Maintenance of Minor Roads Using the Lengthman Contractor System

T. E. JONES AND R. C. PETTS

Current development and research activities on the Minor Roads Program in Kenya are described. The relatively rapid deterioration of unpaved roads compared to paved roads demands that maintenance be programmed rather than respond to changes in surface condition. Road maintenance in developing countries is normally organized on a district or regional basis using ministry teams or contractors. However, the use of lengthmen to undertake routine and possibly recurrent maintenance activities may result in more rapid and cost-effective correction of deficiencies and an improved level of service in some circumstances. The Minor Roads Program is a labor-based improvement and maintenance program for low- and medium-trafficked roads in 28 districts of Kenya with a high agricultural potential. The program commenced in 1986 and is projected to improve 4 500 km of roads to gravel all-weather standard over a 5-year period and to establish maintenance systems. The program will also maintain some 8 000 km of roads constructed under the previous labor-based Rural Access Roads Program. People living alongside the roads are utilized on a casual basis to carry out all improvements and maintenance supported by simple agricultural equipment for certain operations, particularly on the higher-trafficked roads. Routine maintenance on the roads is carried out using a lengthman system. An ex-construction worker is appointed to each section, typically 1.5 to 2.0 km in length. He is provided with the necessary hand tools and is paid for working 3 days per week on the road. This allows him time to continue to work on his land on other days. The principal aim was to establish productivity standards for a range of routine and recurrent maintenance activities carried out by lengthmen using mostly hand tools. The current research will evaluate the influence of geometry, climate, traffic, and materials on the amount of maintenance required and define optimum lengths of road relative to labor inputs for these variables.

A network of more than 8 000 km of rural access and minor roads has been constructed and maintained in Kenya using labor-based methods. Routine maintenance of these roads is carried out using individual lengthmen contractors. Current research work is designed to establish maintenance needs and productivity standards. The results of the research will permit improved planning, implementation, and monitoring of labor-based road maintenance.

The use of individual contractors or lengthmen to undertake routine maintenance over specified lengths of road has been a recognized management technique for many years. However, the effectiveness of the technique over a long period has seldom been monitored in detail.

The Kenyan Rural Access Road Program (RARP) was started in 1974. Its primary objective was to construct farm-to-market access roads using a labor-based method in districts with high agricultural potential. By the end of 1986, approximately 8 000 km of rural access roads had been completed in 26 districts with the majority of them graveled and maintained by individual lengthmen contractors.

Following the success of the RARP in constructing roads at low cost and with high utilization of local resources, the government of Kenya decided to apply the same labor-based methods to the improvement and maintenance of selected D and E roads (Table 1), which are categorized as minor roads (*1*). During the period 1986 to 1992, the Minor Roads Program (MRP) is projected to improve 4 500 km of minor roads and to include them in Kenya's overall maintenance strategy.

The research is concerned with the initial establishment of maintenance productivity standards in the MRP and the determination of the routine maintenance needs of rural access and minor roads (RA/MRs).

For the MRP, routine maintenance is defined as all work required within the road margin capable of being carried out by an individual lengthman contractor. Periodic maintenance of the roads includes regraveling and repairs to structures and this is carried out by special units or contracting companies. Occasionally, urgent work is carried out under various arrangements when the scope is beyond the capabilities of the lengthman contractor.

DEVELOPMENT OF THE MAINTENANCE SYSTEM

Various methods were originally considered for the routine maintenance of rural access roads. For the chosen lengthman system, an ex-construction worker was appointed on a contract basis to each section of road, typically 1.5 to 2.0 km in length. He was provided with hand tools and supervised once a month by an overseer to monitor the condition of the road and to authorize payments for satisfactory work. The payment was based on the contractor carrying out 12 days of work per month on days of his choice. The contractor could be replaced if he consistently performed badly.

The contractor lived adjacent to the road and would therefore not require government accommodation or transport, which consumed considerable resources in a traditional equipment-based maintenance system.

A principal attraction of the system is the comparatively low level of equipment required and consequently lessened support problems. This advantage is coupled with a low foreign exchange component, which in 1981 was estimated to be only 10 percent (*1*). This amount compares with a typical

T. E. Jones, Transport and Road Research Laboratory, Crowthorne, Berkshire, United Kingdom. R. C. Petts, Intech Associates, United Kingdom.

TABLE 1 KILOMETERS OF KENYA ROAD NETWORK UNDER THE RESPONSIBILITY OF THE MINISTRY OF PUBLIC WORKS

CATEGORY	BITUMEN	EARTH/GRAVEL	TOTAL
A. INTERNATIONAL TRUNK ROADS (1)	2,608	971	3,579
B. NATIONAL TRUNK ROADS (1)	1,308	1,443	2,751
C. PRIMARY ROADS (1)	2,293	5,476	7,769
D. SECONDARY ROADS (1)	1,041	10,074	11,115
E. MINOR ROADS (1)	512	25,754	26,266
SPECIAL PURPOSE ROADS (1)	166	2,931	3,097
RURAL ACCESS ROADS (2)	15	7,962	7,977
TOTAL	7,943	54,611	62,554

NOTE (1): Network at September 1990.
(2): Network at June 1990.

foreign exchange component for equipment-based routine maintenance systems of 50 percent (*2*).

The lengthman system also creates productive paid employment in rural areas where there are few opportunities for such work. The contractor is able to live at home with his family and the part-time terms give him the opportunity to work on his own land as well.

