Ministry of Road Transport & Highways

Guidelines for Expressways

PART - II

Volume-III : Operations and Management
Volume-IV : Maintenance

Published by:
Indian Roads Congress

On behalf of the Government of India,
Ministry of Road Transport & Highways

New Delhi

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FOREWORD

Government of India has taken a mission to develop a National Expressway Network dedicated to provide road infrastructure comparable to the world standards, recognizing the importance of providing high-speed facilities connecting ports, major cities, industrial/ agricultural centers and major markets to the significant economic growth. Construction of fully access controlled expressways for 1000 km under National Highways Development Program (NHDP) Phase VI are about to be launched.

Accountability for providing safe, reliable and user comfortable road network utimately rests with the Government. It is, therefore, essential that the Guidelines for Expressways laid down for development of expressways should cover sound engineering practices, safety features and amenities for the users.

Ministry took up the preparation of the Guidelines for Expressways through technical cooperation from Japan International Cooperation Agency (JICA) and constituted a Technical Committee comprising of the following officers for its finilization:

1	Sh. Nirmal Jit Singh, Director General (Road Development) and Special Secretary, MORTH	Chairman
2	Sh. A.V. Sinha, Additional Director General-I, MORTH	Member
3	Sh. S.K. Puri, Additionnal Director General-II, MORTH	Member
4	Sh. C. Kandasamy, Chief Engineer, MORTH	Member
5	Sh. A.N. Dhodapkar, Chief Engineer, MORTH	Member
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7	Sh. S.K. Marwah, Chief Engineer, MORTH	Member
8	Sh. V.L. Patankar, Member (Technical), National Highways Authority of India	Member
9	Sh. Chaman Lal, Director, National Institute for Training of Highway Engineers	Member
10	Sh. S.K. Verma, Superintending Engineer, MORTH	Member
11	Sh. Mamoru TANAKA, JICA Expert	Member

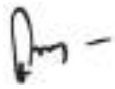
The Guidelines for Expressways, as prepared, highlights appropriate planning and design principles for promoting safety conscious planning and design and will go a long way in guiding the highway engineers and planners to make our expressways safer, comfortable and of international standards.

Guidelines have been structured in four (4) volumes :

Volume - I : Planning
Volume - II : Design
Volume - III : Operations and Management
Volume - IV : Maintenance

The intended users of this guideline will be the transportation professionals/engineers who participate in or are responsible for any phase in the project preparation of the Expressway Project. This includes all public or private “practitioners” (e.g. managers, supervisors, engineers, planners, or technicians) who are involved with any issue or decision (e.g. managers, supervisors, engineers, planners, or technicians) who are involved with any issue or decision (e.g. legislation, policy, program, funding, operation & management and maintenance scenario) that may directly or indirectly infuence the performance of an Expressway facility.

In planning design process, the Highway Engineer strives to develop, within the limits of given constraints, the dimensional layout or geometric configuration that will lead to high level of safety, efficiency and ease in driving. Therefore, the intent of this document is to provide guidance to the designer with the critical aspects of project preparation for an expressway. This guideline is dynamic in nature and the users, based on their experience, give appropriate feedback so as to enable the Guidelines to be revised/improved from time to time.



(Nirmal Jit Singh)
Director General (Road Development) and Special Secretary
Ministry of Road Transport and Highways

Dated February, 2010

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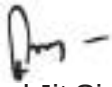
Mr. D.C.De (Consultant engaged by JICA)	:	Consulting Engineering Services (India) Pvt. Ltd. (CES)

MORTH express its gratiude to the JICA team, the Members of the Technical Committee and other Officers who took great pains and contributed immensely in the preparation of this Guideline.

The contributions of Mr D P Gupta, Director General (Retired), MORTH, in editing the Guidelines and Mr R P Indoria, Secretary General, IRC along with his entire IRC team for their efforts in bringing out this publication is thankfully appreciated and acknowledged.



