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Assessing Worldwide Low-Volume Roads: Problems, Needs, and Impacts

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ASSESSING WORLDWIDE LOW-VOLUME ROADS: PROBLEMS, NEEDS, AND IMPACTS

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ACKNOWLEDGEMENT

Members of the Low-Volume Roads Committee gratefully acknowledge the efforts of Neville A. Parker in bringing together the information presented in this Circular. Assessing worldwide low-volume roads problems, needs, and impacts has been one of the major concerns of the Low-Volume Roads Committee. The information presented here will foster a better understanding of the worldwide low-volume roads issues and greatly improve worldwide networking of the low-volume roads community.

The information presented in this Circular originated at a session held at the 71st Transportation Research Board Annual Meeting. The authors updated the material for publication purposes, and the committee conducted a peer review of the papers.

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INTRODUCTION

Neville A. Parker

OVERVIEW

Everyone agrees that road agencies are required to do more with less. Sound decisions based on good information are needed to avoid mistakes in allocating the limited resources because such mistakes can have far reaching effects, both socially and economically. Dealing with inadequate funding for low-volume roads is an especially difficult task.

A significant number of studies on low-volume roads are conducted in isolation. Hence, the results of such efforts generally remain within the realms of respective individual agencies. Often, the other low-volume roads operating agencies are not even aware that such valuable information exists that could benefit their day-to-day operation. One of the areas of emphasis for the TRB Low-Volume Roads Committee has been to facilitate dissemination of and to improve accessibility to information on low-volume roads to the operating agencies worldwide. This is the goal of this Circular.

This Circular contains information on assessing worldwide low-volume roads' problems, needs, and impacts. Information presented covers 4 continents — Australia, Europe, Africa, and North America. Highlights of the several approaches that are presented in this Circular are as follows:

Monitoring Performance of Existing Roads

There is a significant amount of information available on roads that have been in existence for many years and are performing well. Generally, one sees the information on roads that were built recently and have not performed well. The reverse of this should be able to provide us with a large amount of valuable information. Why is a road which has been in place for 30 years and appears to have been constructed to a low standard, still performing well today? That is possibly a more important question to ask than why a road built 5 years ago is already failing. This concept advocates monitoring the performance of existing roads.

Vehicle Operating Costs (VOC)

It has been argued for many years that the work undertaken to date on vehicle operating costs is only the tip of the iceberg. In the past, pleas have been made to organizations to do more work on the applicability of their existing VOC information, and to expand that information.

Personal Computers (PCs) and Micro Computers

This is the age of the PC and micro computers. Consequently, road agencies are interested in building "systems." This is a logical approach provided the systems are built from the best possible information and are of genuine assistance to the decision maker, specifically by enabling one to make more use of the information that is already available. Unfortunately, there is a plethora of systems. However, no system exists, or ever will exist, that will be adequate for all the needs of the low-volume roads community. What we have is a large number of systems that do many valuable things. Hence, what is needed is a much better assessment of what the systems do, what they do not do, what we want them to do, in order to get the right level of information. The comments of several contributors to this Circular demonstrate that this need is well understood.

The Use of Expert Systems

The use of expert systems is also discussed. Expert systems on low-volume roads really mean the application of engineering experience. Ultimately, it is the engineering experience backing up the information systems that will enable us to make the maximum use of the funding that is available for low-volume roads.

Central Tire Inflation (CTI)

Among the research and development items that are described is the work that the USDA Forest Service is conducting on central tire inflation. A Central Tire Inflation (CTI) system allows the tire pressure to be varied over a wide range while the vehicle is in motion. A driver of a vehicle equipped with a CTI system can change tire pressure to an appropriate low level that is suited to low-speed, low-traffic roads or to a high level that is better suited for high-speed, high-traffic roads. In effect, CTI allows vehicles to run on a sponge instead of a hard tire. This effort has significant potential value at this time for both extending the life of paved and unpaved roads and extending the life and lowering the cost of the vehicle.

Appropriate Standards

The subject of appropriate engineering and maintenance standards is addressed in several contributions. "Appropriate standards" have to be achievable. There is no point in defining a standard if we cannot provide a system or the data to support it. One of the many valuable points made is to stress the ability to get the data that we need. This echoes another comment that if the information is not available, or cannot be obtained simply and cheaply and with the enthusiastic support of the people who are collecting the data, then the use to which it is being put, the system which it is driving, is of no use.

Funding

Funding is always the major concern facing road agencies. It always has been and it always will be a fact of life that there will be limits on funding. There will never be the money available which we think ought to be available. Therefore, it is time to maximize what we can do with the funds that are available.

Information Dissemination

Probably the most important and critical issue is *information dissemination*. Presenting all available and relevant information to practitioners is essential to implementing improved procedures and new techniques. Given the amount of research and development that is still being undertaken, the ability to disseminate this information quickly and simply is the key to advancing the low-volume roads situation. How this is done is probably going to need some concerted action. But with the goodwill and the participation and support of the low-volume roads community, there is no reason why this cannot be achieved.

ISSUES RELATED TO PLANNING AND ADMINISTRATION OF LOW-VOLUME ROADS

Jacob Greenstein
Inter-American Development Bank

RURAL ROAD PLANNING

The main objective of rural road planning is to develop investment programs that will allocate available resources based on prioritization of road improvement and maintenance activities. To accomplish this, a comprehensive socioeconomic analysis of the costs and benefits related to the level of accessibility and the economic life of the road is carried out. The economic analysis requires estimating the economic costs and benefits associated with the proposed technical solutions, which are then ranked and scheduled according to economic indicators such as net present value, internal rate of return and first year rate of return. Socioeconomic evaluation criteria distinguish between roads in areas of substantial economic activity, where the level of traffic is considerable, and roads in areas with little or no traffic.

In areas of substantial economic activity, benefits are quantified in terms of savings to users and in the economic costs of transportation, and projects usually involve the improvement of existing roads or the construction of new roads when alternative roads or other modes are available to traffic.

In areas where there is little or no traffic, benefits are quantified in terms of the net increase in the economic value of the production of goods and services through lower costs of inputs, lower costs of marketing and higher farm gate prices. When benefits are estimated from road user savings, these come mainly from reductions in vehicle operation costs, accidents, and road maintenance due to better road conditions.

In rural areas where the traffic volume is low (less than 50 vehicles per day) but a road is a component of an area development program, a socioeconomic methodology that takes into account the relationship between road accessibility, agricultural and forestry production, and social services has been developed to evaluate the costs and benefits of investment in the entire area development program and in the road improvement component of the program. When the most economic type of roadway and corresponding agricultural/forestry social investment go hand in hand, rural road investment is most efficient, and the principal benefits achieved are:

1. Reducing transport costs by the use of larger, more economical motor vehicles;
2. Increasing the amount of agricultural land in production, including the planting of trees in unfarmed semi-arid lands for timber production;
3. Increasing yield per unit area through the introduction of modern farming equipment, fertilizers, pesticides and technical assistance; and
4. Improving all-weather accessibility, which reduces storage requirements and related inventory costs, as well as permitting the harvesting of crops when they are ready for market, regardless of weather conditions.

The purpose of economic evaluation is to ensure that benefits outweigh total maintenance costs incurred over the life of the road. When the internal rate of return exceeds the opportunity cost of capital, road investment is generally considered to be economically justified.