Approximately 80 percent of the direct costs of the system was estimated to be paid directly to the contractors in 1982. The system also enables maintenance to be achieved throughout the year on each section of road. The responsibility for the maintenance of each road section lies completely with one person who requires minimal logistic support.

Unfortunately, the establishment of the maintenance system did not attract the same amount of research and development effort as the construction aspects of the program. It was erroneously assumed that the local administration and people would bring pressure to bear on the contractors to maintain the roads to a good standard. The contractor's appreciation of the maintenance requirements was taken for granted. The need for training and supervision was underestimated and mechanical problems associated with the supervision vehicles had an adverse effect.

It is now realized that the development of effective maintenance systems requires as much, if not more, effort than construction or road improvement systems. In recognition of these problems, a study of maintenance of rural access roads was commissioned in early 1985 (*3*). The report showed the lengthman system to be quite effective. However, it indicated a significant potential for improvement and the need for better direction and control of the contractors. Extensive discussion of the maintenance issues has enabled the principal problems to be identified and appropriate strategies developed for tackling them.

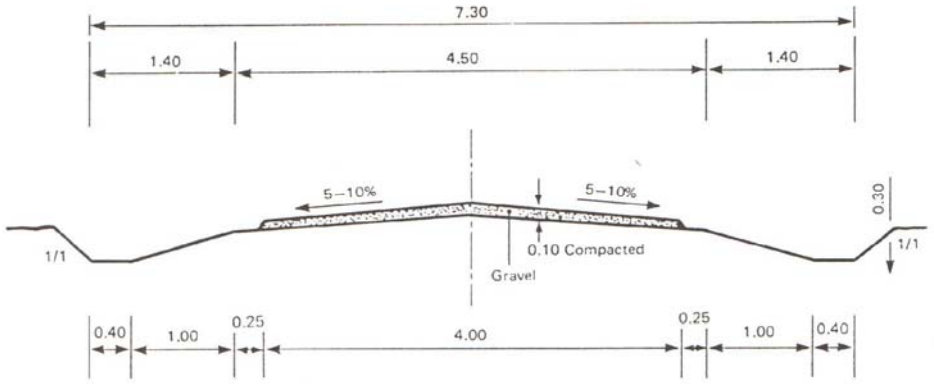
In particular, there was a need to more accurately determine the maintenance requirements of RA/MRs under various conditions of rainfall, alignment, pavement and soil type, and traffic. Rural access roads have a 4-m-wide graveled running surface, whereas the minor road standard is 5.4 m (see Figures 1 and 2).

Methods of determining required maintenance resources and their deployment, direction, and control needed to be developed. Arrangements for dealing with urgent works such as washouts and culvert breakages should be formalized. The methods of identifying spot regraveling and full regraveling required to be developed and the various options for carrying out this work, e.g., by animal-drawn haulage and casual labor or small-scale contractors, needed to be investigated. There was an urgent requirement to ease the supervision burden of the maintenance overseers because of the minimal time that they could allocate to each contractor and the mechanical problems that will always exist to a degree, even with the low equipment component of the system. The scope for the use of headmen, responsible for a small number of contractors, needed to be developed, as well as the methods of training, directing, and monitoring them. On the technical side, there was the problem of maintaining a satisfactory longitudinal profile, especially for the wider, more heavily trafficked minor roads. There was also the question of safety for lengthmen working on the carriageway of the more heavily trafficked roads [>50 vehicles per day (vpd)]. Consideration had to be given to the use of simple tractor-drawn mechanical graders or drags for maintaining the running surface in these circumstances, with pothole-patching support and all off-carriageway work by the lengthmen.

The lengthman concept has been adopted for the maintenance of RA/MRs under the new program. However, a number of major improvements to the system have been initiated or planned. Studies of particular maintenance aspects are being carried out as part of this process.

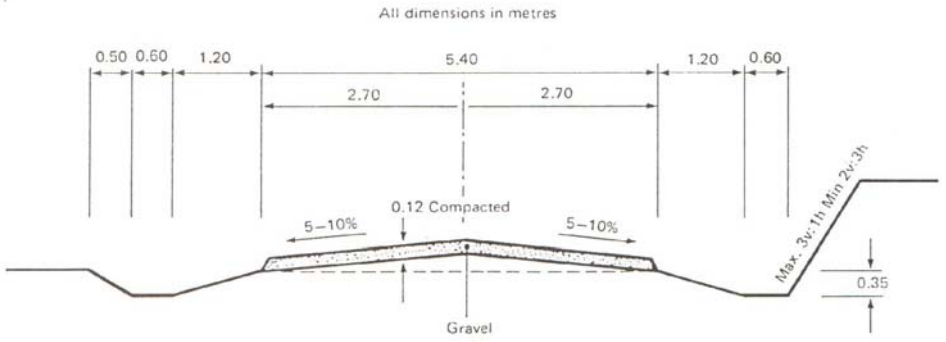
The main areas of improvement to the maintenance system are as follows:

1. The setting of fair contract lengths for the lengthmen including objective consideration of the factors influencing the amount of maintenance required;
2. The supervision of lengthmen activities and concentration on one routine maintenance activity at a time;
3. Arranging for the lengthmen to work progressively from one end of a section to the other on a specified activity, easing supervision and control;
4. The establishment of realistic task rates for routine maintenance activities;



Notes: Camber profile depends on whether constructed from arisings of one ditch or two.
Other sections apply for Black Cotton Soil, severe terrain or embankment situations

FIGURE 1 Rural access road, standard cross section.



