County Maintenance of Unpaved Roads in Indiana

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ABSTRACT

Unpaved roads still form a substantial proportion of the county road network in Indiana and most of the United States. A survey of maintenance practice on such roads by the Purdue University Highway Extension and Research Project for Indiana Counties and Cities shows the existing diversity in maintenance activities, standards, methods, and practices. Faced with the problem of inadequate funds, most highway departments have adopted methods of providing the barest maintenance, and little attempt is made to adopt available guidelines. Clearly, there is a need for uniform practices among counties. In addition, suitable guidelines should be adopted. Such guidelines will enable decisions to be made about project priorities, deferment of major maintenance, paving gravel roads, level and type of maintenance, appropriate abandonment criteria, and levels of expenditure. The suggestions are made that available research material provides a good basis for the development of such guidelines and that suitable maintenance management systems can be implemented successfully in various counties and local areas to provide for any special needs of unpaved roads.

Unpaved roads are an essential part of the existing road network in many states. Though they do not usually form a part of the state highway network, they represent a substantial percentage of the highway network of many counties, cities, and townships. In Indiana 41 percent of the county road mileage is unpaved (1). The Indiana Department of Highways is currently implementing a maintenance management system for state highways. However, maintenance practice in the counties is the responsibility of each county. The standard of maintenance differs among counties. The importance accorded to unpaved roads in the management of each county's system of roads, especially for maintenance, also varies among counties.

A number of counties in other states (2,3) either have implemented or are preparing maintenance management systems. However, the emphasis appears, at least for the moment, to be on paved road networks only. Extensive work on unpaved roads has been undertaken within the Forest Service in the United States and also in various other countries (4,5). In addition, the Transportation Research Board, the Organization for Economic Cooperation and Development (OECD), and the Overseas Unit of the Transport and Road Research Laboratory, United Kingdom, among others, have produced useful documents aimed at assisting in the maintenance of roads, paved or unpaved, in both developed and developing countries (6-8). The Action Series prepared by the National Association of County Engineers included a recommendation for a maintenance management system to be used in counties (9). However, it is not clear how readily such a system or the ideas from the other documents are being adopted and used by various counties in the United States.

The results of a survey of counties in Indiana by the Highway Extension and Research Project for Indiana Counties and Cities (HERPICC), School of Civil Engineering, Purdue University, to ascertain current maintenance practices especially for unpaved or gravel roads are presented. The knowledge gained from this survey will be used in designing a suitable maintenance management system inclusive of the special requirements of unpaved roads for Indiana counties.

SURVEY

A survey questionnaire was mailed to all 92 counties in Indiana. Completed questionnaires were received from 50 counties, representing a sample return of about 54 percent. The survey itself covered various aspects of unpaved road maintenance practice, including the following specific topics: data collection on road condition, traffic volumes, and accidents; equipment use, maintenance, and costs; maintenance personnel assigned to unpaved roads; planning and execution of routine maintenance activities; regraveling or addition of material and surface upgrading or paving; maintenance guidelines or management system used; problems and critical needs of unpaved roads in maintenance; and the pros and cons of abandoning or reducing the road network responsibility of counties faced with decreasing funds and increased network responsibility.

The term "unpaved roads," in this context, means roads that are normally not paved with asphaltic concrete or portland cement concrete or that are surface treated with an asphalt surface treatment. The general term "gravel road" is also used to describe such roads. The results of the analysis of the data obtained are presented in the following sections.

DISTRIBUTION OF UNPAVED ROADS IN THE COUNTIES

Of a total of about 68,297 miles (109 958 km) of roads maintained by the 92 counties in Indiana, about 2 percent are unimproved, 39 percent are gravel or stone, and the remainder are paved (1). The distribution of unpaved roads varies among counties. Fifty-three counties have more than 40 percent of their network unpaved. Fifty-nine counties have 200 miles or more to maintain and two counties list no unpaved roads in their network. In only four of those counties with fewer than 200 miles of unpaved roads do such roads represent more than 40 percent of the network. Table 1 gives the distribution of unpaved roads in counties.

