Approach Toward Provision of Low-Volume Rural Roads in Emerging Countries: South African Experience

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In developing countries, roads are one of the essential elements for socioeconomic development. However, the provision of roads that compare favorably with First-World standards is prohibitive. A better matching of road provision standards to the nature and volumes of anticipated traffic to maximize return on investment is needed. South Africa has a tertiary road network of 240 000 km, and the demand for upgrading these roads to paved standards far exceeds the available funding. Research undertaken by the South African Department of Transportation has led to a much improved insight of the need for and function of low-volume roads. The criteria for road design and construction in more-developed countries cannot be transferred unmodified to South Africa. Changes in the approach to road design and construction over the last 50 years are considered, and it is concluded that technological advances have led to a "recipe" approach to design. Road design has become more of an art than a science, and a return to sympathetic and innovative design is needed. To assist engineers in making this paradigm shift, the Department of Transportation appointed a multidisciplinary team to produce guidelines for the surfacing of low-volume roads. The holistic approach adopted toward determining appropriate standards is discussed, with special reference to geometric and safety aspects. Rather than concentrating on what must be done to provide a paved road that will support travel at 100 km/hr, consideration should be given to what speed can reasonably be provided for with limited upgrading. The need for technology transfer to familiarize highway professionals with the concepts developed and ways in which future user expectations could be met are also considered.

Roads are one of the essential elements of socioeconomic development in developing countries. They provide the vehicle for government to administer societal needs and to promote the welfare and security of the community. However, in most developing countries the cost of providing roads that comply with First-World standards is prohibitive. What is required is a revised viewpoint toward road provision both in terms of standards and approach toward the construction and maintenance of such roads.

This paper, along with two related papers, addresses the standards issue and introduces a South African Department of Transportation study of appropriate standards for low-traffic-volume rural roads. The paper also discusses a way to provide low-volume roads in emerging countries.

The South African rural (and, to some extent, urban) road network is primarily dirt or gravel; the paved portion is provided mainly for commercial and long distance intercity road travel. During the past 40 to 50 years, this paved part of the network has been constructed to modern, First-World standards. However, there are thousands of kilometers of secondary or distributary roads that have not yet been improved and that have been the subject of political pressure to provide an adequate all-weather surface. With the recent political emancipation of the larger part of the South African population, this demand continues to grow. There is a need for a revised philosophy toward the provision of the socioeconomic role of the South African road network. The authors suggest that this need also pertains to the largest part of the African and South American, as well as perhaps the Indo/Asian, continents.

When extending or improving a road network, the cost or standard of the facility should generally be matched to the benefits expected of the network improvement. However, the standard for road facilities is not consistent because of a distinction between gravel or dirt roads and high-quality paved roads. Therefore, costs and benefits do not always match. There is ongoing work on the paving of existing dirt roads, with decisions being based on financial, economic, and sociopolitical criteria rather than solely economics. There is also concern about a sociopolitical redistribution of benefits necessary in a country emerging from decades of political inequality.

The South African Department of Transportation and the South African Bitumen and Tar Association recently proposed appropriate standards and guidelines for upgrading low-volume roads. These include geometric aspects, drainage, pavement design and materials, choice of surfacing type, construction, maintenance, and the environment. Warrants for the paving of these roads have also been proposed taking into account financial, economic, and sociopolitical criteria.

Characteristics of South African Road Network

The South African rural road network has the great variance in standards and serviceability. The modern element of the network consists of high-standard roads, including eight-lane freeways that carry in excess of 100,000 vehicles per day and have cement and asphalt pavement. There are also hundreds of thousands of kilometers of dirt and gravel roads, some of which carry 2,000 vehicles per day, including a high percentage of buses and heavy freight vehicles.

The rural intercity road network is broadly classified into primary (national), secondary (provincial), and tertiary (regional) roads. Primary roads, which are the interprovincial links for travel between the large cities, total some 20 000 km; secondary roads, which cater primarily to traffic within provinces, total 45 000 km. The majority of these roads have asphalt or concrete surfacing. Tertiary roads total 240 000 km and are almost entirely surfaced with gravel. These are the roads identified for the study of the appropriate standards necessary to permit as much of the network as possible, within limited financial resources, to receive an all-weather surface.

