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Planning and Designing Standard of Rural Road Construction in Lusaka Province: An Exploratory Study

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1 Introduction

It has been acknowledged that rural roads should be treated as the last link of the transport network. Despite this, they often form the most important link in terms of providing access for the rural population. Their permanent or seasonal absence acts as a crucial factor in terms of the access of rural communities to basic services such as education, primary health care, water supply, local markets and economic opportunities (Donnges 2003). In a study in Ethiopia (Dercon and Hoddinott 2005) on 15 villages that were

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surveyed between 1994 and 2004, they concluded that access to all-weather rural roads reduced poverty by 6.9% and increased consumption growth by 16.3%. Dercon and Hoddinott (2005) found that, in Ethiopia, an increase of 10 km in the distance from the rural village to the closest market town had a dramatic effect on the likelihood that the household purchased inputs. Mu and Van de Walle (2007) showed that markets in Vietnam were more likely to develop as a result of rural road improvements where communities had access to extended networks of transport infrastructure.

It was shown in Uganda that benefits from improving access to basic education depended on complementary investments in infrastructure (Deininger and Okidi 2003). Road improvements in Bangladesh led to lower input and lower transportation costs, higher production, higher wages and higher output prices (Khandker and Koolwal 2011). Access to rural roads in Nepal improved the productive capacity of poor households. Rural road rehabilitation in Georgia increased the opportunities for off-farm and female wage employment (Lokshin and Yemtsov 2005). Rehabilitation and maintenance of rural roads in Peru improved access and attendance to schools and child health centres (Escobal and Ponce 2003). According to the Rural Accessibility Index of 2010 and also Torero and Chowdhury (2004), majority of rural communities in Africa have inadequate and unreliable infrastructure services with only 34% of rural Africans living within 2 kilometres of an all-weather road compared to 59% in Latin America, 65% in East Asia and over 90% in other developed regions. The Africa Infrastructure Country Diagnostic of 2010 indicated that even where feeder roads exist, the rural environment presents particular institutional challenges for road maintenance. Only half of the existing rural road network is in good or fair condition, which is much lower than the 80% found for the interurban network.

Pinstrup-Anderson and Shimokawa (2010) and Fan (2011) indicated that the provision of rural infrastructure contributed to the delivery of goods and services that promoted prosperity and growth; the quality of life, including social well-being, health and safety; and the quality of the environment. It will help reduce the cost of inputs and transport to markets, also increase farmer's access to enlarged markets, facilitate trade flow and spur value addition and crowd in investment. Foster and Briceno-Garmendia (2010) stated that the variation in road quality throughout the various sub-Saharan African countries reflected several interacting factors. Firstly, the relation to affordability where the GDP per capita is most strongly correlated with the percentage of the main road network in good condition, signifying that richer countries tended to spend more on maintenance. No such clear relationship exists for rural roads. The second factor relates to topographic and climatic influences where mountainous and wet countries normally have poorer road conditions in both main and rural networks (Johannessen 2008). Thirdly, they observed that countries with road funds and road agencies have considerably better road conditions than those that have neither.

Addo-Abedi (2007) noted that a number of African countries had embarked on reforms in the last few decades supported by four "building blocks", namely, ownership, financing, responsibility and management. The main aim of the reforms was to manage roads as a business and bring them into the market place by charging for road use on a fee for service basis. The mean distance to services and community assets diminished significantly due to rehabilitation of rural roads in Zambia's eastern province (Kingombe 2011). The purpose of this study therefore was to review whether the planning of rural road construction in Lusaka province is adequate, as well as to determine whether the design standards and the technology used in Lusaka province are appropriate.

2 Research Methodology

Mixed-methods approach was adopted for this study, with both the qualitative and quantitative approaches. Qualitative data was collected through structured interviews with respondents from the National Council for Construction, Ministry of Finance, National Road Fund Agency, Ministry of Works and Supply, Rural Road Unit as well as Ministry of Local Government. The data collected was used to come up with an informed opinion that was correlated to measurements collected through tests.