In an attempt to understand the current pattern of unpaved road distribution, simple regressions were run between the percentage of the mileage unpaved in each county and the total unpaved road mileage and various population factors. The characteristics of the related variables are summarized in Table 2. The percentage of unpaved roads in any county appears to be significantly affected by the population (rural or total) as well as by the percentage of the population that is rural. The proportion of unpaved roads tends to decrease with an in-

TABLE 1 Distribution of Unpaved County Roads

Percent Unpaved	Number of Counties with Total Mileage Unpaved				Total
	Less than 100	100-200	200-500	More than 500	
Less than 40%	12	17	10	--	39
More than 40%	--	4	36	13	53
Total	12	21	46	13	92

TABLE 2 Factors Affecting Unpaved Roads—Some Regression Relationships

Dependent Variable	Independent Variable	Relationship (Significance F-test)
Total Unpaved Road Mileage	Total Rural Population	Not Significant at < 10%
	Total County Population	Significant at < 10%
	Percent Rural Population	Not Significant at < 10%
	Total Mileage of County Roads	Significant at < 1%
Percent Unpaved	Total Rural Population	Significant at 0.1%
	Total County Population	✓ ✓ 0.1%
	Percent Rural Population	✓ ✓ 0.5%

crease in the population (rural or total), and it increases as the percentage of total county population that is rural increases. Total mileage is also significantly affected by total population. The linear correlation coefficients were, however, all less than 40 percent signifying that relationships other than linear ones may exist between the variables. Further analysis will be required to determine the true form of the relationships but this is beyond the scope of this paper.

In the absence of specific traffic volume data from the counties, no regressions were run with traffic volume as a variable. However, as a proxy for vehicle ownership levels, population provides a close approximation of the levels of vehicle use. This further endorses the previous relationships showing an increase in total mileage with vehicle use and a decrease of the proportion of unpaved roads. It also appears from the results that counties with generally higher percentages of unpaved roads and rural populations would obtain greater benefits from guidelines aimed at improving the maintenance of unpaved roads.

CONDITION INVENTORY, TRAFFIC VOLUME, AND ACCIDENT DATA COLLECTION

The survey indicates that county highway departments seldom collect, on a continuous basis, data on road condition, traffic volume, and accidents for planning and determining priorities for road maintenance and upgrading. The Indiana Department of Highways prepares one major inventory report for all counties but the updating of this report is slow and inconsistent among counties. Thirty-eight percent of the counties responding indicated that they collect some form of traffic volume data. Nine of the 19 that do so collect the data only when needed--often for proposed improvement projects and sometimes only at the request of the commissioner. The frequency of counts varies from once a year or less to every 5 or more years. Counts are usually not made for gravel roads. The main reason given by counties that do not undertake traffic counts is the lack of equipment, staff, and funds. In two cases, traffic counts were not considered necessary because mere observation of patterns and a knowledge of the area were sufficient, in their experience, for making decisions.

Only 16 percent of the counties indicated that they maintained accident reports or kept abreast of accident records in the sheriff's department and used them as needed. Two-thirds of the counties were aware of the records at the sheriff's department but not all counties had used them.

About 36 percent of the sample indicated that they keep regular information on road condition. Seven counties mentioned that they use some form of rating system to differentiate among road conditions.

TYPICAL MAINTENANCE ACTIVITIES ON GRAVEL ROADS

Typical routine maintenance activities reported as undertaken on gravel roads are given in Table 3. In any year every activity would not necessarily be undertaken on every road; activities are undertaken as needed and as funds permit. In any case, maintenance requirements for gravel roads, usually less traveled, may sometimes be considered secondary to those for paved roads that usually carry higher traffic volumes. The smaller funds normally available to county highway departments often enable them to perform only the most basic maintenance activities required, especially on gravel roads. The extent to which this is done varies from county to county.