Notes: Camber profile depends on whether constructed from arisings of one ditch or two.
Other sections apply for Black Cotton Soil, severe terrain or embankment situations

FIGURE 2 Minor road, standard cross section.

5. The setting of priorities for routine maintenance activities according to season;
6. The establishment of reference stations on each lengthman's section for control and reporting purposes;
7. The introduction of both working and nonworking headmen in appropriate situations to control work between overseers' visits;
8. The introduction of control aids for headmen;
9. The introduction of an objective assessment of routine maintenance performance incorporated in an annual inspection system that will also allow periodic maintenance work to be identified and monitored;
10. A training program including formal and on-the-job training, and demonstration sites in each district; and
11. Allocation of the highest priority to the provision, servicing, and repair of routine maintenance overseers' motorcycles.

Items 1 and 4 are the subject of the current study. Other initiatives are being taken to bring about the other improvements. Phase I of the study has already established routine maintenance productivity standards (task rates). Phase II of the study will monitor the maintenance requirements of RA/MRs under the range of principal influential factors experienced; namely rainfall, gradient, traffic, and surface characteristics. Figure 3 shows the flow diagram for the study. Figure 4 shows the proposed district structure for the established maintenance organization.

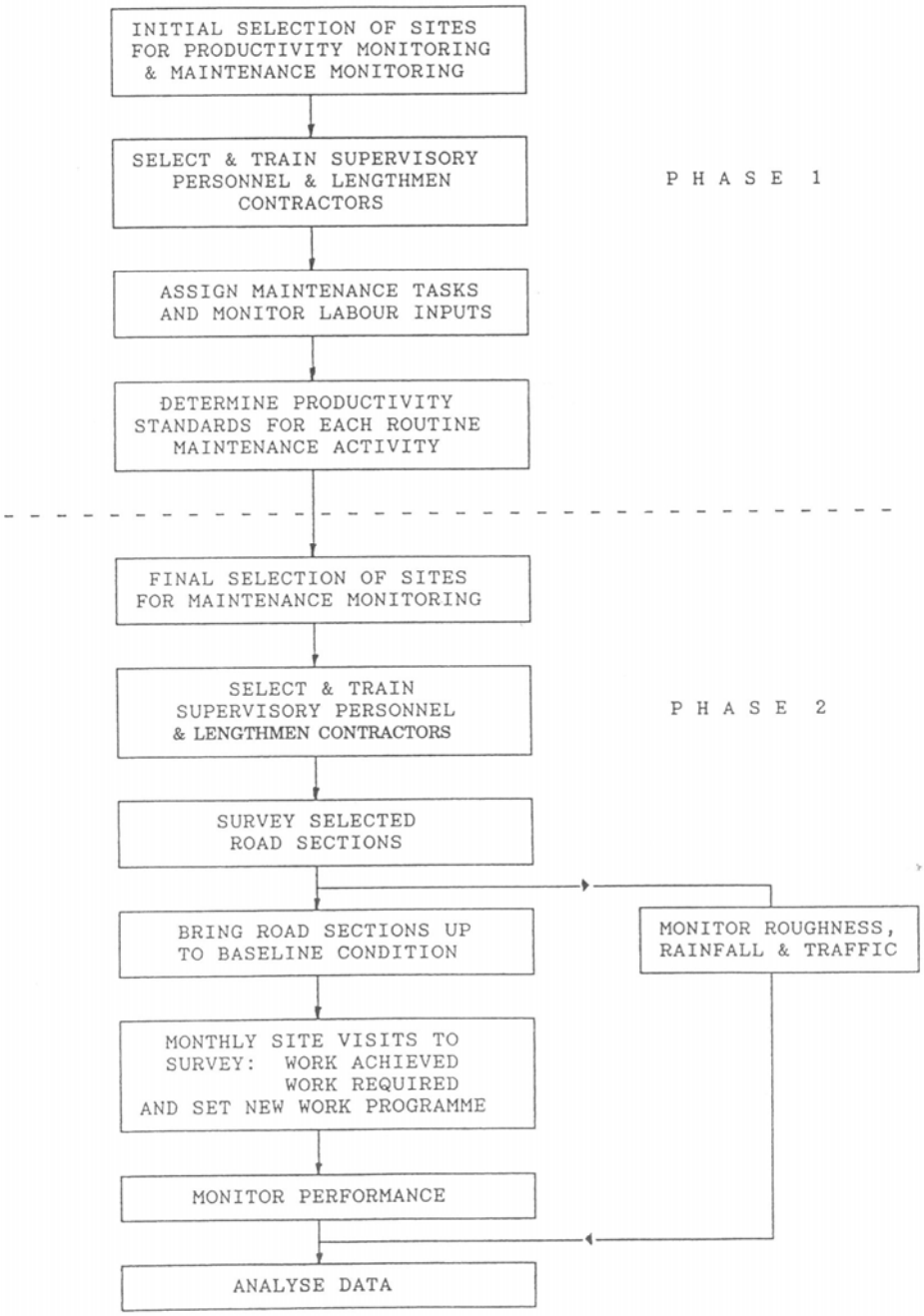
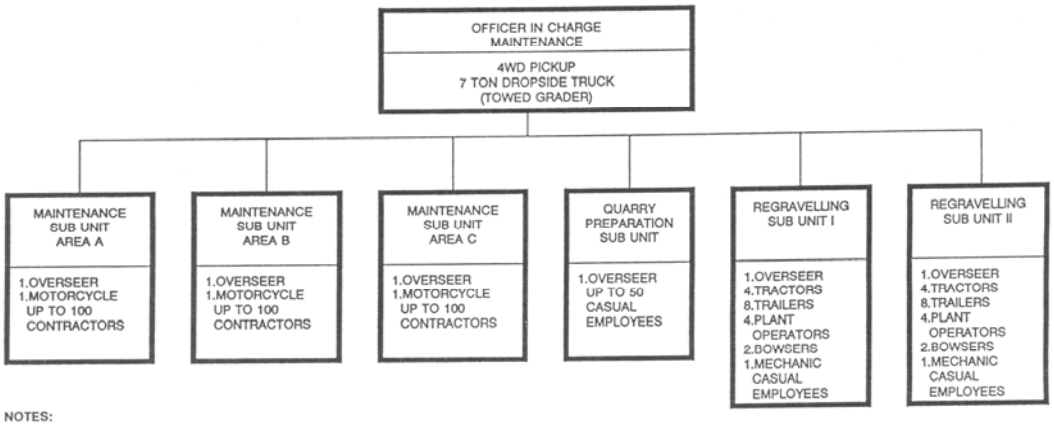