In South Africa, a distinction can be made between tertiary roads in agricultural areas and tertiary roads in rural developing areas. Agricultural roads primarily serve farming communities and are generally in good condition. Roads in rural developing areas are usually in poor condition, mainly because of insufficient funding.

In urban and metropolitan areas, including rural developing areas, estimates indicate that more than 200 000 km of dirt and gravel roads provide access to the poorer section of the community.

The present condition of roads in developing areas is described below.

- Traffic: The traffic volumes on some of these unproclaimed roads, many of which do not have permanent or gravel surfacing, far exceed the established traffic standards for this surfacing.
- Pavement and Surfacing Type: The majority of the lower-order roads and streets are graded and shaped in situ earth; the higher-order roads in rural areas are mainly gravel; and the roads in urban areas are mainly asphalt.
- Stormwater Drainage: There is usually no provision for stormwater in rural roads; unlined side drains are used with only highest-order roads. On urban roads, the majority of lower-order roads have no provision for drainage; unlined side drains are found in the higher-order roads. A few roads are curbed with pipes. The lack of stormwater protection leads to serious deterioration and maintenance needs.
- Maintenance: Maintenance levels and ability range from very low to medium in the case of the highest-order roads.
- Repair Requirements: The percentage of road area requiring repair ranges from about 15 percent on the lowest-order urban to 3 percent on the highest-order urban roads and between 3 and 10 percent on rural roads. Maintenance action required on unpaved roads is mainly regular regrading; a few of the paved roads require resurfacing or rehabilitation.

• Pedestrians: There is generally no sidewalk, with the exception of earth paths along some of the higher-order urban roads. Even there, pedestrians prefer to walk in the street, since the street surface is smoother.

The countrywide total estimate of the extent of these roads is shown in Table 1. There appears to be a major backlog of paved roads in South Africa, primarily for the poorer section of the community.

National organizations and local community leaders in urban and rural areas were surveyed to determine the expectations of road users. The survey was conducted in a broad spectrum and diverse community, and included people and structures that did not have statutory responsibilities at the time of the study. These organizations included political parties, church groups, civic associations, organized negotiations forums, transport associations, traditional leaders, consumer organizations and other similar groups (*1*). Poorer sections of the community usually do not consider issues such as affordability and sustainability; their expectations often exceed what is financially possible in the short term. These expectations are shown in Table 2.

There is pressure to upgrade all categories of roads in rural developing areas. However, current lack of available funds in South Africa do not support these proposals for improvement. All justified proposals must be considered and the highest priorities identified. More roads could be improved if funds become available from international sources; however, the ability to repay the loans must be considered. The situation could also change if the new government adopts a different policy than the previous "user pays" principle for all public expenditure or allocates a higher proportion of available state funds to roads. Without a change in government funding, it is unlikely that even the reasonable expectations can be met in the short term. Therefore, serious attention has been given to a reduction in standards.

Socioeconomic Road Needs: A Return to "Getting Out of the Mud" Approach

Tertiary road networks in urban and rural developing areas consist largely of unpaved roads that are in poor condition. Many of these roads, which generally carry low traffic volumes, were never properly constructed. As the traffic on dirt tracks has increased, the frequency of blading increased and occasional "forming" or "shaping" of the road was carried out to raise the road prism. Drainage has been severely neglected in these improvement schemes. With a rapid growth in car ownership during recent years, traffic on these roads has dramatically increased. The general shortage of funds has led to a need to revise the approach toward providing an adequate paved surface.

Economic revival heads the list of national priorities in the new South Africa. Economic progress will lead to the stability and growth so desperately needed to address South Africa's greatest challenge: the fight against poverty.

