(CONCRETE) BLOCK PAVING IN DEVELOPING COUNTRIES

A technical, economical and human alternative for road construction in developing countries.

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SUMMARY

Road construction in developing countries is often based on methods derived from those used in Europe, albeit that the methods are adapted to meet such local conditions as climate, local materials and traffic flow.

In developing countries, notably landlocked countries, the cost of energy has a relatively large influence on road construction costs as well as maintenance costs. It is thus desirable to consider the usual construction methods for pavement of rural and urban roads and to investigate whether or not more economical variants, adapted to local conditions, do exist. Technically satisfying construction methods, which in Europe have been abandoned because of prohibitive prices and/or for other reasons, may be suitable for developing countries. Pavement types to considered in this paper are:

- block pavements and
- surface treatments

A comparison of the respective construction costs will be made, including any capital investments required as well as a comparison of the maintenance costs. Maintenance aspects of the various pavement types will be reviewed. Last but not least the human and social aspects of the construction methods will be considered. As international donor agencies tend to emphasize the involvement to a large extent of local labour and to reduce the foreign currency requirements of infrastructural projects, it will be demonstrated that block pavement meets both requirements.

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1. INTRODUCTION

Road construction in developing countries is mostly realised by methods derived from those in use in the western world and more or less adapted to local conditions as climate, local materials, etc...

The high oil prices, implying high energy costs, have a considerable financial impact on the road construction industry in developing countries.
Countries mostly affected are landlocked countries and vast countries which have poor transport facilities and where certain regions are remote from import centers.

Thus it is important to reconsider the usual construction methods for pavement of urban and rural roads and to investigate whether or not more economical variants, adapted to conditions likely to be met in developing countries, do exist.

2. ALTERNATIVE CONSTRUCTION METHODS

2.1 GENERAL

Some technically satisfying construction methods have been abandoned in the western world because of prohibitive costs. This is above all due to the relatively high costs of manpower and as such labour-intensive methods have been replaced by equipment intensive methods which offer economically more competitive prices. It is not always evident to apply western techniques in countries with a different economical environment; hence possible alternatives for pavement of roads in developing countries to be considered are:

- block pavement
- surface treatment

Contrary to the developed countries full-depth asphaltic concrete constructions are nearly always too expensive for developing countries, as such they are not considered in this paper.

2.2 BLOCK PAVEMENT

Two types of blockpavements may be considered, i.e. with natural stones or with concrete blocks.

In as far as natural stones or cobble stones are concerned attention is to be paid to a proper choice of the quarry (either granite or quartzite), the grain of the rock, etc... A coarse grain is favoured for curbstones, pavement plates and gutters whereas a fine grain is to be reserved for pavement blocks. Opening a quarry requires little investment and also cutting of the rock does not require many tools (sledge hammers and chisels mainly).

Pavements made of concrete blocks may be considered as artificial rock pavements. The technology is prospering, notably in Europe and Australia. More and more, due to mechanized production and mechanized application techniques, artificially-made blocks are being chosen for pavement instead of cobblestones.

Concrete block pavements have profited from this industrial approach, especially for cost price reasons.

These concrete block pavements are characterised by their excellent wearing resistance, insensibility to hydro-carbonated products, ease of maintenance and above all for their residual value, permitting almost complete recycling.

Production of concrete blocks requires close quality control. The composition of concrete requires much attention in order to assure a homogeneous product; furthermore dimensional tolerances must be kept at a minimum.

It is however not necessary to use highly sophisticated production installations with all the inherent risks. Simple and sturdy installations, with well selected and appropriately trained personnel, can easily produce concrete blocks (and other concrete products) which fulfil the most strict standards.

2.3 SURFACE TREATMENT

The surface treatments (whether double or triple) are a common type of pavement in developing countries. On the other hand this type of pavement is almost not used for urban and trunk roads in Europe.

In Europe surface treatments are used as pavement on rural roads with a low traffic volume and with maintenance operations. For European the this type of treatment is cheap, because only a small portion of its cost price is composed of labour.

