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MANUAL
OF
MAINTENANCE OF LOW VOLUME
UNPAVED RURAL ROADS

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Table 1

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G E N E R A L

1. PREAMBLE The development of agriculture, the distribution of food, the provision of health services, and the access to educational services and other forms of communication in rural regions heavily depend on transport facilities. Although rail facilities play important role in certain areas, a dominant and universal need is for road system that provides an assured and yet relatively inexpensive means for the movement of people and goods. The bulk of this need is for Low-Volume Roads that seldom carry as many as 400 vehicles of all types a day.
2. The planning, design, construction, and maintenance of Low-Volume Roads for rural regions can greatly be enhanced with respect to economics, quality, and performance by the use of Low-Volume road technology.
3. AIM The aim of this manual is to provide useful and practical information for those in rural sector, who have responsibility for the maintenance of roads.
4. INTRODUCTION Nearly all low-volume roads are semi-paved. Here an attempt is made to present clearly the most effective work methods and procedures for individual maintenance operations through series of subsequent chapters.
5. Chapter-I discusses some of the problems commonly

experienced in carrying out road maintenance programmes. The purpose is to make the reader aware of these unique problems, and their consequences, as well as some methods to overcome these problems.

6. Chapter-II briefly describes the typical maintenance functions that are normal requisites of unpaved roads. The reader must understand the technology and general criteria for performing these functions.

7. Chapter-III highlights typical departmental practices for road maintenance, including responsibilities at the various organizational levels.

8. Chapter-IV outlines planning, budgeting and controlling practices for maintenance with special emphasis on practical applications.

9. Chapter-V explores effective utilization of tools and equipment as well as mechanized component.

10. Chapter-VI provides detailed descriptions of generally accepted work methods for individual maintenance activities including alternative approaches utilising mechanized components and methods involving principally hand tools and labours.

CHAPTER - I

11. PROBLEM AREAS Road construction agencies in even the most developed countries often have difficulties in carrying out effective maintenance. As increases in weight and numbers, the benefits resulting from continuing proper level of road maintenance service become apparent.
12. Motorised and non motorised traffic has expanded rapidly in recent years. Extensive road construction programs have been undertaken, often with foreign funding assistance. However, in many cases, road maintenance is so inadequate that even newly constructed roads are deteriorating far more rapidly than would normally be expected.
13. The experience in planning and managing extensive road maintenance programmes is limited to a relatively short period of time, often under trying conditions. There is also an acute shortage of qualified manpower both at the administrative and technical levels. It is important to remember that most of the problems encountered are unique.
14. LABOR-INTENSIVE WORKS In developing countries, the equipment itself and its operation are expensive, particularly in terms of foreign currency, and labour is relatively inexpensive. Also unemployment is a continuing problem, and it is often in the national interest to encourage the utilization of manpower.

15. Thus it is not feasible to accept automatically, the work methods and procedures employing more equipment at the cost of aforesaid interests. Those maintenance operations which can be done with manual labor and small tools must be investigated and clearly defined and obviously so done. In addition, decisions must be made as to which operations will result in significantly greater productivity or higher quality of workmanship if mechanized equipment is used. These decisions should then be clearly documented so that they can be uniformly and consistently applied all over the rural sector.

16. MAINTENANCE VS. CONSTRUCTION Whenever there is a question of allocating available funds for maintenance work or construction of new roads, construction of new roads usually wins, because new construction has more appeal and offers greater satisfaction to engineers than does routine maintenance. Also the socio-political pressure outside or within the councils often influence decisions for new constructions.

Frequently construction work is done by field work staff which is also responsible for maintenance. In routine this often results into neglect of needed maintenance work in favour of construction operations.

17. Several administrative actions or their combinations might help to alleviate this problem, which are as follows:-

- a. A firm commitment that road and bridge maintenance will have first priority and that funds earmarked for the purpose will not be diverted to other uses.
- b. Expenditures for construction work will be limited to availability in excess of maintenance requirements.
- c. Construction works are generally performed by private contractors. Departmental effort should only be on maintenance operations.
- d. If department is to perform both maintenance and construction work, separate organization should be established with separate direction and supervision so that maintenance efforts are not diverted to construction.