FIGURE 3 Flow diagram of the research program.



NOTES:

1. Maintenance sub units as required.
2. Second regravelling sub unit only if required.
3. Regravelling sub units to also replenish contractor stockpiles.
4. Regravelling resources calculated on 7500m³ of regravelling/stockpiling per sub unit year.
5. Bowsers: single axle towed, 1 fuel and 1 water per sub unit.

FIGURE 4 Proposed MR/RAR program district maintenance unit.

PHASE I: ESTABLISHMENT OF MAINTENANCE PRODUCTIVITY STANDARDS

Objective

Phase I of the study concentrated on the following objective: to establish productivity standards for a range of routine maintenance activities utilizing hand tools. The following activities were identified as the principal routine maintenance operations for RA/MRs for which productivity levels were established in the study:

Activity Code	*Description*
R1	Inspection and removal of obstructions
R2	Clean culverts and inlets and outlets
R3	Repair culvert headwalls
R4	Clean miter drains
R5	Clean side drains
R6	Repair scour checks and side drain erosion
R7	Repair erosion on shoulders
R8	Fill potholes in carriageway
R9	Grub edge and reshape carriageway
R10	Cut grass in the side drains
R11	Clear bush

Some of the operations are shown in Figures 5–12.

Methodology

Phase I of the study was conducted in Kisii and South Nyanza districts between October 1988 and March 1989, a period that conveniently overlapped wet and dry seasons in both districts. Kisii is a high-rainfall district with generally cohesive "red coffee" soils at approximately 1800-m elevation and has an annual rainfall of between 1 500 and 2 000 mm. South Nyanza is a drier district with predominantly sandy and "black cotton" soils at approximately 1 100 m elevation, annual rainfall there

FIGURE 5 Lengthmen working collectively.

FIGURE 6 Grubbing edge.

FIGURE 7 Excavating gravel for patching.

FIGURE 10 Cleaning culvert inlet.

FIGURE 8 Reshaping carriageway.

FIGURE 11 Cleaning miter drain.

FIGURE 9 Cleaning culvert outlet.

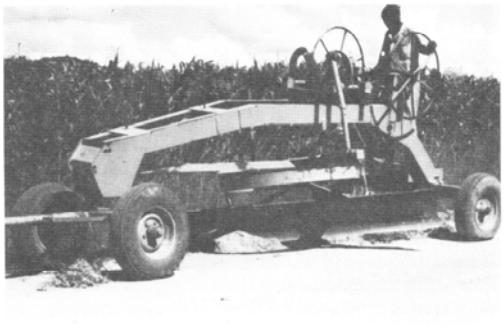


FIGURE 12 Towed grader under trial.

being between 1 000 and 1 500 mm. Program districts are shown in Figure 13. The two districts are considered to be typical of many MRP districts so that the productivity data derived may be applicable across the program.

Three overseers were seconded to the study team, each supervising up to 14 maintenance contractors with the assistance of two nonworking headmen. This ratio contrasts with the supervision ratio planned for the MRP, which would typically be 1 overseer to 8 headmen to 80 lengthmen. In some areas, working headmen have their own maintenance section as well as supervision responsibilities over other lengthmen.

The contractors were generally working on their own separate sections before the study. However, for ease of supervision, during the study they were brought together in small groups of seven under each nonworking headman. Before the commencement of data collection, the contractors and headmen were given approximately 2 weeks of training by the overseers. Various levels of difficulty were defined for each