Quantitatively, six rural roads were sampled including two from Chongwe, two from Lusaka West as well as two from Lusaka North; these were picked at random. Road dimension tests, road profile tests and physical check of the road features were conducted on the full length of these rural roads. The first test was the road dimension test using tapes to check the accuracy of the carriageway and the side drains. The second test was the road profile test using the line level where the camber of the carriageway and the longitudinal profile of the carriageway were checked, and the final test was the visual test that was checking for the presence of culverts, culvert rings, wing walls, head walls, ramps, outfalls, mitre drains, scour checks, lay-bys, ditch and the shoulder, and these were presented in the form of check lists. The following were the check lists used:

1. *Road Dimension Tests*

The standard cross section of rural roads in Zambia is one having a carriageway of 5.5 m, with a gravel coarse of 5 m span, side slope of 1.2 m, a ditch of 1 m and a back slope of minimum 3:1 and a maximum of 1:1. The type of tests carried out were simple checks on the dimensional accuracy of the construction works using measuring tapes.

To test for the camber of the carriageway and check on the longitudinal profile of the carriageway, the research used the line level. For the simple checks on the dimensional accuracy of the construction works, measuring tapes were used.

2. *Road Profile Tests*

Two types of tests were carried out: checking on the camber of the carriageway and checking on the longitudinal profile of the carriageway; for both of them, the line level was used.

3. *Gravel Layer Test*

To test the gravel for the thickness of compaction and degree of compaction, measuring tapes and special laboratory tests were carried out.

4. *Compaction*

The compaction method is usually specified. The following are factors that can influence compaction: moisture content, amount of compaction and thickness of the layer.

2.1 Study Limitations

This research was only conducted in Lusaka West, Chongwe and Lusaka North areas because most of the ministries and agencies responsible for rural road design, approval, procurement, construction and supervision are located in Lusaka. Another limiting factor was the scarce availability of data on the causes of poor quality of rural roads. That which exists is often not readily available or tailored to local conditions. Engineering guidelines are either very old or have not been refined in recent years to exploit possible potential cost savings.

3 Findings

The following data was collected on six rural roads from Lusaka West, Chongwe and Lusaka North areas. The results were compared to the theory with the view of finding out whether our rural roads are built to specifications, or if not, why?

In Zambia the Road Development Agency undertakes annual surveys to determine the road condition indices for unpaved roads within the Core Road Network. The variations are considerable, and give the status of the condition on the Core Road Network. For example, during the period 2014–2015, over 70% of unpaved trunk, main and district roads and 82% of the unpaved primary feeder roads (PFR) were in poor condition. The condition of PFR substantially remained unchanged.

It was clear from the findings that the planning process was followed adequately. It starts from the National Development Plans to the Transport Sector Plans. These are then incorporated into the annual programs and budgets. Local plans are then drawn from them. That's when project plans are done and then the detailed plans, and finally the maintenance plans are done. All these plans are governed by a legal and regulatory framework.

The roads in Zambia are properly classified, and those providing access to and from local communities are often under the jurisdiction of the local authorities. The government develops a set of design guidelines. These design guidelines include general directions on the geometric features of the roads, such as appropriate dimensions of the road cross section and curvature, surfacing options, drainage solutions and road reserves. All public expenditure is governed by a comprehensive set of procedures and directives detailing how funds are to be used and accounted for. These procedures include budgeting and accounting procedures as well as detailed regulations on the contracting arrangements.

3.1 On-the-Spot Tests

On-the-spot check on six rural roads that were picked in Lusaka North, Lusaka West and Chongwe revealed that rural roads are not constructed according to design standards and specifications. The road standard design is one having a carriageway of 5.5 m, gravel coarse width of 5 m, side slope of 1.2 m with a slope of 1 in 4 with the shoulder and a ditch of 1 m. All roads surveyed conformed to the longitudinal alignment as specified in the design standards of 5.5 m carriageway and a gravel coarse of 5 m. Shoulders were not to specifications of 1.2 m. The shoulders on all roads surveyed were less than the desired 1.2 m. Where the ditch was present on the roads, it averaged 0.5 m instead of the recommended 1 m.