18. EQUIPMENT AVAILABILITY Pakistan commonly experienced difficulty in assuring availability of suitable maintenance equipment. The types and number of equipment purchased sometimes does not reflect actual maintenance needs. Equipment preventive maintenance and repair practices may be inadequate. Lack of spare parts seems to be a universal problem. Plans for distributing equipment relative to field requirements should be flexible to allow effective utilization. Acquiring a large equipment fleet can solve maintenance problems, only if comprehensive management system is effectively employed to assure that equipment is economically operated.

19. MATERIAL QUALITY CONTROL Except for foreign funded projects where quality controls for materials may be built into agreement or contract provisions, there is very little knowledge or consideration for the quality of materials used in road construction and maintenance work. Further more, the controls are not observed during construction as much as required.

20. WORK PROGRAMMING AND BUDGETING Annual maintenance work programmes are seldom spelled out. Budgets if any usually reflect estimates of the manpower, equipment, and materials that will be used, based principally on the previous year's experience.

Without any documentation or maintenance objectives, there is no way to evaluate the effectiveness of the field operations. Control may be exercised over funds but there is little or no control over whether or not the work is actually performed. It is essential that we be committed to the concept of annual maintenance work for each field organization. The budget should delegate funds for specific work to be accomplished as spelled out in the programme.

21. MAINTENANCE FUNDS Governments is usually committed to the timely allocation of the funds. If available funds are less than the amount requested, the proposed work plan and staffing complement must be adjusted accordingly by the implementing departments.

22. PERSONNEL TRAINING There is need for training programme in four areas:-

- a. Operator Training - directed to operators of maintenance equipment.
- b. Mechanic Training - directed to equipment workshop personnel so that they may properly service and repair equipment.
- c. Work Methods Training - directed to field supervisors to know and to utilize the most effective procedures for maintenance operations.
- d. Management Training - directed to engineers and officials in the field and headquarters to effectively carry out planning, budgeting, scheduling, and controlling of maintenance programmes.

23. To give it sufficient continuity, status and weight in policy making for the departments, the whole function of training or staff development at all levels needs to be institutionalized. Training efforts have too often been seen as one shot affairs, without allowance for the fact that 10 percent or more of the staff may need to be replaced each year due to retirements and losses to the private sector, and that the remaining staff will need refresher courses only.

24. MANAGEMENT PRACTICES Perhaps the most serious problem confronting us is the lack of systematic approach to management of road construction programme, particularly maintenance. Serious problem with us is the lack of communication between officials responsible for planning maintenance programmes and field supervisors.

25. The answer to these problems is to develop, adopt and follow a system of management which:-

- a. Clearly sets forth the basic road maintenance objectives.
- b. defines policies on maintenance work methods.
- c. defines annual programmes of specific maintenance work
- d. identifies resource requirements.
- e. appropriately allocates resources.
- f. clearly communicates to field units the expected accomplishment.
- g. requires field units be accountable for their progress, accomplishments, and the effectiveness.

CHAPTER - II

26. MAINTENANCE FUNCTIONS This chapter will briefly describe typical maintenance functions required for unpaved roads. The purpose is to establish a common base for understanding the terminology used and to present the general approach for planning, scheduling, and performing the work.

27. MAINTENANCE TERMINOLOGY The under-mentioned definitions are set forth for mutual understanding.

- a. Routine maintenance are works regularly performed by maintenance crews throughout the year as blading and smoothing the surface, patching potholes, cleaning drainage structures, and cutting vegetation.
- b. Periodic maintenance are more extensive maintenance operations required only every several years i.e. resurfacing with gravel to replace lost material. Emergency repairs as a result of floods or slides are few unplanned periodic maintenance.
- c. Rehabilitation and betterment include major restoration of roads and minor construction projects for improvement of facilities.