An example of the planning, design, and administration of 320 kilometers of paved roads, and 500 kilometers of dirt roads used mainly for timber production, is presented in this circular. This case study also includes an analysis of social considerations, such as the distribution of project benefits between different social groups, including local laborers, farmers, road users and the forestry industry, and a discussion of women's roll in project planning and administration.

The current preference in the administration of a rural network is to improve the maintenance of the existing road network rather than to construct new roads. The tendency is that local government (state/province and municipality) will assume most of the administrative responsibility while central government provides technical support in planning, financing and project monitoring. To optimize an expenditure on road improvement, it is necessary first to identify which road segments play a principal role in connecting production centers with markets in a transportation system comprised of roads, highways, railroads, river navigation and ports.

Each road section is identified and its engineering properties evaluated, including road geometry, subgrade, pavement, drainage facilities, bridges, low cost water crossing, local construction and maintenance materials. Knowledge-based expert systems can be useful in screening, verifying and revising field data, and in improving the consistency and quality of decisions on the planning of rural roads.

Another important issue is the application of environmental procedures in the administration of low-volume roads. A proposed project may have a beneficial, neutral, moderately negative, or significantly negative impact on the environment.

For example, road maintenance projects that improve surface and drainage conditions, or which result in improvement of dust control may be classified as beneficial or neutral, and road improvements that require wet-land replacement or erosion control may be classified as moderately or significantly negative. The conclusions of the environmental analysis are implemented in the special provision of the construction documents to minimize or eliminate any damage or risk to people or to the environment.

Assessing Road Surface Conditions

The Pavement Condition Index (PCI) and the International Roughness Index (IRI) are used to describe road surface conditions. The PCI represents the type and severity of some nineteen different types of distress, including:

- Potholes,
- Rutting,
- Weathering/raveling,
- Lane/shoulder drop,
- Bumps/sags,
- Depression,
- Corrugation,
- Shoving,
- Swelling,
- Bleeding, and
- Polished aggregate.

The most common maintenance activities used to improve surface conditions are:

- Pothole filling,
- Crack/joint sealing,
- Patching (skin to full depth),
- Shoulder refill,
- Seal coat/fog-seal, and
- Surface treatment with aggregate and thin asphalt overlay.

To predict pavement performance in terms of PCI and IRI, the relationships between the different types of surface distresses and maintenance activities are developed. Once the PCI, IRI, and traffic projections over the lifetime of the road network are known, vehicle operation costs and maintenance needs can be calculated and used to efficiently allocate and use resources on road improvement and maintenance.

AN OVERVIEW OF THE LVR PROBLEMS, NEEDS, AND IMPACTS FOR THE NATIONAL FORESTS OF THE UNITED STATES

John E. Steward
USDA Forest Service

USDA FOREST SERVICE ROAD TECHNOLOGY AND DEVELOPMENT PROJECTS

USDA Forest Service field notes presented here are intended to provide a nontechnical overview of the road development projects underway or planned. Since the intent of the summary is to demonstrate the range and extent of roads development projects undertaken by the Forest Service, not all projects are included.

The following projects are planned or underway, and the project summaries are categorized to aid in presentation and identification of trends. It is interesting to note that nearly half of the projects are in the Environmental and User categories.

Annually, about $1.5 million is invested in roads technology and development by the Forest Service. Typically, $100,000 to $200,000 of Coordinated Technology Implementation Program (CTIP) funds from the Federal Highway Administration are added to the program. The majority of these projects are managed by the Forest Service Technology and Development Centers at San Dimas, California and Missoula, Montana.

Road Surface

Central Tire Inflation (CTI)

This major project:

- Evaluates the effect on roads of lowered tire pressures,
- Evaluates the central tire inflation technology, and
- Implements appropriate technologies.

Major benefits have been identified through formal studies and field demonstration projects. The Forest Service is currently working with involved industries to implement the technology and has 51 Forest Service trucks operating with CTI systems. Private industry has developed commercial systems and cooperators are beginning to purchase these systems. Significant reductions in traffic-generated sediment from non-paved roads have been quantified by using CTI tire pressures.

Non-Traditional Stabilizers

This Central Tire Inflation project involves the field evaluation of a variety of non-traditional in-place treatment materials for stabilizing road surfacing materials. The study has provided over 160 miles of test and demonstration sections on more than 60 projects across the U.S. Stabilizer types included three pozzolans, four bioenzymes, two sulphinated oils, an ammonium chloride, two mineral pitches, and two clay fillers. The project final report, "Non-Standard Stabilizers" July, 1992, FHWA-FLP-92-011 is available from the National Technical Information Service, Springfield, VA 22161. A follow-up report on the long term effect of the stabilizers is planned for publication in the fall of 1995.

Aggregate Surfacing Design Method Verification

Field trials verify the aggregate surfacing thickness design method in the Surfacing Thickness Program (STP). Variations in soil type, climate, aspect, and other factors may require modifications for local conditions. Result of this work will be either general modifications or procedures for making adjustments for local conditions. The project final report, "Lowell Surfacing Thickness Design Test Road, Final Report" September, 1994, FHWA-FLP-094-15 and FS EM-7170-15 is available from the National Technical Information Service.

Chunkwood Surfacing

Chunkwood is made by processing whole trees through a machine called a chunker. The resulting wood chunks range from 1 to 4 inches (25 to 100 millimeters) in size, resembling "pit run rock" used in road construction. The chunker was developed for producing wood chunks for biomass power generation and for flakeboard source material. Field trials indicated the material is a suitable substitute for aggregate for low-volume roads in aggregate-short areas. The design method developed for using chunkwood as a replacement for aggregate will be included in the "Earth and Aggregate Surfacing Design

Guide for Low Volume Roads" under development by the USDA Forest Service. The design guide is scheduled to be published in the summer of 1995.

Seasonal Adjustment Factors

This study involves the establishment of reliable seasonal factors/adjustments for the design of asphalt and aggregate surfaced roads using deflection testing. There are three volumes planned. Volume 1 and 2 will review international studies done in this area and analyze the data. Volume 3 will be a user's guide giving pointers on how to use these factors in field situations. All volumes are anticipated to be available in 1995.

Winter Haul Effect on Pavements

A literature study and analysis by the U.S. Army's Cold Regions Research and Experiment Laboratory (CRREL) will form the bulk of this study's look at the effect of heavy loads on pavements in freeze-thaw and continuous freeze situations. CRREL will be using their FROST program to develop several operating scenarios for comparison. Final report anticipated November 1995.

Environmental

Fish Culverts/Fish Passage

A fisheries biologist and a civil engineer wrote a report summarizing existing information on fish passage through culverts. The report contains common sense guidelines on what is needed to design, construct, and maintain an acceptable structure that is capable of fish passage. A 15 minute accompanying video developed to aid in training and meetings to increase awareness and understanding is available from the USDA Forest Service Technology and Development Center, 444 E. Bonita Avenue, San Dimas, CA 91773.

Engineering/Environmental Considerations in Road Design

A video titled *The Road and the Environment* has been produced. This video is intended to be shown at public meetings to set the stage for constructive discussions. It is an introduction to the practical considerations of road-building in an environmentally-sensitive area and is designed to encourage cooperation between all parties. The video has a facilitator's guide included that discusses the purpose and key points. The video is available from the USDA Forest Service Technology and Development Center.

