

LOW COST BITUMEN STANDARD ROADS IN KENYA

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ABSTRACT

The choice of road pavement construction materials depends largely on the type and the cost of natural materials locally available. Heavy traffic roads(class T1 and class T2) requires semi-rigid pavement such as dense bitumen macadam while flexible pavement for medium to low traffic (T3 T4 T5) requires fairly deformable materials such as natural gravel or graded crushed stones. Kenya has total road network to 160,886 km with 149,689 Km feeder roads being unpaved. These feeder roads are important for social economic growth and development in agricultural areas but are constructed to gravel/earth standards. Good quality roads construction materials are scarce, and expensive to acquire and to haul. Since the traffic is medium to light construction of these roads feeder construction on to the recommended specification would be unjustifiably expensive. This paper highlights the relax requirement for the construction of low cost bitumen standard for road expected to carry less than 500, 000 equivalent standard axles.

INTRODUCTION

The total road network in Kenya is estimated at 160,886 Kilometers, categorized into classified and unclassified. Classified network is 61,945km while the remaining unclassified. 11,197 km of the classified network is paved.

The road network is distributed as tabulated follows:

Road Network	Agency Responsible	Paved	Unpaved	Total
National Trunk (Class A, B and C)	KeNHA	6,783	6,904	13,687
Feeder Roads (Class D, E, SPRs and Unclassified Roads)	KeRRA	2,268	127,799	130,067
Urban Roads (Classified and Unclassified)	KURA	2,140	10,409	12,549
Roads under KWS	KWS	6	4,577	4,583
Total		11,197	149,689	160,886

A significant proportion of the feeder roads are un-surfaced and are relatively lightly trafficked (traffic between 100,000 and 500,000) equivalent standard axles. These feeder roads are important in that they promote socio economic growth and development of the rural regions and are a key component of development programmes targeted for improvement towards poverty reduction strategies.

Unfortunately, these roads are in poor condition due to limited financial allocation for their maintenance. Most of these roads are either gravel or earth roads and requires routine and periodic maintenance gravelling and re-shaping.

Good quality gravel for road construction and maintenance is increasingly becoming more and more difficult to find in most parts of the country. This is mainly due to increase in population and subsequent changes in land use. Land owners are unwilling to allow the extraction of gravel from their farms and where they do, they demand very high compensation. Haulage of good quality gravel contributes significantly towards high construction cost.

Rate of gravel loss on those roads is so great that a re-gravelling operation is required after 1 to 2years after gravelling.

Conventional construction cost for bitumen roads is, on the average, US \$ 600,000 per kilometer while construction of a gravelling or opening of earth road is US \$ 60,000 per kilometer. This means that a lot of resources will be required if the length of unpaved road network is to be reduced considerably in the foreseeable future.

In order to reduce construction and maintenance cost on this feeder roads, they should be constructed to **low cost bitumen surface**.

LOW COST BITUMEN SURFACED ROADS

Objectives of Low Standard Bitumen Surfaced Roads

While the use of the conventional designs and construction procedures should be adhered to, it is more economical to develop and apply certain relaxations in the specifications in order to fit to low traffic volume roads.

The objectives of the low cost pavements and seals therefore are:

- i. To provide pavements for low volume traffic roads with increased service life by using the locally available materials and adopting relaxed rigid pavement standards
- ii. To reduce routine maintenance cost

Provisions of the current Road Design Manual part 111 on Low Cost Pavements

(1) Natural materials:

(a) Subbase

- An absolute minimum thickness of 100mm.
- Maximum particle Size: 60mm
- Passing 2mm Sieve: Maximum 95%
- Passing 0.075mm sieve: Maximum 40%
- CBR (4 days soak): Minimum 25
- Plasticity Index: Maximum 25

(b) Base

Absolute minimum thickness of 125mm is recommended but 100mm can be accepted if the maximum size of available gravel material is 40mm. Proper drainage of the pavement is highly emphasized on adopting these standards.

Other Requirements

- Maximum Size: 10 to 40mm
- Passing 0.075mm sieve: Maximum 35%
- CBR (4 days soak): Minimum 50
- Plasticity Index: Maximum 20 in dry areas
Maximum 15 in wet areas

(2) Cement/Lime treated Materials Requirements

CBR of Laboratory mixed, at 95%MDD (Modified AASHTO), 7 days cure + 7 days soak:
Minimum 100%

(3) Low Cost Surfacing

i. Single Seal Surface Dressing

This is a single seal of bituminous binders and single layer of surface dressing chippings. It is recommended in dry areas only.