28. In setting up system of planning and reporting maintenance, the individual functions are grouped into several categories of works such as:

- a. Surface maintenance.
- b. Drain-age maintenance.
- c. roadside maintenance.
- d. bridge maintenance.
- e. traffic services.
- f. rehabilitation and betterment and
- g. equipment servicing and repair

29. SURFACE MAINTENANCE Unpaved road surfaces commonly require three maintenance functions, each for a different purpose:-

- a. Blading and shaping: are required occasionally to provide a smooth riding surface by correcting transverse corrugations and longitudinal rutting. This work is generally performed with a motor grader or with home-made drags or even by hand tools. Some low-volume roads may be bladed only once or twice a year, while other roads may require more frequent smoothing.
- b. Patching with gravel - involves repair of isolated trouble spots such as potholes, soft spots, surface erosion, slumped shoulders, or other locations where surface material has been lost. Ordinarily a truck is required to transport the gravel, but the placement and smoothing of the patches are done with hand tools.

- c. Resurfacing with gravel - is scheduled for relatively long road sections to replace lost gravel. Over a period of time, considerable material is lost as dust during dry seasons or erodes away during wet seasons. Resurfacing is a periodic function.

30. DRAINAGE MAINTENANCE Water is perhaps the most serious problem for road maintenance, and particularly for unpaved roads. Several maintenance functions assure water continues to drain away from or through the road-way area. Cleaning and repairing culverts are routine functions performed regularly each year. Sediments and debris often collect in pipe culverts and small box culverts causing the flow to be reduced or may be even stopped completely. During heavy rainfall, sections of the road can be washed away by these debris. Culvert cleaning is performed mostly with hand tools. Cleaning ditches should be performed regularly so that the surface water continues to flow un-obstructed. Usually ditches are cleaned with hand tools. Motor graders, bulldozers, or the special equipment may be used when long sections of ditches need cleaning and/or reshaping.

31. ROADSIDE MAINTENANCE The roadside is area between the shoulders of the road and the right of way line. Appearance, safety, road approaches, and protection of the roadway, all require maintenance.

32. Cutting of bushes and trees is a safety precaution to ensure that motorists have adequate sight distance. This is a hand operation and is seldom needed more than once a year.

33. Erosion control work can be either corrective or preventive maintenance. Roadway slopes and ditches are subject to severe erosion as a result of heavy rainfall. Eroded spots must be repaired, and steps should be taken to try to prevent the erosion from occurring again.

34. Some type of regular periodic bridge inspection programme should be established to identify deterioration and needed repairs. This includes repair or replacement of decks, rails, and structural members, as well as maintenance and repair of stream channels and periodic painting of steel or timber bridges.

35. TRAFFIC SERVICES MAINTENANCE Traffic services include the maintenance and repair of traffic signs, signals, and pavement marking. In the case of rural unpaved roads the concern is principally with sign maintenance, involving the repair or replacement of damaged traffic signs and supporting posts.

36. EQUIPMENT SERVICING Maintenance equipment requires regular servicing operation on a daily basis, to assure effective operation service life.

37. REHABILITATION AND BETTERMENT Major rehabilitation and betterment works are planned and scheduled on a project to project basis.

CHAPTER - III

O R G A N I Z A T I O N

38. GENERAL When discussing organization, most people think in terms of organization charts. On the contrary there is a very essential need to clearly define basic objectives, policies, and the levels of authorities and responsibilities, which have significant effect on how the organization structure might best be established. For a widely dispersed road system it is more of delegation of authority and responsibility to field units. Particularly those engaged in rural sector should review existing conditions, evaluate alternative practices, and formulate basic policies and procedures as guides for establishing the required organization.

39. A typical organization for maintenance usually includes:-

- a. A headquarters unit.
- b. Divisional or district levels, and possibly sub-district units.
- c. Field work units, and
- d. Units responsible for servicing, repair, and management of equipment.

40. GENERAL ORGANIZATION The major functions of road construction works include planning, design, construction, maintenance, equipment materials testing,

and administration. We will center around three of these functions - construction, maintenance, and equipment - and the ways in which department can best organize to carry these out. Several factors influence organization, especially scope of work, responsibilities of the district offices, and communication between headquarters and field offices.

41. DECENTRALIZED FUNCTIONS In most cases, considerable authority and responsibility is delegated to district engineers. The district level sometimes handles responsibilities for:-

- a. supervision and inspection of construction works.
- b. direction of construction.
- c. all maintenance works,
- d. field surveys,
- e. some design work,
- f. some materials testing,
- g. equipment workshops.
- h. right-of-way acquisition, and
- j. administration

42. In this capacity, the district offices are small high-way departments representing the public and private sectors within own geographical area. The headquarters functional divisions principally provide staff guidance and assistance through the chief engineer.