Visual Prioritization Process

This final report is designed to describe and teach the Visual Prioritization Process (VPP). The VPP allows one to inventory and analyze the visual resources of a corridor and to assign priorities to the various segments of that corridor. The VPP can be used for project planning through design, and is intended to be used by all design disciplines including engineers, landscape architects, and planners. The "Visual Prioritization Process User's Manual" July 1994, FHWA-FLP-93-007, is available from the National Technical Information Center.

Surface Drainage/Inslope - Outslope

This project will provide guidance on the various types of roadway drainage devices that are available for low volume roads. Intent is not to be all encompassing, as much of this material exists elsewhere, but rather to act as a checklist for road designers to be certain they are aware of all the available technology. An additional component of this study is to make an assessment of where or when insloping or outsloping of the road surface is the better surface drainage approach. Culvert lining materials for old, deteriorated culverts will also be addressed. Anticipate report being available December 1995.

WEPP (Water Erosion Prediction Project)

This major Department of Agriculture project's goal is to replace the Universal Soil Loss Equation that was developed for agricultural soils and used in forested areas. The WEPP project includes specific field tests and equations for roads in mountainous areas. Some preliminary algorithms, developed at the Forestry Sciences Laboratory, Moscow, ID, are available for testing within the Forest Service.

Environmental Road Initiative

This project will solicit input from field sources on all the good ideas that have been employed to enable transportation facilities to mesh well with the environment. Examples include sediment reduction methods, aesthetic retaining walls and energy dissipators. Intent is to produce a binder that will be periodically updated with material that comes to the attention of the project engineer. Binder to be produced in January 1995.

Users

Getting There and Back

"Access and Travel Management" is a major effort. "Access" refers to the physical facilities or land base used for travel, and "travel management" refers to the control of the users of the National Forests. Decisions in Forest Plans translate into needs for roads into, and through, the forests. Increasingly, recreation users are putting pressure on existing access points, and fostering demand for additional routes.

Road User Information

Demographics on the use of the forest transportation system is the objective of this project.

Vehicle Operating Cost Model

The Forest Service has been using a curves and equations developed in the 1950s to predict haul times of commercial log trucks. These equations form the basis for many of the agency's automated models and this update is being performed to determine what work may be necessary to alter the currently accepted methods. Results are showing that the Byrnes, Nelson and Googins (BNG) analysis performed in the 1950s is still sound. Two current computer truck simulation models are being evaluated against the BNG analysis for comparison related to alignment. Report scheduled for completion 1995.

Engineering/Other

Global Positioning System

This project is a continuing study on application of global positioning (GPS) hardware and methods to surveys, mapping, and locating positions.

Laser Survey Instrument

Work continues on making this portable, hand held laser surveying unit compatible with personal computer road design software. Electronic data recording units have been identified and software has been developed to download directly from the laser surveying instrument to PC design programs. This removes the need for notes taken in the field and dramatically increases the effectiveness of a survey team. Field trials continue across the nation with positive feedback being reported.

Structures

Low Speed Bridge Rail Test

This project involves crash testing of bridge railings on low speed, low-volume roads in order to ascertain whether railing performance standards for bridges on high speed roads are too high for low-volume, low speed roads. These tests will determine the performance of low cost rails attached to timber bridges. Testing should be complete in the summer of 1995.

Demonstration of Wood Bridge Construction

This demonstration project involves the evaluation and testing of improved techniques for building economical wood bridges in conjunction with cities, counties, and states. About 100 wood bridges have been constructed under this program since 1989. As a result of this work, AASHTO has accepted as a design guide the stress laminated wood bridge design criteria which are available from the National Timber Bridge Information Center, Morgantown, WV.

High Performance Level Bridge Rail Tests for Wood Bridges

FHWA and the Forest Service are funding crash tests for bridge railing attached to wood bridges for performance levels I and II (low to medium roads.)

Traffic

Traffic Surveillance and Analysis

A final report will soon be issued that evaluates currently available technology for low volume road traffic surveillance and counting. Report should be available November 1995.

Sign Expert System

This CTIP sponsored project will result in a personal computer (PC) based program using artificial intelligence (AI) software to help make better decisions for road signs. The system queries the user about the site and traffic conditions and rapidly provides written and visual guidance for proper sign installation, maintenance, and management based on published standards. The software chosen for the project did not prove robust enough to perform all of the required tasks. Therefore, the final product is much more limited in scope and usefulness than was originally expected.

Low-Volume Road Signing

A final report for CTIP study H-13 "Evaluation of Traffic Control Devices for Low Volume Roads" was submitted to FHWA in December 1990. The report recommended changes to the MUTCD including the addition of a new class of highway, Special Purpose Roads, as defined by AASHTO. An ITE project also addressed the unique signing needs of low volume roads. The MUTCD is currently being reformatted and a new edition is expected to be published in late 1996. The NCUTCD committee is currently coordinating a separate chapter addressing Low-Volume Roads for inclusion in the 1996 edition of the MUTCD.

Road Traffic Accident Site Investigation Guide

This guide leads Forest Service employees through the accident investigation process by discussing when and where to investigate accidents, including preserving evidence, dispatching the proper investigation team in a timely fashion, interviewing those involved in the accident and witnesses, photographing and videotaping the accidents in the appropriate manner, cooperating with local law enforcement authorities, communicating accident details and causal factors through the Forest Service chain-of-command, preparing for litigation, and facilitating a team approach to road traffic accident site investigation. It presents hypothetical accident scenarios to illustrate potential problems facing investigators.

Monitoring Evolving Technology for Low-Volume Roads

Screen new ideas and use various communication media to convey project results and other technology related news, ideas, and tips to field personnel.

Geotechnical

Develop Slope Stability Analysis Guides

Intermountain Research Station and National Forest System personnel are combining efforts to write a comprehensive slope stability analysis and stabilization guide for forested areas. The three volume guide is coordinated with research and slope stability software programs developed by the Intermountain Station researchers for three levels of analysis for forested areas. The analysis levels are planning, project, and site specific. The guide, "Slope Stability Reference Guide for National Forests in the United States" EM-7170-13, August 1994, is an internal Forest Service Publication with limited distribution.

Geocomposite Drains

This CTIP funded project includes the installation and long term monitoring of geocomposite geotextile drains in the field. The drains will be installed in 1994 and 1995 and their performance monitored for a 5 year period.

Upgrading Retaining Wall Design

The objective is to develop a design guide for low height retaining walls for use on low-volume roads, including geo-textile reinforced walls. The guide will include design procedures, standard details, specifications, and costs. The guide will include designs that can be used directly by non-specialist designer on projects where low retaining walls are required in non-critical conditions. The guide, "Retaining Wall Design Guide" September 1994, FHWA-FLP-94-006 and FS EM-7170-114, will be available from the National Technical Information Center in 1995.

Demonstration of the Soil Nail Launcher

In July and August of 1992 the USDA Forest Service, with financial assistance from the Federal Highway

Administration, facilitated a demonstration in the western United States of launched soil nails for stabilizing failing road shoulders and cutslopes. The project included soil nailing of road shoulders, retaining walls, a cut bank, and a sand bank. The soil nail launcher is capable of rapidly inserting 18 foot long by 1.5 inch diameter steel nails into the ground for reinforcement using high pressure air gun. An "Application Guide for Launched Soil Nails" (FHWA-FPL-93-003 and FS EM 7170-12A, July 1994), and the "Project Report for Launched Soil Nails — 1992 Demonstration Project" (FHWA-FPL-93-004 and FS EM-78170-12B, July 1994(are available from the National Technical Information Service, Springfield, VA 22161. A limited number of the reports and the project video are available from the Forest Service. A second, longer term demonstration of the technology is being planned for 1995 and 1996 in conjunction with the Forest Service and the U.S. Army Corps of Engineers.