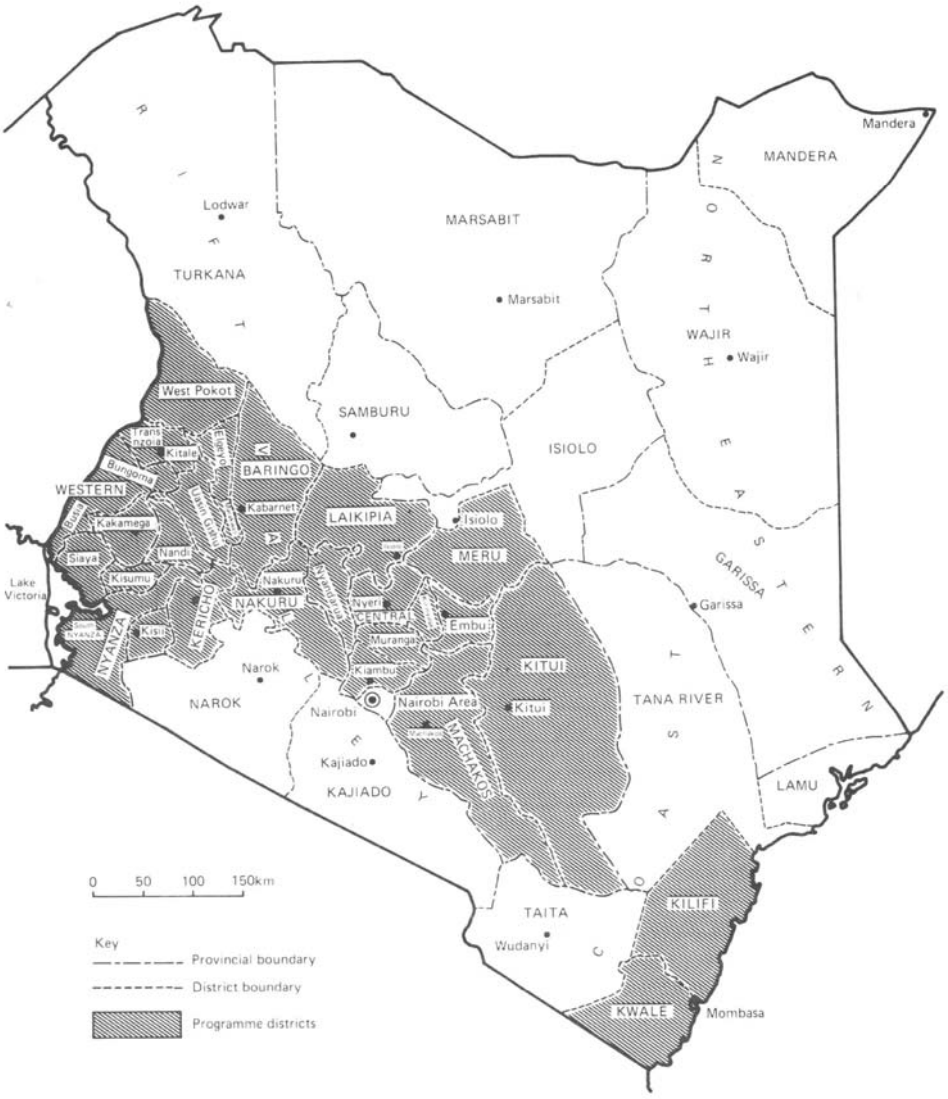


FIGURE 13 Kenya MRP districts.

maintenance activity and some of the activities had to be broken into two-component operations for ease of control or measurement.

Forms were developed to record the relevant technical and personnel data for each day's task. They included name, sex, and age of individuals. Reports were thoroughly checked before being entered on the microcomputer data base, using dBase III Plus software.

Productivities were calculated in terms of quantity of work completed per hour. These values were then adjusted to represent the quantity of work that could be expected for a standard 5-hr closely supervised workday. This work was adopted as the basis for development of daily productivity standards. In the normal situation, the lengthman is subjected to a lower level of supervision. He or she is nominally paid for 8 hr of work, and the 5-hr supervised standard was considered to be an appropriate target for the MRP.

From the data gathered, comparisons were made between performance related to age groups, sex, and districts, and whether the set tasks were successfully completed or not. The lengthmen were given individual daily tasks on various maintenance activities along a short section of road. Tasks were set daily by the overseers and monitored throughout the day by both the overseers and headmen. The starting and finishing times were carefully recorded for each task.

During the study, the contractors were retained for approximately 7 hr if tasks were not completed. However, they were released earlier, normally after 5 hr, if they finished their work satisfactorily. Individuals were rotated between activities on successive days.

Phase I Study Results

A total of 1,960 task-days of data was collected. Of the 11 originally planned activities, 5 were subdivided into two operations, in effect making 16 activities to be monitored, as follows:

Activity Code	*Maintained Activity*
R1	Inspection and removal of obstructions
R2A	Clean culverts and inlets
R2B	Clean culvert outfalls
R3	Repair culvert headwalls
R4	Clean miter drains
R5	Clean side drains
R6A	Repair scour checks
R6B	Repair side drain erosion
R7A	Repair shoulder erosion
R7B	Grass planting
R8A	Fill potholes in carriageway
R8B	Fill ruts in carriageway
R9A	Grub edge of carriageway
R9B	Reshape carriageway
R10	Grass cutting
R11	Bush clearing

For each activity, up to four degrees of difficulty were defined and observations made on the basis of these divisions. As many as 47 observations were made on an individual activity (Activity R3). Records were unobtainable for only one combination of activity and difficulty. For only four activity-difficulty combinations were five or fewer observations made. The lack of data on these combinations reflects their low occurrence in general RA/MR maintenance operations.

The observations were taken on seven road sites, two of which were constructed to minor road cross section standards. From the observations taken, it was not possible to detect a difference in productivity between rural access roads and minor roads.

Little difference was observed in productivities between age groups, districts, or sexes. The most significant observation was that contractors who completed their tasks, and thus left work early, worked significantly harder (by up to 30 percent) than those who failed to do so. This trend shows up fairly consistently throughout the results and is (a) an indication of the quality of the data gathered and (b) a strong argument for establishing a task-based system with fair and achievable targets.

The standard deviation for each data set was calculated and used to define the representative range of productivity for the task around the mean of the observations. These ranges were then used for the final comparisons and are presented in Table 2 (Kisii district) and Table 3 (South Nyanza district).