43. MAINTENANCE-ORIENTED FUNCTIONS The field units are concerned with maintenance and some major construction by own staff. In this capacity, the district offices can be under the immediate direction of headquarters maintenance engineer. The divisional headquarters equipment function is under a separate division of the maintenance engineer. As development continues, the responsibility of the district level will increase and bring about a need for more decentralization.

44. DIVISIONAL HEADQUARTER ORGANIZATION Overall planning, direction, and supervision of maintenance programs are delegated to a maintenance division of the headquarters organization. The head of the maintenance unit normally reports directly to the maintenance XEN. The objectives and responsibilities of him include:

- a. development of maintenance policies and procedures.
- b. development of uniform work performance standards.
- c. development of annual maintenance work programme.
- d. preparation and co-ordination of maintenance budgets.
- e. co-ordination of the allocation of resources.
- f. guiding and assisting district engineers in effective planning scheduling, performance, and control of maintenance programmes.

- g. reviewing field conditions with accountability to top management.
- i. providing effective training.

45. At least four sub departments are needed within the headquarter maintenance division for:-

- a. planning and budgeting unit.
- b. field operations
- c. traffic services and
- d. training.

46. PLANNING AND BUDGETING This office is responsible for developing and implementing standard procedures for maintenance planning and budgeting. It works closely with the district offices in identifying maintenance needs and preparing annual work programmes for the field staff. The office develops work performance standards and establishes values for planning appropriate uniform levels of maintenance services. The unit consolidates the various district programs into a provincial program, prepares cost estimates, and adjusts the work programmes as needed to fit available funds. The programme is reviewed by top management. Following top management approval, it converts the programme to the format required by the government for formal budget requests.

47. TRAFFIC SERVICES The office can be responsible for:-

- a. establishment of policies, procedures, and manuals.
- b. supervision of traffic sign post shop etc.
- c. Regular field inspection.
- d. directing guiding traffic gangs.

48. TRAINING Generally divisional level will establish a central training programme. Such a programme would seek to prepare procedural manuals as well as to develop and carry out training programmes on maintenance work methods.

49. WORK FORCE ESTABLISHMENT With exception of an occasional specialized technical staff, all maintenance manpower is responsible to the district or sub-district offices. The manner in which they are organized and staffed may vary corresponding to local requirements.

50. DISTRICT CREWS Some maintenance work requires special knowledge and capabilities besides special equipment. Bridge maintenance, sign maintenance, major regravelling, rehabilitation, and crusher plants are the examples. It is impractical to staff and equip all field set ups for special works. The work of the staff, which may be organised on required basis in the districts levels where the work is to be performed. For remainder of the field staff there are three common ways of organization. Usually, the choice is related to the size of the area and the density or road system.

- a. Maintenance Depots For small areas and compact road system, maintenance depots or section houses are placed at feasible locations. These

depots provide office space and storage place for equipment, materials, and supplies and usually have facilities for servicing the equipment.

- b. Road Crew When the area is large and road sections ranging from 15 or 20 kilometers up to about 50 kilometers may be established as working sections. A maintenance foreman with 10 to 20 staff members, and appropriate tools / equipment are assigned to each section.
- c. Mobile Crews In remote, less populated areas, resorting to travelling crew is economical which undertake maintenance of long distances roads. This travelling crew are reasonably well mechanized and are provided with camp facilities, including mechanics and facilities for servicing and repair of equipment. This aspect needs to be closely examined in provinces of Sind and Baluchistan.

51. EQUIPMENT ORGANIZATION The following actions and responsibilities are necessary:-

- a. Determination of the type and number of equipment needed.
- b. Preparation of specifications.
- c. Management of the equipment component.
- d. Carrying out programme of equipment servicing and repair.
- d. assuring an adequate continuing inventory of commonly needed spare parts etc.