The lack of financing for roads, coupled with increased welfare spending, reveals that decision makers are short-sighted about the crucial relationship between physical infrastructure and successful, long-term development in the areas—housing, health, and education—where positive reallocation has occurred. Residents of townships, informal urban settlements, and rural areas feel that neglected roads appreciably diminish their quality of life and economic well-being.

These considerations become pertinent when an objective assessment is made of South Africa's road funding resources. Current funds available for construction of the primary (national) road network include only two-thirds of the 1993 amount (in real terms), and the position is not likely to change substantially in the near future. The comparison holds true for other classes of roads. The disparity between the shrinking funds and growing needs requires that the question of how road engineers can build more paved roads with limited funds be addressed. This paper and the study described address that very question.

Road and pavement materials make up a significant proportion of road costs. Interestingly, roads constructed during the fifties and sixties seem to have had better performance records than current roads. This may be because more attention was devoted to moisture conditions in pavements in the early days. Old roads that have been reconstructed for geometric reasons fre-

TABLE 1 Extent of Lower-Order Roads in South Africa

	Lengths of existing roads		
	Access roads and tracks	Access Collector	Local Distributor
Urban developing areas	30 000 km	2 500 km	3 500 km
Rural developing areas	135 000 km	25 000 km	60 000 km

TABLE 2 Expectations of Road Users

Developing area	Road category	Expectations
Urbanising areas	Access roads to serviced or unserviced sites	All streets formed, at least with a dust-free gravel surfacing but ideally a permanent paved surfacing to minimum width, with provision for stormwater, regular maintenance, and provision for later upgrading.
	Collectors and distributors	All collectors and distributors with permanent paved surfacing of standard width, kerbed with stormwater drainage, street lighting, and regular maintenance.
Rural settlements	Access roads to individual sites	Individual access roads bladed periodically; group access roads with gravel surfacing.
	Access to settlements; collectors and distributors	Gravel or permanently paved surfacing of standard width, provision for stormwater, and regular maintenance.

quently perform far worse, from a pavement viewpoint, after reconstruction. Was there some "bedding down" effect that these pavements possessed? Or was more attention paid to the finer points of pavement design and construction by the older engineers who had no knowledge of, or appreciation for, subjects such as multilayer elastic and visco analyses using closed-form solutions and finite-element idealization?

Research that has been undertaken by the Department of Transportation has led to improved insight into the functions that roads fill in a country such as South Africa, with its dichotomy between a sophisticated and spatially dispersed First-World economy and a mostly poor population that is growing rapidly. The imperatives and criteria that shape road design and construction in the more developed countries cannot be transferred without modification to this country. A reassessment of the approach to road design and construction is essential.

For the immediate future, a return to the "getting out of the mud" approach, which characterized the early days of the road program in South Africa, is appropriate and necessary. The primary road network, which is essential to the economic health and wealth generation of the country, should not be neglected. However, sociopolitical considerations have made it imperative that a strongly focused effort be made to meet the needs and expectations of large sectors of the South African population, whose daily life is affected by the poor accessibility associated with inadequate roads. It is essential to get these people out of the mud through a revised approach to road design, construction, and standards.

Philosophical Viewpoint on Road Design and Standards in Africa

The design of a road should embrace all the functions that affect the design. Particularly in developing countries, the design should consider the environment where decisions are made, including the influence of political, social, and economic realities, as well as what specific guidance is provided on engineering issues. Design standards must not be applied rigidly. For example, design speeds should not be rigidly applied, but should take into account the speeds that can reasonably be attained in the circumstances prevailing.

To a large extent, the development of road engineering during the rapid expansion of the South African rural paved road network was led by researchers and practitioners with vision, ingenuity, and a spirit of inventiveness. Because of the rapid developments that were taking place in road and pavement construction, road engineers were often required to use initiative to solve problems that they encountered. This initiative was based on an intimate knowledge of, and feeling for, the earth sciences and geotechnical processes combined with a background knowledge of road performance concepts, especially the capabilities and characteristics of construction equipment. A great deal of field experimentation was also used. Road engineering in those days was more of an art than a science.