Inspection

Apart from one major inspection usually undertaken in the spring covering all roads in the county, opportunity is given to grader operators (assigned to certain gravel roads) and to a smaller extent to foremen and supervisors to provide reports, often verbal, on the changing condition of gravel roads throughout the year.

TABLE 3 Maintenance Activities on Unpaved Roads

Activity	Frequency
Inspection	Once in Spring or during the year.
Dragging or Grading Aggregate Roads.	Whenever required and after rains. Varies with road condition - e.g. Traffic Volume. Grader or Maintainer used.
Brushing/Spraying	As Needed (Not Necessarily Annually.)
Mowing	As Needed (Mostly by adjacent farmers.)
Culvert Maintenance and Replacement	As Needed (Over 4 or 6 ft. by Contract in some Counties.)
Side Ditching	As Needed using grader/gradall.
Bridge Inspection	Every 4 years as part of National Bridge Inspection.
Dust Control (Please specify the method used.)	As Needed. Payment by Residents.
Patching/Adding Gravel Material	Usually during Spring Thaw and as needed after thaw.
Sign Maintenance or Replacement.	As Needed
Snow Removal/Plowing	As Needed-priority to School Bus routes.

Grading and Dragging

Grading is the one basic maintenance activity on gravel roads that is undertaken throughout the year. One pass of the grader is usually considered sufficient though in some cases two or more passes may be undertaken depending on the road condition or the level of service determined for the road. However, the frequency in most counties is governed by that of rainfall. Most grading is done when roads are moist. In some cases grading may be combined with dragging using a truck- or tractor-mounted maintainer, especially when the road is in very poor condition. Otherwise, each may be undertaken independently of the other and as frequently as conditions determine. Pothole repairs usually form a part of grading or dragging.

Side-Ditching, Mowing, Brushing, or Spraying

Side-ditching is usually undertaken when roads are dry using the grader blade or in the winter in some counties using "Gradall" equipment. Mowing, brushing, and spraying may be undertaken if absolutely necessary, usually when conditions have deteriorated so much that bushes encroach on the narrow traveled way. In some counties mowing is undertaken only by the farmers on the roadside adjacent to their farms and not by the highway department.

Dust Control

Dust control, as a maintenance activity, is not undertaken by many county highway departments. In most counties this is the responsibility of the private resident. The highway department arranges for the chemical applicator who applies the calcium or magnesium chloride under highway department supervision. The citizen pays for the chemical. Used or dirty engine oil has been banned by the Environmental Protection Agency (EPA) because of lead contamination of adjacent soils, but the use of lighter emulsified asphalts is increasing.

A more permanent remedy is to use light emulsified asphalts frequently, which leads to an almost permanent hardening of the surface. Citizens sometimes request that a seal coat be used in the vicinity of their homes. Most counties indicate that in such cases the job is undertaken on a shared-cost basis. The county highway department pays half of the cost and the resident pays the other half. In this way, several short sections of gravel roads may be paved to provide effective dust control and a virtual paving of the entire road section.

County governments should ensure that the road base is sufficient to provide a reasonable support for the light surface treatment applied. Otherwise, the county may be creating a higher maintenance cost road, which can lead to dissatisfaction of landowners as well as to escalating highway maintenance costs. New road sections such as those for subdivisions should always meet adequate design requirements before they are accepted in the county or city road system.

Snowplowing and Other Activities

Snowplowing operations are only undertaken when roads are considered very dangerous. Priority is often assigned to school bus routes or high traffic volume roads where these are identifiable.

Culvert cleaning and sign maintenance and replacement are undertaken as needed, and bridge inspection is undertaken at least every 4 years as part of the National Bridge Inspection Program.

Assigning Priority in Maintenance

Thirty-eight percent of the counties stated that, in general, no priority is assigned for maintaining gravel roads. All roads are treated the same. A grader operator, for example, blades all the roads he is responsible for without differentiating between them. In 20 percent of the cases, however, it was stated that priority is assigned to school bus routes (e.g., for snow removal) or to roads carrying high traffic volumes.

