TECHNICAL AUDIT OF REHABILITATION WORKS ON UNPAVED RURAL ACCESS ROADS

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ABSTRACT

Rural access roads (such as district roads, feeder roads and community roads) play a vital role in providing rural areas throughout Africa with access to transport services, thereby stimulating economic and social development. The institutional responsibility for these roads generally lies with local or regional authorities (such as district and city councils), that often experience constraints regarding finances and capacity.

Rehabilitation and maintenance actions on rural access roads should be optimized and programmed, to ensure that technical, economic and socio-economic objectives are met. Due to capacity constraints, local authorities often struggle in managing rehabilitation and maintenance contracts. This increases the risk of substandard road works and non-conformance to the project or programme's contractual obligations.

This paper presents a framework for the technical auditing of rehabilitation contracts on unpaved rural access roads, by an independent entity. This approach is becoming an effective method of quality control and can ensure that deficiencies in design, construction or supervision, be identified from both a programme and project point of view. It can also be used to evaluate the socio-economic impact of roads programmes, and can identify deficiencies to be rectified in future programmes.

The paper also shows the benefits of performing a technical audit, by discussing the objectives and methodology of such an audit, as well as typical results that can be expected of such an exercise.

1. INTRODUCTION

Rural access roads play a vital role in providing rural areas throughout Africa with access to transport services, thereby stimulating economic and social development. Rural access roads typically falls within the category of district roads, feeder roads or community roads and are generally the responsibility of local authorities (such as district and city councils).

Rural access roads are typically unpaved roads with low traffic usage (generally between 10 and 100 vehicles per day), as typically opposed to trunk, main and district roads. This paper therefore considers the technical audit of rehabilitation contracts on unpaved rural access roads, with the context of both a programme and individual projects.

Traffic on unpaved rural access roads typically consists of light vehicles such as passenger cars and four-wheel drives. Heavy vehicle numbers are usually limited to certain areas (e.g. mining areas or agricultural areas) and certain periods of the year (e.g. agricultural seasons). In many African countries, non-motorised traffic on unpaved rural access roads, such as bicycles, animal carts and pedestrians, is fairly high. Communities living along these roads generally are involved in agricultural activities, often subsistence farming. Access to health, education and other services, including transport services, is often very limited.

Rehabilitation and maintenance contracts on rural access roads should be optimized and programmed, to ensure that technical, economic and socio-economic objectives are met. Due to capacity constraints, local authorities often struggle in managing rehabilitation and maintenance contracts. This increases the risk of substandard road works and non-conformance to programme’s contractual obligations. The performing of a technical audit by an independent party is becoming an effective method of quality control and can ensure that deficiencies in design, construction or supervision be identified and addressed.

2. METHODOLOGY

2.1 Objectives of technical audit for unpaved rural access roads

The overall objective of a technical audit for unpaved rural access roads is to review the planning, design, construction and management of rehabilitation works on the roads in a programme, as typically funded by donor organisations such as the World Bank through the relevant ministry responsible for these roads in a country.

More specifically, the objectives of the technical audit can be stated as follows:

- Determine whether consultants and contractors have adequately fulfilled their contractual obligations
- Identify any additional or remedial works required
- Investigate the socio-economic impact of the works
- Identify and extract “lessons learned” that can be applied in subsequent road programmes

2.2 Typical methodology for technical audit

The typical phases for performing a technical audit can be summarised as follows:

- Phase 1: Planning of the audit
- Phase 2: Field investigations
- Phase 3: Evaluation and reporting

3. PLANNING OF A TECHNICAL AUDIT

3.1 Data collection

In performing a technical audit, relevant documentation will be required, such as the following:

- Contract documents for rehabilitation contracts (including design documentation)
- Terms of Reference for the design contracts

- Technical specifications for the country

Additional documents which may assist in the technical audit are progress reports and minutes of project meetings for individual contracts.

3.2 Sampling

In a technical audit, it is typically possible to only investigate a sample of the rehabilitation works, due to cost and time constraints involved in auditing 100 per cent of the works performed.

The trend in technical audits is to audit between 20% and 30% of the rehabilitation works, based on the total length of roads rehabilitated.

In the selection of roads or road sections to be included in the sample, the following factors should be considered, in order to ensure a representative sample:

- The *geographical distribution* of all rehabilitation contracts, to ensure that regional representivity requirements are met
- *Distribution of contracts between contractors*, to ensure that the focus is spread evenly between contractors
- *Distribution of contracts between consultants*, for the same reason
- *Contract values*, to review contracts of various sizes

Figure 1 and Figure 2 show an example of a representative sample with regards to geographical distribution and distribution of works between contractors. The region where most of the rehabilitation work took place (region B) is also the region where most of the audit should be done. Similarly, most of the audit should be done on the roads of contractors who performed most of the rehabilitation works (in terms of kilometres of road rehabilitated).