Unfortunately, during the last 15 to 20 years, there have been severe cutbacks in road funding. It has become impossible to adequately maintain and regularly upgrade the South African road network to meet the

demands imposed on it. Road engineers have had to maintain the existing network and have not been exposed to the judicious use of available plant and materials to "fashion" a road.

Additionally, developments in road and pavement design and rehabilitation procedures, as well as computer-aided design, have led to "recipe" or "cookbook" approaches to pavement design. Only a few practitioners with a thorough understanding of the abilities and deficiencies of road and pavement design theories and procedures are able to properly use the recipes to achieve an appropriate design. Too many practitioners of the art of road and pavement engineering blindly follow the recipes without a proper appreciation of the limitations of the procedures. They are often unduly influenced by the output of computer programs that do not account for the full implications of the variability in criteria and design philosophies involved.

The design of roads is an art, and the mere application of procedures and standards will lead to stilted and unsympathetic road alignments and geometric designs. It is possible to see an artist's touch in a road alignment or bridge design. It is also possible to see judicious use of the available materials and use of an understanding of the geotechnical processes in a specific area. This demonstrates a feeling for road materials and pavement design.

There are not enough current examples paralleling the achievements of road engineers of the past. Previous engineers displayed a sympathetic understanding of the geological and geomorphological processes in an area and the courage to be innovative. This insight enabled them to mold pavements out of available materials that did not at all conform to the specified recipes or criteria.

The optimal use of the road network is a field that has received little attention in the past. Because of the informal and often haphazard way that tertiary roads came into existence, tertiary road networks are frequently not optimal with regard to upgrading costs, maintenance costs, and road user costs. Network optimization techniques, which are aimed at determining an optimum road network in terms of parameters relevant to the particular situation, should be encouraged. These parameters can include

- Socioeconomic benefits,
- Use of existing infrastructure,
- Location of geological formations suitable for road construction,
- Drainage patterns,
- Topography,
- Road user costs and benefits,
- Maintenance benefits, and
- Upgrading costs.

Optimizing road networks should also not be performed in isolation; it should consider the broad development objectives of the area, which generally strive to support the strengths and weaknesses of the area in terms of developmental status, mobility, and economic well-being.

The Approach

Funds are not likely to be increased in the near future. Therefore, it is essential that more "art" and less "science" be applied to road engineering. The approach to highway engineering in South Africa must be more closely related to a practical understanding of the needs of society and the processes involved in road performance, as well as the capabilities of the construction methods. Road engineering includes the art of doing what anyone else can do, at half of the cost. Road engineers must achieve a road structure that is an appropriate compromise between quality and cost, especially in the challenging socioeconomic environment.

To help engineers make this paradigm shift away from the First-World standards to an approach that would improve accessibility at the grass-roots level, the Department of Transportation appointed a multidisciplinary team to produce guidelines for the surfacing of low-volume roads. The team included specialists in road geometry; road safety; road drainage, especially low-level bridges; pavement engineering; road maintenance; and road construction. Two senior roads engineers provided additional assistance.

The project team also obtained input through regular meetings with officials from the 11 Roads Departments in southern Africa. The team first developed a comprehensive discussion document titled *Towards Appropriate Standards for Rural Roads* (2). The results of the latest local and international research and practice were incorporated. Using this document as the basis, guidelines for the upgrading of low-volume roads (3) were produced.

The most important difference between these two documents is the point of departure. In setting standards, the first is usually guided by the chosen design speed and traffic loading. However, in the second document, the optimal use of the existing road or track was considered to be the departure point.

There is a change in attitude from what must be done to provide a paved road on which one can travel at 100 km/hr (general rural speed limit in South Africa) to what speed can reasonably be provided for on the facility with limited upgrading. The emphasis is on providing a paved road that will serve the existing road users with an all-weather facility at virtually the same speed as the gravel or dirt road.

