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The Challenges of Road Construction in Zambia's Western Province: A Case Study of the Mongu – Kalabo Road Project

Joseph M. Goma
Road Development Agency (RDA), Zambia

Abstract: Availability of good quality local construction materials is a major component of road construction as it contributes greatly to the cost of construction. Reserves of good quality construction material may be readily available in some parts of Zambia while in some parts like the Western Province, sources of suitable construction materials are scarce. The lack of suitable construction materials in Western Province has affected the construction, rehabilitation and maintenance of roads in this area as materials have to be hauled from distant sources to site. Plans to construct an all-weather road to ease the transport challenges and ensure development for the people of Western Province started as far back as 1966 but were first affected in 2002 when the first attempt to construct an all-weather paved road embankment across the flood plain was made. This paper discusses some of the challenges faced in road construction projects in Zambia's Western Province, specifically focussing on the Mongu – Kalabo road construction project as a case study. The various challenges faced on this project include financing (high construction cost), challenging terrain (deep Kalahari sands and seasonal flooding) and lack of suitable road construction materials are discussed. The Government of the republic of Zambia has prioritised infrastructure development and has thus embarked on the construction of the 34 km of the Mongu-Kalabo Road Embankment which will include twenty-five bridges across the Barotse Flood Plain at a cost of US$ 286 million. The potential benefits of constructing the Mongu-Kalabo road to the people of Western Province and the country at large, which include opening up trade with neighbouring Angola, are also discussed.

Key words: Mongu-Kalabo, Barotse Flood Plain, Kalahari Sands, Western Province, Embankment.

1. Introduction

Construction of roads in various parts of Zambia is met with a number of challenges which include difficult terrains like escarpments, lack of construction materials and flooding in some areas. The Western Province of Zambia, is one such area where suitable road construction materials which meet the applicable Standard Specifications for Roads and Bridges are scarce. A larger part of the province is covered by single grain sized non cohesive Kalahari sand. Apart from scarcity of suitable road construction materials, the province experiences seasonal flooding. This entails that roads crossing the flood plains have to be constructed on an embankments.

The Western Province is among the least developed regions in Zambia with high poverty levels, estimated at 83% in 2004 [1]. One of the main contributing factors to the low development and high poverty prevalence in the province is the isolation caused by poor or lack of all-weather access roads.

The engineering properties of the sands available in most parts of the province do not usually meet the standard specifications for road works. It is common practice to haul suitable materials from sources which are far from project sites which makes construction projects more expensive and challenging as compared to other parts of the country. The province is also characterized by seasonal floods and extensive sandy soils which range from more than 50m deep in the northern part of the province to less than 12m in the

Corresponding author: Joseph M. Goma.

Southern part towards the Southern Province [2]. The extent of the area covered by Kalahari Sands in the Western part of Zambia is shown in Fig. 1.

2. The Mongu Kalabo Road Project

The Mongu-Kalabo Road which connects Mongu town to Kalabo via Tapo passes through the Barotse flood plain where it crosses the Zambezi River. In the dry season when flood waters have receded, vehicles, mainly four-wheel drive, are able to move in the sandy flood plain and the Zambezi river is crossed via a pontoon. Fig. 2 and 3 show a typical seasonal earth road crossing the flood plain and a pontoon used to cross the Zambezi River respectively. However, the 35 km wide flood plain gets flooded when the Zambezi bursts its banks every year from around December to around June. This not only makes transport and communication between communities across the Zambezi river difficult for the transportation of goods and services but also entails that works can only be undertaken for five (5) months in a year [3]. Canoes and boats are the major form of transport during the wet season. Access to essential commodities and services which mainly come from Livingstone, Katima Mulilo and Lusaka becomes a challenge.

Plans to construct an all-weather road to ease the transport challenges for the people of Western Province and speed up development started as far back as 1966 and were first affected in 2002 when the first attempt to construct an all-weather paved road embankment across the plain was made. A number of studies were undertaken prior to the construction of the road embankment to establish the feasibility of the project and determine the most cost-effective solution.