3. COST PRISE COMPARISON

3.1 GENERAL

In the cost price comparison three case studies are presented viz.: Burundi, Sudan and Guinee Bissau. These countries are regarded as being representative for developing countries. Burundi is a landlocked country, implying long international haulage (mainly by road) of all import/export commodities. Sudan, the largest country of the African continent, has its own import/export harbour, however transport distances to the western and southern regions are extremely long. Guinee Bissau is a West-african country with its own import/export facilities and relatively short internal distances.

As example the cost price of some basic materials and equipment for road construction and labour is given. The situation in Burundi is given for the sake of convenience only, similarly they apply grosso modo for other developing countries (prices are expressed in FBu; exchange rate late 1987: 118 FBU = 1 US $)

COMMODITY	EUROPE	BURUNDI	
Fuel			
petrol per liter	69	100	1.5x more
gasoil per liter	54	88	
Construction materials			
bitumen per ton	27,000	60,000	2 à 4x more
cement per ton	6,500	30,000	
Equipment (running cost/day)			
grader	30,000	90,000	2 à 3x more
10-tons tipper truck	20,000	45,000	
Labour cost (sal/day)			
unskilled	3,500	150	15 à 25x less
skilled	7,000	500	

3.2 CONSTRUCTION COSTS

The cost comparison is based on a typical road cross-section with a 7 m wide pavement the construction of the pavement is based on international design principles whereby for all construction types the cost calculation have been made with sub-base (CBR 25 %) and base-course (CBR 80 %) as follows:

Pavement construction:

Burundi	1. Double surface treatment 15 cm base-course 30 cm sub-base 2. Concrete or natural blocks 40 cm sand
Sudan	1. Double surface treatment 15 cm base-course 20 cm sub-base 2. Concrete blocks 40 cm sand/sub-base
Guinee Bissau	1. Double surface treatment (laterite base + sub-base) 2. Concrete blocks (laterite base + sub-base)

Based on the prices of basic materials a comparison of the unit cost per square meter pavement is given for the african and european situation. This comparison applies only to the pavement construction, that is the double surface treatment or block pavement incl. 40 cm of sand and base plus sub-base. The example given in figure 1 takes the production types valid for either developing or developed countries into consideration and does exclude costs such as local transport, taxes, finances , etc..

Figure 1 considers the following pavement types, vis.: double surface treatment, concrete block pavement and stone block pavement.

It is evident that the least expensive pavements for developing countries are those that make use of a maximum of manpower and avoid imports of relatively expensive products such as bitumen, oil and cement.

The case studies presented are based on the following assumptions:

A. BURUNDI

location of road	: Bujumbura
road section	: according to typical profile
availability of materials	:
1. rock	- quarry at distance of 20 km
2. concrete blocks	- factory at 5 km distance
3. laterite	- borrowpit at 5 km
4. sand	- deposit at a distance of 10 km

B. SUDAN

location of road	: El Obeid
road section	: according to typical profile
availability of materials	:
1. rock	- quarry at 15 km
2. concrete blocks	- factory at workyard
3. laterite	- borrowpit at 60 km
4. sand	- deposits at varying intervals on average 35 km

C. GUINEE BISSAU

location of road	: Bissau
road section	: according to typical profile
availability of materials	:
1. rock	- quarry at 100 km
2. concrete blocks	- factory at workyard
3. laterite	- borrowpit at 10 km
4. sand	- deposit on island just off the coast

