



Ministry of Shipping & Transport
(Roads Wing)

MANUAL FOR MAINTENANCE OF ROADS

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(Roads Wing)**

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FOREWORD

There are no two opinions about the importance of proper and timely maintenance in preserving the investments made on road facilities and in providing safe transportation at a satisfactory level of service. This phase of operation has become all the more important in recent years in the wake of the phenomenal growth of traffic on the roads in the country accompanied by a steady increase in the axle loads of commercial vehicles.

Maintenance of roads in the present day context can not therefore just be limited to isolated actions like filling up potholes, etc., but should follow a system approach involving a series of sequential operations. First is the precise assessment and codification of the present road condition, diagnosis of the problem encountered, and selection of the most appropriate treatment. This would enable a clear understanding as to 'when', 'what' and 'how' to treat, the determination of priorities more objectively and allotment of the available resources where they are most needed, and formulation of a rational road maintenance programme. Second is the effective improvement in the quality of work and productivity. Third is the adoption of an easy and quick reporting and recording system to check on the achievement of jobs assigned to gangs or units, equipment, etc., employed on maintenance in the field. Fourth is the observance of the duties and responsibilities assigned to inspecting staff such as the periodicity of inspection, a check list of items to be inspected, evaluation of productivity and solving of any field problems in this regard. Fifth is the training of all involved in the maintenance methodology and operations. In performing all these activities in the most efficient manner, the most important aspect is the human element, i.e., the personal involvement of all concerned with maintenance, right from the engineering supervisory staff down to gangmen.

For providing guidance on all the above mentioned aspects with the objective of putting the road maintenance activities in the

country on a more rational footing with uniformity in approach, the Ministry of Shipping & Transport (Roads Wing) have brought out this 'Manual for Maintenance of Roads'. The initial draft for this document was prepared by Shri P.K. Lauria, Chief Engineer and Shri M.K. Saxena, Superintending Engineer, P.W.D. Rajasthan. This was reviewed, amplified and finalised in the Roads Standards Zone of the Ministry in consultation with a representative group of State Chief Engineers dealing with roads.

I am sure this Manual will be useful to the Engineers in the field as well as to those in the office dealing with planning, programming and budgetting of maintenance activities. For more positive impact in the different parts of the country, it will be advantageous to translate the portions of this Manual dealing with field activities into local language.

As is the case with any technical document, this Manual may require improvement/revision from time to time in light of the feed-back from the various road construction departments in the country. I do hope that this Ministry will get the necessary feed-back in order to improve this document in the years to come.

K.K. SARIN

New Delhi
December, 1983

*Director General (Road Development) and
Additional Secretary to the Govt. of India*

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1

Scope

1. SCOPE

1.1. Basic Maintenance Objectives and Policies

The basic objectives of maintenance function are to maintain and operate the highway system in a manner such that

- (a) Comfort, convenience and safety are afforded to public
- (b) The investment in roads, bridges and appurtenances is preserved
- (c) The aesthetics and compatibility of the highway system with the environment is preserved
- (d) The necessary expenditure of resources is accomplished with continuing emphasis on economy.

1.1.1. Service to travelling public : The road system should be maintained adequately at all times within the fiscal constraints to ensure safe and convenient travel considering the density and nature of traffic being served.

1.1.2. Employees on call : Emergent conditions may develop from time to time adversely affecting safe and convenient travel. Persons dealing with maintenance of traffic are on call at all times and should be ready to be of service in effective use of the roads.

1.1.3. Preservation of investment : It is the objective, as far as possible, to maintain all roads, bridges and appurtenances in originally constructed or subsequently improved condition, performing work of such conclusive and restorative nature to ensure that the investment of public funds in each road is preserved.

1.1.4. Preventive maintenance : Maintenance of a clearly preventive nature (as opposed to waiting until correction is required) shall be performed by operating units. Planned work of restorative nature (maintenance, replacements or reconstruction) which will be done in a reasonable length of time, shall be the only reason for deferring routine maintenance provided funds are available.

1.1.5. Environmental considerations : Maintenance operations should be performed in such a manner as to preserve or enhance the compatibility of the road system with environment.

The maintenance of roadside shall be directed towards the preservation or enhancement of the natural beauty of the road land. Special emphasis shall be directed towards the control of roadside erosion.

1.1.6. Consistency of maintenance service : All roads providing similar service should require equivalent maintenance care based on needs and requirements of particular region and road.

1.1.7. Economy of operation and performance improvement : It is the objective to constantly devote efforts towards improving the performance of the maintenance organisation through a process of methods of research and analysis, management improvement and training, the investigative research in the field of maintenance, equipment, materials and technology and regular communication with operating personnel to incorporate improvement as developed.

1.2. Definitions

The maintenance of highways can be broadly classified under the following three sub-heads.

1.2.1. Ordinary repairs/routine maintenance : The ordinary repairs include the following nature of works :

- (i) Upkeep of road pavements and side shoulders
- (ii) Upkeep of roadside drain system
- (iii) Upkeep of culverts and bridges, and earth retaining structures and parapets
- (iv) Keeping the sign boards, km stones and other traffic aids and furniture in good shape and condition
- (v) Maintenance of roadside arboriculture
- (vi) Upkeep and maintenance of rest houses, inspection bungalows and gang huts.

1.2.2. Periodic maintenance : It covers periodic renewals to the carriageway whether it is gravelled road, metalled road or black topped road to ensure that adequate level of serviceability is maintained.

1.2.3. Special repairs and flood damage repairs

2

Planning and Financing

2. PLANNING AND FINANCING

2.1. Inventory of Road

The first step to planning of maintenance operation is the evaluation of the existing road in terms of its physical condition, structural capacity and surface profile (roughness) etc. For this purpose, basic road inventory containing all details of the existing highway should be available. The following data are required to have a complete inventory.

2.1.1. **District map (Fig. 2.1.) :** District map on the scale of 1:50,000 should be available with the following details :

- (a) Classification/category width of roads
- (b) Location of streams and C.D. works
- (c) Type of surfaces
- (d) Lane width of road
- (e) Traffic intensity and volume
- (f) Urban limits.

2.1.2. **Strip maps (Fig. 2.2.) :** Strip map of a particular section of the road must have the following details :

- (a) **Kilometerage**, road geometrics viz. road width, steep gradients, if any, culverts with brief particulars, crossings etc.
- (b) Availability of materials and location at quarries
- (c) Availability of T & P, existence of stores and department workshops, gang huts
- (d) Any other features such as sections which require special attention or substandard geometrics, e.g. inadequate sight distance, horizontal or vertical alignment, narrow width, inadequate super-elevation, weak bridges
- (e) Broad soil types.

2.1.3. **Surface history :** Surface history of the road should be compiled in format given in *Appendix I*. It will contain the summary of information available in the road register maintained on the lines prescribed by M.O.S. & T. The information should be as accurate as possible and collected from the available records.

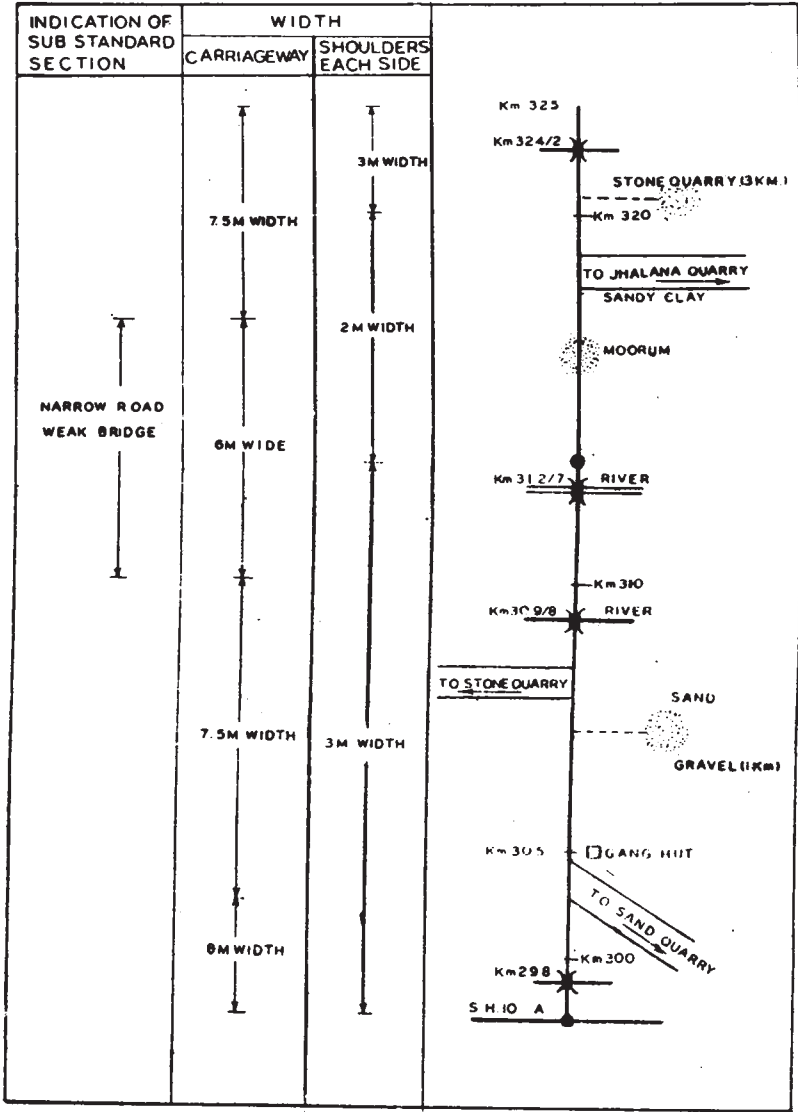


Fig. 2.2. Road inventory chart

2.2. Condition Survey

When all the inventory data of the road are available, condition survey can be carried out :

- (a) By visual inspection
- (b) By mechanical evaluation.

Condition surveys by visual inspection/assessment of the pavement, cover the type, magnitude and location of the deficiency or distress. Necessary information about the routine maintenance can be had by simply going along the road-both past and present and the likely causes of distress.

Pavement surface evaluation based on surface condition (cracking, patching) riding quality (i.e. road roughness) and skid resistance would form basis for taking periodic maintenance decisions. Condition surveys at fixed frequency are necessary for determining periodic renewal requirements and long term maintenance strategy. For that purpose, the condition surveys should be conducted for each stretch of the road as per frequency prescribed in para 3.1.

Generally, the condition surveys are carried out from a vehicle travelling at slow speed supplemented by inspection of more critical spots on foot. The data collected should be recorded methodically kilometre-wise. It is desirable that these condition surveys be carried out by the Junior Engineer/Assistant Engineer. While carrying out inspections, the check list of items given in *Appendix 2* should be kept in mind. The findings of condition survey should be recorded in format given in *Appendix 3*.

2.3. Programming and Planning

Based on the condition evaluation, the causes for the various defects observed should be examined in detail and a decision taken whether to initiate a particular maintenance activity, or to go in for more detailed investigations to determine the maintenance/rehabilitation needs precisely. Whenever distress on the pavement has reached the stage which affects the smooth operation of traffic, it should be rectified straightaway. For other defects like cracking, ravelling etc., the optimal strategy should be determined having regard to the various factors involved and a decision taken whether

to go in for measures like seal/renewal coat or to strengthen/reconstruct the pavement. If the latter appears necessary, further investigations about structural deficiencies must be taken up. In other words, the planning of the various maintenance operations should be correlated and looked upon as a total system rather than each activity being considered in isolation. The criteria for maintenance priorities/rehabilitation needs would be as per Chapter 4.

Once the overall maintenance plan has been drawn up, attention should be given to the proper organisation and management of the whole programme including deployment of various resources i.e. men, materials and equipment, in an efficient manner. For each maintenance activity, the work at site should be carefully controlled so that the optimum out-put and quality are achieved.

2.4. Annual Calender of Road Maintenance Activities

The planning and programming of various maintenance activities throughout the year should be done in advance keeping in view the climatic condition and periods available for carrying out different activities. A suggested programme with regard to various activities involved in respect of maintenance is given in *Appendix 4*.

3

Inspection

3. INSPECTION

3.1. Frequency

The minimum frequency of inspections for condition is suggested in Table 3.1. :

TABLE 3.1.

S. No.	Type of road	E.E.		A.E.		Section /c.	
		Routine	Special	Routine	Sp!.	Routine	Spi.
1.	NH & SH	Twice in a year (April & October)	Before and after mon-soons	Once in two months Jan. March May July Sept. Nov. & Dec.	Before and after mon-soons Twice during rains	Once a month	Every week

The inspection should be carried out not only to check the conditions of works but also for planning future strategies. Senior officers should make it a point to note and communicate the instructions to the subordinates. While on inspection, the senior officer should go through the notes of Junior colleagues and make suitable suggestions so that inspections are meaningful.

3.2. Duties

The duties of supervisory staff such as mates and civil mistries have been defined elsewhere under the sub-head "Out-put of labour". The duties of Engineering subordinates, Assistant Engineers and Executive Engineers are as follows :

3.2.1. Duties of engineering subordinates

- (i) Inspection and supervision of works as per prescribed norms
- (ii) Reporting observations to higher authorities

- (iii) Preparing estimates for repairs after conducting condition surveys of road
- (iv) Reporting about closure of road/obstructions due to any of the following reasons :
 - (a) Over topping/breach
 - (b) Landslides
 - (c) Earthquake
 - (d) Accident
 - (e) Any other reason (specify)
- (v) Arranging for removal of obstructions, dead animals and other debris lying on road
- (vi) Enumerating safety measures and restoration works in case of flood damages and breaches and reports on opening of traffic/completion of restoration.