The productivity results presented in these tables can be used as standards for the MRP. However, these results were obtained under most favorable supervision conditions with trained lengthmen and motivated overseers. They should be treated as reference points to strive for by MRP personnel.

PHASE II: IDENTIFICATION OF ROUTINE MAINTENANCE REQUIREMENTS

Objectives

The principal objectives of Phase II of the study are as follows:

1. To determine the influence of geometry, climate, traffic, and pavement materials on the amount of routine maintenance required expressed in terms of the 16 standard activities; and
2. To determine optimum maintainable lengths of road relative to labor inputs under various soil, topographic, climatic, and traffic conditions.

Methodology

In order to achieve these objectives, detailed observations will be taken over a period of 12 months on existing sections of RA/MRs that are already under routine maintenance.

Selection of Road Sections and Preparation Work

The Kenyan RA/MRs have been constructed over a wide range of climates, vertical gradients, soil types, and traffic levels. Traffic currently using these roads varies from less than 10 to over 100 vpd. Selection will be made of suitable sections of existing roads encompassing as many of these variables as possible.

The most important variables considered to affect the performance of the roads are classified as follows:

- Traffic <20, 20 to 50, and >50 vpd;
- Annual rainfall <500, 500 to 1 500, and >1 500 mm;

TABLE 2 PRODUCTIVITY RANGES FOR ROUTINE MAINTENANCE IN WET HIGHLAND AREAS (KISII DISTRICT)

Activity	Unit	Task Difficulty 1	2	3	4	Notes
R2A: Clean culvert and inlet	As shown	2–5 culverts/day	1–1½ days/culvert	1½–3 days/culvert	3–5 days/culvert	Difficulty—silt depth in culvert 1, up to ¼; 2, ¼ to ½; 3, ½ to ¾; 4, over ¾
R2B: Clean culvert outfalls	m/day	45–60	30–45	15–30	–	Difficulty—silt depth 1, up to 10 cm; 2, 10 to 20 cm; 3, over 20 cm
R3: Repair culvert headwalls	No./day	5–10	3–5	–	–	Difficulty—type of repair 1, minor repairs; 2, major repairs
R4: Clean miter drains	m/day	50–65	35–50	25–35	–	Difficulty—silt depth 1, up to 10 cm; 2, 10 to 15 cm; 3, over 15 cm
R5: Clean side drains	m/day	55–75	35–55	25–35	–	Difficulty—silt depth 1, up to 10 cm; 2, 10 to 15 cm; 3, over 15 cm
R6A: Repair scour checks	No./day	3–8	5–9	–	–	Difficulty—type of scour check 1, wood; 2, stone
R6B: Repair side drain erosion	m/day	90–110	70–90	50–70	–	Difficulty—depth of erosion 1, up to 15 cm; 2, 15 to 30 cm; 3, over 30 cm
R7A: Repair shoulder erosion	m/day	85–110	60–85	40–60	–	Difficulty—depth of erosion 1, up to 10 cm; 2, 10 to 15 cm; 3, over 15 cm
R7B: Grass planting	m/day	90–110	70–90	60–70	–	Difficulty—planting width 1, up to 0.5 m; 2, 0.5 to 1.0 m; 3, over 1.0 m
R8A: Fill potholes in carriageway	w.brws/day	23–30	16–23	11–16	7–11	Difficulty—hauling distance 1, no haul; 2, up to 100 m; 3, 100 to 200 m; 4, over 200 m
R8B: Fill ruts in carriageway	m/day	60–80	40–60	30–40	10–20	Difficulty—hauling distance 1, no haul; 2, up to 100 m; 3, 100 to 200 m; 4, over 200 m
R9A: Grub edge of carriageway	m/day	230–300	160–230	100–160	–	Difficulty—width of grubbing 1, up to 0.5 m; 2, 0.5 to 1.0 m; 3, over 1.0 m
R9B: Reshape carriageway[a]	m/day	55–80	40–55	–	–	Difficulty—type of reshaping 1, light (up to 75 mm); 2, heavy (over 75 mm)
R10: Grass cutting						
Light	m/day	400–450	220–300	150–220	–	Difficulty—width of grass cutting 1, up to 1.0 m; 2, 1.0 to 2.0 m; 3, over 2.0 m
Dense	m/day	275–350	200–275	150–200	–	
R11: Bush cutting						
Light	m/day	400–450	220–300	150–220	–	Difficulty—width of bush 1, up to 1.0 m; 2, 1.0 to 2.0 m; 3, over 2.0 m
Dense	m/day	250–300	200–250	150–200	–	

[a]All tasks except reshaping are measured along one side of the road only.

- Vertical gradients <4, 4 to 8, and >8 percent; and
- Surface materials, graveled and ungraveled.

In addition, the following parameters will also be recorded at the beginning and end of the study:

- Width of carriageway,
- Average crossfall,
- Length of section maintained,
- Frequency of supervision, and
- Thickness of gravel.

As a control, some sections will be selected on which no maintenance (other than emergency repairs) will be carried out during the study.

MRP personnel will be responsible for the initial identification of roads suitable for inclusion in the study. A total of about 50 sections of roads will be required to cover all the principal variables (though some sections may be on the same road). Each section will be of a length maintainable by one individual contractor, i.e., 1 to 2 km, approximately.

The study roads will mainly be concentrated in three areas, Nakuru/Naivasha, South Nyanza, and Kisii; to cover a wider range of variables, some road sections may be located outside these areas.