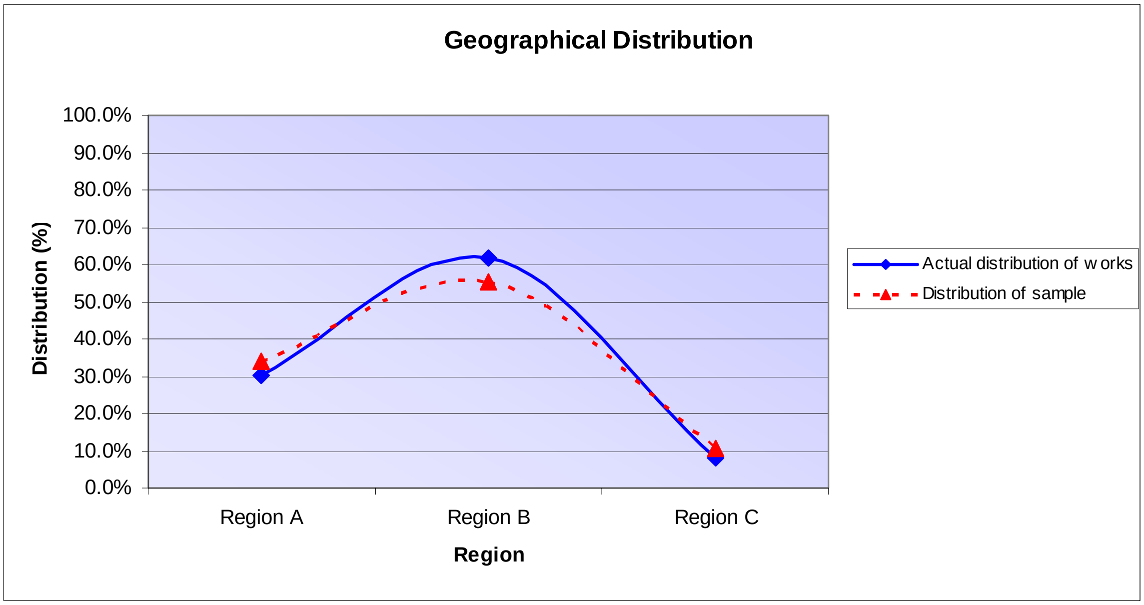

Figure 1: Sample's representation of geographical distribution

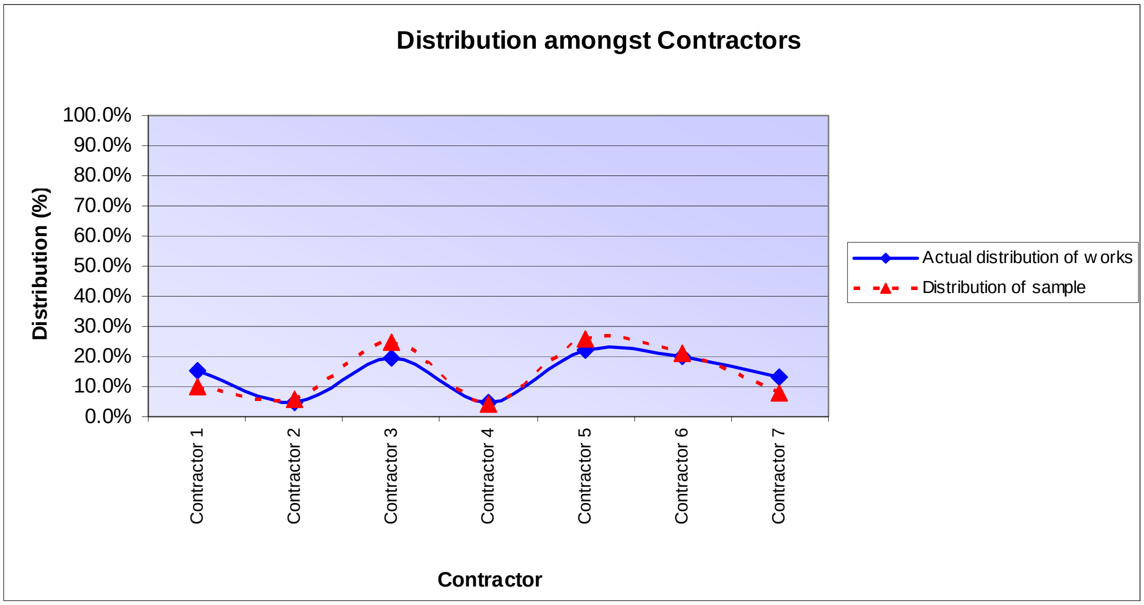

Figure 2: Sample's representation of distribution of works amongst contractors

<u>3.3 Developing an audit framework</u>

In preparation of the field investigations, an audit framework need to be developed and the auditing of roads should be programmed to ensure timely completion. The field investigation will consist of the following activities:

- Physical inspection of works to check whether rehabilitation was done according to contractual specifications
- Evaluating current condition of roads, and identifying failures in construction (i.e. areas where remedial actions are required)
- Material testing of soil samples taken from rehabilitated roads

Survey forms need to be prepared for each road for easy recording of data during the field investigations. The following typical forms are recommended for accurate recording of data:

- Contractual obligation form
- Unpaved road assessment form
- Drainage evaluation form

3.3.1 Contractual obligation form

The contractual obligation form is used for comparing the findings in the field with the actual designs in the contract documents, i.e. to check that the contractor performed all his tasks according to the designs. The forms should be completed prior to the field surveys by using design or construction documentation to enable comparison with conditions in the field.

An example of such a form is indicated in Figure 3 and contains the following items:

- Material specifications
- Geometric requirements

- Drainage specifications
- Drainage requirements (e.g. rehabilitate old culvert, build new culvert)
- Road works to be performed (e.g. regravelling, shaping, grading, vegetation clearing)

3.3.2 Unpaved road assessment form

This form is similar to the unsealed road assessment forms proposed in the TMH12 (CSIR Transportek, 2000), and is used to assess the current condition of the road and to identify remedial actions required.

The following items are recorded on the unpaved road assessment form:

- Gravel quality
- Gravel quantity
- Road profile
- Riding quality
- Drainage from the road
- Occurrence and degree of potholes, rutting, erosion, corrugation, loose material, stoniness and subgrade exposure

Contract Number	**Road identification**		
Region			
	TOR	**Contract**	**Field observation**
Functional classification	Rural access road	Rural access road	
Material specifications			
Compaction % Fill / subgrade	As per Standard Specification for Roads and Bridges (SSRB)	90% Mod AASHTO,	
Compaction % Gravel		93% Mod AASHTO	
Gravel layer thickness		150 mm	
Material specifications		PI < 20, Shrinkage product = 100 to 240 Max size = 37.5mm, Grading coefficient = 16 to 34 CBR >15 @ 95% Mod AASHTO	Material testing
Geometric requirements			
Design speed	60 km/h	60 km/h	
Traffic to be accommodated	10 Tonne Agricultural Trucks	10 Tonne Agricultural Trucks	
Road width	-	5.0m - 5% cross-fall	
Vertical alignment	No alignment changes required	Not changed	
Horizontal alignment		Not changed	
Drainage specifications			
Head walls and side walls	-		
Mitre drains	-	25m length at 50m intervals	
Side drain width / depth	-		
Drainage actions			
Culverts 600mm Armco	-	At km 1.1, 13.3, 18.8, 24.5, 34.6	
Culverts 800mm PC	-	At km 4.5, 8.7, 28.8	
Culverts 1200mm PC	-	At km 31.1	
Mitre drains	-	km 16.2 - 25.0	
Actions to perform			
Standard Cross-section	-	km 0.0 - 36.1	
Add 150mm Gravel	-	km 16.2 - 26.8	
Add 300mm Gravel	-	km 26.8 - 33.5	
Bush Clearing - Light	-	km 0.0 - 16.2	
Bush Clearing - Medium	-	km 16.2 - 36.1	
Bush Clearing - Heavy	-	-	

Figure 3: Contractual obligation form

3.3.3 Drainage evaluation form

This form is used to assess the current condition of drainage structures and to identify signs of erosion and overtopping. The form records the distance and description of the culvert (type and size), as well as the condition of the culvert. For easy processing of data, the description of the condition can be divided into the following classes:

- Good condition
- Insufficient drainage
- Blocked / silted
- Damaged structure
- Erosion around / above structure

3.4 Programming

In preparing a programme for the field investigations, the following needs to be taken into account:

- Rainfall patterns. Typically one would want to perform the field investigation during months of low rainfall, as rain typically inhibits mobility in many countries. This is especially important in regions where relatively high rainfall is experienced during the wet season.
- Expected progress. Experience has shown that the typical average length of unpaved rural roads surveyed per day as part of a technical audit, is about 50 km. This value might differ from region to region, depending on the dispersement of sample roads, condition of main access roads, the accuracy and availability of maps and other factors.