3.2.2. Duties of Assistant Engineers

- (i) Inspection and supervision of works as per norms
- (ii) Reporting observations with suggestion for remedial action to higher authorities
- (iii) Getting estimates prepared and checked after conducting surveys and site investigations
- (iv) Reporting about heavy rainfalls in the area and consequent rain damage
- (v) Enumerating action on the report of engineering subordinates regarding obstructions, accidents etc.
- (vi) Enumerating safety measures and restoration of (both temporary and permanent) works in case of flood damages and breaches.

3.2.3. Duties of Executive Engineers

- (i) Inspection and recording of observations as per prescribed norms
- (ii) Planning and finalisation of nature of maintenance activity e.g. surface removal, repair to CD works etc.
- (iii) Arranging men, materials and machinery in advance as per requirements
- (iv) Finalising action on reports of Assistant Engineers and also on safety measures, diversion in case of breaches and flood damages
- (v) Coordination with various agencies like traffic police, local administration, publicity media etc., in case of emergent repairs interruption to traffic by road blockage, etc.
- (vi) Initiate steps for finalising permanent restoration work.

3.3. Identification of Defects

It is important to identify and locate the defects of surface, shoulders, side drains and cross drainage during the inspection of the road by various officers. Reference should be made to IRC : 82 “Code of Practice for Maintenance of Bituminous Surfaces of Highways” to help in identifying the various surface defects such as bleeding, streaking, cracking, ravelling, edge subsidence, edge fretting, rutting, shoving, pot holes etc. Common defects and deficiencies of shoulder draining and cross drainage works have been indicated in para 5.6. A brief note on field procedure for inspection and planning maintenance works is given in *Appendix 5*.

4

Maintenance Criteria

4. MAINTENANCE CRITERIA

4.1. Once the inspection of road for condition survey has been carried out and its findings recorded in the prescribed format given in *Appendix 3* in accordance with the instructions contained in para 2.2, the priorities for the required maintenance operations are required to be fixed. These priorities are to be assigned judiciously looking to the urgency of the work. The urgency is governed by factors like (a) safe and unobstructed flow of traffic (b) preservation of the assets in the form of roadway and its appurtenances and (c) preventive maintenance to avoid any further deterioration. Guidance regarding assignment of priorities is given in table 4.1 which indicates the priorities for various operations as (a) urgent for jobs requiring top priority (b) special—for jobs which are in next order of priority (c) recurrent—for jobs which occur recurrently and are next to special in order of priority and (d) routine—for jobs which are to be attended to in a routine manner. In case road is breached or blocked, urgent action shall be taken by Mate/Section Officer/Assistant Engineer and others as per steps indicated in *Appendix 6*.

4.2. Criteria for Renewal

Generally, the renewal cycle of bituminous surfacing would be dependent on the traffic density, rainfall and lane width. Table 4.2. gives the guidelines recommended in IRC : 82 “Code of Practice for Maintenance of Bituminous Surfaces of Highways” for National and State Highways.

TABLE 4.1. MAINTENANCE CRITERIA

Feature	Criteria	Action	Priority
A. Features concerned with safety of traffic			
A-1 Major breaches in the roadway	Any type of breach which endangers safety of traffic and causes obstruction to flow of traffic	Steps to be taken as listed in appendix	Urgent
A-2 Minor cuts, ruts or blockades	Cuts or blockades which do not completely obstruct the traffic but endanger safety of traffic	Get blockades removed and get the cuts repaired	Urgent
A-3 Branches of trees at height less than 4.5 m over the roadway	Any kind	Get them cut in order of lower ones first	Special attention
B. Carriageway and crust conditions			
B-1 Cracking not accompanied by rutting	(a) Cracking in local areas equal to or less than 25 per cent of the total area (b) Cracking in large areas exceeding 25 per cent of the total area	Local sealing or filling of the cracks (b) Binder @ 1.5 kg/m ² of bitumen emulsion or 1 kg/m ² of cutback for local sealing (c) Chippings (6-10 mm) for local surfacing repairs Needs surfacing after local sealing	Routine Special attention
B-2 Stripping	(a) In local areas exceeding 25 per cent of the total area	Apply local sealing	Routine

Feature	Criteria	Action	Priority
B-3 Bleeding	<p>(b) In long areas exceeding 25 per cent of total area</p> <p>(a) In local area not exceeding 25 per cent of total area</p> <p>(b) In local areas exceeding 25 per cent of total area</p> <p>(a) Less than 50 mm accompanied by cracking of less than or equal to 10 m/m²</p>	<p>Apply surface dressing</p> <p>Spread and roll over 6 mm size aggregate, heated to 60°C</p> <p>Apply surface dressing</p> <p>Apply coat @ 0.5 kg/m² and fill bituminous mix using a rake and leaving an excess thickness of about one third the depth of rut. Compact till surface is level and local sealing of cracks.</p>	<p>Special attention</p> <p>Routine</p> <p>Special attention</p> <p>Routine</p>
B-4 Rutting	<p>(b) Less than 50 mm accompanied by cracking more than 10 m/m²</p> <p>(c) More than 50 mm accompanied by cracking more than 10 m/m²</p>	<p>—do—</p> <p>With surface dressing over cracks</p> <p>Overlay required</p>	<p>Special attention</p> <p>Work of original nature</p>
B-5 Pot holes	Pot holes as soon as they occur	Local restoration by patching	Special attention
B-6 Reflection cracks	<p>(a) Widely spaced cracks</p> <p>(b) Closely spaced cracks</p>	<p>Seals</p> <p>Apply surface dressing</p>	<p>Recurrent</p> <p>Special attention</p>
B-7 Edge subsidence and rutting	Any extent	Patch road edge and repair shoulder	Recurrent
B-8 Defective camber	Any extent	Check and correct by reconstructing to proper camber profile	Special attention

Feature	Criteria	Action	Priority
B-9 Undulations	Any extent	Investigate the cause and rectify	Special attention
B-10 Loss of material from unpaved road	Any extent	Do regravelling	Special attention
C. Shoulders—side drains			
C-1 Deformation or scour of shoulders	Any extent	Fill and compact and bring its surface to desired camber	Routine
C-2 Silting of side drains	Any extent	Clean out the drains	Routine
C-3 Damage or scouring of drain	Any extent	Reconstruct to adequate shape and size	Special attention
D. C.D. Works			
D-1 Causeways			
(a) Pot holes in paved surface	Any extent	Repair by filling	Special attention
(b) Erosion at inlet/outlet	Any extent	Repair	Special attention
(c) Guide posts/flood gauge missing	Any	Repairs/Replace	Special attention
D-2 Culverts			
(a) Silting	Any	Desilting	Special attention
(b) Erosion at inlet/outlet	Any extent	Repairs	Special attention
(c) Settlement cracks	Any	Repair	Special attention
E. Other Works			
E-1 Road furniture and warning dirty or corroded or damaged missing	Any extent	Clean and repair replace	Routine
E-2 Missing road signs	Any	Fix new one	Special attention

TABLE 4.2.

Class of road	Lane width	Traffic (commercial vehicles per day)	Type of renewal and periodicity of the renewal treatment for		
			Low rainfall upto 150 cm per year	Medium rainfall 150-300 cm per year	High rainfall above 300 cm per year
National Highways and State Highways	Single	(i) Less than 450	SD 4	SD 4	SD 4
		(ii) 450-1500	SD 4	SD 3	SD 3
		(iii) More than 1500	PC 6	PC 5	PC 4
			or MS 8	or MS 7	or MS 6
	Double	(i) Less than 450	SD 5	SD 4	SD 4
		(ii) 450-1500	SD 4	SD 3	SD 3
		(iii) More than 1500	PC 6	PC 5	PC 4
			or MS 8	or MS 7	or MS 6

Notes :

- (1) S D = Single coat of surface dressing with 3½ cu. ft. of chips and 25 lb of bitumen
P C = 20 mm premix chipping carpet as per IRC : 14
M S = Mix seal surfacing as per Ministry of Shipping and Transport (Roads Wing) Specification for Roads & Bridge Works clause 508
- (2) The denominator refers to the periodicity of renewal in years
- (3) For areas subject to snowfall and hilly areas with steep side slopes and heavy rainfall, the periodicity of renewal may be at closer intervals
- (4) The periodicity of the renewal indicated in the table above should only be taken as a general guideline for the purpose of budgeting and determining the extent of renewal programme. It does not indicate either the expected life of the particular type of treatment or the imperative need for renewals after the period indicated.

5

**Execution of
Maintenance
Operations**

5. EXECUTION OF MAINTENANCE OPERATIONS

5.1. Safety of Labour and Road User During Maintenance

5.1.1. Principles : In the implementation of maintenance operations, the road user and personnel involved in the work should not be exposed to hazards. Besides, delay and inconvenience to the traffic should be reduced to the minimum. Road user, even when fully aware that maintenance is for his ultimate good and safety, does not take it kindly if it is not done in a proper manner.

Traffic hazards and inconvenience can be minimised by use of temporary road signs and controlling/guiding of the traffic, while keeping in mind the positioning of road signs as follows:

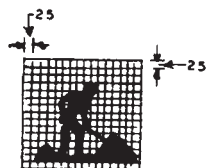
The standard signs in good and clear condition should be displayed in a proper and standard layout, so as to give the drivers sufficient time to understand and react to the information on the sign. The signs to be used should be as per IRC : 67 "Code of Practice for Road Signs", some of which are shown in Fig. 5.1.

Maintenance operations should at a time be confined to small lengths, say 30 m in half the pavement width, leaving the other half for use by traffic. However, some times this may not be possible and in such a case, maintenance work can be divided in the following four categories from the point of view of safety and traffic control :

- (i) Repairing the edges of the carriageway, shoulders, cleaning out drains, cutting grass etc., where carriageway is not affected
- (ii) Repairing the carriageway restricting to one lane while traffic can be allowed on the other lane
- (iii) While working on the centre line such as centre line marking/ painting necessitating the traffic to use restricted width on either side
- (iv) Total closure of the road necessitating use of diversion due to widening/reconstruction of an existing CD work or construction of a new structure or due to breach or damage to existing road or CD works. The detailed instructions for various categories are as follows:



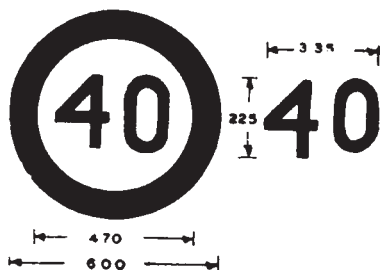
RESTRICTION ENDS



MEN AT WORK



NARROW ROAD AHEAD



SPEED LIMIT

Fig. 5.1.

5.1.2. Works on edges and shoulders : The positioning of the cautionary signs for this category are illustrated in Fig. 5.2. Before starting the work, all warning signs should be installed in the following manner. "Men at Work" should be placed 200 m before approaching the work area and "Restriction Ends" sign should be displayed 200 m beyond the work area. When the work is completed, these signs should be removed in the reverse order.

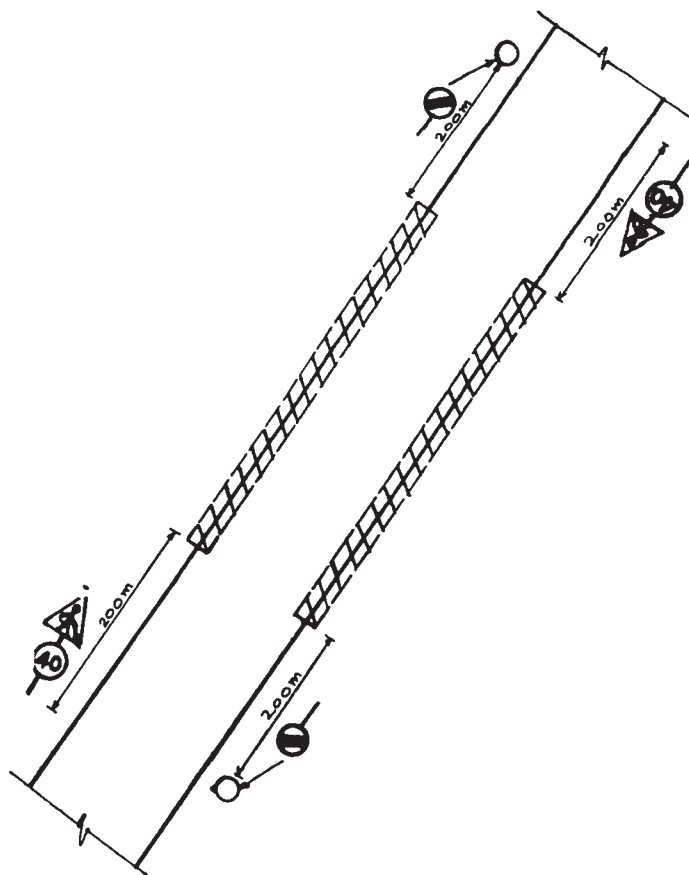


Fig. 5.2. Arrangements of signs for work on edges and shoulders

5.1.3. Restricting the traffic to one lane : At times, the traffic is to be restricted to one lane only due to repairs being carried out in the other lane such as major patch repairs, etc. The position of various cautionary and warning signs are illustrated in Fig. 5.3, which are to be installed before start of the work in the following sequence :

- (i) "Men at Work" sign to be put up 200 m before commencement of work

- (ii) "Narrow Road Ahead" should be at 100 m ahead of work area
- (iii) "Keep left/right" sign to be placed at the commencement point of work and next to the barriers on either end of the work area
- (iv) "Barriers" should be placed on both sides of the work area