Materials requirements design and construction procedures for the conventional surface dressing applies, though the most appropriate chipping sizes are 10mm and 6mm depending on the hardness of the base.

ii. Sand Seal

This is an application of bituminous binder covered with sand or fine aggregates suitable for the arid and semi arid areas (Turkana and North Eastern) where sand is abundant and suitable stone for surface dressing is not available. Trials were done on Lokichar – Lodwar Road (A1).

The binders used for this surfacing are cationic emulsion K1-60, K1-70 and medium curing cut – backs MC 800, MC 3000 and pen grade 800/1400. The sand is of a specified grading and should have non plastic fines (passing 0.425mm).

iii. Gravel Seal (Otta Seal)

This is an application of bituminous binder covered with graded granular material. The cover aggregate consists of natural gravel or graded crushed stone or a mixture of both though natural gravel is by far the cheapest.

The gravel is of a specified grading and should be non plastic though plasticity indexes up to about 10 may be acceptable where it is not possible to get non plastic gravel. The most suitable binders are medium curing cut – backs MC 800, MC 3000 bitumen emulsion K1-60, K1-70 can also be used.

Depending on the traffic, single or double gravel seals will be required.

iv. Emulsion Slurry Seal

Emulsion slurry seal may be used wherever stone for chippings are scarce or chippings are of marginal quality. There are three types of emulsion slurry seals depending on the aggregate grading; Type I (0/2), Type II (0/6) and Type III (0/10).

Emulsion slurry seal:

- can be used as surfacing on new roads
- Type II and Type III as final seal on surface dressing (cape seal)
- Where siliceous sand is available and scarce defective chippings

Type II slurry seal, applied in two layers of equal thickness, is recommended for use as surfacing for new roads, directly on a primed base or as a final seal on surface dressing for water proofing the surface (Cape Seal).

v. Road Oiling and Mixed – in – Place Surface Treatment (ETB)

This is the application of slow curing cut – backs SC 70 or SC 250. The light oil penetrates into the base, conferring cohesion and preventing moisture absorption.

The same effect can be obtained by mixing in place the upper part of the road base with anionic emulsion A2 or A3 and medium curing cut backs MC 250 or MC 800.

RECENT RESEARCH PROGRAMS UNDERTAKEN

1. Ken 042: Low Cost Pavements

This was a road construction research trial aimed at developing specifications for low – volume roads in Kenya through optimization of the use of local materials of marginal quality for pavement layers thereby reducing the cost.

The program targeted areas devoid of high quality materials for pavement and surfacing around Nairobi (Kiambu), Nyanza (Kisii, Oyugis), Mombasa (Majengo, Kwale), Rift Valley (Narok) and North Eastern (Garissa). The research was done using phonelites, laterites, weathered siltstone, quartzite, coral stones, weathered lava limestone and bituminous binders.

The findings of the report recommended the following for low cost surfacing;

- Removal of fine aggregates (less than 6mm) for surfacing aggregates
- Laterites are not suitable aggregates for surface dressing.
- Use of quartzites, corals, calcretes, kunkar limestones, weathered lava and siltstones for surfacing.
- To enhance binder adhesion the aggregates should be cleaned
- For aggregates with poor bitumen affinity, anti stripping agents should be used.

KEN 042 research project

KEN 042 research report on Low Cost Pavements recommended separation of the low traffic Class T5 in the design manual into two categories based on AADT and ESA as follows

- (i) Very Light Traffic, 0 to 50 AADT (0 to 100,000 million cumulative ESA)
- (ii) Light Traffic, 50 to 100 AADT (100,000 million to 500,000 million cumulative ESA)

For base construction the following material properties were recommended;

Parameters	Very Light Traffic	Light Traffic	RDM III Recommendations
Maximum Size mm.	10 - 40	10 - 40	10 - 40
Fines 0.075mm %	<40	<35	<35
Plasticity Index Max.			
1. Dry areas	<25	<20	<20
2. Wet areas	<20	<15	<15
CBR (4 days soak) min			
1. Dry areas	25	35	50
2. Wet areas	35	50	50
LAA Max.	70	60	-
ACV Max.	45	40	-
Minimum thickness, mm	200	200	150

2. Low Cost Pavement and Surfacing Trials (Roads 2000)

The objectives of the trials are:-

- (i) to promote construction of low cost sealed pavement for low volume traffic instead of the conventional gravel wearing course .
- (ii) to determine the life of a low cost surfacing pavement structure on a modified subgrade formation against the life of a standard two layer pavement structure on a standard subgrade formation;
- (iii) to develop unit construction costs for labour intensive low cost pavements and surfacing;
- (iv) to provide practical training to regional and district implementing units on pavement construction and related bituminous works; and,
- (v) to develop specifications for low cost surfacing pavements based on labour intensive construction methods.