Culverts were missing, inadequate or wrongly constructed. The 300-mm culvert ring seems to be the most preferred against the standard 600 mm that is easy to clean in case of silting. Observed on some of the roads were wing walls constructed at angles outside the 45° and 75° alignment to the centreline band. Head walls were not constructed to the right height and width, and most culverts did not have ramps to protect the rings; where ramps existed, they were not of the recommended two-thirds height. The outfall on most of the culverts was beyond the recommended 20 m.

All the roads surveyed had few or no mitre drains at all. Where they existed, they were wrongly constructed and positioned. In some cases,

Table 15.1 Transmitter road dimension test (rural road dimension test using the tape)

Test	Average (mm)	Location	Every (m)	Tolerance (mm)
Width of carriageway	5.5	Field	300	±50
Width and depth of side drains	0.5 and 0.2	Field	10	±20

Source: Made by the authors

Table 15.2 Transmitter road profile test (rural road dimension test using the line level)

Test	Average (m)	Location	Test interval (m)	Tolerance (mm)
Camber	0.1	Field	20	±10
Longitudinal profile	–	Field	20	±50

Source: Made by the authors

instead of discharging the water from the drains, they were charging the drain. No scour checks were observed on any of the roads surveyed. And no lay-by was observed either as shown in Tables 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8, 15.9, 15.10, 15.11, 15.12, 15.13, 15.14, 15.15, 15.16, 15.17 and 15.18, respectively.

3.1.1 Transmitter Road in Lusaka West of Lusaka District

Total length of road, 2.5 km; carriageway, 5.5 m

3.1.2 China-Zambia Road in Lusaka West of Lusaka District

Total length, 1.9 km; carriageway, 5.5 m

Table 15.3 Transmitter road condition inventory check list

Road condition inventory	Specifications	Comments
Soil type	Laterite	Laterite soil present
Surface material	Laterite	Laterite
Road surface width	5.5 m	5.5 m
Maximum gradient	12%	<6%
Camber	5% after compaction	5%
Shoulder	1.2 m	1 m
Side slope	1:4	0.2 m
Side drain left	1 m	0.5 m
Side drain right	1 m	0.5 m
Tree and stump removal	6 m clearance from centre	Not adhered to
Sand removal	Must be removed	Done
Boulder removal	<0.5 m boulders buried along the road	No presence of boulders observed
Clear side drain	Must be cleared	Overgrown with grass
Clear mitre drains	Must be cleared	Overgrown with grass
Scour checks	12% gradient must be 6 m apart	No scour checks observed
Grass planting	Must be done	Done
Catch water drains	5 m away from the ditch	Present but less than 5 m from the side drain
Gravel surface thickness	125 mm after compaction	Less than 50 mm thickness
Culverts per km	For maximum gradients of 12%, 2 to 4 per km	No culvert for the entire stretch of the road
Culvert pipe size	600 mm	No pipes culverts present
Wing walls	45° < centreline < 75°	No wing walls present
Head walls	200 mm	No head walls present
Ramp	20 m approach distance	No ramp present
Lay-by	5 m	No lay-by found

Source: Made by the authors

Table 15.4 China-Zambia road dimension test

Test	Average (m)	Location	Every (m)	Tolerance (mm)
Width of carriage	5.5	Field	300	±50
Width and depth of side drains	0.8 and 0.2	Field	10	±20

Source: Made by the authors

Table 15.5 China-Zambia road profile test

Test	Average	Location	Test interval (m)	Tolerance (mm)
Camber	<0.1 m	Field	20	±10
Longitudinal profile	–	Field	20	±50