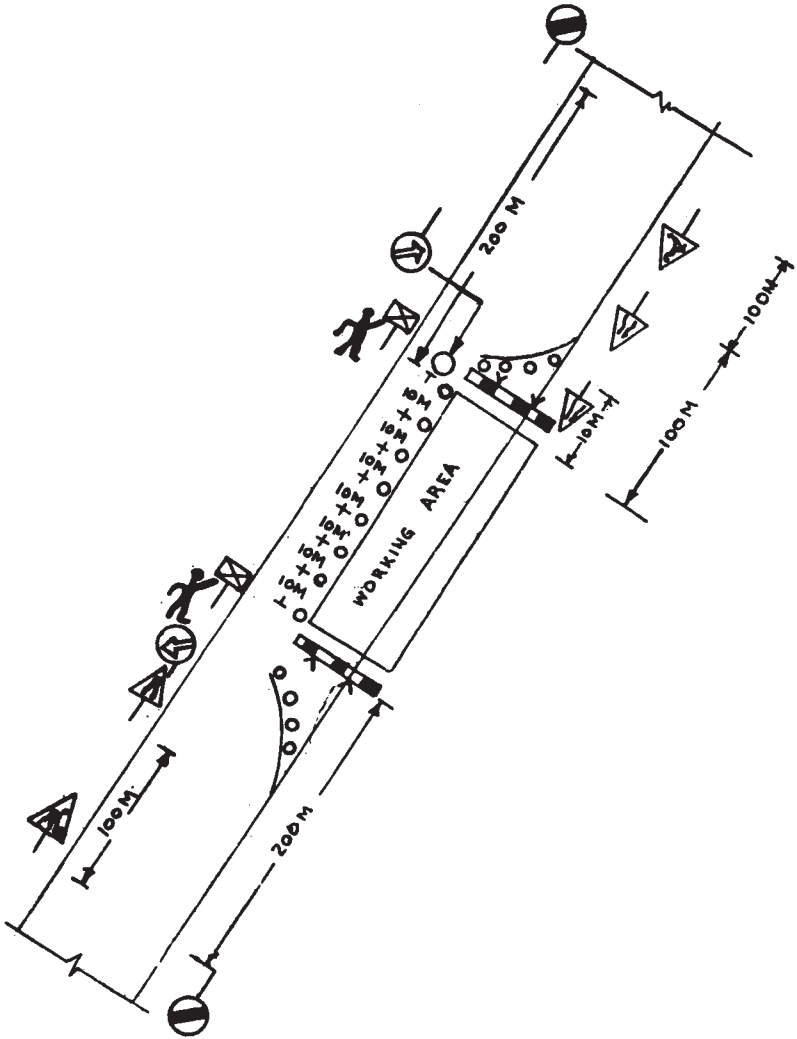


Fig. 5.3. Arrangements of signs for closure of one lane

- (v) Drums painted white and black should be placed at 10 m interval for guiding the traffic. In the approaches these are to be kept in a tapered manner
- (vi) "Restriction Ends" sign should be installed 200 m beyond the work area.

In addition to the above, a watchman should be present at the barrier to control the traffic at all times. Police assistance may also be sought for in case of need. Necessary lighting arrangements may be made during night with flashing lights when required. The barricade should be protected with red warning lamps at night which should stay lit from sun set to sun rise. In addition, alternate black and white diagonal strips should be marked on these for effective advance warning, preferably with reflectorised paint.

Signs, lights, barriers and other traffic control devices should be kept maintained in a satisfactory condition till such time that the traffic is restored and allowed to follow its normal path.

5.1.4. Working in the centre of the carriageway : While working in the centre of the carriageway, adequate attention has to be paid from the safety point of view, for example, marking/painting of centreline. The positioning of the various cautionary and warning signs are illustrated in, Fig. 5.4. The sequence of installation of these signs are the same as explained in para 5.1.3. except in this case, the vehicles will keep only to the left in each direction. When the work is completed, it should be ensured that the signs are removed in the reverse order.

5.1.5. Diversions

5.1.5.1. In the interest of safety and convenience of traffic, appropriate measures must be taken whenever traffic on any section of a National Highway is to be diverted to another route, or made to sever from its normal path into another. Basic principles to be kept in mind are (i) that the traffic must be guided properly where it is required to follow an alternate facility and (ii) given a clear warning of any hazards that may be present ahead.

5.1.5.2. Arrangements when traffic is suspended on a section

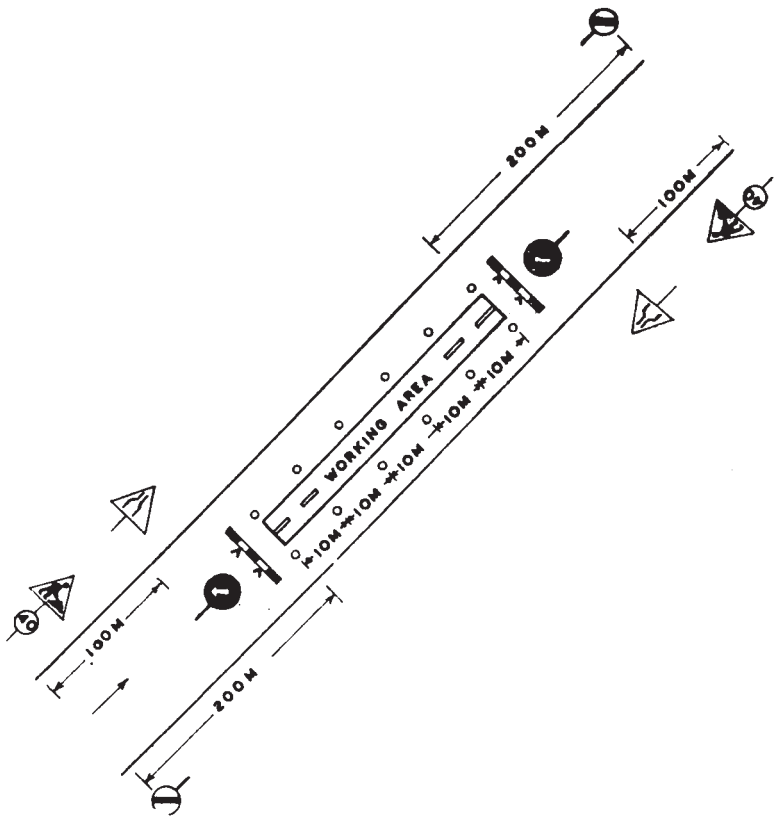


Fig. 5.4. Arrangements of signs for working in centre of carriageway

of a National Highway because of flood breach or damage caused due to certain other reason

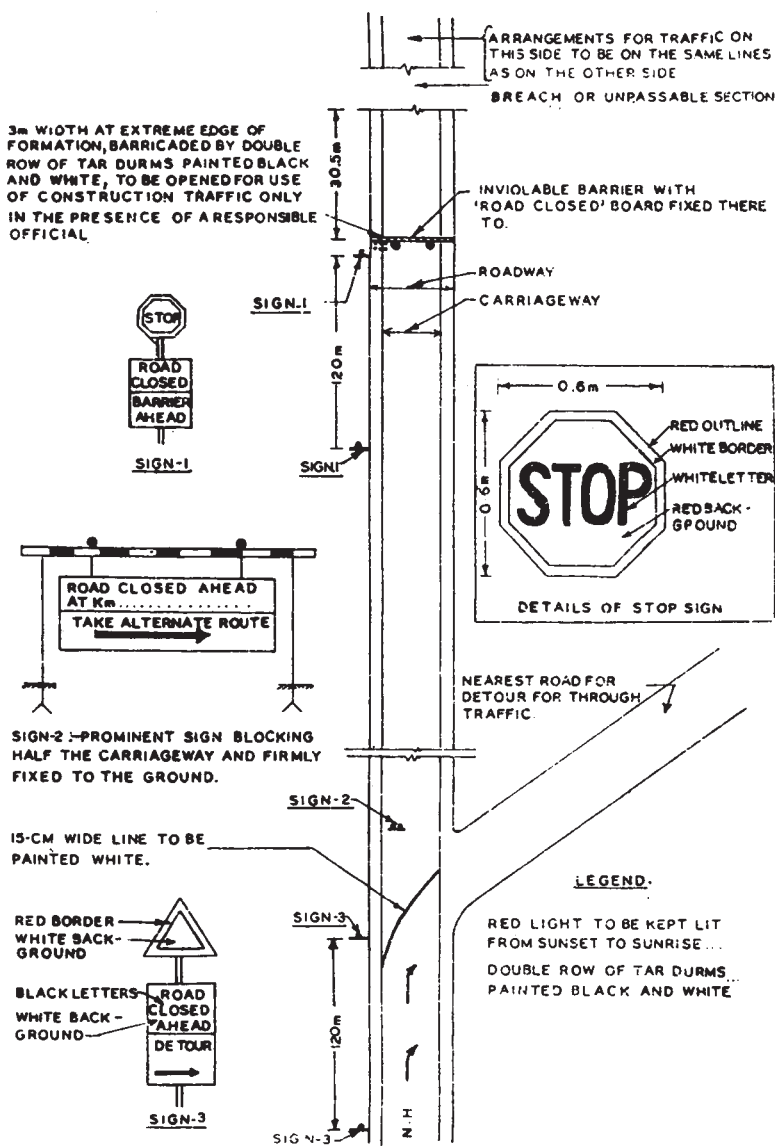
- (i) If the duration of suspension is such as to necessitate diversion of traffic to another route, guidance about this should be provided at the appropriate road intersection, on either side of the damaged section where it would be possible for the through traffic to alter its course. This should be done with the help of suitable warning signs put up in a pair, one just close to the intersection and the other 120 metres away. In addition, a prominent 'road closed' sign should be fixed on the far side of the intersection blocking half the width of the carriageway. Word message on the signs may be in more than one language according to needs of the traffic. To regulate traffic at the points of re-routing, police help may also be requisitioned.

Together with this, press and other mass media should be availed of to notify the public about road closure, and alternative routing for the through traffic;

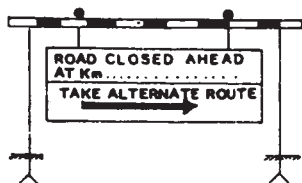
- (ii) Strong, inviolable barriers should be erected in the immediate vicinity of the damaged section on both sides so that traffic can have no chance of going through imprudently. Besides, regulatory signs announcing that the road ahead is closed should be installed on the approaches, one sign at 10 m from the barrier and the other 120 m further away. These should be supplemented by a "road closed" sign affixed to the barrier in a prominent position. Word messages on the sign may be in more than one language as dictated by needs of the road users;
- (iii) The barricades should be protected by red warning lamps at night which should stay lit from sun set to sun rise. In addition, alternate black and white diagonal strips should be marked on these for effective advance warning. Preferably, reflectorised paint should be used for this purpose;
- (iv) A watchman should be present at the barrier at all times. Whenever the barrier is to be temporarily opened for construction traffic in connection with repairs to the damaged section, a responsible officer must be present at the site for supervising traffic arrangements and explaining the hazard ahead to adamant drivers. The construction traffic may be allowed through a small opening (about 3 m wide) at the extreme edge of the roadway, normally kept blocked with a double row of painted tar drums which should be removed only for permitting the construction vehicles to pass each time and put back in position immediately thereafter
- (v) Signs, lights, barriers and other traffic control devices should be kept maintained in a satisfactory condition till such time that the traffic is restored and allowed to follow its normal path; and
- (vi) Typical arrangements according to the above plan are illustrated in Fig. 5.5.

5.1.5.3. Arrangements for traffic when repairs to an existing cross-drainage structure are to be carried out : The following instructions should be kept in mind when undertaking these works :

- (i) Traffic may be passed either over part width of the structure, or a temporary diversion, depending on site conditions, intensity and volume of traffic, preferably on economic considerations and other related matters. The former method should be employed as far as possible, specially when the work could be conveniently carried out in half width at a time and there are no undue problems in channeling the traffic through the available road width. In both cases, the

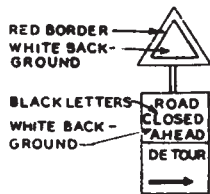


SIGN-1

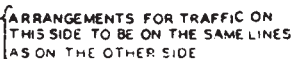


**SIGN-2 :- PROMINENT SIGN BLOCKING
HALF THE CARRIAGEWAY AND FIRMLY
FIXED TO THE GROUND.**

15-CM WIDE LINE TO BE
PAINTED WHITE.



SIGN-3

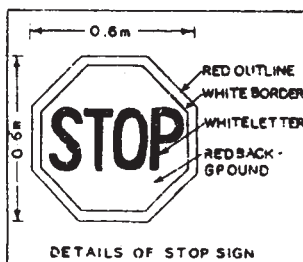


BREACH OR UNPASSABLE SECTION



-ROADWAY

- CARRIAGEWAY



WHITE BORDER
WHITE LETTER
RED BACK -
GROUND

DETAILS OF STOP SIGN

NEAREST ROAD FOR
DETOUR FOR THROUGH
TRAFFIC.

LEGEND.

RED LIGHT TO BE KEPT LIT
FROM SUNSET TO SUNRISE...
DOUBLE ROW OF TAR DURMS..
PAINTED BLACK AND WHITE.