Poor geometric elements must be improved if this is to be cost-effective. The following items require special attention:

- Provision of stopping sight distance at the operating speed of a section of road,
- Poor location of intersections,
- Abrupt changes in operating speed necessitated by geometric restrictions, and
- Areas of considerable pedestrian activity.

To upgrade a rural road to a paved standard, an estimate of the attracted traffic should always be made. Any attraction rate greater than 20 percent should be studied carefully to determine the origins and destinations of this attracted traffic. Whether the route will be considered (and used) as a through route by traffic strange to the local conditions on the road can be determined.

A low-volume road that largely serves local users would not likely experience an increase in traffic collisions. However, an appreciable increase in the amount of through traffic may lead to more collisions.

The guidelines for the surfacing of low-volume roads should therefore only be used for local access roads. They should be avoided if the road may be used as a through route. For a through route, providing a facility with a uniform operating speed would be more appropriate.

Road Design, Geometrics, and Safety Aspects

Many low-volume gravel roads have been upgraded to levels where they could be effectively paved at low cost. Usually, the alignment of these roads does not need to undergo major changes, and provision need only be made for reducing unsafe situations, providing adequate drainage, and providing an adequate pavement structure for carrying expected loads over its design life. The emphasis is on the optimum use of existing road prism and in situ strength.

Although guidelines are given on appropriate standards, these should be discussed with the local communities to ensure acceptance. Funds for road maintenance are generally limited, so care should also be taken to ensure that the surfacing option will not increase the maintenance burden.

Before upgrading a road, a general assessment of the existing road is required to establish the condition and the extent of upgrading required. The general assessment is made by considering the following aspects of the road and its surrounding environment.

History of the Road

The history of the existing gravel road can be used to determine the extent of structural and geometric upgrading that will be required when the road is paved. If the road has been in use for many years and performs well structurally, and accident black spots have been progressively eliminated, then it is likely to perform well as a paved road.

Geology, Terrain, and Climate

A limited geological investigation will answer questions about the subgrade conditions, such as Does the road traverse decomposed basic rock (black turf), more stable subgrade, or both? Is the overburden deep or shallow?

Traffic

Along with the normal requirements for traffic data, the possibility of attracted traffic and of industrial traffic using the road (such as quarries and cement works) should be considered.

Drainage

The drainage structure of the road affects the life of the road. A detailed investigation should be made regarding the adequacy of surface drainage (standing pools due to rutting, etc.), table drains (longitudinal drains), miter drains, and culverts.

Geometry and Alignment

The geometry and alignment of the road must be analyzed with respect to their suitability for the traffic projected for the design period of the paved road. Consideration should be given to the cost implications of geometric upgrading. As a general rule, geometric improvements are not justified simply because the road is being paved. The analysis should consider the existing cross section of the road; intersections (position and safety, merging lanes); passing lanes, depending on traffic; necessity for surfacing part of the wearing course to act as shoulders or part of shoulders; minor horizontal and vertical alignment changes that may be required, as well as inadequate superelevation; and the existing standard of the road or sections from a safety point of view. The involvement of the community served by the road

in the selection of appropriate geometric standards is very important.

Source of Materials

The source and availability of surfacing and base course material and the cost implications (e.g., crusher run versus natural gravels) should be considered. Generally speaking, the upgrading of the geometric elements of a road is very costly. The geometrics of a road should be upgraded at minimal cost whenever possible. When necessary, the geometrics of the existing road should be accepted, and the road user informed of the possible dangers on the road and safe operating speeds by means of the relevant road signs. The following situations, however, may require improvements to the geometry of a road:

- If obvious reductions in construction costs can be achieved,
- If minor and low cost improvements may have significant safety benefits,
- If the road alignment obviously does not serve the adjacent land uses optimally, and
- If hidden situations, requiring a low operating speed, exist.