3.5 Socio-economic data collection framework

An evaluation of the socio-economic impact of the road works will provide a good indication of whether the rehabilitation works generated adequate value for money. It will provide the funder of the works an indication of the effect of the road works on the community's quality of life, and on the economy of the region.

The scope of the socio-economic survey can vary greatly depending on the requirements of the client and the availability of information. An effective though simple method to use in assessing the socio-economic impact of the road works, is to identify and determine certain critical indicators, and compare these with the "before" scenario. Such indicators should typically cover the sectors of health, education, economic activities (such as agriculture, fishing, employment), mobility and transport services. Examples of indicators and their units to be used include the following:

- Traffic levels on roads (veh/day)
- Freight transported on the road (heavy veh/day carrying freight or tonnes/day)
- Frequency of public transport services (veh/day where vehicles constitute busses, mini-buses, taxis etc)
- Public transport tariffs (local currency)
- Yield in agricultural products per person (kg/person)
- Market prices of agricultural products (local currency/kg)

- Annual income per capita ($/person or local currency/person)
- Employment (% of population in catchment area)
- Average travel time to nearest school (minutes)
- Average travel time to health facility (minutes)

The indicators above should be determined through interviews and surveys (traffic and travel time surveys) during the field investigation.

4. FIELD INVESTIGATIONS

4.1 Site visits

All the roads selected for the sample should be visited and the technical audit performed in accordance with the audit framework.

Surveys should be conducted and interviews held with appropriate individuals or organisations, to establish the relevant socio-economic indicators to be surveyed.

4.2 Materials testing

During the field investigation, soil samples should be taken at frequent intervals for purposes of materials testing. The purpose of the materials testing exercise is to assess in broad terms the quality and strength of materials used in the road construction. For the purpose of a technical audit, one soil sample every 5 km of rehabilitated road should be sufficient, depending of course on the variability of materials experienced over the road length.

The following minimum material tests should be performed in the field:

- Dynamic Cone Penetration (DCP) tests
- Measurement of gravel wearing course thickness

The DCP tests provide an indication of the in situ bearing strength of the material used in the construction of the gravel wearing course, as well as the degree of compaction that was achieved during the construction process. California Bearing Ratio (CBR) values can be derived from the penetration rate (mm per blow) of the DCP tests. These should ideally be calibrated with soaked CBR tests from material samples. The in situ moisture condition of the soil and subgrade should also be taken into account when determining the in situ bearing strength. Similarly, DCP tests also provide an indication of the pavement structure and the strength of the subgrade layer. Pavement layer thicknesses can also be determined from a plot of DCP penetration rates.

The soil samples should be taken to a laboratory and the following tests performed on them for each horizon:

- Grading of the soil
- Atterberg limits (linear shrinkage, plasticity index, liquid limit)
- Limited CBR tests for calibration of DCP tests

The indicator tests (grading and Atterberg limits) described above provide an indication of the suitability of the material for use in the construction of a gravel wearing course, in terms of the country specifications.

5. EVALUATION AND REPORTING

5.1 Technical evaluation

The technical evaluation and reporting has as its goal to portray the following:

- Whether the consultant and contractor have fulfilled their contractual obligations
- Whether any additional or remedial works are required

Based on the data that was gathered in the field, a short write-up should be done for every contract audited.

An effective way of summarising the findings, per contract, of the technical audit, is by means of a Table of Engineering Standards. Such a table, an example of which is provided in

Figure 4, should also be included in the report.

The contractual obligation forms completed during the field investigations should also be included in the report, to enable the reader an accurate assessment of whether the contractor performed his works in accordance with the contract. In practice this form often confirms notions previously identified of non-performing contractors on specific contracts, within the context of standardised comparison with other contracts.