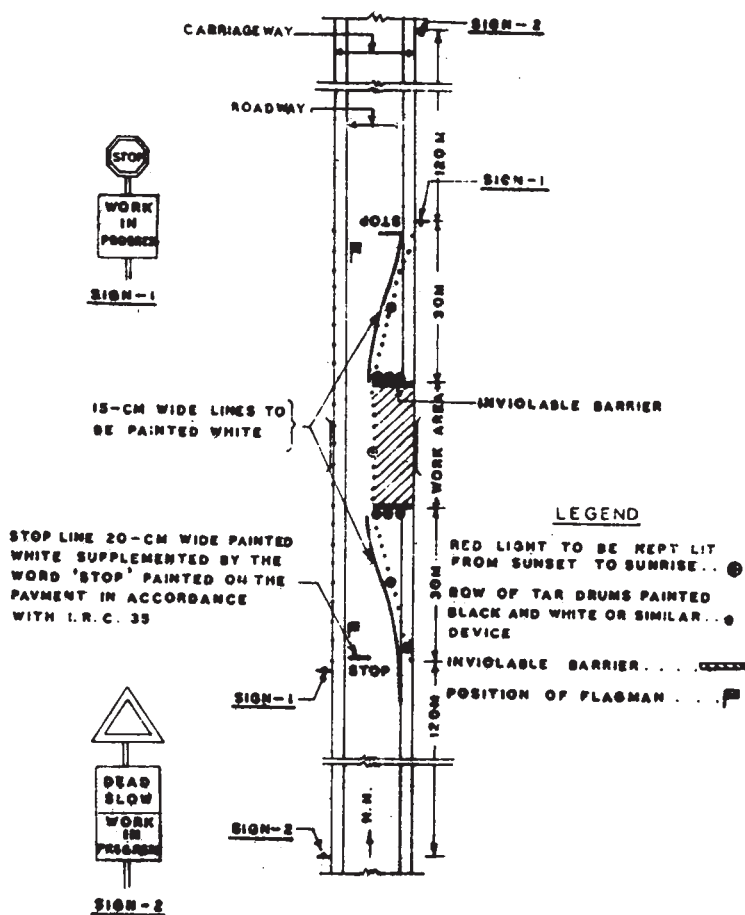
(Not to scale)

Fig. 5.5. Arrangements for traffic when a section of N.H. is to be closed due to breach or damage

work should be so planned that repairs of the cross drainage facility is over in the shortest time possible following properly conceived repairs and maintenance execution schedules. This will be facilitated if all the materials and other equipment are collected at site in advance before the work actually commences;

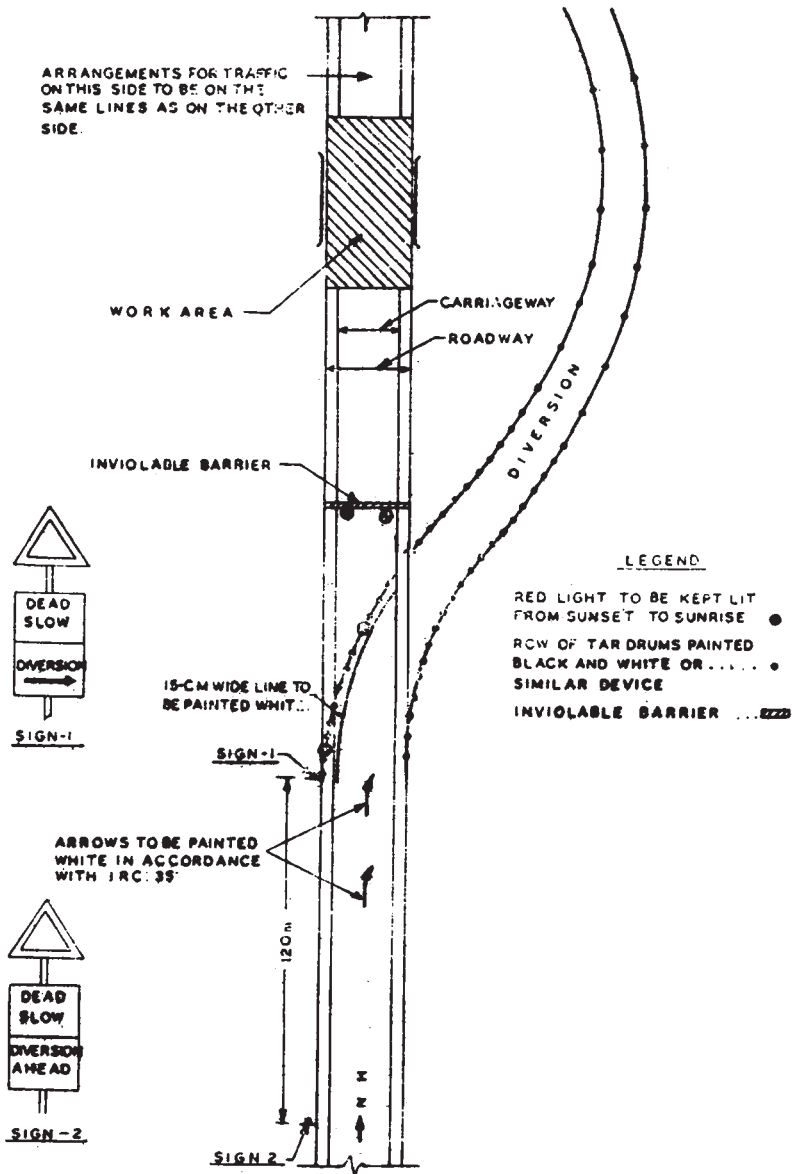
- (ii) Where for any reason traffic cannot be passed over part width of a structure, a temporary diversion should be constructed. The width and paving specifications for the diversion should be decided on factors like the period for which diversion will be in use, intensity and volume of traffic and climatic conditions. Appropriate consideration must also be given to the avoidance of dust nuisance. On both ends, the diversion should be joined to the main carriageway with smooth transitions, with visibility requirements fully taken care of;
- (iii) One-way traffic operation should be established whenever the traffic is to be passed over part width of a structure. This should be done with the help of flagmen, positioned on opposite sides, who should be on duty during all hours. For regulation of traffic, the flagmen should be equipped with red/green flags and lanterns/lights;
- (iv) At the points where traffic is to deviate from its normal path (whether on temporary diversion or part width of the carriageway), the channel for traffic should be clearly marked with the aid of pavement markings, and painted drums or a similar device. At night, the passage should be delineated with lanterns or other suitable light source. To enhance night visibility, reflectorised paint may be used for the painting of markings and drums;
- (v) Strong barriers of suitable design should be erected on either side of the portion of carriageway closed to traffic, both when the traffic is to be turned to a diversion road or channeled on to part width of the structure. For protection of traffic, red lanterns or warning lights of similar type should be mounted on the barriers at night and kept lit throughout from sun set to sun rise. Besides, barricades should be painted with alternate black and white markings, for which reflectorised paint should be preferred to improve their night visibility;
- (vi) On both sides, suitable regulatory/warning signs should be installed for the guidance of road users. Word message on the signs may be in more than one language as necessary. On each approach at least two signs should be put up, one close to the point where transition of carriageway begins and the other 120 m away;
- (vii) Signs, lights, barriers and other traffic control devices, as also the temporary diversion, should be kept well maintained till such time that the traffic is again able to follow its normal path; and

- (viii) Typical arrangements for two cases where traffic may be passed (i) over part width of a structure or (ii) over a temporary diversion, are illustrated, respectively, in Figs. 5.6. and 5.7.



(Not to scale)

Fig. 5.6. Arrangements during reconstruction of cross drainage structures where traffic can be passed over part width of the structure



(Not to scale)

Fig. 5.7. Arrangements during reconstruction of cross drainage structures where traffic is to be passed over a diversion

5.1.5.4. General : It will probably not be possible to provide all the safety equipments recommended for small works, due to paucity of funds and limitation of resources. Hence, engineer must take his own decisions depending upon the traffic on the road. However, for National Highways, these systems must be adopted. The following further precautions must be taken :

(a) For Safety Workmen

- (i) Workmen must be trained in use of tools and plant
- (ii) Gum boots, spectacles, etc. must be given to persons using bitumen
- (iii) First aid training and kits should be provided.

(b) For Safety of Road User

- (i) As far as possible, the material, equipment and machinery should be collected/installed/parked in places sufficiently away from the berms in the available road-land. Only in the unavoidable cases, the same shall be allowed to be collected/installed/parked near the edge of the berms. In any case, no material should be collected nor any equipment/machinery installed/parked on berms near and in the curves
- (ii) Caution sign boards should be maintained at all the desired places
- (iii) Machinery should be parked at appropriate places with red flags and red lights on
- (iv) Minimum quantity of material required for one operation should be collected.

5.2. Symptoms, Causes and Treatment of Surface Defects

5.2.1. General

The types of defects in bituminous surfacing are grouped under four categories :

A - Surface defects : which include fatty surfaces, smooth surfaces, streaking and hungry surfaces

These are associated with the surfacing layers and may be due to excessive or deficient quantities of bitumen in these layers.

B - Cracks : can be broadly classified as hair-line cracks, alligator cracks, longitudinal cracks, edge cracks, shrinkage cracks and reflection cracks

A common defect in bituminous surface is the formation of cracks. The crack pattern can, in many cases, indicate the cause

of the defect. As soon as cracks are observed, it is necessary to study the pattern in detail so as to arrive at the cause. Immediate remedial action should be taken thereafter because of the danger of ingress of water through the cracks and of the formation of pot holes and ravelling. Cracks can hardly be observed from moving vehicles and inspection on foot is always desirable.

C - Deformation : under this are grouped slippage, rutting, corrugations, shallow depressions and settlements, and upheavels

Any change in the shape of the pavement from its original shape is a deformation. It may be associated with slippage, rutting, etc. The treatment measures aim at the removal of the cause, and bringing it to the original level by fill material or by removing the entire affected part and replacing it with new material.

D - Disintegration : covering stripping, loss of aggregates, ravelling, formation of potholes, and edge breaking

There are some defects which if not rectified immediately result in the disintegration of the pavement into small loose fragments. Disintegration, if not arrested in the early stages, may necessitate complete rebuilding of the pavement.

5.2.2. The details of various types of defects and their treatment are given in Table 5.1.

5.3. Out-put of Labour

Maintenance of road in developing countries like India is labour intensive and therefore, the output depends upon "labour productivity". The operations require use of skilled and un-skilled workers. The need is to increase the productivity of labour by various means.

5.3.1. **Clear directions :** There should be no ambiguity regarding duties assigned to the supervisory staff so that there is full coordination while identifying jobs and giving directions to the labour. If conflicting directions at wrong times are given, the labour not only lose interest in work but become indisciplined.

TABLE 5.1. SYMPTOMS, CAUSES AND TREATMENT OF DEFECTS IN BITUMINOUS SURFACINGS

Type of distress	Symptoms	Probable causes	Possible types of treatment
1	2	3	4
A. Surface defects			
1. Fatty surface	Collection of binder on the surface	Excessive binder in premix, spray or tack coat, loss of cover aggregates; excessively heavy axle loads	Sand blinding; open-graded premix; liquid seal coat; burning of excess binder; removal of affected area
2. Smooth surface	Slippery	Polishing of aggregates under traffic, or excessive binder	Resurfacing with surface dressing or premix carpet
3. Streaking	Presence of alternate lean and heavy lines of bitumen	Non-uniform application of bitumen or at a low temperature	Application of a new surface
4. Hungry surface	Loss of aggregates or presence of fine cracks	Use of less bitumen or absorptive aggregates	Slurry seal or fog seal

B. Cracks

1. Hair-line crack	Short and fine cracks at close intervals on the surface	Insufficient bitumen, excessive filler or improper compaction
2. Alligator cracks	Inter-connected cracks forming a series of small blocks	Weak pavement, unstable conditions of subgrade or lower layers, excessive overloads or brittleness of binder
3. Longitudinal crack	Crack on a straight line along the road	Poor drainage, shoulder settlement, weak joint between adjoining spreads of pavement layers or differential frost heave
4. Edge crack	Crack near and parallel to pavement edge	Lack of support from shoulder, poor drainage, frost heave, or inadequate pavement width
5. Shrinkage cracks	Cracks in transverse direction or interconnected cracks forming a series of large blocks	Shrinkage of bituminous layer with age
6. Reflection cracks	Sympathetic cracks over joints and cracks in the pavement underneath	Due to joints and cracks in the pavement layer underneath

The treatment will depend on whether pavement is structurally sound, or unsound. Where the pavement is structurally sound, the cracks should be filled with a low viscosity binder or a slurry seal or fog seal depending on the width of cracks. Unsound cracked pavements will need strengthening or rehabilitation treatment

Table 4 (Contd.)