The trials are being carried out on the following roads Mackenzie – Kandara Road (D415) and Nyangera – Uhanya – Nyenye Beach Road (E1158). Construction details are given below:

A. Mackenzie – Kandara Road (D415)

Specifications

Construction of a sealed single layer pavement for Traffic class T5 (514,186 esa), based on 10 year design life and projected traffic growth rate at 5% ,on class S3 subgrade .

- (i) **Subgrade:** Processing and compaction of the top 200 mm of the native subgrade material below the formation level.
- (ii) **Pavement:** Construction of a single layer pavement to the following standards:

Pavement Material	Layer Thickness (mm)	Length (Km)
Natural Gravel	200	2.0
Cement Improved Gravel	100	1.0
Composite Bitumen Emulsion Treated Gravel	100	1.0
Consolid System Treated In situ Material	100	1.7
Hand Packed Stones	150	1.0

- (i) **Surfacing:** Construction of surfacing to the following standards:

Surfacing Type	Thickness (mm)	Length (Km)
Cold Asphalt Concrete	15	4.7
Geotextile Reinforced Cold Asphalt Concrete (0/6)	20	1.0
Cape Seal (14/20 mm Surface Dressing + 0/6mm Slurry	20	1.0

B. Nyangera – Uhanya – Nyenye Beach Road (E1158)**C. Construction details**

- i) **Subgrade:** Processing and compaction of the top 300 mm of the native subgrade material below the formation level and Construction of improved Subgrade by providing 300mm capping layer on black clay sections.
- ii) **Pavement and Surfacing :** Construction of pavement layers to the following standards:

Pavement Type	Pavement Layer	Details	Length of Section (Km)	
A	Surfacing	Penetration Seal(20mm)	2.0	
	Base	Lime stabilised (100mm)		
	Sub base	Neat Gravel (125mm)		
B	Surfacing	Penetration Seal(20mm)	2.0	
	Base	Composite emulsion treated		
		Base (neat gravel 67mm and ETB (33mm)		
	Sub base	Neat Gravel (125mm)		
C	Surfacing	Cold Asphalt (premix) (20mm)	0.9	
	Base	Lime stabilised (100mm)		
	Sub base	Neat Gravel (125mm)		
	C	Surfacing	Dressed stone pavement(100mm)	0.2
		Base	Neat Gravel (120mm)	
		Sub base		
D	Surfacing	Cold Asphalt (premix) (20mm)	1.6	
	Base	Composite emulsion treated		
		Base (neat gravel 67mm and ETB (33mm)		
	Sub base	Neat Gravel (125mm)		

3. Trials on alternative Stabilizing Agents

Several chemical soil stabilizers have been put on research and trials either as an alternative to the conventional stabilizers (Lime and Cement) and to explore on the possibility of using them with native/insitu non standard soils in road construction.

The stabilizers were supplied and subjected to testing and application procedures as advised by the promoters. Such stabilizers are: Permazyme, RBI (AnyWay Natural Soil Stabilizer).

Machakos – Kangundo Road (C99) Trial Section

The trials were done on 1.3 Km long section of Machakos - Kangundo Road (C99) at the end of the existing tarmac road, approximately 20 Km from Machakos Town.

The trials involved construction of 150mm thick base course and 150mm thick subbase using chemical soil stabilizers; Permazyme and RBI on insitu materials.

Subbase standard quality gravel was used in the Neat gravel section and cement improved gravel section was constructed for controls to monitor and compare the strength gains by using the two stabilizers. 25mm thick double surface dressing was applied as the surfacing for the whole section.

The section is divided as follows:

- Permazyme insitu treated Section: 400m
- Cement gravel treated Section: 400m
- RBI insitu treated Section: 120m
- Neat Gravel Section: 380m

The section is under monitoring.

Way forward

The Kenya's vision 2030 aspires that within the next 20 years, the country should have upgraded most of the feeder road network to bitumen standard. Achievement of this target therefore requires implementation of the recommendations of these research findings.

However further research is still required to determine the suitability of marginal materials for low cost pavements.

Construction cost needs to be quantified and compared to the conventional method of construction where the recommended specification are applied.



Plate 1: Mixing of Consolid system by Rotovator



Plate 2: Application of Consolid C444 on sub base



Plate 3: Compaction of Consolid system stabilized section

Reference:

- (1) Road design manual 2nd edition 1987. Materials and pavement design for new roads.
- (2) Pavement design and construction specification developed for low-cost. Low-volume roads in Kenya. By JHG Wambura, Ms Odera and DR Ikundu.