52. EQUIPMENT ORGANIZATION AT DIVISIONAL LEVEL This is responsible for:-

- a. Receipt of new equipment.
- b. Establishing policies and procedures.
- c. Directing and supervising major overhauls and repairs.
- d. Co-ordinating acquisition of ware housing and distribution of spare parts and supplies.
- e. Developing manuals of procedures and training.

53. These functions and responsibilities can be carried out as follows:-

- a. a central equipment workshop made responsible for all major overhauls and repairs.
- b. An equipment management section responsible for analyzing equipment needs, receiving equipment, distributing and controlling.
- c. Equipment training unit.

Chapter - IV

54. MANAGEMENT PRACTICES Effective road maintenance programme depends on good management practices. Government departments provide maintenance staff, equipment, and materials, but rely on them to plan and execute day-to-day operations. The results generally may not be satisfactory. There is tendency to assume that more workers, equipment, and money will improve the level of maintenance. The fact is that a good system of management only can improve maintenance conditions to desired standards.

55. All management systems should include formal procedures for:-

- a. Planning annual work programmes.
- b. Determining the most effective ways for performing the works.
- c. Allocating available resources to execute the programme.
- d. Authorizing and scheduling work in ways that are clearly understood by field staff.
- e. Reporting work and evaluating performance.

56. WORK ACTIVITY DEFINITION Typical maintenance work activities are discussed in Chapter-II. Generally a code number is assigned to each activity for use in planning and reporting the work.

57. Another important element is established work measurement for each activity.

58. ROAD SYSTEM CLASSIFICATION The road system comprises routes and road sections. All roads cannot be treated same. Segments of the road system can be placed in categories. These variations exist among different kinds of unpaved roads. Unpaved road with considerable traffic will require more surface maintenance attention than a lightly travelled. Roads designed and constructed with better materials and to modern standards require less maintenance.

59. The following four classes are suggested for the purpose of maintenance planning:-

- a. Class-I - Principal roads designed and constructed to higher standards.
- b. Class-II - Principal roads with lower standards.
- c. Class-III - Secondary roads of lesser importance.
- d. Class-IV - Tertiary or local village roads.

60. There are no fixed criteria relating to traffic flow of particular road classes. Primary roads will exceed 200 ADT. Traffic volume on class IV roads usually is less than 20 ADT.

61. WORK PERFORMANCE STANDARDS There is always a best way to perform various maintenance operations, i.e. both from standpoint of the quality of workmanship and the economical utilization of manpower and equipment. There are also reasonable standards for expected work accomplishment.

62. These standards should be documented in a maintenance manual and incorporated in training programmes. These standards should include:

- a. The most effective manpower size for each maintenance function.
- b. The tools and equipment to be provided.
- c. Materials needed.
- d. Detailed work methods and procedures, and
- e. An estimate of the average daily output expected.

63. Undermentioned Table shows illustrative maintenance performance standards for activity of blading and shaping with a motor grader. Similar standards for other activities should be documented. Chapter-VI discusses alternative work methods and procedures which might be incorporated in these performance standards:-

Table-1

MAINTENANCE PERFORMANCE STANDARDS
(Activity-Blading and Shopping)
(Activity Code No. _____)

<u>Description and purpose.</u>
Periodic shaping/smoothing of unpaved road surfaces with motor grader to (1) remove corrugations, (2) correct rutting and other surface irregularities, (3) redistribute loose surfacing material from shoulders, and (4) to restore proper roadway crown to provide drainage of surface water.

Performance Criteria.

To be scheduled and performed at time intervals according to the level-of-service standards established for the particular road class and location.

Should be scheduled shortly after rains when there is a small amount of natural moisture in the surface. Avoid scheduling the work under extremely wet or extremely dry conditions

Manpower, Equipment and Materials:

<u>Crew</u>	<u>Equipment</u>	<u>Materials</u>
1. Equipment Operator	1. Motor Grader	None
2. Labourers	2. Shovels	
3. Flagmen	3. Rakes	

Work Methods:

1. Place signs and safety devices.
2. Make pass with motor grader pulling loose material from shoulders, cutting high spots and placing windrow at center of roadway.
3. Make second pass with motor grader in opposite direction in the same manner, depositing material in windrow at center.
4. Adjust blade for proper crown slope of 3 % and spread material evenly toward each shoulder.
5. Check crown slope with slope board and make additional passes to assure correct crown.