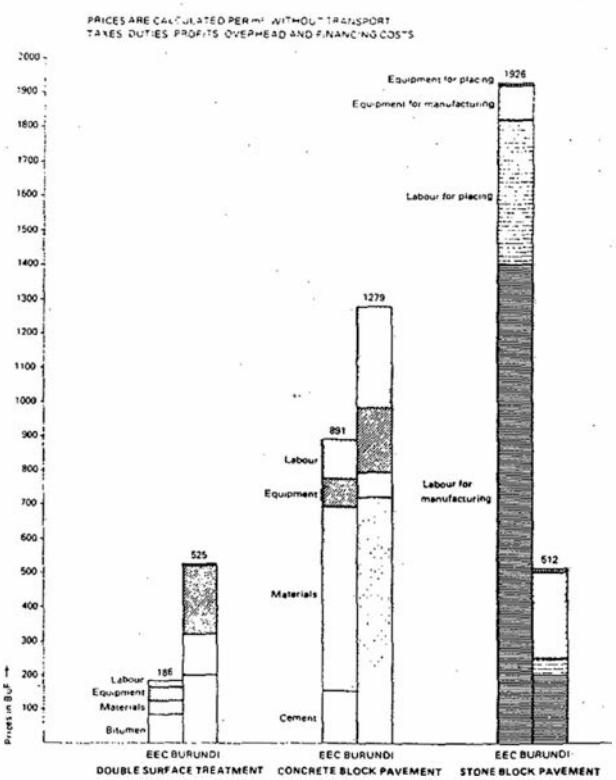


Figure 1 - Cost comparison of different pavements

Construction costs, established per km of pavement, are based upon price levels valid at the time of the respective case-study and comprise materials, equipment, labour, transport, etc.. Financing costs as well as taxes are not included. The construction cost per kilometer of road (width 6 m) for the pavements considered amount to (US $ * 1,000):

	PAVEMENT TYPE		
COUNTRY	DOUBLE SURFACE TREATMENT	CONCRETE BLOCKS	STONE BLOCKS
Burundi	81,400	84,000	64,700
Sudan	143,800	248,000	--
Guinee Bissau	66,000	119,300	--

3.3 MAINTENANCE COSTS

The economical life for a road in developing countries is set at 15 years. To prolong the economical life is not warranted since forecasts of traffic intensities beyond a horizon of 15 years become too inaccurate.

Furthermore a distinction has been made between preventive or recurrent and curetive or periodic maintenance. Preventive maintenance is normal recurrent maintenance to ensure an acceptable level of user servicability of the road and to ensure that the lifetime will be reached. Its frequency depends on the traffic volumes of the road under consideration and climatological and geographical conditions. It is considered normal practice that a double surface treatment type of pavement should receive a single surface dressing every 5 to 6 years and that after 15 years, depending on traffic intensities and road condition, a reconstruction with a hot-mix asphaltic concrete (thickness between 5 and 8 cm) is required. For a pavement made up of block elements it is considered necessary that, apart from normal recurrent maintenance, the road requires repaving every 15-20 years, whereby about 10 % of the area to be repaved is to receive new blocks.

Budgettary constraints are normally the reason that preventive maintenance is neglected and often postponed to beyond reasonable time limits. This custom leads to an increased demand for periodic or curative maintenance. even if preventive or recurrent maintenance is carried out repairs are always required. This is due to the fact that certain damages are caused by deficiencies of the sub-grade, sub-base or base-course (subsidences, deformations, insufficient surface drainage, etc...).

The table hereinafter gives per kilometer, an indication of the annual costs of preventive and curative maintenance of the carriageway for the various types of pavement (amounts in US $):

Year (after opening to traffic)	Double Surface Surface Treatment	Block Pavement
1	2,100	1,800
2	2,100	1,800
3	2,100	1,800
4	2,100	1,800
5	2,100	2,700
6	14,100	1,800
7	2,100	1,800
8	2,100	1,800
9	2,100	1,800
10	2,100	2,700
11	14,100	1,800
12	2,100	1,800
13	2,100	1,800
14	2,100	1,800
15	110,000	4,500

The Nett Present Value (for the discount rates given) of above maintenance costs at year 0 amount to resp.:

4 %	100,540	22,860
12 %	43,758	13,553
8 %	64,698	17,288

It is evident that, when repairs to sub-grade, sub-base or base course are required heavy equipment is needed, increasing the maintenance cost per kilometer. However, for the pavement types considered these costs will be on par and as such play no role in the comparison. Superficial repairs to surface treatments (filling potholes, localized surface dressing) are also relatively expensive because of the costs of materials, notably bitumen, required. Moreover, these repairs are difficult to execute properly with inexperienced labour and, often, equipment problems (s.a. clogged bitumen sprayers).