Road and weather conditions, special needs, and citizen complaints are the other important considerations governing the assignment of priority for the maintenance of gravel roads.

EQUIPMENT USED TO MAINTAIN UNPAVED ROADS

Forty-four counties responded to questions about the number and types of equipment used in the maintenance of unpaved roads. The distribution of the types listed is given in Table 4. The returns showed a disparity among counties as to the number and type of equipment and vehicles owned or used. As expected, however, predominant among them are dump trucks, motor graders, and tractor- or truck-mounted maintainers. Some counties had no graders but used maintainers or vice versa; others had and used both types of equipment. These characteristics are a further indication of the varying standards of maintenance on gravel roads in the counties.

TABLE 4 Equipment Availability in Counties

Equipment Type	Number	Number of Counties
Dump trucks	243	18
Graders	157	39
Maintainer with tractors	53	18
Tractors	12	2
Trucks with Under Blades	53	6
Loaders	21	9
Gradall	14	9
Mowers/Brush Cutters	13	4
Back hoes	9	5
Excavator	3	3

Forty-seven of 50 counties indicated that they maintain their own equipment. The others either do not or gave no answer. Except for eleven counties, the others send some specialized maintenance jobs to outside firms when the counties do not have the expertise or other resources to do the jobs. Such jobs include major engine overhauls, particularly of diesel engines, and transmissions. The ability of counties to maintain their own equipment is usually an asset especially where preventive maintenance is concerned. Adequate control and supervision are usually required if potential cost savings are to be fully realized.

Maintenance Cost Accounting

Cost accounting of maintenance and sometimes of construction activities in some counties is not always up to the standard required by existing guidelines in Indiana. The quality of accounting tends to depend highly on the caliber and experience of the cost clerk in each county. Most current cost figures are grossed up according to the requirements of the annual reports submitted to the county and the state legislature. It is not always possible to isolate costs for specific items unless the particular county specially compiles them. In Indiana special accounting guidelines produced by HERPICC are used by counties to prepare reports. Provision exists in the guidelines to enable costing of individual items, but it appears that the implementation of this is on a voluntary basis. Budgetary and staff constraints seem to affect this tremendously. Some counties have, nevertheless, made considerable advancement and adopted computers for analysis or have plans to do so.

REGRAVELING OR ADDING NEW GRAVEL MATERIAL

Regraveling, usually involving a complete resurfacing with 15 cm (6 in.) thick stone or gravel base, which is classified as a periodic or major maintenance activity, is generally not undertaken separately by most counties. Instead, additional gravel or stone is usually applied to the gravel surface as part of recurrent annual or other more frequent activity depending on the rate of gravel loss or the weakness of subgrade support. This is usually done after the spring thaw to strengthen the weakened road surface that results from moisture saturation and freezing. Because the surface material usually contains little fines to act as binder, they are dispersed more quickly by traffic and are respread during the grading operation. When the traffic volume is heavy, more grading is required and the addition of material is required more than once a year.

Reasons for Adding Material

Forty-eight of the 50-county sample stated that the decision to add new material is based largely on inspection reports submitted by grader operators, foremen, or supervisors on routine or casual inspection. In 68 percent of the cases, citizen complaints were the second major deciding factor followed by traffic safety (32 percent) and traffic volume (26 percent). In a number of cases, material is added only after a need is created as a result of inclement weather conditions. Most decisions are based on personal judgment rather than on measured criteria.

Method of Execution

All maintenance activities are generally undertaken by the county highway departments themselves using their own resources. However, 16 percent of the counties undertake some major activities on a contract basis. These activities are mainly the construction or replacement of culverts larger than 6 ft in diameter and bridges. In several counties culverts 4 ft in diameter were considered the minimum size above which such projects were awarded on contract.