Design Year Traffic

The design year traffic, usually measured in equivalent vehicle units (EVUs) per day, is determined by applying an annual growth rate for the design period of 10 years to the present daily traffic. The growth rate has to be carefully estimated, since it can vary between 3 percent a year in the more developed areas to 8 percent a year in the developing areas. Car ownership is rising rapidly in the developing areas, and the resulting increase in mobility should be considered in selecting a growth rate. If appropriate, the traffic that may be attracted to the upgraded road should be estimated and added to the present daily traffic before applying the growth rate.

Road Cross Section

Figure 1 shows several cross sections, with an indication of the design year traffic volume warrants. The width of the existing road is the most important factor in selecting a cross-section type. For any appreciable amount of design year traffic (for example, 150 EVUs or more per day) cross-section type 5, with a paved width of 6.0 m, is the minimum that should be provided. At smaller paved widths, the wear on the edge of the paving will be severe, requiring excessive maintenance.

If the road has a curving alignment with relatively sharp curves and carries an appreciable amount of large heavy vehicles or buses, cross-section type 5 should be used with care. The amount of widening required around curves could be extensive, and cross-section type 4 may be more economical.

The implementation of paved single-lane roads should be limited to situations where the design year traffic is less than 150 EVUs per day, where the terrain provides good visibility to the road user, and where the maintainability of the shoulders, especially with respect to drop-offs, can be assured.

Paving Shoulders

Although paved shoulders are highly desirable, they result in increased construction costs, which lead to a shorter length of paved road that could be provided with a given construction budget. Shoulders should therefore be paved only if warranted by special circumstances, (e.g., suitable gravel not available, high erosion potential, or low maintenance capability).

Road Signs

Reasonable facilities should be provided at the minimum construction cost. The road user is expected to adapt his operating speed to suit the facility. The road user should always be advised by road signs of the safe speed on the various segments of the road. Care must be taken not to surprise the driver with a dangerous situation that is totally unexpected, since a road sign may be obscured, stolen, or missing.

Design standards must take into account environmental road conditions, traffic characteristics, and driver behavior. The selection of design standards is related to road function, volume of traffic, and terrain; additional procedures are needed for the recognition and appropriate treatment of potential hazards. Drivers should receive clues about the standard of the road from local surrounding features such as terrain, levels and types of flow, and geometric elements. Additional design consideration or special signing is necessary if the information available to the driver may lead to incorrect interpretation and consequent danger.

Pedestrian Facilities

Pedestrian fatalities constitute 50 percent of the total road fatalities in South Africa and 40 percent of all pe-