Operation and Maintenance

Maintenance Management Systems

This project report evaluates several different computer maintenance programs for low volume roads. Included are the National Park Service and Bureau of Lan Management systems as well as several local variations from the Forest Service. A comparison chart enables managers to select the items that best fit their needs.

Commensurate Share Damage

This project involved the construction of a four section test track in the dry climate of Nevada. Intent is to determine the ratio of roadway deterioration attributable to heavy hauling vehicles, light vehicles and traffic with reduced tire pressures. Results point out that grade and alignment have considerable influence on relative road surface deterioration between heavy and light vehicles. The final report due in December 1994.

In-Place Road Reconditioning

This project will evaluate existing technology for the processing of aggregate materials on the surface of a roadway. One of the more promising pieces of equipment was located in New Brunswick, Canada and is mounted on a front-end loader. Geotechnical testing results and production rates will be included in the final report which is scheduled for completion in November 1995.

Road Closure and Obliteration

Throughout the Forest Service there has been a need to close and obliterate redundant and unneeded roadways. This project will examine the various techniques being employed by the agency and review their successes and failures. Included is an examination of the various treatments from simple closure and seeding to full recontouring of the roadway prism. Guidelines for estimating costs will also be included. Report anticipated in December 1995.

Projects Requested, Not Funded

- Road standards for low-volume roads;
- Field demonstration of soil nail launcher;
- Optimal Maintenance Investments;
- Mobile Rock Crusher Evaluation;
- Support FHWA geotextile durability study;
- Bentonite dispenser for road maintenance;
- Collection of economic data on wood bridges;
- Field performance of geocomposite drains;
- Logging road C&M video;
- Produce national user guide/expert systems:
    - Geotextile use with pavement,
    - Retaining Walls,
    - Drainage structures, and
    - Dust treatments;
- User cost estimator for roads;
- Effects of winter haul on pavement; and
- Stabilizing "boney" road surfaces.

RURAL ROADS IN SUB-SAHARAN AFRICA: POLICY ISSUES AND STRATEGIES

John D.N. Riverson and Jean H. Doyen
The World Bank

INTRODUCTION

The development of road networks and transport in Africa over the past two decades has been vital to economic activity in all countries. At present, the road networks of 47 African countries include about 700,000 kilometers of main roads (37 percent paved), and an equal length of rural feeder roads. Roads connect most productive areas with markets and trade centers, and where business conditions are favorable, road transport services have become available.

Given the large area covered by Africa, the present road length averages only 5 kilometers for every 100 square kilometers, with some variation among sub-regions. Such an average is low compared to other developing regions. For example, Latin America averages 12 kilometers, and Asia averages 18 kilometers for every 100 square kilometers.

The low average road length, the need to provide reliable access to all economically productive areas, and the demand from fast growing populations require selective upgrading and expansion of both the international and national road network.

From 1964-1989, the Bank provided about US $1.7 billion (constant 1988 US$) in loans and credits for 127 projects to construct, rehabilitate or maintain over 160,000 kilometers of rural roads in Sub-Saharan Africa (SSA). The review of these projects, as well as the analysis of the experience of the six countries — Cameroon, Kenya, Malawi, Nigeria, Senegal and Tanzania— provide an adequate basis to recommend several new directions for improved policies and operational strategies.

PLANNING

The importance of rural roads extends to all aspects of the economic and social development of rural communities. As a result, planning for rural roads has been driven by a multiplicity of objectives and institutions with a lack of continuity and a lack of attention to sustainability, and generally poor use of resources. The first and foremost conclusion regarding planning is the necessity for each country to formulate a coherent Rural Road Strategy, including measures to strengthen related capabilities at all levels, i.e., national/central, regions, districts and local communities. Country strategies should recognize the need for close coordination with programs and policies concerning main roads, as well as agricultural development.

Typical approaches used for planning and evaluation of rural road programs have shown systemic shortcomings. They have not paid sufficient attention to maintenance and have not fostered community involvement. The scarcity and poor quality of data on production and traffic have limited the validity of economic return computations based on savings in vehicle operating costs and producer surplus. Moreover, such approaches have tended to neglect increases in personal travel which have characteristically been one of the most striking impacts of rural road improvements.

The experience from several successful rural road programs point out the need to think of rural road planning in terms of a system comprising not only methodology and criteria, but also the process and the procedures through which key constituencies are involved at various levels. This points towards multi-tiered planning and programming systems based on locally acceptable criteria allowing participation of local communities. The method used to assess relative priorities should reflect the determinants of community demand for rural roads; these would normally include: population, area, production, and social, economic and cultural services. It should also include technical information on terrain, materials, hydrology, etc. Further research is needed to guide the design of planning systems for rural roads.

The poor record of SSA countries in rural road maintenance points to the need to establish a consolidated framework for network-based programming and budgeting so that requirements for maintenance and rehabilitation are considered along with construction and improvements. Such fungibility may be politically difficult to accept but it is essential if one considers that earth road improvements have a life span of three to five years. A consolidated framework is further justified by the fact that the tasks and skills involved in maintenance of earth roads are basically the same as those needed for construction.

DESIGN AND TECHNOLOGY

The scarcity of resources, the low traffic volume and the fact that all-year vehicular access is not always essential, indicate that conventionally engineered rural roads are in many instances neither necessary nor possible. This points out the need to design and maintain rural roads in relation to specific levels of serviceability defined in terms of access by specific types of vehicles during various seasons. The prime considerations in defining rural road improvements should be reliability and durability rather than width and speed. This would lead to concentrating expenditure on essential access, spot surface improvements in critical sections (poor subsoil, gradients), on surface drainage and essential structures, rather than on geometric characteristics determined by design speeds.

Considering the lack of income opportunities in many rural areas and the intractable problems inherent in the deployment and operation of mechanical equipment for small scattered works, labor-based methods should be considered as the normal choice for rural road works. Conditions inappropriate for labor-based methods may be found in very sparsely populated areas, and also for specific tasks, e.g., long distance earth movements.

The development of labor-based capability for road works is a long-term undertaking requiring considerable up-front inputs in technical assistance and training. Successful efforts supported by the International Labor Organization (ILO) have typically been sustained over a period of ten years starting with pilot projects and leading to the development of country-wide programs relying on a critical mass of trained engineers, field supervisors, etc. The future development of labor-based capability would benefit greatly from transfer of expertise among Sub-Saharan African countries. It would be useful in this respect to support the preparation by African experts of guidelines concerning the range of application of labor-based methods and the employment of women in such operations.

Problems of supervision, poor motivation of workers and the inherent lack of flexibility of public sector operations, have proven very difficult to overcome in force account work. Contract operation, although not without problems, is generally a preferred alternative. The weakness of domestic contracting capability is a major obstacle. A long term rural road program would provide the opportunity to build up the capability of the domestic construction industry: a policy decision to favor the use of contractors is necessary. Specific measures to facilitate their development and to improve their operation should be part of rural road projects. The experience gained under ongoing rural road projects in Ghana which include training of domestic contractors in the use of labor-based methods should be useful in designing similar programs.