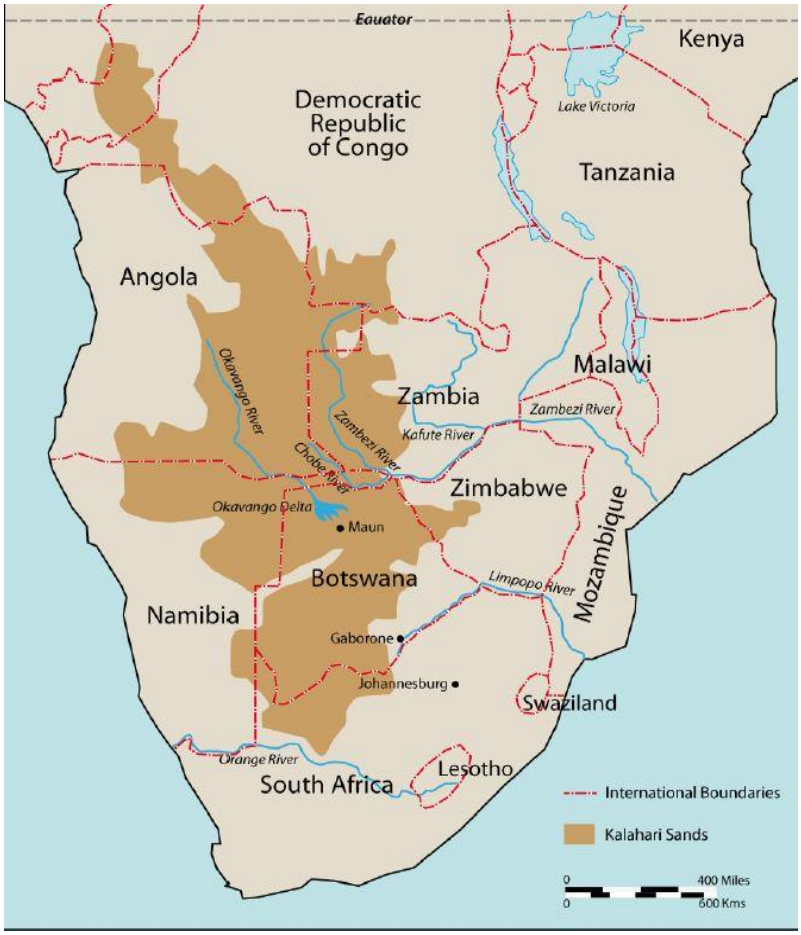

Fig. 1 Extent of Kalahari Sands [4].

Fig. 2 Typical seasonal earth road used to cross the flood plain in the dry season.

Fig. 3 Pontoon used to cross the Zambezi River.

A feasibility study undertaken by a German consulting firm, DIWI, proposed three options for the Mongu – Kalabo road which were: (i) to construct a tunnel under the flood plain, (ii) to construct a bridge over the flood plain, and (iii) to use an intermittent design of constructing an embankment and several box culverts and round culverts as relief culverts [5]. The study concluded that the project was feasible and recommended a minimum hydraulic capacity of 1,500 m^2 bridge area though the design provided by the consultant had a hydraulic capacity of 700m^2 bridge area due to limited availability of funds.

The major challenges the Mongu – Kalabo Road project faced include lack of suitable road construction materials, seasonal flooding in the plains which only allows about five months construction time in a year and financing as the project required substantial funds to be completed.

3. Importance of the Project

The majority of the population in Western Province depend on a mixed livelihood approach where they combine fishing, crop farming, livestock farming and exploitation of natural resources like timber [6]. The construction of the Mongu-Kalabo road is expected to lead to more investments in the province, increase farming activities as access to the markets will be easier and faster, increased trade in various merchandise and increased access to social amenities. Once completed the project is expected to open up the province to the rest of the country and to link Zambia to neighbouring Angola. This will ease transport challenges, movement of goods within the province will be faster and access to markets will improve which will lead to economic growth.

Most of the existing roads in Zambia's western regions are of unpaved earth and track, which become impassable during the rainy season. Travelling from Mongu to Kalabo is particularly problematic since the only choices available entail either crossing the flood plain or taking a more circuitous 360-km route. This limited access has left many areas, particularly the small town of Kalabo, cut off from a number of potential benefits. Worst hit is the agriculture sector, which has suffered large revenue losses due to the region's inability to receive farming inputs and evacuate produce. The province's education and health sectors are also adversely affected by the lack of integration.

OFID reports that the road will run between the towns of Mongu and Kalabo through Tapo and will have a significant impact on the social and economic integration of the region.

4. Type of Materials

According to the report by DANIDA [7] there were five types of sands encountered in the area covered in the feasibility studies. These were described in terms of

colour and plasticity or general grading. The first type was the grey sand which was described as single grain sized, free draining with no fines and very difficult to traverse with vehicles even when wet. The grey sand was also extremely difficult to compact and not suitable as a construction material. The second type was the yellowish sand without clay content which was said to have some fines and relatively easier to traverse. The yellowish sand was useable as a fill material. The third type was the yellow sand with some clay content which was said to be suitable as fill and in road pavement layers when stabilised. The fourth type was reddish brown sands with slight clay content and appeared to have a relatively better grading. This sand was also said to be useable as a fill material and for pavement layers when stabilised. The fifth type was Red clayey sand which was said to be a far better construction material and did not appear to be collapsible as the other sands. However, this type of sand was said to be rare in the province. The general properties of the usable sands in the region estimated the angle of internal friction (φ) to be 32˚, unit weight (γ) of 17kN/m^3 and Young's Modulus (E) to range from 10 MPa to 20MPa. The feasibility study conducted by DANIDA did not involve detailed geotechnical investigations to characterise the described sands and the properties used were based on local reports or regional experiences. Fig. 4 shows the range of grading envelopes for the Kalahari sands. A detailed study was undertaken by the Botswana Roads Department to characterise the Kalahari sands covered by area shown in Fig. 1 and a summary of the physical properties of the various sands sampled is given in table 1. To fully characterise the relative physical and chemical properties of the available sands in Western Province, a detailed study similar to the Botswana study would be required.