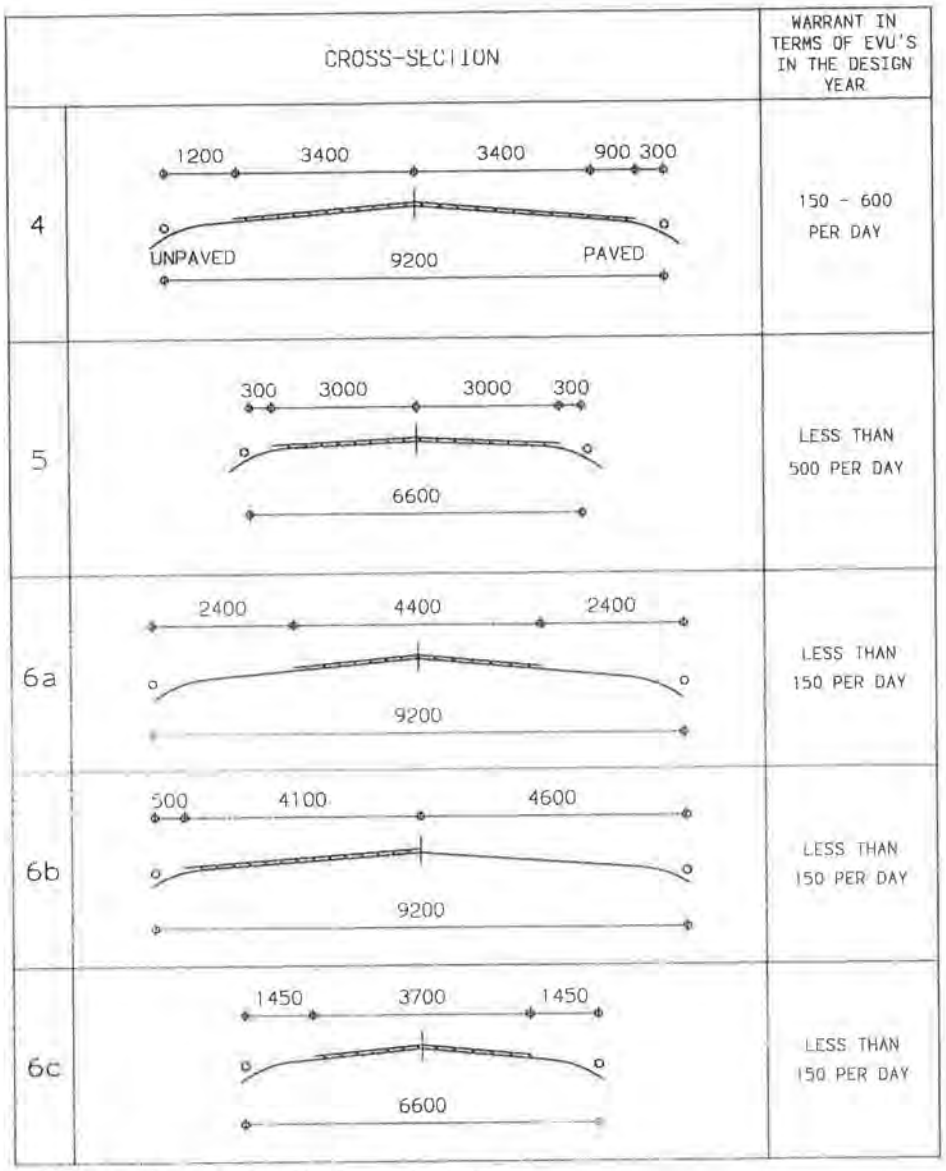

FIGURE 1 Cross sections for low-volume roads.

destrian fatalities occur on rural roads. The severity of injuries is higher on rural roads; the ratio of slightly injured to seriously injured to fatally injured is 1:1:1 on rural roads compared with 6:3:1 on urban roads.

Cost-effective ways of segregating pedestrian traffic must be considered at the earliest stage in the road design process. The local community should be involved and could assist in the construction of walkways in areas where they are warranted.

Usually no provision is made for pedestrians and pedal cyclists along rural roads. Pedestrians are dependent on the road shoulder when walking to a bus stop or from one place to another. Footways with a minimum width of 1 m in rural areas and 1.5 m in periurban areas should be considered. Footways in rolling or mountainous terrain through cuttings and fills may be situated adjacent to the roadway.

When footways are not warranted but large numbers of pedestrians walk alongside the road, the shoulder should be upgraded for them. The minimum width of these shoulders should be 2 m, and shoulders should be compacted and graded regularly.

Legal Aspects

The position of the road authority in South Africa is not always clear and is subject to interpretation by the courts. In broad terms, the road authority responsible for the construction of roads will not be liable for any

damages suffered by a user of the road unless such damage is caused by wrongful conduct of such authority. A road user who wishes to file a claim against the relevant authority must prove that either intention or negligence on the part of the authority actually caused the damages suffered. In determining liability, all the particular circumstances of the relevant case must be investigated to determine whether the fixing of minimum standards by the authority constituted wrongful conduct or were merely actually inadequate. The damage caused by the occasion should have been reasonably foreseeable by the authority when it fixed the standards; if it is not, liability is excluded.

In South Africa, if the investigation determines that the road authority, intentionally or negligently, created or allowed a dangerous situation to develop that caused harm to others, the road authority will be held liable.

Technology Transfer

In many developed countries, systems for technology transfer are firmly in place. Commonly, a professional engineer must attend a certain number of short courses annually for continued registration. In most developing countries, this is not the case. Furthermore, there is a great scarcity of suitable short courses for practising highway engineers.