Each road will be inspected by a supervising engineer to confirm its suitability and to carry out a detailed condition survey. This will include identifying maintenance defects and preparing a schedule of repairs.

The supervising engineer will also be responsible for the final demarcation of the road sections to be included in the study, and will also ensure that each road section is clearly marked with a signboard indicating the section reference number. This initial survey will record the relevant details of soil

TABLE 3 PRODUCTIVITY RANGES FOR ROUTINE MAINTENANCE IN DRY LOWLAND AREAS (SOUTH NYANZA DISTRICT)

Activity	Unit	Task Difficulty 1	2	3	4	Notes
R2A: Clean culvert and inlet	As shown	2–5 culverts/ day	1–1½ days/ culvert	1½–3 days/ culvert	3–5 days/ culvert	Difficulty—silt depth in culvert 1, up to ¼; 2, ¼ to ½; 3, ½ to ¾; 4, over ¾ Tasks for 600 dia culverts with 7 rings
R2B: Clean culvert outfalls	m/day	45–60	30–45	15–30	–	Difficulty—silt depth 1, up to 10 cm; 2, 10 to 20 cm; 3, over 20 cm
R3: Repair culvert headwalls	No./day	5–10	3–5	–	–	Difficulty—type of repair 1, minor repairs; 2, major repairs
R4: Clean miter drains	m/day	50–65	35–50	25–35	–	Difficulty—silt depth 1, up to 10 cm; 2, 10 to 15 cm; 3, over 15 cm
R5: Clean side drains	m/day	soft, 45–60; hard, 25–35	soft, 35–45; hard, 20–25	soft, 25–35; hard, 20–25	–	Difficulty—silt depth 1, up to 10 cm; 2, 10 to 15 cm; 3, over 15 cm
R6A: Repair scour checks	No./day	3–8	5–9	–	–	Difficulty—type of scour check 1, wood; 2, stone
R6B: Repair side drain erosion	m/day	75–100	40–75	20–40	–	Difficulty—depth of erosion 1, up to 15 cm; 2, 15 to 30 cm; 3, over 30 cm
R7A: Repair shoulder erosion	m/day	85–110	60–85	40–60	–	Difficulty—depth of erosion 1, up to 10 cm; 2, 10 to 15 cm; 3, over 15 cm
R7B: Grass planting	m/day	90–110	70–90	60–70	–	Difficulty—planting width 1, up to 0.5 m; 2, 0.5 to 1.0 m; 3, over 1.0 m
R8A: Fill potholes in carriageway	w.brws/day	20–30	14–20	10–14	7–10	Difficulty—hauling distance 1, no haul; 2, up to 100 m; 3, 100 to 200 m; 4, over 200 m
R8B: Fill ruts in carriageway	m/day	40–60	20–40	10–20	5–10	Difficulty—hauling distance 1, no haul; 2, up to 100 m; 3, 100 to 200 m; 4, over 200 m
R9A: Grub edge of carriageway	m/day	150–220	80–150	50–80	–	Difficulty—width of grubbing 1, up to 0.5 m; 2, 0.5 to 1.0 m; 3, over 1.0 m
R9B: Reshape carriageway[a]	m/day	55–80	40–55	–	–	Difficulty—type of reshaping 1, light (up to 75 mm); 2, heavy (over 75 mm)
R10: Grass cutting						
Light	m/day	275–350	200–275	150–200	–	Difficulty—width of grass cutting 1, up to 1.0 m; 2, 1.0 to 2.0 m; 3, over 2.0 m
Dense	m/day	275–350	200–275	150–200	–	
R11: Bush cutting						
Light	m/day	400–450	220–300	150–220	–	Difficulty—width of bush 1, up to 1.0 m; 2, 1.0 to 2.0 m; 3, over 2.0 m
Dense	m/day	250–300	200–250	150–200	–	

[a]All tasks except reshaping are measured along one side of the road only.

and gravel type, mean gradient, gravel thickness, road width, etc., for each contractor's section.

MRP personnel will be responsible for carrying out the repairs to bring the road to an acceptable and maintainable standard within a reasonable period of time to suit the study program. A check inspection on completion of the repair works will be carried out by the supervising engineer.

Before the commencement of the study and at the end of the study, manual traffic counts will be taken over seven consecutive days and two nights on each road and thereafter on 1 day per month.

Rainfall gauges will be established in the vicinity of each road to monitor daily rainfall, and surface roughness measurement will be carried out on each road section using the MRP vehicle-mounted bump integrator on a monthly basis.

Study Data Collection

The study will be carried out over a period of 12 consecutive months on each road section with an additional 1 month's trial data collection at the commencement of the study.

Every month, an MRP inspector, under the direction of the supervising engineer, will visit each road and record and assess the previous month's work. He will also survey the road and locate, quantify, and record all defects or outstand-

ing maintenance requirements. He will inform the overseer supervising the road of the maintenance program for the following month on the basis of the productivity norms established by the MRP under *Maintenance Study II Phase I Productivity Standards* (*4*), which was completed in early 1989.

Each month the schedule for each contractor will show (a) maintenance work achieved and (b) outstanding work required.

If the maintenance contractor is falling behind with the work, then he will be given additional time to ensure that the road condition is satisfactorily maintained (provided the delays are not caused by inefficiency on the part of the contractor). In certain cases, additional personnel may be temporarily employed to help catch up on any backlog of work.

All survey data including the regular monitoring of rainfall, roughness, and traffic will be input to a microcomputer data base and analyzed to establish relationships between the extent of each maintenance operating required and the monitored characteristics of the road section.