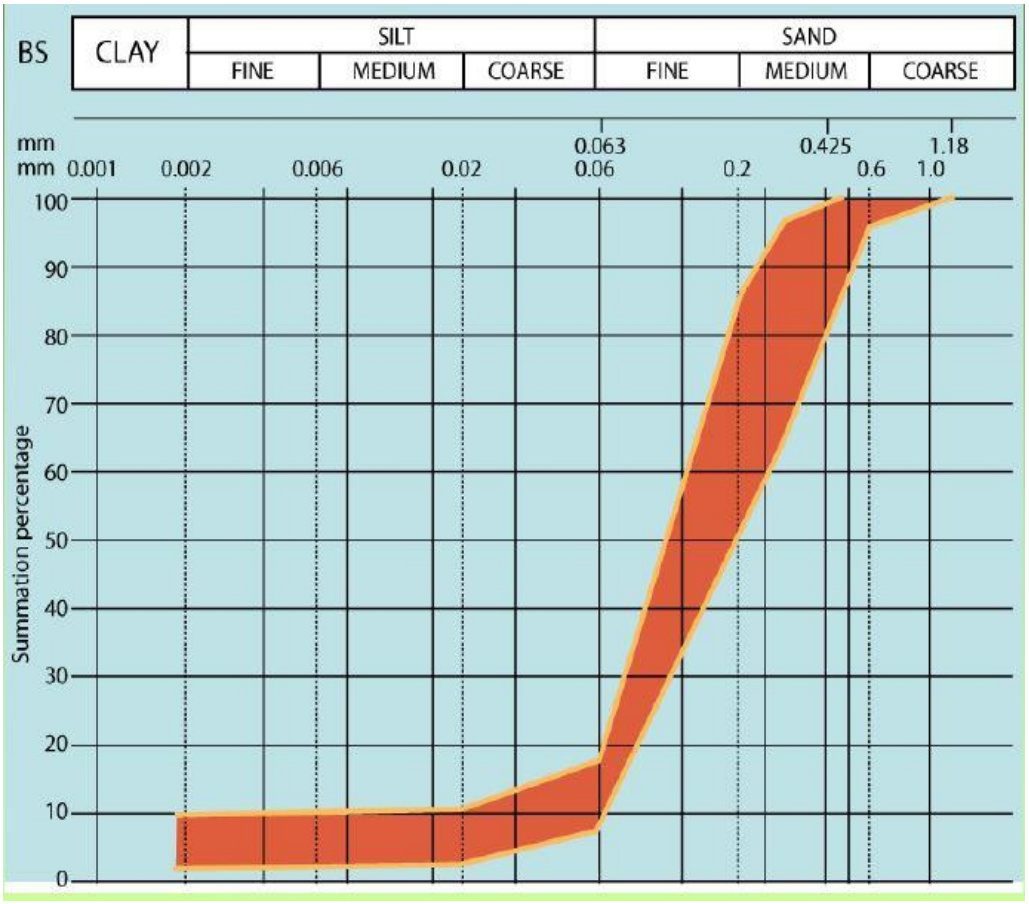

Fig. 4 Grading envelope for a range of Kalahari sands.

Table 1 Relative properties and compactibility of the Kalahari sands.

Colour Type	Sand (%)			Sand Total (%)	Silt Total (%)	Clay Total (%)	Atterberg Limits & Linear Shrinkage (P075)			
	Coarse	Medium	Fine				LL	PL	PI	LS
Dark Brown	3.74	44.33	42.34	90.41	3.99	5.60	56.4	35.7	20.7	17
Reddish Brown	2.35	33.73	52.40	88.48	4.01	7.51	65.4	37.9	27.5	18
Yellow	1.98	33.96	57.01	92.95	3.04	4.01	47.7	28.8	18.9	11
White	0	14.38	77.49	91.87	6.83	1.30	27.1	19.5	7.6	5
Brown	0.71	17.64	70.32	88.67	7.37	3.96	41.4	24.4	17.0	11
Orange-Brown	0.50	16.03	66.58	83.11	8.53	8.36	50.2	32.2	18.0	13
Fineness Index		Compactability Rating								
0 – 200		Good in layers up to 1m								
200 – 400		Poor in depth but fair in 150mm to 200mm layers with mixing								
>400		Progressively poor, rapidly becoming unworkable								

5. Flooding

The Barotse flood plain is one of Zambezi river's largest wetland complexes found in the Western Province. Timberlake stated that the extent of the Barotse flood plain is not easy to estimate, however, the flood plain covers an area of approximately 550,000 hectares. The wet season starts around November/December with maximum flood levels usually attained in April during which the Kuomboka Ceremony, a local traditional ceremony, takes place. During the peak of flooding the entire 35 km wide plain is flooded and the floodwaters start receding around May up to July which leaves a short period for construction work.