Sources of Materials

Eighty-eight percent of the counties obtain their gravel and stone material from private gravel pits or quarries. The rest obtain their material from county owned or leased pits. In half of these cases, pit run gravel is obtained from county pits and graded aggregates are obtained from private pits or quarries. Even in cases in which material is obtained from private sources, in some counties, county trucks load and haul material from the pits to their respective locations.

PAVING OF GRAVEL ROADS

During the period 1978-1982, only 19 counties in the sample undertook any program of paving gravel roads. The rest said they did not pave any gravel roads within the period. Paving in this case includes ap-

plication of surface treatment or chip-and-seal to the gravel surface. In a few cases, some paved roads, mainly surface-treated roads, were scarified and returned to a gravel state. A total of about 670 miles of gravel roads was paved by chip-and-seal or hot or cold mix asphaltic concrete. This represented an annual paving rate of 7.1 miles per county, which also includes the application of a second or third seal coat to some paved road surfaces. Considering all counties in the sample, an estimated annual paving rate of 2.7 miles per county was achieved. Many counties would prefer to pave more roads if that were possible.

Reasons for Paving Gravel Roads

The major reasons for paving gravel roads in order of importance, according to number of responses, are given in Table 5. Higher traffic volume is the most important reason for paving gravel roads as indicated by 80 percent of the sample. However, 70 percent also indicated that local requests sometimes involving cost-sharing by the residents are also a major deciding factor. The latter appears to be a very important consideration especially if gravel roads can be paved at all with the limited funds usually available to the counties for such programs. In 48 percent and 28 percent of the cases, respectively, the roads that were paved were continuations of existing roads or were considered to be of administrative importance and were usually paved at the request of the county commissioner.

TABLE 5 Reasons for Paving Gravel Roads

Reason	Number of Responses
Higher traffic volumes	40
Local request/complaint	35
Continue existing paved road	22
Administrative Importance	14
Environmental (Dust)	9
Increase in Accidents	9
Other	5

MAINTENANCE MANAGEMENT AND PLANNING

Maintenance Guidelines

The National Association of County Engineers published, as part of its Action Series, guidelines for maintenance management of county roads (9). The survey of counties showed that 22 percent of the sample know of the guidelines but only three stated that they had previously used them or referred to them for any purpose. Asked what guidelines were used for maintenance, 30 percent indicated that common sense, experience, or the recommendations of the district supervisor or county engineer were the main sources of direction in their maintenance practice. A few others said the manuals of the Indiana Department of Highways or the Asphalt Institute were their main references for maintenance of their paved roads. The rest either use no guidelines or gave no answer.

Priority Rating System

Eleven of the 50 counties said they use some form of priority rating system for maintenance purposes. The main bases for assigning priority are traffic volume or population and to a large extent decisions by commissioners or the council. Forty percent of the sample follow an existing plan for carrying out major improvements including paving of gravel roads. The rest based their ad hoc decisions on needs as determined periodically or gave no definite answer.

Organization of Personnel and Equipment for Maintenance

About half of the counties in the sample make no distinction between gravel and paved roads in their assignment of personnel and equipment for road maintenance. A combined team carries out all maintenance activities and personnel and equipment are usually dispatched from a central workshop. Six counties said they have separate units responsible for paved and unpaved roads. In eight cases, personnel with assigned equipment (grader) operate from their homes, usually over specified zones or subdistricts, and receive supplies periodically from a central workshop.

It is anticipated from the foregoing that the importance accorded gravel roads in each county's organization will be largely dependent on the total mileage to be maintained and the proportion of the total network comprised of gravel surface.

Problems Connected with Gravel Road Maintenance

When asked to rank the top three problems they face with unpaved road maintenance, most counties (about 70 percent) indicated that clearly the inadequacy of funds is the number one problem. This problem seems to have affected the nature of maintenance activities and programs, especially the continuing paving of gravel roads in the counties.