6. Remove all rocks and oversize materials from surface, and rake smoothly where necessary.

7. Remove signs and safety devices.

Work Measurement Unit:

Km bladed and shaped

Average Productivity

6 Km per day

64. ANNUAL WORK PROGRAMMES Basic maintenance management practice is the development of annual work programme that identifies specific kinds of work to be performed, the amount of each kind of work, and the manpower, equipment, and materials needed to perform. The annual work programme is developed from four sources of information:-

- a. The current roadway inventory, and the characteristics and conditions of individual road sections.
- b. the adopted level-of-service standards, which identify the estimated annual quantity or frequency of work needed for appropriate maintenance conditions;
- c. the work performance standards, which provide a basis for estimating productivity and resource requirements; and

- d. periodic field inspections to identify needed special rehabilitation and betterment works.

65. RESOURCE REQUIREMENTS The standard staff consists of five men, one motorgrader and miscellaneous hand tools. No materials are required. The resources needed for a 800 crew days programme amount to 4,000 man days and 400-800 motor grader days.

66. The resource requirements are estimated for all other maintenance activities also in the following sequence:-

- a. Annual quantities of work are identified from the work programme.
- b. Annual crew day requirements are computed from estimated productivity rates.
- c. Manpower and equipments are determined from standard patterns and equipment assignments.
- d. Materials requirements (when applicable) are derived from work programme and performance standards.

67. WORK REPORTING AND CONTROL There are two reasons for the above:-

- a. Accounting information is needed for pay-rolls/expenditures, i.e. costing.
- b. Management information, for guiding and corrective actions.

68. In a single reporting system both requirements can be met.

A simple reporting systems should be developed and implemented to fulfill the following basic criteria:-

- a. Weekly work reporting of each crew should identify the kind of work performed.
- b. Summaries of reported work should be prepared on monthly basis.

69. Two important evaluations can be formulated from these summaries:-

- a. the current progress.
- b. Efficiency of operations.

70. TRAINING We essentially require a system and procedure for managing maintenance programmes.

71. The types of information that should be documented in official statements should include:-

- a. Basic organizational structure for maintenance, with authorities and responsibilities at each level.
- b. Policies and responsibilities for preparing annual maintenance programmes.
- c. Policies and responsibilities for preparing performance based budgets and for allocating resources.
- d. Equipment utilization and management framework.
- e. Construction and betterment works completed.

CHAPTER - V

TOOLS AND EQUIPMENT UTILIZATION

72. MECHANICAL CONSIDERATIONS Developing countries seldom acquire mechanized equipment for road and bridge maintenance only. Often they utilise available loans or grants. The programmes can be realistic and effective if given due attention.

73. CAPITAL INVESTMENT The initial capital investment in equipment is less painful, if when loans or grants are readily available but eventually units of equipment need to be supported and replaced. However, there must be a practical local financing plan that recognizes the need for spares, repair and periodic replacement of obsolete equipment.

74. Experience dictates that the initial acquisition of equipment should be accompanied by the purchase of spare parts and supplies, with a cost approximating 25 percent of value of main equipment. These spare parts etc are needed to assure continuing operation for the first life of equipment.

75. RECURRING COSTS Mechanized maintenance programme must be accompanied by provision of annual funding for its operation. Such expenditures will include:-

- a. fuel and oil.
- b. spare parts and supplies, and
- c. workshop repairs.

76. Recent rapid increases in the cost of fuel have had a significant impact particularly on us because of our limited resources. It does little good to invest in expensive equipment and then let it be idle. Also as operating costs increase further a closer look must be taken periodically at the economics of alternative methods.