RESOURCE MOBILIZATION

Given the severe lack of resources at the local level, rural road development will continue to require central funding, a large portion of which will be provided from external sources. It is clear, however, that the stepped-up mobilization of local resources is an essential element of improved rural road policies. It is the only way to address the problem of maintenance. Review of World Bank experience offers no ready made solution. Approaches in which local constituencies have been involved in all stages of rural road programs have been more successful in mobilizing local resources. In many instances it will be necessary to undertake measures to build up basic organizational and technical capabilities at the local level. Bank experience in Latin American Countries suggests that once basic institutional capabilities have been established at the central and at the local level, matching fund schemes can be effective in encouraging local resource mobilization, and ensuring the implementation of country-wide policies. Further field investigations and policy analysis will be necessary to evolve suitable approaches to mobilize local resources for rural road maintenance.

The deployment of technical assistance in support of rural road programs has been a source of difficulty. The low unit cost per kilometer and the scattered nature of the work have contributed to high overheads and lack of effectiveness. Except in the case of ILO-sponsored labor-based programs, training has suffered from the lack of continuity and lack of institutional anchor. The aims, objectives and target outputs for technical assistance need to be clearly specified and agreed upon. Training should be undertaken in the perspective of capacity building efforts sustained over sufficient length of time varying from eight to ten years. Results of technical assistance and training need to be routinely monitored. Reliance on local engineers and planners should be encouraged.

SECTORAL ORGANIZATION AND INSTITUTIONAL PERFORMANCE

Institutional problems are endemic to rural road projects. Improvements have been slow. However, a number of principles have emerged from the projects which have been considered successful:

- Rural road units or departments set up in a main roads agency, with an adequate degree of autonomy and separate funding have proven to be effective in launching and implementing rural road programs of national scope.
- Participation of agricultural officers and local communities at the planning stage has led to better sub-project selection and has facilitated subsequent maintenance.
- Steady commitments and simple and well established planning procedures have encouraged participation and resource mobilization at the local level.

Overall, the most effective institutional arrangement is likely to involve a small centralized agency acting as a focal point for policies, overall planning and funding and overseeing regional community organizations responsible for local planning and operations. The latter should be able to raise their own funds, but would receive technical advice and matching funds from the central agency.

TRANSPORT SERVICES

Improvements in transport infrastructure serving rural areas have not necessarily been followed by increased availability and efficiency of transport services for goods, or people. Chronic shortages of fuel resulting from inadequate pricing and marketing policies have affected rural areas most severely. Deficiencies in transport services are often the outcome of inadequate policies concerning pricing and marketing of fuel, tariffs regulation, and para-statal control. More attention should be given to policies affecting the availability and cost of transport services at the local level. These should also deal with intermediate means of transport (i.e., intermediate between head-loading and motorized transport) which are generally underdeveloped.

Programs to improve the productivity of farmers in SSA have, by and large, not focused on transport activities which account for a sizable part of the work involved in agricultural production and household upkeep. The introduction of productivity improvements related to on-farm transport and movements could be considered under (Benor-type T&V) extension programs. Such improvements would rely primarily on the initiative of the farmers either individually or organized in groups; however, they would have to be spurred by advice, demonstration, technical assistance and possibly credit. Improvements would have to be sought through changes in transport technology, especially alternatives to headloading (wheelbarrow, bicycle, animal draft, power tillers, etc.), improvement in off-road infrastructure, and changes in post-harvest practices (processing and storage).

COUNTRY LEVEL ACTION PLANS

In most countries, an action plan will be needed to introduce the policies outlined above. The key elements of such plans would include:

- Preparation of country strategies for rural roads closely coordinated with main road policies and programs, and with agricultural development strategies;
- Development of labor-based contracting capabilities; and
- Review of policies affecting motorized transport services in rural areas and promotion of intermediate means of transport.

ASPECTS OF LOW-VOLUME ROAD RESEARCH IN SOUTH AFRICA

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The Division of Road and Transport Technology of the Council for Scientific and Industrial Research (CSIR) in South Africa has been involved in research and implementation of findings on all aspects of low-volume roads for four decades. It is from this work that the Division has acquired a vast base of knowledge on the unique conditions of the African continent both in terms of the use of materials under different climatic conditions and socioeconomic problems associated with road construction.

The following is a brief outline of the type of work which has already been done and is now being done within the region, both on paved and unpaved low-volume roads along with some examples of each.

UNPAVED ROADS

At the lowest level, techniques are being developed for the provision of acceptable means of communication for the less privileged communities within informal and semi-formal settlements, using, as far as possible, in-situ materials.

Research into unpaved roads constructed with imported gravel wearing courses has resulted in the development of specifications for the optimum use of these gravels, the structural design and maintenance procedures and management systems for unpaved roads. A computer program for the economic optimization of the construction and maintenance of unpaved roads has been developed. Other ongoing research is involved with the protection of unpaved roads against surface erosion, optimum techniques for the palliation of dust and investigations into criteria for the passability of unpaved roads. In order to quantify the dust emissions from unpaved roads an electronic dust monitor has been developed and calibrated with the public acceptability criteria for dustiness.

Maintenance management techniques for unpaved roads have been developed and a computer program to prioritize the management of maintenance of unpaved road networks has been developed. Investigations into the performance and predicted usefulness of proprietary stabilizers and dust palliatives are also being carried out.

A computer program for analyzing economic warrants for upgrading unpaved roads to a sealed standard is also available.

PAVED ROADS

Research into low-volume paved roads is being actively pursued at present. This involves primarily the study of existing roads constructed with light pavement structures and/or marginal materials and low cost surfacings. It is anticipated that this research will result in significant relaxations of current pavement designs and material specifications with concomitant cost savings and the ability to design appropriate and cost-effective roads for very light traffic. Problems with the chemical stabilization of marginal materials are also being investigated.

The application of recent research findings to the rehabilitation of paved roads is currently a high priority.

THE FUTURE

With the rapid urbanization presently occurring, the necessity to provide large lengths of access streets and commuter routes (primarily taxi and bus) is going to increase dramatically. These need to be provided with the following constraints:

- Minimize cost: As much of the funding should remain within the community as possible.
- Optimize social impact: Minimize dustiness during dry season and muddiness during wet season for health and safety reasons.
- Minimize environmental disturbance: Use in-situ and waste materials as far as possible and reduce dustiness to acceptable standards.
- Minimize maintenance.
- Maximize creation of employment: Utilize labor intensive construction and maintenance.

In the rural context it is considered that the existing road networks will, in the main, provide an adequate transportation system but will need to be carefully maintained and rehabilitated at the optimum times to retain their asset value. The quality of these roads must not be allowed to deteriorate to such an extent that the road user costs and safety aspects are detrimentally affected.

Many of the existing unpaved roads in rural areas will, in the next decade, need upgrading to a paved standard in order to retain the maintenance and road user costs at acceptable levels. In addition, the roads in many agricultural areas where dust generation affects the quality of the product may need to be dust-proofed in order to maximize exportable products.

Environmental aspects will need to be investigated further with careful attention being paid to dust generation from roads, borrow pits, construction sites, etc., and the pollution of rivers (and hence sedimentation of dams) through erosion from roads and associated structures.