1	2	3	4
C. Deformation			
1. Slippage	Formation of crescent-shaped cracks pointing in the direction of the thrust of wheels	Unusual thrust of wheels in a direction, lack or failure of bond between surface and lower pavement courses	Removal of the surface layer in the affected area and replacement with fresh material
2. Rutting	Longitudinal depression in the wheel tracks	Heavy channelised traffic inadequate compaction of pavement layers, poor stability of pavement material, or heavy bullock-cart traffic	Filling the depressions with premix material
3. Corrugations	Formation of regular undulations	Lack of stability in the mix, oscillations set up by vehicle springs, or faulty laying of surface course	Scarification and relaying of surfacings, or cutting of high spots and filling of low spots
4. Shoving	Localised bulging of pavement surface along with crescent-shaped cracks	Unstable mix, lack of bond between layers, or heavy start-stop type movements and those involving negotiation of curves and gradients	Removing the material to firm base and relaying a stable mix
5. Shallow depression	Localised shallow depressions	Presence of inadequately compacted pockets	Filling with premix materials
6. Settlement and upheaval	Large deformation of pavement	Poor compaction of fills, poor drainage, inadequate pavement or frost heave	Where fill is weak the defective fill should be excavated and redone. Where inadequate pavement is the cause, the pavement should be strengthened

D. Disintegration

1. Stripping

<p>Separation of bitumen from aggregate in the presence of moisture</p>	<p>Use of hydrophilic aggregate, inadequate mix composition continuous contact with water, poor bond between binder and aggregate, poor compaction, etc.</p>	<p>Spreading and compacting heated sand over the affected area in the case of surface dressing; replacement with fresh bituminous mix with added anti-stripping agent in other cases</p>
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2. Loss of aggregate

<p>Rough surface with loss of aggregate in some portions</p>	<p>Ageing and hardening of binder, stripping poor bond between binder and aggregate, insufficient binder, brittleness of binder, etc.</p>	<p>Application of liquid seal, fog seal, or slurry seal depending on the extent of damage</p>
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3. Ravelling

<p>Failure of binder to hold the aggregate shown up by pock marks or eroded areas on the surface</p>	<p>Poor compaction, poor bond between binder and aggregate insufficient binder brittleness of binder, etc.</p>	<p>Application of cutback covered with coarse sand, or slurry seal, or a premix renewal coat</p>
--	--	--
4. Pot-hole

<p>Appearance of bowl-shaped holes, usually after rain</p>	<p>Ingress of water into the pavement, lack of bond between the surfacing and WBM base, insufficient bitumen content, etc.</p>	<p>Filling pot holes with premix material or penetration patching</p>
--	--	---
5. Edge-breaking

<p>Irregular breaker of pavement edges</p>	<p>Water infiltration, poor lateral support from shoulders inadequate strength of pavement edges, etc.</p>	<p>Cutting the affected area to regular sections and rebuilding with simultaneous attention paid to the proper construction of shoulders</p>
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In this connection, duties of the following supervisory staff have been spelled out:

- (i) Duties and responsibilities Mate *Appendix 7*
- (ii) „ „ „ „ *Munshi Appendix 8*
- (iii) „ „ „ „ *Mistry Appendix 9*

5.3.2. Task norms of gangmen : The gangmen must fully know the tasks they are to carry out and the expected out-put. There should be regular checking whether the tasks assigned and output achieved are as per norms. The recommended tasks for labour are given in *Appendix 10*.

5.3.3. Gang beats : The gang should be made responsible for a particular section of the road depending upon the nature of works in that reach and the mobility of the labour. Normal beat of a gang is from 15 to 20 km (see *Appendix 11* for general norms). Storing materials, tools and plant should be at a central location for quick and proper access.

5.3.4. Mobile gangs : Mobile gangs may be made use of more conveniently, cheaply and efficiently where pick vans or trucks are available. The headquarters of one or more mobile gangs should be fixed at a convenient location on the road where the necessary store-sheds for tools, plant and construction materials would be available together with rest-shed.

5.3.5. Proper tools and plant : Proper tools and plant having multi-purpose use increase efficiency of the labour. Tractors with trailers, disc-harrows, small mechanical rammers can do multi jobs. Use of tar-patcher, motorized equipment for preparing cut back by cutting with kerosene, folding wooden camber boards, etc. are small equipments which add to the efficiency of labour and quality of work.

A list of tools to be kept with each gangman is given in *Appendix 12*.

5.3.6. Training : Right type of person should be employed for every type of work. Whereas female labour can be good transporters for small loads, only skilled male labour should

be employed for work like bituminous construction. Regular training regarding works to be carried out, use of tools, plant and materials, etc. should be imparted to these workers.

5.4. Material Procurement

Material that is used for maintenance for bituminous paved surface is bitumen and aggregate. The procurement can be divided into different operations.

5.4.1. Control procurement of binders : The materials that are procured and stored centrally are bitumen, cut-backs and emulsions. These bituminous products should be procured and stored centrally in each section for use in the work. The quantity required will be calculated from the repairs programme approved which will also decide the time schedulings of procurement.

5.4.2. Aggregate : The aggregate for renewal work should be collected at site of work only when it is required to be used. The best season is April—June and mid-Sept. to mid-November.

Aggregate for patch work can be collected at the time of starting the work after calculating actual requirements and also can be procured before critical seasons (such as rains) and stored in every kilometre on a specially prepared platform by the side of each kilometre stone. A judicious decision in this respect has to be taken by the engineer-in-charge depending upon likely work and availability of materials at short notice.

5.5. Mechanisation and Equipment Planning

The spectrum of technologies available for maintenance of roads ranges from labour based to equipment based, although the relative proportions can differ substantially. The socio-economic requirements in India is basically for labour based maintenance to provide employment to a large number of people but it may be necessary to use special equipment to achieve a specified quality in the end product of certain activities, such as the use of (a) roller for compaction or (b) grit spreader and bitumen distributor for good surface dressing. Even the labour based methods use equipment in the form of hand tools and equipment based approaches use labour in the form of operator. Work animals are also very

useful and cost effective in construction with labour and simple equipment such as carts and rollers. Tables 5.2 and 5.3 give an indication of the range of maintenance methods potentially appropriate for use in India. The adoption and modification of agricultural equipment like tractors and blades for grading of shoulders are the useful intermediate techniques. Agricultural ploughs drawn by animals or small tractors are useful for digging operation. The loosened excess materials are then removed by hand or small scrapers.

5.5.1. Mobile gang system : Mobile system of gangs in the place of the conventional labour gangs, who are practically immobile and have little or no equipments will go a long way in streamlining the routine maintenance work. In this system, the labourers instead of moving individually on foot move about collectively in groups of 10 or more in a truck equipped with necessary basic tools for routine maintenance work. In addition to the required equipments, the truck may carry premixed stock piled patching material. Such groups, because of their mobility are capable of looking after sections of road from 30 to 50 km with much greater ease and efficiency than the dispersed gang labourers as now. Despite its initial cost, it is advantageous in the long run. The headquarters of one or more mobile gangs should be fixed at a convenient location on the road side where the necessary store sheds for tools/plant and construction materials could be available together with rest shed.

5.5.2. A list of equipment that is needed for various types of bituminous works is given in IRC-72: "Recommended practice for use and upkeep of equipment tools, and appliances for bituminous construction".

5.6. Maintenance of Drains, Shoulders, Slopes and CD Works

5.6.1. Drainage

5.6.1.1. Objective : To ensure that drainage elements remain free of obstruction and retain their intended cross sections and grades.

TABLE 5.2. SPECTRUM OF MAINTENANCE METHODS APPROPRIATE FOR USE IN INDIA

Activity/task	Labour Based Methods	Intermediate Methods	Equipment Based
1. Excavation of soils and rock	Soft soil Firm soil Hard soil Soft soil Medium rock Hard rock For leads of 0-50 m 50-100 m 100-200 m	Phowrah** " Pick axe*** crowbar " Hand drilling and blasting**** Phowrah animal carts Heat chipping**** and bitumen over open wood fire, mixed by rake Haul by head load or by bamboo stretcher, lay by rake Bitumen through**** containers with holes, chips from baskets Durmats****	Dozer for short leads slips Dozer tipper** Compressed air drill blasting** Dozer wheel loader Integrated hot mix plant* Tipper and paver Chip spreader and* bitumen distributor Vibrating compactors* Rollers**

*Excellent

**Good

***Average

****Poor

TABLE 5.3. ALTERNATIVE METHODS

Haulage Method	Recommended Haul Distance (m)	Constraints
1. Head baskets	5—30	A traditional method. Better results can be obtained with a little supervision. Route conditions and steepness not critical.
2. Sacks		Inefficient, particularly loading but useful for long distance haulage in hilly terrain and for fine granular material.
3. Two man bamboo stretchers		Inefficient but useful for hot materials.
4. Hand-carts		Need good haul route.
5. Wheel barrows with ball bearings	25—125	Very competitive if well organised, Haul route condition and critical, this can be improved by using steepness.
6. Donkeys	50—125	Reasonably independent of haul route condition and steepness. Gang balance fairly critical for good results.
7. Ponies	50—125	
8. Mules	50—125	
9. Camel-carts	100—600	Can be used in sandy soil with balloon tyres.
10. Bullock-carts	100—600	Require average route conditions.
11. Tractor/trailer	250—500	Good organisation critical for economical results.
12. Trucks flat bed or tipping	500+	Cost dependent on organisation to maximise trips.

They must function properly so that surface water, and ground water can drain freely and quickly away from the road or under the road. Water is the worst enemy of any road, it can.

- Erode soils
- Weaken pavements
- Destroy shoulders and slopes
- Wash out culverts, and even bridges.

5.6.1.2. Side drains

(a) ROUTINE ACTIVITIES

- Reshape/regrade/deepen
- Clearing and cleaning
- Erosion repair

(b) PERIODIC ACTIVITIES

- Provision of lateral ditches (turn outs)

5.6.1.3. Culverts

(a) ROUTINE ACTIVITIES

- Clearing and cleaning
- Erosion repair
- Repairs to cracks
- Repairs to protection works

(b) PERIODICAL ACTIVITIES

- Repair of invert

5.6.1.4. Causeways

(a) ROUTINE ACTIVITIES

- Minor surface repair
- Replacing guide posts
- Repairing flood gauges
- Repairing protection works

5.6.1.5. Inspection : Inspection of drainage system is an year round task. Structures must be examined in dry season when little

or no water is flowing so that structural damage cracks, settlement, erosion can be better seen and identified and waterway cleared of debris. The functioning of drainage system during the rainy season should also be inspected.

The drainage structures usually require examination on foot. The Junior Engineer, Assistant Engineer must check them on foot and look for signs of damage and distress.

If surface and ground water drains freely as intended the system can be deemed satisfactory. However, if water does not flow as intended, there is something wrong and needs to be repaired.

For example

- If a culvert outlet discharge is small when the inlet is at full head or submerged the culvert is not functioning
- Where the carriageway does not have an adequate camber or cross fall, the surface water will pond on the surface and accelerate the formation of ruts, pot holes and unintended ditches
- Where drains have little or no scope or inadequate turn outs, sitting will occur and cause ponding of water and weakening of pavement.

5.6.1.6. Inspection check list

(a) DRAINS

- Drain cross section destroyed
- Ponding in drain
- Silting
- Erosion

(b) CAUSEWAYS

- Potholes in paved surface
- Cracks in paved surface
- Guide posts missing
- Flood gauge missing/tilted

(c) CULVERTS

- Silting, sanding, blockage of debris
- Erosion at inlet and outlet
- Settlement cracks

5.6.1.7. Defects, causes and remedies

DRAINS

(a) DEFECT—PONDING

CAUSE—Cross section too small. The shoulder material becomes soft and can easily erode. The pavement can also be flooded and thus weakened.

ACTIVITY—Deepen drain

(b) DEFECT—SILTING

CAUSE—Invert slope is too flat, the water can not flow at sufficient velocity. If neglected the drain will get blocked.

ACTIVITY—Deepen drains (desilting) and/or provide lateral drains (turn outs).

(c) DEFECT—Uneven drain invert varying cross section.

CAUSE—Blockade by debris, and vegetation, if neglected cross section is reduced and water cannot flow as intended.

ACTIVITY—Cleaning, clearing, repairing.

(d) DEFECT—Invert and sides of drains are eroded.

CAUSE—Invert slope is too steep. If neglected, water flows at too high a velocity and starts carrying away the soil. The drain becomes deeper (ravine). The sides then cave in, the shoulder can even part of carriageway can be washed away.

ACTIVITY—Reinforce drain slopes and invert

—Regrading/realigning drains

—Provision of drain checks.

5.6.1.8. Causeways : The surface of causeways is endangered by washouts and slash movement caused by water current. Routine maintenance in this case can only be regarded as temporary measure. The activities include masonry repair, placing of stone crates; and erosion protection of causeway openings.

DEFECT—Cracks in paved surface.

CAUSE—Settlement of slab. If neglected, the cracks in concrete slab spread and widen especially during the following flood season.

ACTIVITY—Minor surface repair (sealing cracks).

DEFECT—Guide posts/flood gauges are missing or damaged.

Execution of Maintenance Operations

CAUSE—Accident, vandalism, flood damage. If neglected, when the pavement becomes submerged during flood the edge of pavement can not be seen, vehicles can accidentally drive into deep water.

ACTIVITY—Replacing guide posts.

5.6.1.9. Culverts

DEFECT—Siltng, sanding, blockage by debris.

CAUSE—Invert slope too flat.

—Culvert constructed too low, so that material from stream bed gets deposited in the culvert.

—Vegetation and flooding debris carried by water have become lodged in the culvert. If neglected, the intended waterway opening will be so reduced that flood water cannot flow. It will back up or pond on the upstream side of culvert and may eventually overflow the road embankment. The road is in danger of being washed away.

ACTIVITY—Cleaning and clearing. If flooding debris is a problem, the provision of debris rack should be considered.

DEFECT—Erosion of stream bed at culvert outlet.

CAUSE—The culvert invert has been constructed on too steep a grade so that water flows too fast.

—The culvert invert has been constructed on too flat a grade. If neglected, the stream bed is eroded and a pool or ravine develops. The culvert downstream head wall and wing walls and even a section of the culvert and road embankment can collapse into the pool or ravine.

ACTIVITY—Erosion repair.

DEFECT—Settlement cracks.

CAUSE—Settlement of soil below culvert if neglected.

—Minor damage—If the settlement is minor, only light cracking will result in head walls, wing walls and main structure. This will hardly affect the functioning of the structure.