Four factors shared the second ranking in problems listed based on the number of times they were mentioned. Some officials expressed concern about the number and total mileage of gravel roads in their networks. They would like to see a marked reduction in the mileage of gravel roads as more of them are paved. In addition, the problems caused by dust in neighborhoods, the lack of suitable equipment, and the effect of heavy traffic on the condition of their roads were mentioned by some counties as second-ranked problems. Heavy traffic on unpaved roads and the environmental problem created by dust stood out as the third-ranked problems of concern to county highway departments.

Critical Needs of Unpaved Roads

According to the number of responses, drainage maintenance is the most critical need of unpaved roads, followed by bridge rehabilitation and replacement and widening of unpaved roads. Routine maintenance needs followed fourth in rank. In general, the critical areas cited seem to be tied up with the inadequate right-of-way (ROW) on most unpaved roads in the counties. Widths of between 14 and 18 ft are common. This inhibits the provision of adequate side drainage and the possible widening of such roads. Most of the roads are adjacent to farmlands and highway departments cannot widen roads any further. Most unpaved roads drain directly onto the farms or, in some instances, the farms drain onto the road. For some of the unpaved roads, however, wider roadways would normally not be warranted owing to very low traffic volumes, but it should be possible to widen such roads when required for either drainage

or safety. This could be negotiated and appropriate modifications made in each county to cater to road-widening needs.

PROBABLE IMPACT OF ROAD SECTION ABANDONMENT

The problem of the inadequacy of funds coupled with the shear size of the road networks in the counties and the cost of maintaining them, especially in the face of decreasing funds, has often raised the question of abandoning some sections or leaving them to be maintained by private landowners. Fruin (10) suggests that perhaps the number and mileage of rural roads in many areas are excessive and that consideration should be given to reducing them.

When asked their opinion of abandoning road sections to reduce total mileage of roads, 29 of the sample of 50 county highway departments agreed with the idea. They considered that roads likely to be chosen in such an exercise include roads providing access to a single property or to individual farms and also roads generally leading to a dead end. Both conditions were mentioned by 18 counties. About half that number indicated that very low-volume roads or roads for which alternative routes exist to perform the same function with a shorter connection from particular locations could be considered. However, it was not clear what traffic volume would represent a good cutoff point. Traffic volumes of even up to 20 vehicles per day were suggested but the level could be set much lower for practicality.

Pros and Cons of the Abandonment of Road Sections

In spite of the apparent acceptability of the idea of abandoning roads and the fact that 30 percent stated that the inclusion of some roads in their networks at present actually reduces their efficiency, some problems were raised about the idea. Most counties were apprehensive about discontinuing the precedent by which they maintain all roads irrespective of use. Most thought that everyone currently served by a county road is entitled as a taxpayer and should have access provided and maintained by the county. It was thought that considerable public reaction and complaints would accompany any attempt to abandon road sections under the jurisdiction of the county. It was pointed out that provisions within the Indiana State Statutes restrict abandonment and a change in state law would be required if counties were to be able to implement a scheme of abandoning or relinquishing responsibility for maintaining some road sections.

These considerations imply that sound arguments and adequate justification would be necessary if abandonment were ever to be accepted as an appropriate policy. At present, it appears that it will be necessary to spread the maintenance budget thin if no alternative is possible and no additional funds are forthcoming. There is already considerable private participation in the paving of gravel roads and in dust control as well as in the mowing of roadsides. A compromise is possible when further funds cannot be raised through the regular county sources. This could include relinquishing the county's responsibility for maintenance of some roads to private citizens.

CONCLUSIONS

The current maintenance practice for unpaved roads in Indiana counties could well represent that of similar counties elsewhere. Though reasonable amounts of maintenance already take place on unpaved roads, the need for uniform practices is evident. The diversity inherent in the different counties with regard to population, mileage (paved and unpaved), level of development, and availability of financial and other resources clearly affects the performance of individual counties. It may also present initial problems when attempting to implement uniform guidelines that can be adapted to individual county characteristics and needs for maintenance of unpaved roads.