PROJECT OUTPUT

The two phases of the study should enable the labor-based maintenance of RA/MRs to be significantly improved.

The research in Phases I and II will result in

1. A rational basis for implementing routine maintenance using the lengthman principle over the range of site conditions experienced in Kenya,
2. Identification of any shortcomings in the lengthman system,
3. The provision of data to prepare realistic estimates of resources and costs for routine maintenance, and
4. More realistic productivity standards for use in the TRRL guide to maintenance management for district engineers (*5*).

These results will permit more effective planning, execution, and monitoring of gravel road maintenance, particularly when lengthmen contractors are used.

OTHER INITIATIVES

In addition to the Phase I and Phase II studies, the Ministry of Public Works has taken a number of other initiatives to improve the lengthman maintenance system.

The improvements identified and described earlier have been adopted as policy for the MRP. Pending the results of the two study phases, including completion of productivity standards and maintenance needs, other improvements will be introduced through a planned program of training and demonstration sites.

In recent TRRL studies, research on unpaved roads has often concentrated on comparisons between motorized graders and tractor-drawn graders (*6*).

The maintenance project in Kenya has afforded the opportunity of evaluating maintenance strategies incorporating a mix of towed graders and contract lengthmen. The intention is to investigate a mix of low-cost equipment and labor-based maintenance during Phase II of the project. This strategy will be used only on the more highly trafficked roads (>50 vpd) of the Minor Roads Program. It is intended that the towed grader will only lightly grade the running surface, with pothole patching and all side drainage and off-carriageway work being carried out by the lengthmen.

The results from this additional research will provide new and valuable information on the most appropriate maintenance strategies using low-cost techniques for gravel roads in developing countries.

RECOMMENDATIONS FROM THE PHASE I INVESTIGATION

The results of Phase I of the study are summarized in Tables 2 and 3. For the guidelines to be applicable in each district of Kenya, some allowance, based on previous experience, will be required to adjust the separate task rates for the particular workforce involved.

The subdivision of five of the maintenance activities permits better control and measurement of these tasks and has been recommended for incorporation into the present reporting system.

The guidelines themselves have been established under virtually ideal supervisory conditions with a well-trained workforce under the control of motivated overseers. As such, the guidelines represent the best overall productivities that can be expected under conditions in Kisii and South Nyanza districts. They should be treated as realistic targets that can be strived for as the management of routine maintenance is improved. More important perhaps, the guidelines provide a reference against which the performance of contractors can be assessed.

The maintenance activities are not directly comparable to those of construction and improvement work. A number of activities are of a similar nature although there are differences in scale of work and in methods of working and measurement. When a broad comparison is possible, the productivities achieved for maintenance activities are somewhat below the RARP/MRP construction productivity standards. This fact reflects the generally smaller scale and dispersed nature of the maintenance work.

At the commencement of Phase I, it was found that many contractors and headmen did not fully appreciate what the various maintenance tasks were, how they should be carried out and controlled, or what methods were to be used for measuring them. There was an obvious need for training, particularly because, if the task system was to work effectively, the headmen had to take on a much stricter supervisory function than they had in the past. Besides their direct supervisory function, headmen had to also become fully conversant with the methods for measuring each activity so that they could assist the overseers in their overall management role.

It will be important to introduce the experience gained from Phase I, and in due course that from Phase II, into the training and maintenance operations of the MRP.

The lengthmen, headmen, and overseers should have a clear understanding of the reasons for and methods of desilting. It is just as important that they appreciate when desilting is not required because of established vegetation and good drainage conditions.

Recommendations include updating of the planning and reporting system and introduction of the new productivity standards. Training material, manuals, and courses will also be necessary.

ACKNOWLEDGMENTS

The authors wish to acknowledge the support given to the research project by S. Otonglo; the staff of the Ministry of Public Works, especially that of B. Ariga; and the Swiss Development Corporation, who funded Phases I and II of the project.

The contribution of TRRL forms part of the research program of the Overseas Development Administration (Unit Head: J. S. Yerrell) and is published by permission of the director of TRRL.

Graham Williams was the project engineer for the Phase I field work. The paper is reproduced by permission of Her Britannic Majesty's Stationery Office.

REFERENCES

1. R. C. Petts. *Maintenance of Rural Access Roads and the Scope of the Extension of Labour Based Methods into the Routine Maintenance of Classified Roads in Kenya*. International Labor Organization and Ministry of Transport and Communications, Kenya, Africa, 1982.
2. Howard Humphreys and Partners. *Maintenance Study*. Main Report, Vol. 1, United Republic of Tanzania, Ministry of Communications and Works, 1984.
3. Ove Arup and Partners. *Kenya Rural Road Maintenance Study*. Draft Final Report, International Labor Organization, 1986.
4. Howard Humphreys and Partners. *Routine Maintenance Study II Phase I, Productivity Standards*. Final Report, Ministry of Public Works, Kenya and Swiss Development Cooperation, 1989.
5. TRRL Overseas Unit. *Maintenance Management for District Engineers*. Overseas Road Note 1. Transport and Road Research Laboratory, Crowthorne, Berkshire, U.K., 1987. Second Edition.
6. T. E. Jones and R. Robinson. *A Study of the Cost Effectiveness of Grading Unpaved Roads in Developing Countries*. TRRL Research Report 91. Department of Transport, Crowthorne, Berkshire, U.K., 1986.

Views expressed are not necessarily those of the British government.