Source: Made by the authors

Table 15.6 China-Zambia road condition inventory check list

Road condition inventory	Specifications	Comments
Soil type	Laterite	Laterite soil present
Surface material	Laterite	Laterite
Road surface width	5.5 m	5.5 m
Maximum gradient	12%	<6%
Camber	5% after compaction	5%
Shoulder	1.2 m	1 m
Side slope	1:4	0.2 m
Side drain left	1 m	0.8 m
Side drain right	1 m	0.8 m
Tree and stump removal	6 m clearance from centre	Not adhered to
Sand removal	Must be removed	Done
Boulder removal	<0.5 m boulders buried along the road	Presence of boulders observed along the road
Clear side drain	Must be cleared	Overgrown with grass
Clear mitre drains	Must be cleared	Overgrown with grass
Scour checks	12% gradient must be 6 m apart	No scour checks observed
Grass planting	Must be done	Done
Catch water drains	5 m away from the ditch	Present but less than 5 m from the side drain
Gravel surface thickness	125 mm after compaction	125 mm thickness
Culverts per km	For maximum gradients of 12%, 2 to 4 per km	No culvert for the entire stretch of the road
Culvert pipe size	600 mm	No culverts pipes present
Wing walls	45°< centreline < 75°	No wing walls present
Head walls	200 mm	No head walls present
Ramp	20 m approach distance	No ramp present
Lay-by	5 m	No lay-by found

Source: Made by the authors

Table 15.7 Kapepe-Nyendwa road dimension test

Test	Average (m)	Location	Every (m)	Tolerance (mm)
Width of carriage	5.5	Field	300	±50
Width and depth of side drains	0.5 and 0.2	Field	10	±20

Source: Made by the authors

Table 15.8 Kapepe-Nyendwa road profile test

Test	Average	Location	Test interval (m)	Tolerance (mm)
Camber	<0.1 m	Field	20	±10
Longitudinal profile	–	Field	20	±50

Source: Made by the authors

Table 15.9 Kapepe-Nyendwa road condition inventory check list

Road condition inventory	Specifications	Comments
Soil type	Laterite	Laterite soil present
Surface material	Laterite	Laterite
Road surface width	5.5 m	5.5 m
Maximum gradient	12%	<6%
Camber	5% after compaction	5%
Shoulder	1.2 m	1 m
Side slope	1:4	0.2 m
Side drain left	1 m	0.5 m
Side drain right	1 m	0.5 m
Tree and stump removal	6 m clearance from centre	Adhered to specifications
Sand removal	Must be removed	Done
Boulder removal	<0.5 m boulders buried along the road	No presence of boulders observed
Clear side drain	Must be cleared	Overgrown with grass
Clear mitre drains	Must be cleared	Overgrown with grass
Scour checks	12% gradient must be 6 m apart	No scour checks observed
Grass planting	Must be done	Done
Catch water drains	5 m away from the ditch	Present at 5 m from the side drain
Gravel surface thickness	125 mm after compaction	Less than 50 mm thickness

(*continued*)

Table 15.9 (continued)

Road condition inventory	Specifications	Comments
Culverts per km	For maximum gradients of 12%, 2 to 4 per km	Two culverts per km observed
Culvert pipe size	600 mm	300 mm culverts pipes
Wing walls	45° < centreline < 75°	Not to specifications
Head walls	200 mm	Not to specifications
Ramp	20 m approach distance	<20 m approach distance
Lay-by	5 m	No lay-by found

Source: Made by the authors

Table 15.10 Evergreen-Nyendwa road dimension test – width of carriage and side drains

Test	Average (m)	Location	Every (m)	Tolerance (mm)
Width of carriage	5.5	Field	300	±50
Width and depth of side drains	0.6 and 0.1	Field	10	±20

Source: Made by the authors

Table 15.11 Evergreen-Nyendwa road dimension test – camber and longitudinal profile

Test	Average	Location	Test interval (m)	Tolerance (mm)
Camber	0.2 m	Field	20	±10
Longitudinal profile		Field	20	±50