6. Financing

The costs of road construction projects in the Western Province are relatively high as compared to other parts of the country mainly due to the challenging terrain and scarcity of suitable construction material. The Mongu – Kalabo project is the most expensive road construction project per kilometre cost that the country has ever embarked on. However, it is important that this cost is put into perspective considering that the 34 km stretch involves construction of about 26 bridges. Initially, the Government of the Republic of Zambia engaged a Kuweit based construction company in 2002, Messrs Consolidated Construction Company (CCC), to construct the approximately 74 km Mongu – Kalabo Road at a contract sum of about US$ 37 million with financial assistance from Kuweit Fund, BADEA and OPEC Fund for International Development. In the 2003/2004 rain season the road embankment constructed by CCC based on an intermittent design of constructing several box culverts and round culverts as relief culverts and the embankment was washed away due to the seasonal floods. Figs. 5 and 6 show part of the embankment constructed by CCC and one of the sections that was washed away in the 2003/2004 rain season respectively. Following the premature failure of the embankment, the contract for CCC was terminated and the project was resuscitated in 2010 with a Chinese contractor, AVIC International [8], at a contract sum of US$ 286 million. The funding for the current project was financed through a loan from Exim Bank of the Republic of China [9]. The current Mongu-Kalabo road construction project alone is more than the Road Development Agency's 2010 total expenditure on the road sector, which was about US$ 286 (Raballand & Whitworth, 2012). According to Raballand and Whitworth (2012), the 34 km long Mongu – Kalabo project is considered one of the most expensive rural roads per kilometer in the world. While this analysis is generally true, it ignores or fails to clarify the fact that comparison of this project with any other which does

Fig. 5 Part of the embankment constructed in 2002 by CCC.

Fig. 6 Part of the section washed away in 2003/2004 rain season showing exposed box culverts.

not share similar site conditions and complexity is comparing mangoes with apples. The construction of about 26 bridges on this project adds significant cost to the project and in making any cost comparison, this factor has to be taken into account. The cost of earthworks and bridge structures is about 24% and 33% of the total project cost respectively.

7. Current Design

As compared to the previous design which cost about US$ 37 million for 74km of the Mongu-Tapo-Kalabo road, 35km of which was crossing the flood plain, the current design for 34 km (Mongu-Tapo) across the flood plain will cost US$ 286 million. The design and build approach was used in the current Mongu - Kalabo road project where the designs are prepared by the Contractor AVIC International and reviewed or approved by the Supervising Consultant, Rankin Engineering, before implementing the design. The cost of the project includes field investigations, design and construction. The current road embankment across the Barotse Flood Plain will have twenty-six bridges instead of the culverts which were used in the previous failed embankment. Figs. 7 and 8 show the embankment and one of the 26 bridges, respectively, under construction by AVIC international. The 26 bridges comprise of 21 concrete hollow slab bridges, 4 steel girder (composite) bridges and one 1022m span bridge which will a combination of the two types of bridges. The geotechnical investigations report for the project revealed that no liquefaction was determined in the saturated sand layer up to a depth of 20m from the topsoil hence liquefaction was not considered for the embankment, small and medium bridges. The total length of the 26 bridges in the current design will be 3896m, 10.5m wide and the main bridge to be located across the Zambezi River is 1022m long. The main material used for the embankment fill is yellow sand which has some plasticity. The embankment slopes will be protected by planting vegetation and using stone mortar-laid stone.

Fig. 7 Construction of embankment under the current design [10].

Fig. 8 One of the 26 bridges crossing the flood plain under construction (2014).

8. Conclusion

Some of the challenges faced in road construction projects in Zambia, particularly in the Western Province, have been discussed. The Mongu-Kalabo road project is one of the most expensive projects that the Government of Zambia has ever constructed [11]. The major challenge which has made the project to be considered very expensive is the challenge of sourcing suitable construction materials and the flood plain the road passes through. Economic analysis shows that it is not justifiable to construct such an expensive road in a rural area, however, the need to improve people's lives in Western Province and the Zambian Government's policy to develop rural areas through infrastructure development such as roads justified the decision to construct the road. Literature has reviewed that the Mongu-Kalabo road will lead to greater economic benefits for the country.

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