COST EFFECTIVE METHOD FOR WIDENING OF BITUMINOUS SURFACINGS USING A COARSE GRADED SLURRY

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ABSTRACT

Damage to the road edge of a bituminous surfacing becomes a major maintenance problem especially if the seal width is narrow, thus forcing heavy vehicles when passing oncoming traffic to travel partially on the shoulders. Traditional widening of the pavement with the placement of narrow but deep pavement layers is difficult and costly to construct with the added difficulty of achieving adequate compaction using small plant. This invariably results in a post compaction edge drop, itself a safety problem, and leads to premature failure of the widening and adjacent insitu pavement.

The Namibian Road Authority was faced with this problem on many of their routes in the less populated areas. After investigation, their road maintenance company and slurry applicator developed a cost effective solution to widen the existing bituminous seal by using a coarse graded emulsion based slurry mixture which was applied by a continuous mixing slurry machine with a special spreader box.

This paper reports on the various aspects of the edge widening process which has been conducted on a 175 km section of Namibia's Trunk Road 1 between Rehoboth and Mariental. The subsequent methodology of the construction process and the cost effectiveness of this remedial action is evaluated and reported on.

1. BACKGROUND

The road between Rehoboth and Mariental forms part of Trunk Route 1. This is the main North South arterial route which carries road freight traffic between Windhoek and its southerly neighbouring country South Africa. The average daily traffic is 700 vehicles per day with a high heavy vehicle percentage of 20. The original surfacing was constructed between 1959 and 1967 to a width of 6.2 m. The 6.2 m width resulted in an unsafe road with high maintenance costs regarding edge break repairs as the large trucks often drive partially on the gravel shoulders to avoid oncoming traffic. This also caused a confined feeling when travelling at 120 km with heavy vehicles tending to straddle the centre line of the road. Given the level of traffic the recommended level of service required a minimum lane width of at least 3.4m. This meant that the road required widening of 300 mm on both sides.

The traditional method of repairing the damaged edge was done by cutting the broken surface and excavating the shoulder gravel to allow the placement of a new layer of gravel which was surfaced with coldmix asphalt.

Besides being very expensive and time consuming this method suffers from the following drawbacks:

- Uses large quantities of gravel which is a scare resource and which required to be hauled long distances
- Difficult to construct and achieve proper compaction of the narrow strip with small plant
- Failure and/or post compaction at the joint of the of the newly placed material and existing surface
- Lengthy construction periods resulting in longer traffic delays

Given the above deficiencies a more cost effective and efficient method was sought after which would render a fit for purpose remedial treatment within the limited budget constraints of the Namibian Road Authority.

2. INVESTIGATION

This prompted the Namibian Road Authority in 1998 to approach the Road Contracting Company, which was responsible for conducting routine maintenance, to investigate a non-traditional solution to widen the surfacing. The desired outcomes of their investigation should render a low cost treatment which must be able to perform under the traffic loading of the outer wheel of heavy vehicles and render improved road safety. The construction method should result in reduced gravel usage and lower maintenance costs.