—Major damage—If the settlement is average, it will cause large relative movement of culvert pipes so that embankment soil will enter through the cracks and block the culvert, or that the culvert can collapse. The culvert must be, in such a case reconstructed.

ACTIVITY—Cracking repair for minor damage.

5.6.2. Shoulders : Shoulders (Berms) provide lateral support to the pavement. They are used for parking vehicles in case of single lane roads, provide room for passing vehicles where carriageway width is insufficient and also comes in handy for the parking of disabled vehicles. These are at times serve as a track for slow moving vehicles. The properly maintained shoulders also helps the drainage of surface water quickly to the side drains. Improper maintenance of side shoulders will cause drainage along the edge of the pavements resulting in caving and there by penetration of moisture to the subgrade.

In order to perform satisfactorily the functions stated above, it is necessary that the surface of the shoulders are hard enough to resist the abrasive action of vehicles and likewise the disrupting influences of the elements of nature.

The shoulder surface should always slope uniformly from the edge of the pavement so that any water falling on the road surface or shoulders, is speedily drained off. If funds are available, it is better to have the shoulders paved or have hard shoulders with B.T. surfacing.

The work of maintenance consists of periodically replacing earth or moorum carried away from the shoulders, to remove ruts, and restore the slope to the designed level. This work is generally heavy during and after the rains.

5.7. Maintenance of Road Furniture

5.7.1. Traffic signs : Traffic signs are the principal means of conveying information about the road to drivers and, as the road network becomes more extensive, the number of traffic signs increases. As traffic flow increase, an increasing effort on their maintenance is needed. Signs which are clean and in good repair can be easily seen and understood and inspire confidence that their message is accurate and reliable. Damaged or missing signs should, for the same reasons, be replaced promptly, as should temporary signs upon completion of the maintenance works to which they are related. The provision and care of signs is very cheap and cost effective.

Signs should be inspected and cleaned at least twice a year. Wherever repairs can not be carried out at site, the signs can be taken to the workshop and got done as decided by the Engineer-in-charge.

It is worthwhile keeping records of traffic signs: they should be included in an inventory and transferred to a signs register in which inspections, repairs and replacements are recorded. It is useful if their location is recorded in strip map.

5.7.2. Rails and kilometre stones : Guard-rails and parapet rails are provided to protect roads users: guard-rails to prevent vehicles from running over high embankments and parapet rails on bridges to safeguard pedestrians and vehicles. They should be repaired promptly if damaged and kept clean and repainted regularly so as to maintain their visibility.

Kilometre stones provide both drivers and the maintenance organisation with the basic reference for the position of any point on the road. Kilometre stones should be kept clean and repainted regularly, and vegetation around these should be cleared so that they can easily be read from a moving vehicle.

Similar requirements apply to bridge and culvert marker stones. It is recommended that each bridge and culvert is provided with a marker stone (or stones), serially numbered within the kilometre in which it is located thus: 80/2 is the second culvert or bridge in km 80. These numbers should be used as references in the culvert and bridge registers.

Delineators are usually provided only on high bank or on bends. They should be kept clean and colour washed/painted regularly, reflectors may also be fitted. Vegetation around the delinators should be cleared so that they can be easily seen at a distance.

5.7.3. Requirement of equipments : The team required to carry out these works require the following equipments :

- 1 Pick—axe
- 1 Spade or shovel
- 1 Hand rammer
- Dry mixed concrete
- 1 small ladder
- Water
- Paints
- Brushes
- Solvent for brush cleaning
- Safety equipment.

6

**Organising
Maintenance
Operations
in Field**

6. ORGANISING MAINTENANCE OPERATIONS IN FIELD

The section incharge may follow the following steps suggested for efficient working :

6.1. Preliminary Steps

6.1.1. Examine the section to be repaired : The section of road to be repaired must be examined along its whole length in order to determine :

- The types of defects
- The extent of defects

6.1.2. Look at work sheets : These sheets give the dates on which work on the road section concerned is to be carried out as well as information on the materials to be used. The format of work-sheet is given in *Appendix 13*.

6.1.3. Check required resources

Please check

- All necessary personnel are available
- All items of tools and plant available
- All traffic signs available
- Required quantity of bitumen and other required materials available.

6.1.4. Temporary sign posting

- This is to ensure the safety of
 - Road users
 - Personnel working on site
 - Vehicles and equipment employed.

6.2. Execution of Work

6.2.1. Treating bleeding

- Coarse sand/chipping over 6 mm size scattered over effected surface preferably during sunny hot afternoon or after preheating sand/chipping to 60°C.

- Coarse sand/chipping is spread by a broom so that surface is evenly covered.

6.2.2. Local sealing

- Sweep the area. The surface must be clean and dry.
- Mark the area to be repaired by a brick piece or chalk.
- Spread bitumen (cut-back/emulsion) using watering either at the rate of
1.5 kg/m² of bitumen emulsion or
1 kg/m² of cut-back bitumen
- Distribute aggregate
- Chipping (6-10 mm size) when dealing with local surface repairs. Chippings should be compacted.

6.2.3. Crack sealing using slurry

6.2.3.1. Closely spread cracks

- Sweep the area clean and dry
- Mark the area to be repaired
- Slurry is prepared by mixing bitumen emulsion with sand in a wheel barrow
- Sand—20 lt
emulsion—6 lt
- Material may be spread approximately 5 mm thick over the whole of marked out area and not in a thin layer.

6.2.4. Treatment of isolated cracks : Filling cracks with hot bitumen/cut back bitumen

- Sweep the area
- Distribute bitumen to follow line of crack .
- Distribute sand using a shovel.

6.2.5. Filling in depressions : To deal with subsidence, and surface irregularities due to shoving

- Sweep the area clean and dry
- Mark the area to be repaired
- Apply tack coat at a rate of about 0.5 kg/m²
- Fill in the depression

Mix is placed within a marked out line using a rake and leaving an excess thickness of about one third of the depth of depression to allow for compaction

- Compaction of material by either durmats or vibrating rammer.

6.2.6. Patching

6.2.6.1. Patching is used to repair

- Mesh cracking
- Ruts and depressions
- Edge, subsidence and rutting
- Pot holes
- Edge surface failures
- Shoving

6.2.6.2. Four steps are involved

- Marking of area to be repaired
- Excavation of area to be repaired

These steps are necessary to

- (a) remove all material from the marked out area
 - (b) increase the depth of hole until firm material is found then dress the walls of the hole so that they are vertical
 - (c) dress the bottom of hole such that it is flat and horizontal and then compact it
- Back filling the hole with selected well graded material which may consist of a material of base layer to be repaired.

The material is placed in the hole and compacted in one or more layers of regular thickness depending on the depth involved. The last layer, prior to compaction, must have an excess thickness of about one fifth the depth of excavation, in order to allow for settlement on compaction. Compaction is continued depending on the size of excavation, using durmats or vibrating rammer until the surface is level.

—Completion and removal of temporary signs

- (a) Remove all excavated material
- (b) Sweep all aggregate from edges of repairs, apply sand to all areas where too much binder has been applied
- (c) Signs should be removed, removing the MEN AT WORK sign in the last

6.3. Work Report

Report on work accomplished during the week should be filled in the form of work report given in *Appendix 14*.

7

Monitoring

7. MONITORING

7.1. In order to ensure the desired progress in terms of physical and financial targets, it is essential to keep a close watch by monitoring through returns. The required returns for monitoring at field level have been explained elsewhere. For monitoring at circle level, a proforma at *Appendix 15* has been suggested. This return of the physical and financial performance should be submitted by the Executive Engineer to the Superintending Engineer after finalising the yearly accounts, in no case later than the 15th of June every year. The shortfalls, if any, should be discussed for better performance next year.

7.2. Detailed procedure and time schedule for the State Government's to forward proposals for maintenance and repairs of National Highways has been laid down by the Ministry of Transport vide letter No. NH III/Misc/139/77 dated 5th December, 1977. The time schedule is as under :

(a) Proposal for ordinary repairs/renewals /maintenance of urban links and major bridges	1st Jan. of each year
(b) Continuing S/R and flood damage repair works	30th April
(c) S/R (New) works	1st June of each year
(d) F.D.R. (New) works	15th Oct. of each year
(e) Reappropriation of funds	28th February

It is also to be ensured that all the special repair works and Flood Damage repair works are completed within two years.

Training in
Maintenance
Operations and
Management

8. TRAINING IN MAINTENANCE OPERATIONS AND MANAGEMENT

8.1. Training of all the personnel involved in maintenance is an integral part of the maintenance function. Such training, as may be required by the operating and maintenance personnel to achieve better performance can be classified as below :

- (a) Training of Engineering subordinates/section officer.**
- (b) Training of gangmen/mate.**

8.1.1. Training of section officers : The section officers are either diploma holders or fresh degree holders. Either way they are expected to perform all the necessary management tasks sometime without any formal management orientation or training. The typical section officer learns about maintenance management while he is on the job. This can be effective but most of the time bad practices are learnt with the good ones. Frequently the new section officer handles the job in the same manner as the person before him. Techniques which may or may not have worked twenty years ago are tried again today. Section officers and potential section officers must be provided with the opportunity to attend maintenance management and operations training. The areas to be covered during the training should be

- (1) Identification of defects**
- (2) Planning maintenance operations effectively**
- (3) Crew scheduling and control to achieve higher productivity at low cost consistent with quality**
- (4) Problems of crew supervision—communicating and coordinating**
- (5) Preparing road inventory**
- (6) Management by objectives**
- (7) Repair methods**

8.2.1. Training of gangmen/mates : The training of maintenance gangmen in two areas is very essential.

- (a) Safety aspects**
- (b) Repair methods**

72 Training in Maintenance Operations and Management

The training in safety aspects will include :

- (i) training of flag-men**
- (ii) use and lay out of temporary traffic signs for repair works**
- (iii) safety oriented handling and parking of machinery and equipment.**

The training in repair methods will include :

- (i) proper patching methods**
- (ii) proper grading of shoulders**
- (iii) maintenance of drainage structure**
- (iv) crack sealing**
- (v) painting and maintenance of the traffic signs and warnings**
- (vi) equipment maintenance.**

Problems of Special Areas

9. PROBLEMS OF SPECIAL AREAS

Roads in special areas like desert areas, hilly and heavy rainfall areas and high altitude areas pose problems of maintenance which need greater attention. Even though the planning, implementation and monitoring of maintenance activities will be, by and large, as detailed so far, still there are specific points which need special treatment and these are detailed below :

9.1. Maintenance of Roads in Desert Areas

The road maintenance of desert areas has two unique problems :

- (a) Removal of drifting sand dune which cover the road during the summer months.
- (b) Weak shoulders and rain cut erosions on shoulders and cross drainage works.

The problem of drifting sand dunes can be remedied by :

- (a) Choosing correct alignment during construction of the road. The alignment should be as far as possible run parallel to the sand dunes and the sand dunes should be crossed without disturbing the existing profile of sand dunes, and
- (b) Plantation of shelter belts using right species of plants such as Acacia Tortis and Prosopis Juliflora. Shelter belts should be planted during early July immediately after the first rain. Along with it, Moonj grass or locally available grass can be grown behind the shelter belt over the entire sand dune as ground cover to stabilize the same.

The solution to rain cut gullies lies in shoulder packing, check walls, pitching and lined chutes. These works are to be executed as and when need arises.

9.2. Special Problems and Techniques for Maintenance of Roads in Hilly Terrain in Heavy Rainfall Areas

9.2.1. General : In heavy rainfall areas in hilly terrain, the major problems faced in maintaining the roads are landslides,

drainage and soil erosion, apart from frequent damages to road pavement. The remedial measures to be adopted are discussed below.

9.2.2. Landslides problem : Landslides constitute by far the most serious problem in maintenance of roads in hilly terrain subjected to heavy rainfall. The remedial measures for controlling/minimising landslides will be :

- (i) The side slopes of the hill should be maintained to proper angle so that they are stable.
- (ii) Minimum deforestation should be allowed on the hill face above the road as this causes disturbances to the stability of hill slopes.
- (iii) All potential landslide/disturbed slopes should be identified and suitable treatment should be provided e.g. terraced bally afforestation, turfing/plantation of shrubs/bushes, along with asphalt mulch treatment, or jute/coir netting etc.
- (iv) Terraced paddy cultivation, *Jhoom* cultivation in hill slopes above the road constitute potential factors for destabilising hill slopes and this should be discouraged.
- (v) Indiscriminate blasting in hill slopes causes destabilisation and this should be avoided as far as possible.
- (vi) Apart from the treatment of disturbed hill slopes, protective structures in the form of check walls/low breast walls/toe walls help in stabilising hill slopes and contain the landslides and should be properly maintained.

9.2.3. Drainage problem : Most of the maintenance problems in hill roads of heavy rainfall areas starts from improper drainage. It is, therefore, very essential to provide adequate system for ensuring easy and prompt drainage of rain water flowing to the road from the upper catchment areas.

Following steps should be taken to ensure effective drainage :

- (a) Surface/subsurface water should be led to natural water courses below road through cross drainage structures. In particular, intercepting or catch water drains provided above the cut slopes for speedy and safe disposal of rainwater should be kept in good repair and cleared of obstructions. Side drains should be maintained to their capacity for ensuring effective drainage even when partially

blocked/choked due to debris, growth of plants, etc. The drains should have gentle gradients and side slopes to enable carrying the flow without erosion. Drains should be lined/cement pointed where erosion is anticipated due to poor or weak soil and in subsidence areas.