Source: Made by the authors

3.1.3 Kapepe School to Nyendwa Bar Road in Chongwe District

Total length, 10.8 km; carriageway, 5.5 m

3.1.4 Evergreen to Nyendwa Road in Chongwe District

Total length, 9 km; carriageway, 5.5 m

Table 15.12 Evergreen-Nyendwa road condition inventory check list

Road condition inventory	Specifications	Comments
Soil type	Laterite	Laterite soil present
Surface material	Laterite	Laterite
Road surface width	5.5 m	5.5 m
Maximum gradient	12%	<6%
Camber	5% after compaction	5%
Shoulder	1.2 m	1 m
Side slope	1:4	0.1 m
Side drain left	1 m	0.6 m
Side drain right	1 m	0.6 m
Tree and stump removal	6 m clearance from centre	Adhered to
Sand removal	Must be removed	Done
Boulder removal	<0.5 m boulders buried along the road	No presence of boulders observed
Clear side drain	Must be cleared	Cleared
Clear mitre drains	Must be cleared	Cleared
Scour checks	12% gradient must be 6 m apart	Scour checks observed
Grass planting	Must be done	Done
Catch water drains	5 m away from the ditch	Present and at 5 m
Gravel surface thickness	125 mm after compaction	Spot gravelling 125 mm thickness
Culverts per km	For maximum gradients of 12%, 2 to 4 per km	6 culverts
Culvert pipe size	600 mm	300 mm culverts pipes
Wing walls	45° < centreline < 75°	Present
Head walls	200 mm	Present
Ramp	20 m approach distance	Ramp present
Lay-by	5 m	No lay-by found

Source: Made by the authors

Table 15.13 Mpandika's Palace road dimension test

Test	Average (m)	Location	Every (m)	Tolerance (mm)
Width of carriage	5.5	Field	300	±50
Width and depth of side drains	0.6 and 0.2	Field	10	±20

Source: Made by the authors

Table 15.14 Mpandika's Palace road profile test

Test	Average	Location	Test interval (m)	Tolerance (mm)
Camber	0.1 m	Field	20	±10
Longitudinal profile		Field	20	±50

Source: Made by the authors

Table 15.15 Mpandika's Palace road condition inventory check list

Road condition inventory	Specifications	Comments
Soil type	Laterite	Laterite soil present
Surface material	Laterite	Laterite
Road surface width	5.5 m	5.5 m
Maximum gradient	12%	12%
Camber	5% after compaction	5%
Shoulder	1.2 m	1 m
Side slope	1:4	0.2 m
Side drain left	1 m	0.6 m
Side drain right	1 m	0.6 m
Tree and stump removal	6 m clearance from centre	Adhered to
Sand removal	Must be removed	Done
Boulder removal	<0.5 m boulders buried along the road	No presence of boulders observed
Clear side drain	Must be cleared	Overgrown with grass
Clear mitre drains	Must be cleared	Overgrown with grass
Scour checks	12% gradient must be 6 m apart	No scour checks observed
Grass planting	Must be done	Done
Catch water drains	5 m away from the ditch	Not present
Gravel surface thickness	125 mm after compaction	Earth road
Culverts per km	For maximum gradients of 12%, 2 to 4 per km	3 culverts
Culvert pipe size	600 mm	600 mm culverts pipes
Wing walls	45°< centreline < 75°	No wing walls present
Head walls	200 mm	Head walls present
Ramp	20 m approach distance	No ramp present
Lay-by	5 m	No lay-by found

Source: Made by the authors

Table 15.16 Spin-along road dimension test

Test	Average (m)	Location	Every (m)	Tolerance (mm)
Width of carriage	5.5	Field	300	±50
Width and depth of side drains	0.5 and 0.3	Field	10	±20

Source: Made by the authors

Table 15.17 Spin-along road profile test

Test	Average (m)	Location	Test interval (m)	Tolerance (mm)
Camber	0.1	Field	20	±10
Longitudinal profile	Ok	Field	20	±50

Source: Made by the authors

Table 15.18 Spin-along road condition inventory check list

Road condition inventory	Specifications	Comments
Soil type	Laterite	Laterite soil present
Surface material	Laterite	In situ laterite
Road surface width	5.5 m	5.5 m
Maximum gradient	12%	<6%
Camber	5% after compaction	5%
Shoulder	1.2 m	No shoulder observed
Side slope	1:4	0.3 m
Side drain left	1 m	0.5 m
Side drain right	1 m	0.5 m
Tree and stump removal	6 m clearance from centre	Adhered to
Sand removal	Must be removed	Done
Boulder removal	<0.5 m boulders buried along the road	No presence of boulders observed
Clear side drain	Must be cleared	Overgrown with grass
Clear mitre drains	Must be cleared	Overgrown with grass
Scour checks	12% gradient must be 6 m apart	No scour checks observed
Grass planting	Must be done	Done

(*continued*)

Table 15.18 (continued)