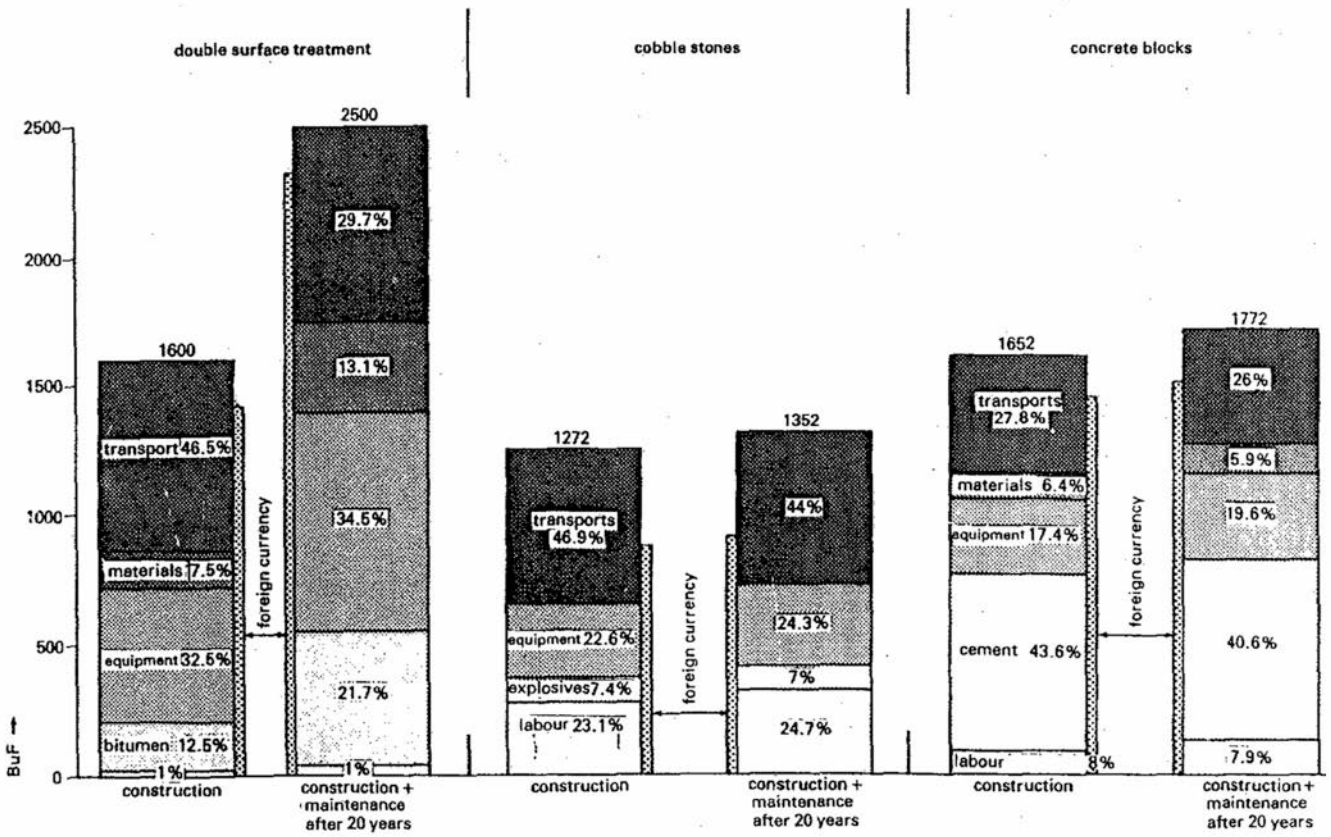
Superficial repairs to block pavements on the other hand may be executed quite easily, moreover upto about 90 % of blocks may be reused.