77. HAND TOOLS AND SMALL EQUIPMENT PIECES Even the developed countries started out with road maintenance practices at relatively little cost using hand tools and homemade equipment. Nearly all maintenance work can be performed with hand tools alone, although more time and a larger labour force may be required than when heavy equipment is utilized. This section will discuss hand tools and improvised small units of equipment.

a. HAULING EQUIPMENT The first step toward mechanization will involve equipment for hauling materials. Wheelbarrows with pneumatic tyres are considered efficient for hauls upto 75 meters or less. For longer hauls local carts should be used which can be effective for distances up to 500 meters.

b. SURFACE SMOOTHING EQUIPMENT Motor grader is generally accepted as the most effective unit of equipment for shaping and smoothing unpaved surfaces. There are alternatives

for maintenance of unpaved road surfaces which employ labour intensive methods but need to be related to jobs particularly for those roads in remote locations with lower traffic volumes.

c. HEAVY EQUIPMENT Significant initial expenditure and continuing operating costs are required for heavy equipment. Also management and control of mechanized equipment is considerably more complex than for labour oriented works.

CHAPTER - VI

MAINTENANCE WORK METHODS

78. There are several important reasons for adopting standard work methods for individual activities.

- a. Without standard work methods, the quality of materials and workmanship may vary considerably among field units.
- b. Under a given set of conditions, there is usually a best way to perform the work from the standpoint of costs and productivity.
- c. For advance programming of maintenance activities standard work methods and average productivity rates are necessary to estimate the resource requirements and funding.

79. SURFACE MAINTENANCE The principal objectives for maintaining unpaved surfaces are (1) to keep the surface reasonably smooth, firm and free of excessive loose material and (2) to maintain the proper roadway crown for surface water runoff. The various activities directed to these objectives are:-

- a. Surfacing Materials. The quality of surface materials has an important influence on the effectiveness of maintenance operations.

Surfacing of unpaved roads can range from the natural soils to carefully graded crushed aggregate. Sometime the natural soil has characteristics that it can provide a reasonably stable wearing surface. Thus a careful consideration should be given to quality of the materials initially employed in or being now added to an unpaved surface.

b. Mechanical Blading and Shaping Periodic smoothing

and reshaping is most common maintenance operation for unpaved surfaces. The motor grader is most suited for this operation. A less expensive approach is employing underbody blades mounted on trucks. The equipment may be hydraulically operated from the cab, but will have to be designed as such.

c. Hand Tools and Drags When motor graders are not

available regular smoothing of unpaved surfaces can be accomplished entirely with hand tools. This is particularly applicable in remote areas for roads of low traffic volumes. Corrugations, ruts, and loose gravel can be leveled and smoothed with hand picks, shovels, and rakes.

d. Patching Examples of these problems may include

soft spots caused by unstable material, potholes, and surface erosion. These conditions require patching with additional surfacing material. The

material quality factor should be remembered even with simple patching operations. Roadside materials should be used only when they are of acceptable quality otherwise, patching materials should come from designated pits or from nearby stockpiles established for that purpose. If the problem involves soft unstable spots, two things should be done before new materials is added:-

- (1) A check should be made to see if the problem is caused by water. Excess water in the subgrade caused by ponding along the roadside often causes instability. It may be necessary to revise drainage ditches, construct new outlet ditches, install a culvert, install perforated pipe underdrains, or even raise the level of the roadbed.
- (2) Any material with unstable characteristics should be excavated and disposed of.

(e) Resurfacing One of the characteristics of unpaved roads is that surfacing materials are lost over a period of years. Under average conditions, this can amount to approx. 2 cm of depth in a year. If lost materials is not replaced on natural soil roads, the surface elevation gradually becomes lower and lower

until it may be below the adjacent ground level.

When this happens, deterioration accelerates because the roadway itself often becomes a drainage channel.

The thickness of resurfacing courses are seldom less than about 8 cm and may be 15 cm or more.

Thus surfacing material requirements may be well over 1,000 cubic meters per kilometer of road.

The length of major resurfacing projects may be as short as a few kilometers, or they be 20 or 30 kilometers long. The following work methods and procedures are set forth for agencies that are in a position to undertake resurfacing:-

- (1) The existing surface should be shaped so that the new surfacing can be laid to uniform thickness.
- (2) The source of surfacing material should be determined by laboratory testing but should be as close as possible to the work site.
- (3) One or more front end loaders can be assigned to the material source site (crusher plant or borrow pit).

(4) The number of dump trucks assigned to the work will depend on the haul distance and the rate at which material can be spread and compacted on the roadway.