IMPLEMENTATION OF SECONDARY ROAD MANAGEMENT SYSTEMS IN BELGIUM

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INTRODUCTION

Belgium has a population of ten million inhabitants and an area of thirty thousand square kilometers. Its secondary road network consists of 115,000 kilometers of public roads. Less than 5% are unpaved, and about 26,000 kilometers are made up of cement concrete. If one adds to it the state network which is just over fourteen thousand kilometers, one obtains the highest world road density of 4.2 kilometers per square kilometers of territory.

This network performs the following functions:

- Local access to grounds and housings, residential quarters, agricultural lands, industrial zones (connecting roads);
- Collecting local traffic in order to feed it to the primary road network (collecting roads); and
- Linking villages together and also with principal administrative, industrial, and commercial centers (transit roads).

These roads have been progressively deteriorating owing to a lack of appropriate maintenance. The major effort at country level has been focused until recently on construction and improvement of the primary road network.

MANAGEMENT OF SECONDARY ROADS

The management of the secondary roads is the responsibility of the provincial administrations (for the provincial roads) and the communes or municipalities (for the parish roads and the local unclassified network). The burden of budgetary restrictions induces the need to make use of integrated maintenance and rehabilitation management systems.

Conditions of use by local agencies and features of the systems have been identified. Such systems should enable road managing authorities to assess their networks objectively, to rank road sections according to the severity of distresses, to optimize the short and medium-term programming of maintenance budgets and works (on a period basis of three to six years), by choosing the best available strategy for upgrading actions, to justify the efficiency of investments and most important to estimate the extra cost which would result from failure to carry or to postpone maintenance.

Maintenance in this context includes also activities of rehabilitation (improving on structural conditions, strengthening, and reconstruction). Routine maintenance and local repair action are usually carried out on force account basis: generalized repairs and strengthening are produced by contract. The application of the management systems should therefore also attract the interests of contractors by providing means to identify works and their correlative needs in resources and to market their activities.

Management Systems

Management systems must be simple, flexible, and allow the user to add new criteria to the pre-programmed data base of technical and economic criteria. Such systems should be designed to be applicable to towns, municipalities and non-urban low-volume roads (with levels of traffic of the order of 2000 vehicles per day or less), but should also be of use by private road managers. Management systems must be applicable to both bituminous and cement concrete surfacing.

An elaboration of such a system by the Belgian Road Research Center was based on an intensive sample data collection regarding the nature and the local condition of the Belgian secondary road network. Feedback from three pilot tests was incorporated in configuring the system.

GERSEC

The system, called GERSEC, integrates technical approaches and economical evaluations with a view to optimize the distribution of the available funds at the network level.

The activities developed within the system are the following:

- Overall assessment of the road network;
- Detailed assessment of a part of the network selected by the local agency (visual inspection of the extent of defects and roughness monitoring);
- Interpretation of the results;

- Maintenance and rehabilitation policy proposals for the selected network; and
- Production of work programs and scheduling.

The maintenance and rehabilitation policy proposals for the network include a choice of priorities based on the optimization of cost effectiveness. The benefit considered in the cost-effective evaluation is that of increased residual service life of the pavements. This has been preferred to other types of benefits such as the ones based on user's costs or level of service standard. A study was initiated to compare the results obtained by the GERSEC system with those of applying the World Bank's HDM III model. Basically, both came to the same conclusion.

An alternative system is being evaluated to limit the assessment of road condition only to visual inspection (both extent and severity of defects). The latter will most suitably be applied to the lower traffic level roads and is thought to be a less expensive data collection process. The optimization process used which is derived from a cost-effect matrix maximization is fundamentally different from the one applied in the GERSEC system (which involves optimization of global quality index thresholds).

The application of the GERSEC system is at present performed on a consultancy basis at the intentional request of communes. Legal enforcement of the use of management systems is presently being investigated particularly in view of warranting maintenance subsidies. Fortunately there is a legal obligation now to manage the communal patrimony on a computerized basis. This situation is favorable to the full implementation of road management systems.

SOME THOUGHTS ON RESEARCH AND ENGINEERING OF LOW-VOLUME ROADS

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DEFINITION OF LOW-VOLUME ROADS

From the outset, it would seem useful to point out what is meant by the term "low-volume roads." As far as this discussion is concerned, it refers to a road that supports traffic of less than 50 heavy vehicles per day (trucks carrying a payload of over 5 metric tons or more per day and per direction.) This figure is obviously not a precise limit but is used to give a clearer picture of the roads under discussion, and to indicate that the important definition criterion is the amount of heavy vehicle traffic that a road carries.

Low-volume roads then, although having very different aspects depending on their context, have a number of characteristics in common:

- Extremely contrasting horizontal alignments, which can be either very sinuous or very straight. However, the longitudinal profile keeps very closely to the natural configuration of the land in order to avoid earthworks wherever possible.
- Narrow-width pavements, which are generally not very thick and do not include bound layers. Generally, they are unpaved or covered with a thin bituminous layer: surface dressing or bituminous mixes less than five, or three centimeters thick. They are generally built in the in-situ soils without improving the natural soil bearing capacity. When this type of pavement fails it is generally due to deformations of the subgrade.

All of these characteristics are justified within a general context of funds insufficient to cope with all building and maintenance requirements for the entire road network. Under these conditions, expenditures must be decided according to priorities, with most of the spending on studies and construction being allocated to high-volume roads.

CONSEQUENCES OF LOW-VOLUME ROADS

The consequences of the eventual deterioration of low-volume roads are considered less damaging to the economy in general, even in terms of level of service rendered to the users. Therefore, when planning for low-volume roads a higher risk of failure is permitted than for high-volume pavements, and intervention standards are adopted that allow a higher rate of deterioration and the use of "light construction" techniques, which may even be reduced to mere localized interventions.

Risks of Deterioration

The conditions under which studies and construction are carried out may increase the risks of deterioration, in one or more of the ways listed below.

Uncertainties as to Traffic Volume

Usually very little is spent on traffic counts, and it is not possible to measure small and highly variable numbers (weekly variations, for instance) with a great deal of accuracy. Traffic counts are more liable to error in the 10 to 15 heavy vehicles range than the 500 to 1000 range.

Limited Geological and Geotechnical Surveys

These studies are most often carried out as part of earthworks projects. Low-volume roads generally require little earthwork and, therefore, little is known of the long-term bearing capacity of the soil and how to obtain good performance. Rather, calculations are based on the soil bearing capacity found on the construction site. Yet low-volume pavement means that the natural soil is subjected to greater stress than with high-volume roads where soil is frequently improved or replaced with sounder materials.

General Drainage

Drainage can be difficult to achieve since the road is at natural ground level. Drainage depends on the gradient of the natural relief and existing networks. This could be expected to lead to sophisticated solutions since, in addition to the difficulty of realization, drainage is exceedingly important both for the pavement structure and for the soil bearing capacity. But this is not always the case.

Little Control over the Characteristics of the Construction Materials Used

Local materials, whether bound or not (sand, gravel) can, when correctly extracted and implemented, be perfectly satisfactory and suitable for the circumstances. However these reputedly less "noble" materials, compared to those used for high-volume roads which generally include binders, can sometimes be of insufficient quality. In France, based on detailed experience with "rustic" materials, it was realized that, contrary to past practices, just as much care was required in the preparation and utilization of these materials as for the materials used for high-volume roads. Satisfactory results can be obtained only if these efforts are made.

The maintenance conditions of low-volume roads are extremely variable.