Using the amounts calculated in the previous chapters for construction and maintenance of a road during its economical life one arrives at the following figures (US $ * 1,000):

	BURUNDI		SUDAN		GUINEE BISSAU	
	DST	CONCRETE BLOCKS	DST	CONCRETE BLOCKS	DST	CONCRETE BLOCKS
Construction costs:	81,4	84,0	143,8	248,1	66,0	119,3
N.P.V. of maintenance costs						
at 12 %	43,8	13,6	43,8	13,6	43,8	13,6
total	125,2	97,6	197,6	261,7	109,8	132,9
at 8 %	64,7	17,3	64,7	17,3	64,7	17,3
total	146,1	101,3	208,5	265,4	130,7	136,6
at 4 %	100,5	22,9	100,5	22,9	100,5	22,9
total	181,9	106,9	244,3	271,0	166,5	142,2

The above table illustrates that the discount rate applied influences the total costs involved. As donor agencies tend to provide loans with favourable terms (such as an initial grace period and low interest rates) the decision with regard to the pavement to be applied depends to a large extent on the type of funding secured for a given project.

The result for the Burundi case is reflected in figure 2, pavement unit cost per m^2; first construction and after 20 years.



The histograms clearly demonstrate, when comparing double surface treatments with con crete block pavements, that the foreign cur rency requirement for block pavements during the economical life is only about 60 % of the foreign currency required for surface treat ments, whereas the labour involvement with concrete block pavements is about 8 times the labour involvement with surface treatments.

Above calculations have been carried out without using shadow prices for those materi als and/or equipment etc. for which the ex penditures are to be incurred in for develop ing countries foreign currency. Shadow prices reflect in fact the scarcity of hard currency and/or certain commodities. Using shadow prices in above calculations would emphasize the economical advantage of concrete block pavements.

4. HUMAN AND SOCIAL ASPECTS OF BLOCK PAVEMENTS

The local labour components involved with the construction of the various types of pavements are estimated to be as follows:

- double surface treatment	1.2 à 2.0 %
- concrete block pavement	6.5 à 9.0 %
- cobblestone pavement	approx. 23,0 %

In developing countries it is important to involve as much labour as possible in con struction projects and subsequent maintenance operations. Stone cutting is a specialism, an art certainly which can not be embarked upon prior to preliminary training. Having acquired the capability many persons are able to find a suitable and meaningful job in road con struction and maintenance. Albeit to a lesser extent, the above is equally true for concrete block paving where both the manufacturing of concrete blocks and the construction of roads provide jobs for locals.

An equally important human aspect is that the problems of constructing and maintaining roads with labour-intensive methods, requiring large numbers of local workers and relatively small investments can be handled by the local industry, without having to appeal to foreign contractors. This is undoubtedly beneficial for local organisations and contractors.

5. CONCLUSIONS

This paper, although being typical for three specific situations on the African continent, aimes at providing a realistic picture of the various solutions for the problems of constructing roads in developing countries, taking into account the technical, economical and human aspects.

The paper compares (concrete) block pavements as an alternative solution for double surface treatments. It is noted that in the "Manual for dimensioning roads in tropical countries" (1980 edition) of the CEBTP only pavements with triple surface treatments are distinguished. This implies that with an initial application of a double surface treatment a third surface dressing is required shortly after the road has been opened to traffic.

A simple transposition of European decision procedures is not desirable; each developing country has its own characteristics. It is evident that the proximity of either a refinery or a cement industry will influence the decision with regard to the pavement type to be applied.

Each project requires a technical as well as an economical approach, whereas in addition sufficient weight is to be attributed to the social or human aspects. Hence it is necessary to take many factors into consideration when facing the selection of the type of pavement; technical factors certainly but also economic and human factors are to be weighed in the decision process.
Such choices are primarely the concern of the local authorities, who are to analyse the different aspects and take decisions with full knowledge of all facts.