(5) The new surfacing material may be spread in one or more layers and should be compacted, preferably with a pneumatic roller.

f. Drainage Uncontrolled water can be most destructive force on rural roads. For this reason, designers of new roads should carefully set the size and location of culverts and drainage ditches to assure the controlled flow of surface water in ways to avoid damage to the roadway or interruptions in the movement of traffic. With lack of proper maintenance, the following problems may arise:

(1) The amount of water that can flow through a crossdrain culvert will be reduced if the culvert becomes partially clogged with debris.

(2) If road-side ditches become clogged, water will back up. Over a period of time the ponded water will saturate the roadbed, and decrease both strength and stability

(3) When the flow in outlet ditches is obstructed by vegetation and debris, water will back up and saturate the roadway, or possibly even overflow the surface.

(1) Cleaning and Repairing Culverts Culverts include round metal or concrete pipes, and rectangular shaped wooden or concrete boxes. Cleaning of Culverts is basically a manual operation with hand tools. The key to good drainage maintenance is regular inspections and cleaning activities. Three types of inspection should be scheduled:-

- (a) detailed inspection and cleanout of all culverts just prior to beginning of wet season.
- (b) casual observation of culverts and their inlets and outlets during the wet season to identify potential problem areas, and
- (c) detailed inspection after the wet season to locate/repair any damages etc.

(2) Hand Cleaning of Ditches Two types of drainage channels need periodic cleaning and shaping

- (1) ditches constructed parallel to roadway to intercept surface water and carry it to locations where desired.
- (2) inlet and

outlet ditches at culvert locations carrying water under the road. Cleaning and shaping is needed because water flow may be slowed or blocked due to growth of vegetation, accumulation of debris, rock and earth and erosion of slopes. All ditches should be cleaned at least once a year. The work should be completed before the beginning of the wet season.

(3) Machine Cleaning of Ditches The motor grader is probably the most common piece of equipment used for reshaping roadside ditches, by adjusting angle and position of the blade. When the ditch is dry, the right front and rear wheels are set in the ditch, and the blade is angled vertically so that material spills off the center of the blade.

(4) ROADSIDE MAINTENANCE These operations include vegetation control, correction and prevention of erosion, and even litter pickup.

(5) Erosion Control Erosion control involves both repair of eroded locations as well as prevention of future erosion.

(6) Litter Pickup It may be a desirable policy to schedule periodic cleanup of litter which accumulates along roadsides adjacent to cities and towns.

(7) BRIDGE MAINTENANCE These require some special knowledge, skills, and equipment. For this reason, one or more specialized bridge crews are required for maintenance. These someless technical works can be indicated and performed solely by the local crews.

(8) Signing and Approaches The following works usually can be performed by local crews with hand tools:-

(a) install new signs where needed.

(b) clean and repair existing signs so that messages are legible.

(c) remove brush, grass, weeds, etc that obscure signs, and

(d) repair and paint guardrails at bridge ends.

(9) Waterways Local crew should remove debris (trees, logs, and brush). Debris should be removed from the banks. Eroded areas on banks and adutments should be repaired and reinforced.

(10) Substructures Nearly all maintenance and repair works on bridge substructures require special knowledge, tools, and equipment. The works should be planned by engineers and performed by special crew etc.

- (11) Decks Maintenance and repair work on bridge decks can be performed with some special tools and materials which must be available to the crew. Spalled areas in concrete decks may be repaired by cutting out all damaged material cleaning exposed reinforcing steel and filling the holes with concrete.
- (12) Cleaning and Painting Concrete and timber structures normally are not painted except for the painting of curbs, railings, and railposts. Steel structures are painted to protect the metal against corrosion.
- (13) Traffic Safety in Work Areas The first step in every maintenance performance standard should be a provision for setting out appropriate traffic safety devices such as
- (a) advance warning signs that are placed about 400 meters ahead of the work area reading as "Reduce Speed Road Repairs Ahead".
 - (b) follow up warning signs placed about 100 meters ahead of the work site i.e. "Thank you"
 - (c) barricades to separate the crew and equipment from traffic.
 - (d) flagmen to direct and control traffic.

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(14) REHABILITATION AND BETTERMENT Normally, the planning, scheduling, and financing of these works is necessary part of the total maintenance programme.