimal edge break occurs because of the high strength of the Sasol Ash Rollcrete base (Degree 3).

No bleeding occurs on the seal surface.

3.7 Slurry (5 years)

3.7.1 Gravel and 20% Slag Emulsion Treated Base.
There are no deformations in the road surface profile. There is only a one meter long and 4mm wide longitudinal crack in the middle of the street. This could be a construction joint

where the two base course sections joins because the ETB was done in half widths of the street, or it could be a construction joint where the two sections of slurry sections join as these were also constructed in half widths.

This section of base is constructed between concrete street sections. There are a number of parallel cracks occurring where the slurry joins the concrete at the one end, but no cracks occur at the other end where the slurry joints the other concrete section.

There is no discernable loss of slurry (Degree 1), only two patches where the surfacing is stripped from the base, 50 and 75 mm diameter respectively. Tyre marks are evident on the surfacing over a section of 5 m in length and 400mm wide which was caused by a vehicle which drove over the wet slurry immediately after the construction of the slurry seal.

There are three rough patches on the surfacing along the edge of the concrete side drain ranging from 1 to 1.5 m in length and 400 mm wide where the fines have been lost from the surfacing.

There is no clear development of potholes in this section of the street (Degree 1). The edge break is Degree 3 and is caused by the difference in level of the surfacing edge at the high end of the cross-section of the street and the surrounding ground level of the verge.

No bleeding occurs on the seal surface.

3.8 Cape Seal (10 years)

Both the curves, the one where the Cape seal is joining the 10 mm coarse slurry and where the Cape seal is joining the single seal are constructed with Cape seal. The Cape seal is performing well on both curves, taking into account that the curve where the Cape seal joins the single seal, water and gravel are spread onto this curve during the rainy season, and the addition of traffic using this point as an access to the four streets.

The Cape seal surfacing shows no sign of deformation in the street surface profile, accept for the area where the stormwater pipe was installed across the street by the local municipality. This area was backfilled but the surfacing has not been reinstated.

Crocodile cracking appears on a very small area (Degree 3, 0.5% area) in the wheel path next to the stormwater side drain of the seal.

Two areas where the cars are entering the driveway show stripping of the surfacing, both 300 mm long and 150 mm in width, but are insignificant compared to the surfaced area.

One pothole of 400 mm diameter (Degree 4) and two smaller potholes of 100 mm diameter (Degree 3) developed in the base. Three potholes of 300 mm diameter (Degree 4) were caused by a backactor/digger loader on the curve while working on the stormwater trench across the street.

Minimal edge break occurs along this street. (Degree 3)

The surface appears rich in binder, but no bleeding occurs on this surfacing.

3.9 Cape Seal (7.5 years)

The Cape seal section of the street is in very good condition with little distress. At one location a section about 40 m^2 has failed. In this area there are several potholes followed by a pattern of cracking at various stages from hair line to about 10 mm. This section coincides with the first ETB trial mixes. This area is in need of urgent attention. There are also a few areas where some stone loss, cracking and small potholes starting to develop. There are indications that the road has been previously repaired (patches).

3.10 Cape Seal (4 years)

3.10.1 Botrivier

There is no deformation in the street surface profile. There are no visible cracks present in the surface seal (Degree 1).

There are a few isolated spots along the edge of the street where surfacing loss occurs (Degree 5), which was probably caused by mechanical damage or a lack of binder during construction. There is a strip of 3 m long and 75 mm wide of surfacing loss caused by mechanical damage.

No clear development of potholes occurs in the surfacing seal (Degree 1).

Edge break occurs at the section of street where children are offloaded at school (Degree 3) and length 9%.

Bleeding occurs along a 300 mm wide strip along the centerline of area 1% and length 50%. There is also a small area showing bleeding (area of 0.5%) on the surfacing.

3.11 Cape Seal (4 years)

3.11.1 Elandsbaai

There is no deformation in the street surface profile. No visible cracks are present in the surface seal (Degree 1).

There is no discernable loss of slurry (Degree 1). There is no clear development of potholes (Degree 1). There is no clear development of edge break because there are concrete channels on the one side of the street and concrete edging on the other side of the street.

The stones are well proud of the binder.

Table 1. Suggested Surfacing Lives (SABITA Manual, 1992).

Surfacing	Urban Environment		Rural Environment	
	Poor conditions	Good conditions	Poor conditions	Good conditions
Double Seal & Cape seal	5-7	8-11	6-8	9-13
Single Seal	3-5	5-8	4-6	5-9
Thick Slurry	4-7	7-9	4-7	

Note: Poor conditions means third world environment or problems such as a weak pavement structure, poor quality control, poor drainage.

4. DISCUSSION

The single seal was constructed in a rural environment under good conditions ten years ago (life span of 5– 9 years, table 1). The seal performed well and is due for maintenance.

The double seal was constructed in a rural environment under good conditions ten years ago (life span 9 – 13 years, table 1). The seal will last longer than the suggested life, but needs 6.7 mm aggregate to provide a better appearance and protection to the 13.2 mm aggregate.

The slurry seal was constructed in a rural environment under good conditions ten years ago (life span 7 – 9 years, table 1). The seal performed well and is due for rejuvenation, the edges and potholes need to be repaired.

The slurry seal that was constructed seven and a half years ago in an urban environment under good conditions (life span 7 – 9 years, table 1) performed well, but needs a rejuvenation to prevent the seal from becoming brittle.

The three slurry seals that were constructed five years ago in an urban environment under good conditions (life span 7 – 9 years, table 1) vary in performance. The seal that was constructed on the gravel with slag ETB shows the best results, followed by the Sasol ash rollcrete base and than the neat Sasol ash ETB. The seal constructed on the Sasol ash rollcrete needs crack sealing to prevent the ingress of water, while the seal constructed on the neat Sasol ash ETB needs pothole repairs. The slurry seal will outperform its suggested lifespan if minor maintenance is carried out, namely edge break and pothole repairs and crack sealing on cement stabilized bases.

The Cape seal was constructed in a rural environment under good conditions ten years ago (life span 9 – 13 years, table 1). The two potholes need to be repaired, but the surfacing will last longer than its suggested life.

The Cape seal that was constructed seven and a half years ago in an urban environment under good conditions (life span 8 – 11 years, table 1) performed well except in an area where the base failed, there are some patches and stone loss (less than 5%) on the surfacing.

The two Cape seals that were constructed four years ago in a rural environment under good conditions (life span 9 – 13 years, table 1) are performing well. There are no potholes to date and small areas where the loss of surfacing occurs, which can easily be repaired by minor maintenance. The performance of the two seals needs to be monitored.

5. CONCLUSIONS

The single seal may be used, but it has to be monitored and maintained.

The double seal is a strong seal, but it is difficult to construct. It needs a well trained team to produce a seal of an acceptable standard.

The ten millimeter (wet) slurry seal is good for residential areas for children to play because of its medium grading aggregate, but the surface may be damaged by residents walking and driving over the wet slurry before the emulsion has broken, leaving the seal with unsightly marks. This can be eliminated by patching up the seal prior to rolling.

The Cape seal is a very strong and durable seal and very labour friendly which requires minimal maintenance, making it the ideal labour based surfacing type.

6. REFERENCES

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