- (b) Where the side drains are likely to be choked with sliding materials, they should be covered temporarily during rainy season with closely placed wooden ballies where feasible, in order to ensure uninterrupted drainage.
- (c) At the upstream side of the culvert, the catchpit provided should be kept clean.
- (d) Drains, catchpits, etc. should be cleared of all debris and repaired where necessary before the onset of the rainy season.
- (e) In order to avoid rain water flowing across the road surface, when side drains are blocked in part length due to landslides/erosion of hill slopes, false drains with guide bunds should be provided by the side of the choked drain in order to channelise water to the unaffected portion of road side drain.
- (f) Weep holes of retaining walls and breast walls should be cleared and all vegetative growth/chokage should be removed before onset of monsoon.

9.2.4. Soil erosion problems : Measures should be taken to ensure that erosion of soil from hill slopes both above and below the road formation is kept to the minimum, as this eventually leads to landslides/chokage of drains and natural water courses. Some of the erosion control measures are indicated below :

- (a) It should be ensured that the cross drainage structures discharging water on the valley side do not cause erosion even when flowing for a long period. Necessary channel training and erosion control works like paving/pitching of the channel and outfall points, drop walls, apron, etc. below the outlet of cross drainage structures should be properly maintained.
- (b) Vegetative cover should be established on cut/fill slopes through any of the techniques described in IRC : 56 "Recommended practice for treatment of embankment slopes for erosion control". The activity of establishing vegetation on barren slopes should be treated as part of the regular maintenance activities on roads.

9.2.5 Repairs of damages of pavement : Repairs to damages to pavement like potholes and depression form another important maintenance task. Such repairs should be done to regular

shape and should match the existing surface to correct level and grade. The paras 4.1. and 5.2. may also be referred

9.2.6. Miscellaneous repairs/maintenance : Vegetative growth from roadside berms and from hill slopes for a height of at least 2m above the ground level should be trimmed regularly.

9.3. Special Problems and Techniques for Maintenance of Roads in High Altitude Areas

9.3.1. General : The main problems in maintenance of roads in high altitude areas are of drainage caused by rapid melting of snow during spring, extreme cold climate during winter and consequent restrictions in working, loss of efficiency of men and machines in the rarified atmosphere.

9.3.2. Drainage problems : There is scanty rainfall in high altitude and most of the precipitation consists of snow. The drainage problems are mostly due to thawing of snow and ice. Temperature rise during the day results in rapid melting of snow with the advent of spring. The streams in the region have heavy floods during spring. Large amount of debris and ice carried in such streams results in more drainage problems. Since the soil surface is invariably frozen at the end of winter, there is no absorption of moisture by the soil and the run off coefficient is some times as high as 100 per cent. Flash floods also sometimes occur in the streams due to breaking of glacier dams and cloud bursts. The major factors responsible for drainage problems in these regions include temperature, humidity, snowfall and consequent run-off, nature of soil and catchment area, etc.

9.3.3. Problems of snowfall : Heavy snowfall combined with severe cold climate causes numerous problems for the maintenance of roads at high altitudes. The problems faced are as under :

(a) **Slow seepage :** In stretches subjected to heavy snowfall, melting of snow results in slow seepage into sub-soil and subgrade causing subsidence of subgrade over long lengths. Slow seepage from the accumulated snow above road formation also destabilises the hill slopes above the road formation resulting in landslides.

(b) **Snow avalanches** : Often huge accumulation of snow comes down the slope at great speed and carries boulders and debris. Such avalanches along the re-entrants cause considerable damage to road formation, pavement and permanent structures, apart from the potential danger to traffic, life and property.

(c) **Drainage problems during snow clearance** : During heavy snowfall large stretches of road are affected. For the quick opening of the road communication, the normal practice is to clear minimum road width required for passing of vehicles for one way traffic, in the first instance. The restricted width of road acts as drain for melting snow and causes slow seepage of water in road crust and subgrade and often causes damages to road crust/settlement of subgrade.

(d) **Effect of frost** : Freezing of water behind the retaining walls causes cracks in the structure due to increase in volume of backfill. Formation of ice pockets in some stretches also causes heaving of subgrade and curst.

(e) **Icing Problems** : Where a thin layer of snow has remained in pavement for some time, it becomes more dense and compact due to drop in temperature caused by cold wind blowing on the surface during winter months and also hardening effect of moving traffic. The top layer of snow is rapidly coated with an ice glaze, which is very hard and slippery and extremely dangerous for traffic due to the skidding effect of vehicles. This thin layer of ice poses great problems for removal as it is hard and adhere tenaceously to paved surface.

9.3.4. **Restricted efficiency of men and machines** : Efficiency of men and machinery decreases at high altitudes due to lack of oxygen, low atmosphere pressure and severe climatic condition. Working hours are also restricted. Working season for construction works involving cement and bitumen is normally limited between middle of May to middle of November. Loss of efficiency upto 30 per cent for men and machines for altitudes of 3000 m above MSL is common.

9.3.5. Remedial measures

(a) **Meeting effects of snowfall** :

(i) Quick removal of snow from whole formation by using wheel dozers,

motor graders and special rotary cutter type snow clearance machines.

- (ii) Clearing of roadside drains promptly.
- (iii) If restricted width of road has been opened due to compulsion of providing prompt road communication by clearing snow, then cross drains must be opened on either side of the road at intervals to guide melted snow to valley sides or roadside drains.

(b) **Snow avalanches** : Potential snow avalanche zones must be identified and camping, movement of traffic, etc. must not be permitted in such avalanche prone areas during the snowfall seasons. Effect of snow avalanches can be controlled/maintained by provision of following :

- (i) Stopping structures like snow bridges, snow rakes, snow fences, avalanches fences, terraces and snow nets.
- (ii) Drift control structures like inclined roofs, wind baffles and snow fences.
- (iii) Deflecting structures like gallery construction, guide and diversion walls.

(c) **Effect of frost/icing** : Efficient drainage of water is to be ensured from back face of retaining/breast walls through weep holes, etc. Surface water on road formation and drain should not be allowed to stand but drained out quickly so that the same does not seep through to the sub-grade. Common salt/urea can be sprinkled on ice/frost on critical stretches to cause deicing and avoid skidding and slipping of vehicles.

(d) When maintenance work has to be carried out in cold climate, the specification for original works as detailed in clauses 1710 and 1711 of Ministry of Shipping & Transport (Roads Wing) "Specification for Road and Bridge Works", may be followed.

9.3.6 Problems in maintenance of machinery : In high altitude areas, the work is mainly equipment oriented. The maintenance of equipment and machinery requires detailed planning as various types of snow clearance machinery and vehicles are involved and repairs have to be carried out on an emergency basis. Temperature prevailing in most of the snow removal detachments/

locations can be much below subzero level. Proper precautions for men engaged on repairs/maintenance of the equipment have, therefore, to be ensured. Apart from providing the men with adequate snow clothing, the repair workshop shed is also to be kept warm by use of space heaters. Some of the preventive maintenance measures for the equipment are :

- (a) Radiators are drained and wrapped up after working hours
- (b) Batteries are removed and kept in heated/covered rooms
- (c) Subzero diesel is used as primary oil
- (d) Close and proper check on change of lubricants is ensured.

Problems of providing the required spares for equipment, plant and vehicles for snow clearance efforts also need close attention and advance planning for ensuring timely procurement. Particularly for the snow clearance equipment which are of foreign make, procurement of spares for repairs of FIP assembly, hydraulic pump assembly, impellers, outer blade, etc. involves long range advance planning, in view of the high lead time involved for materialisation.

Appendices

Appendix 1

SURFACE HISTORY OF ROAD

NAME OF ROAD JAIPUR-DAUSA

KILOMETERS 1/0 TO 20/0

PARA 2.1.3

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	REMARKS
1970-71																					YEAR OF COMPLETION
1971-72																					
1972-73																					
1973-74																					
1974-75																					OVERLAY
1975-76																					EARTHEN DRAIN
1976-77																					
1977-78																					
1978-79																					
1979-80																					
1980-81																					
1981-82																					
1982-83																					

THIS INFORMATION WILL BE PICKED UP FROM ROAD REGISTER PREPARED ON THE LINE OF LETTER NO PL-10 (76)/74 DATED 8TH MAY 1980 FROM M O S&T

RENEWELS

1975																				
1976																				
1977																				
1978																				
1979																				
1980																				
1981																				
1982																				
1983																				

TRAFFIC/DAILY

P.C.U. IN '000

YEARS

P.C.U. IN '000

YEARS

P.C.U. IN '000

YEARS

STATION-- KMS

LE'END

BITUMINOUS MIX W.B.M SOLING DRAINS K(KUTHA) P(PURCA)

STABILISED SOIL 20 CARPET 50 SURFACE DRESSING AC 8M BITUMINOUS MACADAM

*Appendix 2***CHECK LIST OF ITEMS REQUIRED TO BE INSPECTED
DURING INSPECTION FOR MAINTENANCE OF ROADS**

Assistant Engineers and Junior/Sub Engineers while going on inspection on roads in their jurisdiction should examine the points mentioned below :

1. Safety aspects

- (i) Safety precautions for blockade and breaches taken
- (ii) Deep cuts on roads
- (iii) Damaged culvert/bridge
- (iv) Branches of trees at less height
- (v) Power line crossings provided with guard cradles as per IRC:32
- (vi) Vertical clearances for power lines should be as per IRC:32
- (vii) Horizontal clearances for poles carrying power and telecommunication lines as per IRC:32
- (viii) Berms not lower than 25 mm from carriageway
- (ix) For new plantation only the horizontal clearances to be kept as minimum 5 m wherever possible.

2. Carriageway and crust conditions

- (i) Location magnitude of pot holes and patches
- (ii) Condition of edges
- (iii) Magnitude and location of undulations
- (iv) Location of crust failures, along with their causes.

3. Berms (shoulders)

- (i) Width of berms is adequate or not as per PWD specifications
- (ii) Cross slope kept as 3 to 5 per cent
- (iii) Side slopes
- (iv) Berms properly dressed
- (v) If turfing exists, whether it is properly cut or not.

4. Road drainage

- (i) Cross sectional area of drains adequate or not
- (ii) To check if the drains are blocked or damaged
- (iii) Whether proper disposal is provided to the drains

5. Road fixtures

- (i) Km stone, 5th km stone, 200 m stones, boundary stones exists in proper condition
- (ii) Traffic signs correctly located and maintained
- (iii) Location and condition of drums on curves and high embankments
- (iv) Painting and numbering of culverts required
- (v) History of the road mentioned on km stones.

6. Road protection works

- (i) Retaining walls and pitchings on slopes properly maintained or not
- (ii) Condition of drains, spouts and weep holes in retaining walls and in pitching on slopes
- (iii) Condition of parapet walls on culverts, etc.

7. Road side trees

- (i) Check up numbering of trees done or not
- (ii) Disposal of dead trees
- (iii) Register of trees maintained

8. Road geometrics


- (i) Horizontal curves laid out properly or not
- (ii) Extra width on curves conforms to IRC : 38
- (iii) Sight distances conform to IRC standards
- (iv) Vertical curves properly laid out or not
- (v) Ruling gradients conform to IRC standards.


ROUTINE INSPECTION CARD (RECORDING FORMAT)


STATE HIGHWAY NO. 14
K.M.O. AT MOHAN NAGAR
DATE ... 15th JUNE 1983


RECORDED BY -----
AE / JE


S.NO.	PARTICULARS ACTION TO BE TAKEN	KM - 100	KM-101	KM-102	KM 103	KM 104
		.2 .4 .6 .8	.2 .4 .6 .8	.2 .4 .6 .8	.2 .4 .6 .8	.2 .4 .6 .8
1.	<u>SIDE DRAIN</u>					
	RESECTION R					
	FILL SCOUR HOLE / R					
	CLEAR SITE L					
2.	<u>SHOULDER & SLOPE</u>					
	CORRECT CAMBER R					
	FILL POT HOLES R					
	FILL EROSION CUTS L					
	FILL RAIN CUTS R					
3.	<u>CARRIAGEWAY</u>					
	(i) FILL PATCHES					
	(ii) FILL POT HOLES					
	(iii) GRIT FOR BLEEDING					
	(iv) RENEWAL NEEDED					
4.	<u>C.D. WORKS.</u>					
5.	<u>ENCROACHMENTS</u> R					
	DETAILS L					
6.	<u>ROAD FURNITURE</u>					
	(i) MISSING BOARDS					
	(ii) K.M. STONES					
	(iii) REPAIRABLE BOARDS					
	(iv) PAVEMENT MARKINGS					


0.5KM 


0.5KM 


0.5KM 


0.5KM 

0.4KM 


200.50M 


2 SHOPS 


100.50M 


2 NOS 

LEGEND

 REQUIRING URGENT ACTION

 REQUIRING SPECIAL ATTENTION

 REQUIRING RECURRENT ATTENTION

 REQUIRING ROUTINE ATTENTION

× Recommended period for activity in North India

[illegible]

*Appendix 5***1. FIELD PROCEDURE FOR INSPECTION AND PLANNING
MAINTENANCE WORKS****1.1 General**

Each road should be divided in sections of 5 km. and each km. should be further subdivided into 200 metres stretches for inspection purposes. All roads must invariably be inspected immediately before and after rains in addition to routine inspections.

The extent of defects should be marked in bar lines extending over lengths over which they occur and the severity of the defect may be marked in colours in accordance with the maintenance criteria as given in *Section 4*.