- Sometimes unsuitable techniques are used merely because they are the only readily available within the locality. Sometimes the maintenance agents are insufficiently qualified.
- There are situations where frequent "spot" interventions are necessary. The drainage network is often damaged by natural phenomena, and as this type of road is often highly accessible, the frequent traffic passing over it, causes further damage. Damage can spread very quickly and cause interruptions to traffic.

All of these risks are taken to the detriment of the user, with the government making savings at the user's expense, whose traffic costs are higher on low-volume roads than on the roads of other networks.

Although it is probable that in view of funding difficulties low-volume roads will continue to reflect high traffic costs, how to reduce the risk of serious situations of interruption of traffic, and how to obtain maximum value for money remain important questions.

These questions are all the more important where funds are low. In this context we should note that although the amounts of money involved in providing a lower volume of traffic are lower than for other categories of roads, considerable sums are nevertheless at stake and therefore must be optimized.

SUGGESTED ACTIONS

Seeking to reduce risks of interruption to traffic, and obtain better value for money, two lines of action are suggested:

- Due to the extreme sensitivity of low-volume roads to weather conditions (and their variations), and to the nature of the soils and to the effects of the loads they support, improved performances could be obtained by carrying out far more comprehensive studies than is customary, especially in the field of geotechnics and drainage. In this regard, studies and construction costs for low-volume roads would be higher than for high or very high-volume roads. However, this would lead to a reduction in uncertainties as to the foreseeable performance of this type of road.
- An economic optimum is not solely determined by a trade-off between initial investment and maintenance spending under these conditions. Construction cost inputs should be augmented by realistic investment rates based on average values.

Research is required to determine how such factors as availability and deployment of technology and manpower, for example, affect the economics of investment in low-volume roads.

LOW-VOLUME ROADS IN AUSTRALIA

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Australian Road Research Board

CONTEXT

With a population of about 17 million, over 9 million registered motor vehicles and a land area of 7.7 million square kilometers, Australia is both highly motorized and one of the most sparsely populated countries in the world. With over 60 per cent of the population living in major cities on the coast, it is also a highly urbanized country. Non-urban road travel is characterized by long distances, high speeds and low traffic volumes.

Parts of the primary (National) highway network and a substantial proportion of the secondary (State) highway networks can carry less than 400 vehicles/day. Hence low-volume roads play a very important role in Australian transport, serving not only rural access functions, but also primary and secondary highway functions.

DESIGN

Pavement

Many of the low-volume roads have evolved from earth surfaces, and this road type is still common for the lower volume access roads. Constructed pavements typically comprise 100 to 300 millimeters of unbound granular material, often a local material which may not fully satisfy traditional specification requirements. Depending on traffic volume and road function, a chipped bituminous surface seal may be applied. As well as providing a better running surface for road users, the surface seal also serves to maintain an equilibrium moisture condition within the pavement structure.

For the sealed network, ride quality is generally good and does not have a great influence on vehicle operating costs.

Cross-Section

Carriage way widths for unsealed roads typically range from 5 to 8 meters. The narrower carriageways pertain to very low traffic volumes and little anticipated growth. The wider carriageways are for higher traffic growth situations where future upgrading to a sealed roadway is anticipated.

Sealed roadways typically comprise a 6 meter seal (2 x 3 meter lanes) and 1 meter gravel shoulders. The earlier practice of 5.6 meter seals for less than 300 vehicles/day has largely been abandoned because of excessive seal edge maintenance costs.

Current design policies call for single-lane (3.7 meter) seals if a seal is to be provided on roads carrying less than about 150 vehicles/day. This practice is falling into disfavor, however, because of perceived safety problems, and seal edge and shoulder maintenance costs.

RECENT DEVELOPMENTS

Maintenance Standards

With continued tightening of roads budgets, maintenance funding is coming under greater scrutiny. Asset management reviews have been undertaken at both state and local government levels to develop maintenance and rehabilitation strategies. These reviews have typically indicated that past maintenance standards on many low-volume roads have been higher than is economically warranted. In some instances, previously sealed roads may be converted back to a gravel surface to avoid the cost of maintaining a bituminous seal.

In-Situ Stabilization

The granular resheet (overlay) has been the traditional rehabilitation treatment for Australian unbound granular pavements. However, with increasing cost and, in some regions, scarcity of pavement materials this is becoming a relatively expensive treatment. This has resulted in renewed interest in in-situ recycling by cement stabilization as a rehabilitation and strengthening option.

Seal Widths

Some sealed roads are being converted back to gravel, and many planned extensions to the sealed network are being deferred. However, where seals are applied there is a trend to greater seal width. This has come about from the realization that, in a life-cycle cost sense, the initial seal is relatively cheap but maintenance is expensive. At least for low-volume State Highways, several agencies are now including part-sealing (0.5 m) of shoulders in the seal width. This is based on increased safety, reduced shoulder and seal edge maintenance, and shifting the pavement edge zone which is seasonally weakened by moisture ingress away from the outer wheel path.

Geotextile Reinforced Seals

In the drier regions of Australia, earth formations are structurally adequate to carry low traffic volumes, provided they are kept dry. However, dust is a nuisance in the dry season and roads can become impassable in the wet season. Recent trials have demonstrated that these problems can be overcome with a geotextile reinforced bituminous seal laid directly over clay subgrades. This can be achieved at about 25 per cent of the cost of a conventional unbound granular base and seal.

EMERGING ISSUES

Funding

Most of Australia's low-volume road network is under the control of local government authorities. Funding for these roads comes from three sources: federal government road grants; state government road grants; and local taxes. Current funding levels are not sufficient to maintain the low-volume network in its present condition, but it is becoming accepted that lower condition targets may be more appropriate. The whole question of inter-governmental funding of roads is currently under review and it is likely that, at least at the federal level, road grants to local authorities will be replaced by untied grants. It remains to be seen whether roads are sufficiently high on the local political agendas for road expenditures to be maintained at current levels under such an arrangement.

Community Service Obligations

Low-volume roads in Australia have long been seen as having a social as well as an economic purpose, particularly for sparsely populated rural regions. However, for many of these roads, ongoing maintenance cannot be justified in a strict economic sense. As with Australian rail and telecommunications services, it is now recognized that the road agencies will need to differentiate between the community service obligation and economic objectives for roads, and that different maintenance criteria and funding arrangements may be required to meet these different objectives.

LOW-VOLUME ROADS: PROBLEMS, NEEDS, AND IMPACTS

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ENGINEERING

Materials

In many parts of the world there are large areas where roadbuilding materials which meet standard specifications are in short supply or simply not available at all. There is considerable scope in the construction of low-volume roads for using marginal quality materials or materials which are available in the vicinity of the road. Considerable work has been carried out in this area by the Overseas Unit of TRL (Transport Research Laboratory), and others, who have developed appropriate specifications and methods of use based on empirically derived performance data. There is considerable scope for extending this work to cover a wider range of materials and a wider range of climatic and loading conditions. For example, with increasing tire pressures there is evidence to show that road 'damage' is not properly taken into account using standard methods and more empirical research into the relationship between tire pressures, contact areas and road damage is needed.

Structural Design

Associated with the use of lower standards of materials is the need for suitable structural designs which are commensurate with the specifications derived for the materials themselves.