In South Africa, with its dualistic developed and developing society, some short courses are available. However, these courses are a result of the activities of professional societies and are, for financial reasons, held only in the major centers. Each of the estimated 1,000 engineers active in highway engineering probably attend fewer than one short course per year. Geographic limitations mean that numerous engineers probably do not even attend one course per year.

In response to this situation, the Department of Transportation has embarked on a major technology transfer exercise to disseminate the approach propagated for the paving of low-volume roads. Six two-day workshops were held at various locations throughout South Africa. Approximately 270 delegates attended these workshops.

The aim of the workshops was twofold:

1. To introduce roads engineers to the concept of maximizing the use of the existing facility, even at the expense of operating speed, and
2. To obtain feedback from the delegates on improving guidelines.

The reorientation of roads engineers away from the traditional design-speed approach was met with some resistance. South Africa has an unacceptable road safety record. Some delegates felt that the approach propagated would increase road collisions. However, most people agreed that as long as only local access roads are treated in this way, the road safety situation may improve.

Achieving feedback from practising engineers was effective, and numerous practical hints, local practices, and comments were received. These are being consolidated, and revised guidelines will be prepared.

Conclusion

This paper has a twofold purpose. First, as the initial paper in a series of three papers, it introduces the results of a South African Department of Transportation study of appropriate standards for rural roads with the aim of improving the cost efficiency of the provision of these roads. Second, and perhaps more important, it suggests a philosophy toward the provision of paved roads in underdeveloped countries, with particular reference to Africa and South Africa.

The standard stereotyped approach to road design and construction is not appropriate to developing countries, which have vast needs and inadequate resources. This inadequacy of resources does not only apply to finance, but also includes personnel and organizational resources. It is essential that, in addition to developing design philosophies and approaches to road provision in these regions, attention also be given to improving the road management structure. Roads are important national assets for emerging and developing countries and must be well managed to produce value for money. They are currently poorly managed, badly maintained, and grossly underfunded (*4*).

This lack of adequate management is reflected in inadequate organizational structures, the shortage of qualified technical staff, and poor-quality road maintenance. In addition to inadequate and generally unenforceable road pricing approaches, traffic rules and regulations are often not well enforced, high accident rates prevail, and there is a growing concern about the environmental damage caused by road traffic and construction.

Clearly, efforts to improve the efficiency of the total road network must go beyond the mere provision of appropriate standards for upgrading these roads to encompass all activities involved in road network administration. The required reforms range from fundamental ones involving changes in legislation to process reforms that are applicable to road provision and operational aspects. There is also a need for organizational and capacity enhancement efforts in these countries, to enable road agencies to acquire and retain adequately qualified technical staff. However, to ensure successful implemen-

tation, the reforms cannot be imposed from outside. They must be home grown and take account of the sociopolitical and institutional context in each country. For this reason, guidance in Africa is more appropriately provided by the more advanced African countries, such as South Africa, rather than Western countries that are generally not familiar with the sociopolitical and sociotechnical environment in this region of the world. The process of reform is just as important as the substance of the reform if sustainable improvements are to be attained.

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REFERENCES

1. Dehlen, G. L., and A. P. van der Reis. The Adequacy and Needs of Road Infrastructure Serving Poorer Communities. *Proc., 6th Conference on Asphalt Pavement in Southern Africa*, Cape Town, South Africa, Oct. 1994.
2. Van Zyl, G. D., P. W. Jordaan, et al. *Towards Appropriate Standards for Rural Roads: Discussion Document.* Report RR 92/466/1. Department of Transportation, Pretoria, South Africa, 1993.
3. Van Zyl, G. D., P. W. Jordaan, et al. *Guidelines for Upgrading of Low Volume Roads.* Report RR 92/466/2. Department of Transportation, Pretoria, South Africa, 1993.
4. Heggie, I. G. Strengthening Management and Financing of Roads in Sub-Saharan Africa. *Proc., XII Congress of I.R.F., Madrid, Spain, May 1993.*