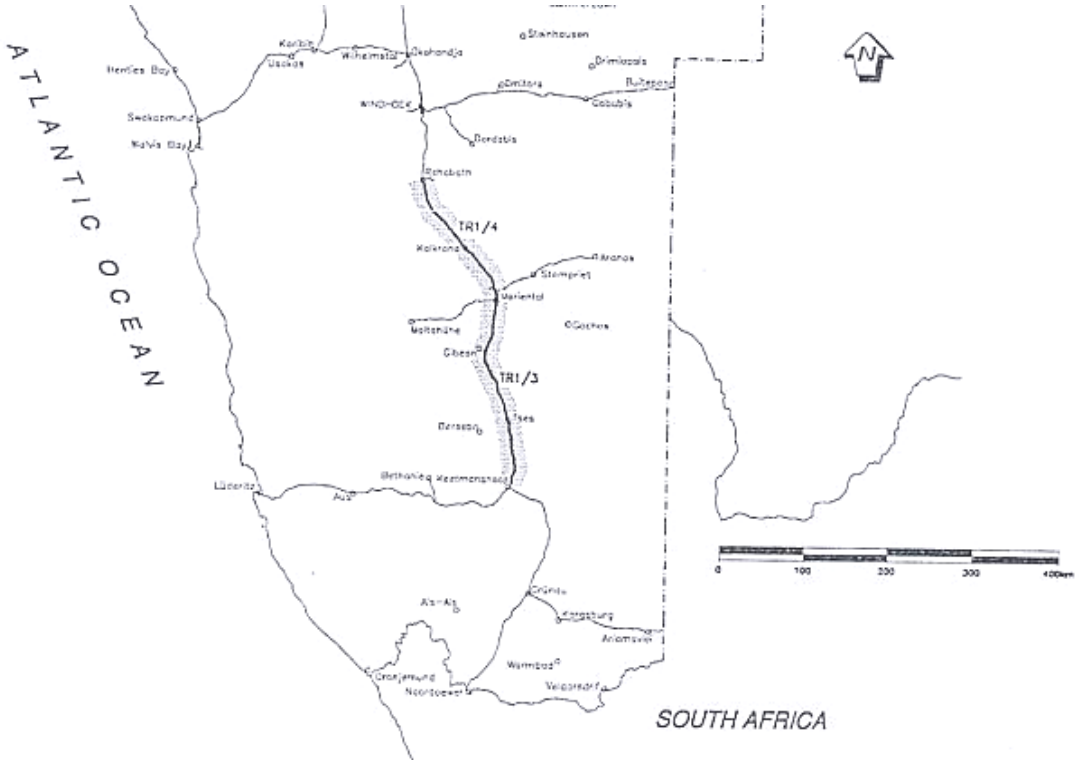

Figure 1. Locality sketch.

The Road Authority later also appointed a consulting firm in October 2000 to review the current maintenance strategy and further investigate a strategy to rehabilitate the Trunk Road 1 to incorporate the section from Keetmanshoop to Mariental. Some of the findings of the Consultants are incorporated in the paper below. However the main focus of this paper is to report on the development and implementation of the edge widening of the existing bituminous seal by using a coarse graded emulsion based slurry mixture.

The strategy recommended by the consultants to improve the level of service was to continue with the simplified road widening and reseal with a slurry without reconstructing the shoulders. The latter operation was to be incorporated into the periodic maintenance programme of which the lengths of the yearly sections to be widened were dictated by the annual budget.

The terrain between Mariental and Rehoboth is relatively flat. A locality map showing where the edge widening was carried out is shown in figure 1.

2.1 Accident Statistics

Accident statistics obtained by the Consultants for a five-year period between 1996 to 2000 for the road between Mariental and Rehoboth are shown in Table 1.

Table 1. Accident statistics.

Category	Average per Annum	% of total
Damage only	41	62.2
Slight injuries	12	18.4
Serious injuries	7	10.9
Fatal	6	8.5
Total	**66**	**100.0**

From these accident statistics, the Consultant calculated the average accident rate per million vehicle kilometers as 1.55. The rate was considered higher than the generally accepted rate of 0.99. The relative high rate could be attributed amongst other factors to the below standard carriageway width. Most of the accidents were single-vehicle accidents caused by loss of control and overtaking maneuvers.

2.2 Pavement Condition

The edge breaks manifested in the breaking away of the surfacing at the edge of the carriageway and were pronounced all along the entire route. The unpaved shoulders exhibited extensive wear due to traffic which resulted in a step between the edge of the surfacing and the shoulder. From visual inspections it was determined that the shoulder gravel was more or less a G4 quality material. Although no tests were done it was felt that the insitu material had sufficient bearing strength to continue carrying the heavy vehicle loads probably as a result of increased compaction by traffic over the years.

Falling Weight Deflectometer tests were conducted during 1998 by the Roads Authority and the average remaining life of the pavement was estimated at 14.1 years. This meant from an economic perspective that an appropriate holding action was needed to postpone heavy rehabilitation for at least 10 years.

3. CONSTRUCTION METHODOLOGY

An inspection of the damaged edges revealed that the existing gravel surface was still intact. Any attempt to cut and level the existing surface with a grader resulted in larger rocks being dislodged and ultimately led to disturbing the density of the insitu material. Also, in order to minimise the use of gravel, by placing and compacting a leveling coarse of gravel resulted in a biscuit layer forming.

It was concluded that if the gravel shoulder could be protected from the effects of the traffic then the application of a coarse graded slurry placed with a continuous mixing machine could be a cost effective remedial treatment for widening the surfacing.

3.1 Preparation

The shoulder was prepared as follows prior to the application of the slurry:

- The shoulder was first treated with weed killer before the existing vegetation was later removed by hand.
- The existing shoulder was then swept by hand to remove any loose material. This material was reused in later re-shouldering.
- Inverted bitumen emulsion prime was then sprayed at an application rate of 0.9 litres per square metre on the swept shoulder and left open to cure.

Picture 1. Primed shoulder.

3.2 Slurry Mixture

The use of slurry seals for resealing existing bituminous surfaces is fairly common practice in Namibia. However slurry does have limitations in that it cannot be applied in a single layer with a thickness greater than 1.5 times the maximum aggregate size. For the COLTO coarse 9.5 mm graded slurry this limits the overlay thickness to 15 mm.

3.2.1 Aggregate grading

In order to place a thicker layer which could withstand the heavy traffic loading it was necessary to utilize a continuous graded aggregate with larger size stones. Thus a blend of 13.2 mm and 9,5 mm single sized stone aggregate and minus 6.7 mm crusher dust was used. Figure 1 shows a comparison between COLTO coarse 9.5 mm slurry and the grading used for the edge breaks.