- | | |
|----------------------|---|
| (1) Severe | Requiring urgent action – In red |
| (2) Less severe | Requiring special attention – In dotted red |
| (3) Defect requiring | Recurrent action – In blue |
| (4) Ordinary | In dotted blue |

Recording must be both accurate and legible. Reaches in 30 metre length should be measured correct to the nearest metre & width to the nearest 0.1 metre.

The numerical figures indicating numbers, length, area, etc. of the defects should be indicated over the bar lines in the ink. The recording is to be done in the inspection card given in *Appendix 3*.

The list of the instruments and equipments required for inspection work is as follows :

- | | |
|--|--------|
| 1. Tape measuring 30 mts. steel | 1 No. |
| 2. Tape measuring 15 mts. steel | 1 No. |
| 3. Steel tape 3 mts. steel | 1 No. |
| 4. Spirit level with straight edge and camber templates with graduated wedge | 1 No. |
| 5. One metre square light-weight portable frame | 1 No. |
| 6. Printed inspection forms | 1 No. |
| 7. Clip board and ball point pen | |
| 8. Coloured pencil/sketch pencil | |
| 9. Warning signs | 2 Nos. |
| 10. Maps of the area | |
| 11. Maintenance Manual | |

1.2. Methods of assessment

1.2.1. Visual assessments—Most of the assessments should be done with careful observations. However, instruments are to be used for purposes of accuracy.

1.2.2. Side drains and turn outs—Side drains should be maintained at least one metre below the formation level. The depth and cross section should be checked and measured at least 200 mts. intervals.

1.2.3. Corrugations—They can be measured with a straight edge and measuring wedge at 200 mts. intervals along the roads. The mean of the reading at each 200 mts. is to be recorded. The readings are to be at closer intervals, any 50 metre, where by visual inspection it is noted that the surface is highly corrugated.

1.2.4. Rutting—The depth of rut is to be measured by keeping the straight edge placing transversely across the wheel tracks and using graduated measuring wedge. The mean value for the wheel tracks to be worked out.

1.2.5. Potholes—The area covering majority of pot holes should be measured along with number in every 200 metreage. The percentage area is to be worked out.

1.2.6. Camber and cross fall—It should be checked with a camber templates on both side of the centre line.

1.2.7. Loss of materials—The thickness of the W.B.M. layer should be checked at 15 mts. intervals to assess the loss of material. The measurements should be done at least at three places across the road.

1.2.8. Cracking—The light weight portable frame of 1 m × 1 m size should be planned and type and extent of cracking should be assessed visually at 200 mts. intervals or the places of defects whichever is less.

Appendix 6

**ACTION TO BE TAKEN IN CASE THE ROAD IS
BREACHED OR BLOCKED**

1. Action to be taken by the mate

The following actions will be taken by the mate :

- (a) Immediate report of the road breach/blockade will be made to Sub/Junior Engineer and Assistant Engineer. The following points will be included in the reports :
 - (i) Name of the road
 - (ii) Location of the breach/blockade
 - (iii) Length and nature of the breach/blockade
 - (iv) Date and time of occurrence
 - (v) Assessment of the assistance in the form of men and material required.
- (b) "Road closed" boards and "Diversion" boards shall be fixed on both sides at 120 m distance in advance of the hazard in case of N.H. & SH. (In case of MDRS & ODRS this distance will be 90 m and 60 m respectively).
- (c) Arrangements for red lights to be done in case of darkness
- (d) Beldars will be deployed to guide the traffic to prevent any accident
- (e) Construction of diversion, if possible.

2. Action to be taken by Engineering subordinate

The Engineering subordinate in charge of the road will take following actions at once :

- (a) He will at once visit the site of the hazard and shall ensure that :
 - (i) Road has been closed by means of barricading with empty drums or kachha wall or by any other means available at the site.
 - (ii) That caution and diversion boards have been fixed on both the sides
 - (iii) Arrangements made to guide the traffic by posting a gangmen having red flags.
 - (iv) Arrangements made for red light and chowkidars, etc.
 - (v) Steps to stop further damages to the road are taken as per site requirements
 - (vi) Possibilities of construction of diversion to be explored. If possible the diversion should be constructed with available resources.

- (b) He will immediately report to the Assistant Engineer, Executive Engineer and Superintending Engineer telegraphically regarding the road breach, duration of blockade of the traffic followed by a detailed report containing :

- (i) Name of the road
- (ii) Location of the breach/blockade
- (iii) Length and average depth of the breach
- (iv) Duration of suspension of the traffic
- (v) Date and time of occurrence
- (vi) Requirement of man and material for restoration of traffic and road and the approximate cost

- (c) All out arrangements and efforts shall be made for restoration of traffic

- (d) He will intimate the details of any losses and injuries to the public if any including the extent of compensation if payable.

3. Actions to be taken by the Assistant Engineer :

The Assistant Engineer will take the following action in case of an emergency of road breach, etc.

- (a) He will at once inspect the site of the hazard
- (b) He will inspect all safety measures taken by the engineering subordinate
- (c) He will ensure that the restoration of traffic is done at the earliest
- (d) He will send a detailed report regarding the breach/blockade enumerating all the points given under 2. (b) In addition to these he will also include the following points:
 - (i) The causes of the breach/blockade
 - (ii) Forecast estimate for restoration of traffic and road
 - (iii) Remedial measures to avoid any future occurrence with forecast estimates
 - (iv) Any other information which he wants to include.

4. Action to be taken by the Executive Engineer :

The Executive Engineer will take the following action in case of an emergency of a road breach of similar blockade

- (a) He will at once visit the site of breach. In case of more than one occurrences, he will inspect them in order of priority and importance
- (b) He will ensure speedy restoration of traffic
- (c) He will send a detailed report about the road damage indicating:
 - (i) Nature and cause of damage with locations.

- (ii) Proposals for remedial measures with financial implication
 - (iii) Nature and course of consequential damages to public properties, etc.
 - (iv) Action taken for restoration of traffic and restoration of damages with financial implications.
 - (d) He will be fully responsible for all the actions taken for the protection and safety of traffic and road.
-

Appendix 7

DUTIES AND RESPONSIBILITIES OF MATE

1. To report to Mistry/Junior Engineer/Sub Engineer.
 2. To make daily attendance of labour working under him.
 3. To help in the layout, dagbelling, marking, checking up the quality and quantity of work done by the labour and get the work executed as per instructions.
 4. To assist the Mistry/Junior/Sub Engineer in taking out the measurement for daily work done by labour.
 5. To display necessary caution boards from safety point of view as per standard layout.
 6. To report to his senior about any casualty, accident, encroachment to Government property or any type of serious damage to the Government property within his beat.
 7. To maintain T&P and sign boards under his charge.
 8. To carry out jobs of semi-skilled nature connected with his trade along with his gang.
 9. General supervision over unskilled labour.
 10. To get the lime/cement/composite mortar prepared in his presence as per instructions of Junior/Sub Engineer/Mistry incharge.
 11. To report about damages to structures, kilometre stone etc. and keeping them in position.
 12. To comply with any instruction given by his immediate superior.
 13. Daily labour report, D.L.R.
 14. To ensure quantum of work being done by gang, conform to norms.
 15. To keep account of permanent articles, for example direction boards, trees, drums, etc. in his beat.
 16. To ensure providing and proper upkeep of diversions.
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*Appendix 8***DUTIES AND RESPONSIBILITIES OF STORE MUNSHI/MUNSHI**

1. To report to Sub Engineer/Supervisor/Junior Engineer.
2. To maintain proper receipt and despatch register, wherever necessary.
3. To maintain proper work-wise files and records as maintained in other offices with the guidance and instructions of Junior Engineer/Sub Engineer/Incharge of works.
4. He will work like a LDC under the Assistant/Junior/Sub Engineer or where he will be posted from time to time to maintain all records including those of labour establishment of the Section.
5. To maintain T&P and its register, issue and receipt of T&P as per order of Junior/Sub Engineer/Incharge of Section.
6. To assist the Junior/Sub Engineer in correspondence connected with labour engagement and payment and other matters.
7. To maintain requisite register for repairs/maintenance for buildings/roads and put up to Junior/Sub Engineer every day for seeking his orders.
8. To maintain the register for occupancy/vacation for Govt. bungalow and quarters.
9. To prepare timely pay bills/medical bills/arrears bills/advance loan bills, etc. for the work-charge establishment working under Junior/Sub Engineer.
10. To maintain casual leave/P. leave records for staff working in the section.
11. To work in Section/Store of Sub-Dn./Dn. Office as per instructions.
12. He will do the typing work where facilities are available and will make copies of estimates and letters as directed by Junior Sub Engineer.
13. To comply with the instructions given to him by his immediate superior.

Appendix 9

DUTIES AND RESPONSIBILITIES OF MISTRY/SR MISTRY

1. To report to Sub Engineer/Junior Engineer.
2. To maintain daily diary of the work done by him and put up to the section incharge.
3. To maintain daily receipt/daily consumption of material used in original repair works.
4. To prepare estimates for minor works and repairs in consultation with the section incharge.
5. To help in giving layout of building and bridges and alignment of roads as per approved drawings.
6. To ensure execution of work according to specifications and drawings.
7. To take round of various buildings, bridges and roads under his charge from time to time and report to section incharge about repairs to be done. He shall also assist to plan out a programme for such repairs in advance and ensure their execution through the departmental labour within the specified period.
8. To assist Junior Engineer/Sub Engineer in taking out measurements and distributing work to labour daily and checking their attendance.
9. To estimate and indicate rough quantities of materials for structure.
10. To take measurement of daily work done.
11. To maintain material at site account, and account of traffic signs.
12. To report about unauthorised encroachment, addition and alteration in Govt. premises.
13. To comply with the instructions given to him by his immediate officer.
14. To lodge F.I.R. with police for encroachments and damages to Govt property, road, building, arboriculture.
15. To ensure submission of daily report.
16. To see that log books are filled daily for machinery and machinery are parked properly with lights, etc.
17. To maintain details of land width on road and check encroachments.
18. To ensure proper maintenance of speed humps including painting and caution boards.

*Appendix 10***RECOMMENDED NORMS FOR TASK FOR ROAD GANGS**

- | | |
|---|----------------------|
| 1. Earth work such as in berms, desilting of drains, etc. | |
| (a) Ordinary soil | 2.5 Cum/person/day |
| (b) Hard soil | 1.75 Cum/person/day |
| 2. Dressing of berms | 75 Sqm/person/day |
| 3. Jungle clearance | 100 Sqm/person/day |
| 4. Patches by | |
| (a) Surface painting | 0.2 Cum/person/day |
| (b) Premix carpet | 0.75 Cum/person/day |
| 5. W.B.M. patches | 0.30 Cum/person/day |
| 6. Blinding of WBM surface | 150 Sqm/person/day |
| 7. Edge covering | 60 Metres/person/day |
| 8. Other items as per norms worked out from BSR of that area. | |

Note : The quantity mentioned is that of grit and ballast used for patch repairs.

Appendix 11

**NORMS FOR WORK CHARGED STAFF ENGAGED ON
MAINTENANCE OF ROADS**

The norms for engaging work charged staff on maintenance of roads will be as follows:

Category of roads	Labour			
	Mate	Gangmen		
		For traffic		
		<450 c.v.ds.	450 – 1500 c.v.ds.	>1500 c.v.ds.
National Highways (Beat 16 Km)				
(a) Single lane	1	5	6	7
(b) Double lane	1	4	5	6
State Highways & Major District Roads (Beat 20 Km.)				
(a) Single lane	1	4	5	6
(b) Double lane	1	3	4	5

Appendix 12

TOOLS FOR GANGMEN

(One gang for 20 km beat having 5 gangmen and one mate)

Road work	Essential (with gangs)	Option with Section Incharge
1. Spades	3 Nos.	
2. Pan (parat)	3 Nos.	
3. Pick axes	2 Nos.	
4. Axe	1 No.	
5. Hand-cart with solid rubber tyres	1 No.	
(a) Wooden—5 kg to 10 kg weight	1 No.	
(b) Iron—10 to 15 kg weight	1 No.	
6. Tar sprinklers (Jharas)		1 No.
7. Tar buckets		1 No.
8. Tar kettle or tar boiler (mini)		1 No.
9. Brushes		
(a) Wire brushes	5 Nos.	
(b) Coir brushes	5 Nos.	
(c) Hair brushes	5 Nos.	
10. Hammer	1 No.	
11. Rope 12 mm	1 No.	
6 mm	1 No.	
12. Cross slope template for berms with original level (camber 3 per cent)	1 No.	
13. Tar thermometer		4 Nos.
14. Spring balance		1 No.
15. Tape 15 m	1 No.	
16. Measuring wooden boxes (35 cm × 25 cm × 40 cm)		2 Nos.
17. G.I. bucket	1 No.	
18. Straight edge		1 No.
19. Caution board		2 Nos.
20. Goggles for dust protection (For desert areas)		10 Nos.

Appendix 13

WORK SHEET

WEEK FROM... ..TO.....

ROAD NO.....FROM.....TO.....

Type of repair

Road surface

- i. Correct depressions
- ii. Fill cracks
- iii. Patch repairs

Others

- Resurface shoulders
- Clean drains

Materials required

BITUMEN.....
EMULSION.....
OTHER

AGGREGATES.....
WOOD.....

MAINTENANCE OF ROADS-FORMAT OF PERFORMANCE FOR
ANNUAL MAINTENANCE IN THE DIVISION

Name of road	Budget allotment	Routine Maintenance				Job No.	Special Repairs					Remarks	
		Expenditure					Renewal/Reconditioning						
		Materials	Others	Labour	Total		Target		Achievement		Others		
							Financial	Physical km	Financial	Physical km	Financial target		Actual exp.