Maintenance Management

While the problems of managing road maintenance for the primary road networks of developing countries have been well documented and much effort is currently being devoted to improving this, the results of such work are unlikely to be directly applicable to the low-volume roads which comprise the majority of the network. Management techniques will need to be modified for this purpose and there is considerable scope for developing the elements of such a system. For example, it is unlikely that many countries will be able to afford a condition responsive system for the maintenance of the lower classes of road, especially gravel and earth roads, and therefore better predictive models will be required to schedule maintenance activities.

Unpaved Roads

Over eighty percent of roads in developing countries are unpaved and are likely to remain so for the foreseeable future. The trafficability of such roads remains an important area for research, especially in wet areas. Granular material to provide all-weather surfaces is a dwindling natural resource in many countries and techniques for making better use of this resource are needed.

Miscellaneous

Environmental considerations will enforce the inclusion of safety components at the design stage and greater emphasis will have to be placed on engineering modifications to minimize adverse environmental impacts, even for the lowest class of road. For example, the control of dust from unpaved roads is seen as an important issue in some areas.

TRANSPORT PLANNING

Basic Statistics

To assess priorities for planning rural road networks in the poorest developing countries there is a need for more background information concerning how far people live from basic vehicular access, engineered seasonal roads and all-weather roads. The economic benefits of bringing such access 5 kilometers nearer to rural populations are typically two orders of magnitude greater than that of upgrading the same length of earth track to gravel standard. It would be valuable to know how current road programs are directly affecting rural accessibility and whether stated policies are being implemented effectively.

The Use of Transport Demand and Agricultural Supply Elasticities in Road Planning

In the economic appraisal of low-volume roads the most difficult components to estimate are the development benefits associated with generated traffic or induced agricultural production. In the literature, much attention has been given to methods of appraisal but in practice very little work has been done to empirically relate forecasted changes in traffic and agricultural production with changes in transport costs and the relevant elasticities of transport demand and agricultural supply. Various estimates of these elasticities have been calculated for different purposes in the past and they could be usefully employed in this area.

The Opportunity Cost of Labor and Traveling Time

There are many rural road (and bridge) projects where project viability hinges on the value of time. Although this topic is hardly new there are still many uncertainties associated with valuing time in the poorest developing countries. Where new vehicle access is provided the alternative transport modes will usually be very labor intensive (walking or the use of animal transport). Bridge projects which replace drifts impact personal time values by shortening waiting times. The following issues need to be addressed:

1. Seasonality: The demand for labor varies with the agricultural cycle and affects the value of time.
2. The valuation of time spent in different activities (i.e. walking, headloading, riding, and waiting): Intuitively time spent carrying a heavy load should be valued more than that spent walking or waiting. More thought needs to be given to this area.
3. Itinerant traders and self-employed people: In many countries the self-employed often form a substantial part of the traveling public. Because they are traveling on business it is usual to value time at the full wage rate. For this group the standard categorization of working and non-working time is inappropriate.
4. Government servants' time: In many countries, civil service numbers have been expanded as a form of social welfare - hence the wage rate may not be a good proxy for the opportunity cost of labor.

The Use of Tariffs and Fares to Predict Changes in Vehicle Operating Costs

Research shows that there is far more inter-country variability, in vehicle operating costs (VOCs) than is often claimed. Despite the research that has been carried out in this area, VOC modeling is still very weak. Simple ways are needed to ensure that the VOC models chosen for road appraisal, and any additional calibrations applied, produce realistic results. One way of checking VOC model formulations is to compare results with competitive freight tariffs and bus fares. At the Sixth International Low-Volume Roads Conference held in 1991, TRL showed one way of using freight tariffs (from Pakistan) for this purpose. More work in this area is required.

LOW-VOLUME ROADS: PROBLEMS, NEEDS, AND IMPACT STATUS IN CANADA

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Transportation Association of Canada

BACKGROUND

The Canadian Road Network consists of over 800,000 kilometers of roads that serve a population of approximately 26 million. Approximately 610,000 kilometers, or 76 percent, of these roads can be classified as rural local roads that carry low traffic volumes. In addition, 490,000 kilometers of these rural local roads have either earth or gravel surfaces.

In the past, geometric design standards for these types of roads were not specifically addressed in Canada. Both road planners and designers were faced with either using national standards that were developed for a higher classification of roads, which resulted in roads being built at a great cost that was unrelated to their function, or reducing these higher classification standards to meet economic constraints, usually without a logical basis for doing so.

In many instances, the lack of national design standards for these roads and the pressure to reduce costs resulted in agencies developing their own design standards or, in certain instances, in constructing roads without regard for any design standards. This has resulted in the creation of standards that are not compatible with the road function, non-uniformity of standards between jurisdictions, arbitrary selection of standards, and in many cases, an unsafe road.

It was therefore evident that there was a need within the Canadian road system for a set of national geometric design standards that recognized the unique qualities of rural roads with local traffic volume.

In 1983, the Transportation Association of Canada (TAC), a non-profit, non-partisan association of corporate members including federal, provincial, territorial and municipal governments; a wide range of carriers and suppliers of transportation goods and services; and the academic community, approved the establishment of a project steering committee to research and develop a set of geometric design standards for low-volume, rural roads that would be the product of a consensus of the majority of users in Canada.

These standards were incorporated as a separate chapter in the 1986 TAC Manual of Geometric Design Standards for Canadian Roads. The objectives of the project were defined as follows:

- To establish uniform national standards for the classification of low-volume roads to meet the special services requirements of road agencies across Canada;
- To provide standards compatible with the present economic requirements without jeopardizing the safety or effectiveness of the road; and
- To provide standards for road agencies that relate to the type of road function and that will ensure standardization.

DEFINITION

Low-volume roads (LVR) in Canada include rural road systems, roads to or within isolated communities, recreational roads and resource development roads. The maximum ADT presently specified for low-volume roads in Canada is 200. Design speed ranges from 30 kilometers/hour to 100 kilometers/hour. Standards were developed for one lane/one way, one lane/two way, and two way roads. Based on the results of the questionnaire the LVR Subcommittee has recommended:

- Including the object height of 380 millimeters used for determining crest vertical curvature in Chapter H, in addition to the 150 millimeter object height. The lower object height would be used for roads with low maintenance, since low-volume roads are low cost roads. The higher object height, as used for roads with higher volumes, is appropriate for low-volume roads.
- Continuing monitoring research on roadway widths.
- Reviewing the definition of low-volume roads with the goal to increase the ADT to 300 or 400 as the next step.

PROBLEMS AND NEEDS

Because this was the first attempt at developing Canadian Standards for LVR, a LVR Subcommittee within the Geometric Design Technical Standing Committee (which reports to the Infrastructure Council) of the Transportation Association of Canada was formed to:

- Monitor and evaluate current research;
- Form liaisons with organizations/agencies involved in similar LVR activities including the Transportation Research Board, the various road agencies, universities;
- Review, evaluate and recommend changes to Chapter H Low-Volume Roads of the Manual of Geometric Design Standards for Canadian Roads;
- Recommend and undertake approved research projects; and
- Conduct workshops as required.

A large percentage of roads in Canada are low-volume (approximately 76%). A substantial effort went into developing national standards for LVR to minimize the non-uniform treatment of LVR between road jurisdictions. Since the standards were developed utilizing information available prior to 1986, the LVR Subcommittee has had a minimum amount of feedback which would support any observations on their application by road agencies in Canada. In 1991, a questionnaire was distributed to many government agencies, municipalities, consultants to determine the extent of their usage, and any shortfalls in the standards identified through the questionnaire would be addressed in the next Manual update.