Table 1. Aggregate grading.

Sieve size (mm)	Cumulative % passing sieve by mass	
	COLTO coarse slurry Type 2	Edge widening coarse slurry
13.2	100	96 – 100
9.5	85 – 100	70 –80
6.7	70 – 90	40 – 60
4.75	60 – 80	35 – 50
2.36	40 – 60	20 – 40
1.18	25 – 45	10 –25
0.600	15 – 30	5 – 15
0.300	10 – 20	3 – 11
0.150	6 – 15	1 - 8
0.075	4 - 10	0 – 5

3.2.2 Material components

220 litres of anionic stablemix 60 % emulsion was added per cubic metre of aggregate to manufacture the slurry. 1 % by mass of dry aggregate of Ordinary Portland Cement was used as a setting agent. A further 200 litres per m³ dry aggregate of water was added to achieve the desired workability of the mix. It was important that the mix had sufficient workability to flow into the crevices of the existing road edge but stiff enough to form a sharp outside edge after placement.

3.3 Application

A string line was erected on the shoulder to demarcate the outside edge. The coarse graded slurry was mixed in a continuous mixing machine and poured into a purposely-designed box for placing in a single pass. Initially the slurry was poured via a chute and spread by hand between the road edge and steel shuttering. Once confidence had been built up in the performance of the slurry mixture, a spreader box was used to place the slurry negating the need for using shuttering. The box was designed so that it was dragged from an arm behind the machine. The bulk of the box ran on the existing surface while the outside edge operated on a spring-loaded skid. A strike off plate would ensure that the freshly placed slurry would be leveled off with the existing road surface. The average depth that the slurry was placed was 35 mm with the maximum reaching 50 mm at times. The fresh slurry edge widening was rolled with a pneumatic tyred roller 3 hours after placement prior to opening to traffic.

Picture 2. Placing coarse graded slurry.

4. COSTING

The typical daily production rate achieved for mixing and laying the slurry for the edge widening was 60 m3. This equated to a unit cost rate of R14.43 per running metre or R1, 374.00/m3 for mixing and placing the slurry to a width of 300mm by 35 mm deep. This cost is however minimal when compared to the conventional method of boxing out and replacing with gravel and surfacing with asphalt which would have been in excess of R45 per running metre. The rate for the mix and lay of the coarse slurry includes all materials which was based on the unit costs shown in table 2.

Table 2. Raw material unit costs.

Item	Unit	Unit cost (N$ or R)
Supply Aggregates	m³	130.00
Delivery of aggregates	m³	210.00
Emulsion ex works	Litre	2.43
Delivery emulsion	Litre	0.35
Delivery of water	Litre	0.10
Cement	Kg	1.20

This rate excludes compaction of the slurry, labour for traffic control and sweeping the base. The cost of priming the shoulder was R1.18 per running metre. All the latter costs would need to be included in both methods of construction.

5. BENEFITS

The main benefits of widening the road surfacing using a coarse graded slurry placed with a continuous mixing machine can be summarised as follows:

- Provides a low cost alternative to conventional widening techniques
- Reduces the construction time considerably
- Minimises the disruption to traffic during construction
- Minimises the use of non-renewable materials
- Reduces the routine maintenance costs
- Improves the safety by providing a wider carriageway without a sharp drop off

Picture 3. Finished edge widening.

6. CONCLUSION

The slurry method of edge widening has considerable time, cost and material resource advantages over conventional methods. However this method is only appropriate to roads where suitable shoulder material is present. This was the case on the Trunk Route 1 between Mariental and Rehoboth were some 175 km of edge widening has been completed as part of a routine maintenance between 1998 and 2003.

This method of using a coarse graded emulsion slurry applied with a continuous mixing machine and placed with a special box has been used else where in Namibia as a cost effective remedial solution for repairing edge breaks and widening of existing bituminous surfaces. The most like failure to occur in slurry widening would be longitudinal rutting. It is unlikely that rutting would occur at the outside edge as it will not be continuously trafficked. However if rutting did occur an additional thin layer of slurry can be applied in the rut only or as part of a full width slurry overlay. Inadequate compaction of the coarse slurry can lead to longitudinal cracking between the old surface and the new edge widening but this can easily be repaired under the routine maintenance programme using a cold pour cracksealant. The earlier sections are still performing well after being subjected to traffic for 5 years without signs of failures.

The decision to use coarse graded slurry to widen the road edge rather than to box out the existing shoulder gravel and replace with new gravel and surface with hotmix asphalt was sought as the most cost effective option at the time in light of the limited funds available.

Lastly the development and implementation of this technique can also be seen as a good example of how a partnership can work between the Client, Contractor and Supplier to provide a cost effective remedial solution to overcome a severe road safety problem within the confines of a limited budget for road maintenance.

7. ACKNOWLEDGEMENTS

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