EVALUATION OF CONSULTANT

Contract name	**C 1**		**C 2**			**C 3**				
Consultant	Cons 1		Cons 2			Cons 3				
Road width (m)	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Road bed materials										
Compaction	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
Gravel wearing course										
Thickness (mm)	Good	Good	Fair	Fair	Fair	Good	Good	Good	Good	Good
Compaction	Good	Good	**B A D**	**B A D**	**B A D**	Fair	Fair	Fair	Fair	Fair
Drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

EVALUATION OF CONTRACTOR

Contract name	**C 1a**	**C 1b**	**C 2a**	**C 2b**	**C 2c**	**C 3a**	**C 3b**	**C 3c**	**C 3d**	**C 3e**
Contractor	Cont 1	Cont 2	Cont 3	Cont 3	Cont 3	Cont 4	Cont 4	Cont 4	Cont 2	Cont 5
Road width (m)	Good	Good	Good	Good	**B A D**	Good	Good	Good	Good	Good
Material										
Quantity	Good	Good	**B A D**	Good	Good	Good	Good	Good	**B A D**	Good
Quality	Good	Good	**B A D**	Fair	Good	Good	Good	Good	**B A D**	Good
Gravel wearing course										
Thickness (mm)	Good	Good	Fair	Fair	Fair	Good	Good	Good	Good	Good
Profile	Good	Good	**B A D**	Good	Good	Good	Good	Good	**B A D**	Good
Riding quality	Good	Good	**B A D**	**B A D**	**B A D**	Fair	Good	Good	**B A D**	Good
Erosion / Potholes	Fair	Good	Fair	Fair	**B A D**	Good	Good	Good	**B A D**	Good
Longitudinal drainage	Good	Good	**B A D**	Fair	Good	Good	Good	Good	**B A D**	Good
Geometry										
Vertical	Fair	Good	Fair	Fair	Fair	Good	Good	Fair	Fair	Fair
Horizontal	Fair	Good	Fair	Fair	Fair	Good	Good	Fair	Fair	Fair
Drainage										
Condition	Good	Good	Good	Fair	Good	Good	Good	Good	Good	Good
Inlet / Outlet	Good	**B A D**	Good	Fair	**B A D**	Good	**B A D**	Good	Good	Good
Headwalls	Good	Good	Good	Fair	**B A D**	Good	Good	Good	Good	Good
Overtopping	Good	Good	Good	**B A D**	Good	Fair	Good	Good	Fair	Good

Figure 4: Table of Engineering Standards

5.2 Socio-economic evaluation

The result of the socio-economic evaluation will be a comparison between specific indicators for the "before" and "after" scenarios, indicating the impact of the road works as perceived by the population living in close proximity to the road. A typical example of such a comparison is indicated in Table 1.

Table 1: Comparison of socio-economic indicators

Item	Before rehabilitation	After rehabilitation
Traffic level Road 1 Road 2 Road 3	 30 veh/day 23 veh/day 34 veh/day	 50 veh/day 45 veh/day 72 veh/day
Freight transport	2 heavy veh/day	9 heavy veh/day
Public transport services	5 buses per day	12 buses per day
Public transport fee	$1.00/trip	$0.80 per trip
Yield in agricultural products	200 kg maize/person	250 kg maize/person
Market prices Maize Groundnuts Potatoes Sorghum	 $0.20/kg $0.50/kg $0.15/kg $0.60/kg	 $0.16/kg $0.40/kg $0.12/kg $0.50/kg
Annual income per capita	$330 per person	S360 per person
Employment	30%	35%
Average travel time to school	30 minutes	25 minutes
Average travel time to health facility	50 minutes	35 minutes

5.3 Lessons learnt

The final step in the technical audit is to make recommendations in the final report on pertinent issues that came up during the audit, especially problems that were encountered frequently and measures to be taken to avoid these problems in future contracts.

Typically, during this step conclusions can also be made about the proficiency of contractors or consultants to work in a specific environment.

6. CONCLUSIONS AND RECOMMENDATIONS

This paper presents a framework for the technical auditing of rehabilitation contracts on unpaved rural access roads, by an independent entity.

The framework suggests that a sample of rehabilitated roads be selected for the auditing process. The sample should be representative of aspects such as the geographical distribution of rehabilitation works and the distribution of contracts between contractors.

The framework presents various survey forms that can be used to assess the degree of contractual compliance, as well as the current condition of the roads and remedial actions required. The framework also describes specific socio-economic indicators to be used in assessing the socio-economic impact of the rehabilitation works.

The framework proposes the use of a table of engineering standards to summarise the findings of the technical investigation. From this table, deficiencies in design and construction can be identified and trends determined which can be addressed early in future rehabilitation programmes.

In summary, this framework can be used to obtain an overall as well as focussed view of the effectiveness of unpaved roads rehabilitation projects and programmes.

7. REFERENCES

[1] CSIR Transportek, 2000. “Draft TMH12 Pavement Management Systems: Standard Visual Assessment Manual for Unsealed Roads Version 1”, pub Committee of Land Transport Officials, p.66-69