Road condition inventory	Specifications	Comments
Catch water drains	5 m away from the ditch	Not present
Gravel surface thickness	125 mm after compaction	No gravel
Culverts per km	For maximum gradients of 12%, 2 to 4 per km	No culvert for the entire stretch of the road
Culvert pipe size	600 mm	No culverts pipes present
Wing walls	45°< centreline < 75°	No wing walls present
Head walls	200 mm	No head walls present
Ramp	20 m approach distance	No ramp present
Lay-by	5 m	No lay-by found

Source: Made by the authors

3.1.5 Headman Mpandika's Palace Road in Lusaka North

Total length, 4.2 km; carriageway, 5.5 m

3.1.6 Spin-Along Road in Lusaka North

Total length, 3.2 km; carriageway, 5.5 m

4 Discussions

During planning at the local level, annual work plans are done by people who are inexperienced and unqualified. The processes of identification, screening, appraisal, ranking and approval are not properly followed, and in most cases, they are influenced by excessive political pressure without due consideration to the social and economic significance of these rural roads. The unfortunate result of this is having improperly designed rural roads that substantially hinder and prevent vehicle movement whether seasonally or throughout the year due to deep rutting, soft soils, slippery surfaces, poor water crossing and so on. Roads missing basic infrastructure such as culverts, bridges or poor surfaces are a common feature of most rural roads. All ten provinces had five engineers, two in Lusaka, whereas Central, Northern and Northwestern had one each. Muchinga, Luapula and Eastern were manned by diploma holders, while Southern was manned by a certificate holder. This issue of human resource is so profound that right from drawing up annual work plans to the actual implementation of the works, it is felt.

The specifications and standards from literature need to be and must be clear and understandable, appropriate to the local road environment, capable of being applied by local contractors, aimed at producing a technically sustainable rural road, cover all relevant technical and cost issues and compatible with the overall regulations. From the findings of the research, it is clear that we have a problem in adhering to the specifications and the implementation of the plans. All the roads surveyed demonstrated that quality issues were not taken seriously. The 14-m bush clearing width is not adhered to. This is supposed to be the first item to be carried out on a rural road construction. Neither is the 12 m tree and stump width adhered to. Also from the quality of the culverts observed, it is clear that not only didn't the vertical alignment take precedence over the longitudinal alignment of the road, but also the culverts weren't constructed according to specifications.

Observed were wrong angles of wing walls that were outside the recommended 45° to 75°, wrong height of head walls, missing guard posts, excessive culvert outfall length (beyond the recommended 20 m or less), silting of the culvert, silting of the culvert outfall, erosion of the culvert outfall and most of these culverts had 300 mm, instead of the 600 mm, bore rings that are very difficult to clean. Also, the overfill in most cases was less than two-thirds of the bore diameter. The mitre drains were mainly inadequate, missing and not constructed according to specifications. The angles were wrong, and in some cases, instead of the mitre drain discharging water away from the drainage, they actually feedback water to the drainage system, thereby compromising the integrity of the road. Almost all the roads observed had no scour checks, and the effect of fast-flowing water was very evident on the roads: gulleys. The procurement processes are too long such that by the time they are done, the factors on the ground would have changed resulting in incorrect works being done.

5 Conclusion and Recommendations

The potential contribution of rural roads to the socio-economic development of Zambia cannot be overemphasised. The impact of quality rural road infrastructure could be far reaching, going beyond poverty reduction, a goal which many leaders now view as unambitious to sustain economic growth and structural transformation. Zambia's large and sparsely populated landmass underscores the relevance and important role of rural roads in the successful implementation of most, if not all, development policies. In essence, poor quality rural road systems negatively affect other sectors of the economy.

The research established that planning is adequate but the problem lies with the planning personnel who are inadequately trained to undertake the tasks. While designs and specifications needed to take into account the alignment requirements, technical performance, pavement solutions, material requirements and structures that are specific to an area, results indicate that planners use a one-size-fits-all kind of approach of designing. This is compromising the quality. This chapter therefore recommends that local councils employ competent people who will help, especially during the planning process, to come with detailed plans, project plans and local plans. Design standards should be based on reliability and durability not just concentrating on accessibility.

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