In spite of the availability of several guidelines, including the series produced by the National Association of County Engineers, it appears, at least in Indiana and possibly in other states, that dissemination has not reached the potential users--the county highway staff. The establishment of Technology Transfer Centers throughout the United States is an initial step toward the dissemination of technical information useful to counties. This task, which has been begun by HERPICC, Purdue University, for Indiana, will continue with the new process.

For maintenance of roads, particularly unpaved roads, in a monetarily constrained situation, actions aimed at making the best use of the money available would be most expedient. In particular, among many other possible actions, suitable guidelines would be required for making decisions with regard to the following specific areas:

1. Priority setting among projects and on a network level;
2. Deferring major maintenance;
3. Requirements for and timing of the paving of gravel roads;
4. Methods for determining the appropriate level and type of maintenance; specific proposals for drainage maintenance and dust control would be of great benefit based on the ranking of problems; and
5. Suitable criteria for abandoning road sections or reducing the mileage responsibility of counties.

Considerable progress has been made in the development of methods through the research process initiated or assisted by the World Bank; the Transport and Road Research Laboratory, United Kingdom; and other agencies in Kenya, Brazil, and India. Some of the results are adequately reported in the Proceedings of the Third International Conference on Low-Volume Roads (11). Nevertheless, the maintenance practices identified for Indiana counties, especially for unpaved roads, confirm the needs identified here. The process of dissemination of research results should, however, ensure that methods to be applied are acceptable to local officials. Though most of them think that the application of common sense is sufficient for determining maintenance needs of unpaved roads, one cannot overemphasize the fact that a sound maintenance management system is still essential. Although they generally carry lower traffic volumes, unpaved roads still play an important role in the local economy and deserve proper maintenance planning.

Any system adopted should be simple and adaptable by even the less sophisticated counties or local authorities. Methods developed should also aid in making decisions about the appropriate levels of maintenance expenditures within the total road network. Methods should take into account the influence and role of various road surface types and enable optimum investment levels to be determined at any time. Using existing methods, a major step can be taken toward achieving these goals.

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REFERENCES

1. Annual Reports January-December 1982. Indiana County Highway Departments; Highway Extension and Research Project for Indiana Counties and Cities, Purdue University, West Lafayette, 1983.
2. M.L. Young. Maintenance Management: A Report of Planned Road Maintenance. Mason County, Washington, Department of Public Works, Jan. 1979.
3. B. Harrington. Pavement Management Saves County Dollars. Maricopa County, Arizona, Highway Department; County News, March 1979.
4. B.F. McCullough, F.L. Roberts, and A. Pelzner. Implementing a Pavement Management System in the Forest Service. In Transportation Research Record 702, TRB, National Research Council, Washington, D.C., 1979, pp. 277-285.
5. A.T. Visser and W.R. Hudson. Performance, Design, and Maintenance Relationships for Unpaved Low-Volume Roads. In Transportation Research Record 898, TRB, National Research Council, Washington, D.C., 1983, pp. 164-174.
6. Maintenance of Unpaved Roads. Transportation Technology Support for Developing Countries. Synthesis 1. TRB, National Research Council, Washington, D.C., 1979.
7. Maintenance Techniques for Road Surfacing: Assessment, Choice of Treatment, Planning, Implementation. Organization for Economic Cooperation and Development, Oct. 1978.
8. Maintenance Management for District Engineers. Overseas Road Note 1. Transport and Road Research Laboratory, Crowthorne, Berkshire, England, 1982.
9. D.H. Park and G.W. Burnette. Maintenance Management. Action Guide Series, Vol. VIII. National Association of County Engineers; National Association of Counties Research Foundation, Washington, D.C., July 1972.
10. J.E. Fruin. Issues in Rural Road Management. In Rural Roads of America, ESCS-74, A.R. Bunker and T.Q. Hutchinson, eds., Economics, Statistics and Cooperatives Service, U.S. Department of Agriculture, 1979.
11. Low-Volume Roads: Third International Conference, 1983. Transportation Research Record 898. TRB, National Research Council, Washington, D.C., 1983, 378 pp.

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