(Nirmal Jit Singh)

Director General (Road Development) and Special Secretary

Ministry of Road Transport and Highways

Dated February, 2010

LIST OF ABBREVIATIONS

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Official
AAV	:	Aggregate Abrasion Value
ADB	:	Asian Development Bank (ADB)
ADS	:	Automatic Debiting Systems
ADT	:	Average Daily Traffic
AMC	:	Annual Maintenance Contract
AP	:	Aerial Photography
APL	:	Longitudinal Profile Analyzer
ATCC	:	Automatic Traffic Counters cum Classifier System
ATIS	:	Advanced Traffic Information System
AVC	:	Automatic Vehicle Classification
AVI	:	Automatic Vehicle Identification
B/C	:	Benefit Cost Ratio
BFC	:	Braking Force Coefficient
BI	:	Bump Integrator
BIS	:	Bureau of Indian Standards
BOOT	:	Built Own Operate and Transfer
BOT	:	Built Operate and Transfer
CCR	:	Central Control Room
CCTV	:	Closed Circuit Television
C-D	:	Collector – Distributor
CDMA	:	Code Division Multiple Access
CFRP	:	Carbon Fiber Reinforced Plastics
CO	:	Carbon Monoxide
CPU	:	Central Processing Unit
CRRI	:	Central Road Research Institute
CVI	:	Coarse Visual Inspection

dB	:	Decibels
DBFO	:	Design Build Finance and Operate
DCF	:	Dynamic User Flow
DDHV	:	Directional Design Hourly Volume
DNPT	:	Diagonal Non-Pull through type
DSRC	:	Dedicated Short Range Communication System
DTM	:	Digital Terrain Model
DUE	:	Dynamic User Equilibrium
DVI	:	Detailed Visual Inspection
ECB	:	Emergency Call Boxes
ECP's	:	Emergency Crossing Points
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
EIS	:	Environmental Impact Statement
EMP	:	Environmental Management Plan
EOCC	:	Economic Opportunity Cost of Capital
ETC	:	Electronic Toll Collection
FAQ	:	Frequently Asked Questions
FFS	:	Free-flow Speed
FIRR	:	Financial Internal Rate of Return
FRL	:	Finished Road Levels
FS	:	Feasibility Study
GAD	:	General Arrangement Drawing
GDP	:	Gross Domestic Product
GIS	:	Geographic Information System
GNP	:	Gross National Product
GPS	:	Global Positioning System
GSDP	:	Gross State Domestic Product
GSM	:	Global System for Mobile Communications

GVW	:	Gross Vehicle Weight
HAR	:	Highway Advisory Radio
HCM	:	Highway Capacity Manual
HCV	:	Heavy Commercial Vehicle
HDC	:	High Density Corridors
HDT	:	High Density Traffic
HFL	:	High Flood Level
HTMS	:	Highway Traffic Management System
HTV	:	Heavy Truck Vehicle
HWL	:	High Water Level
IC	:	Interchange
IDRS	:	Integrated Digital Referencing Scheme
IEE	:	Initial Environmental Examination
IR	:	Infrared Ray
IRC	:	Indian Roads Congress
IRI	:	International Roughness Index
IRR	:	Internal Rate of Return
ITS	:	Intelligent Transport Systems
JICA	:	Japan International Cooperation Agency
JKR	:	Jabatan Kerja Raya
km	:	kilometer
kmph	:	km per hour
LCDs	:	Liquid Crystal Displays
LCV	:	Light Commercial Vehicle
LED	:	Light Emitting Diodes
Lm	:	Linear meter
LN	:	lane
LOS	:	Level of Service
LUP	:	Land Use Planning

LWL	:	Low Water Level
MAV	:	Multi Axle Vehicle
MCA	:	Model Concession Agreement
MDR	:	Major District Roads
MMS	:	Maintenance Management System
MOEF	:	Ministry of Environment and Forests
MORTH	:	Ministry of Road Transport & Highways
NATM	:	New Austrian Tunnelling Method
NBSS	:	National Bureau of Soil Surveys
NCMA	:	National Concrete Masonry Association
NEXCO	:	Nippon Expressways Company
NH	:	National Highway
NHAI	:	National Highway Authority of India
NHDP	:	National Highway Development Project
NMS	:	Network Management System
NO	:	Nitric Oxide
NO_2	:	Nitrogen Dioxide
NPV	:	Net Present Value
NRSA	:	National Remote Sensing Agency
NSDP	:	Net State Domestic Product
NSRC	:	National Remote Sensing Centre
NTPC	:	National Transport Policy Committee
O&M	:	Operation and Maintenance
OBU	:	On Board Unit
O-D	:	Origin-Destination
ODR	:	Other District Road
OECD	:	Organisation for Economic Cooperation and Development
pc/hr/ln	:	Passenger Car Per Hour Per Lane
PCPHPL	:	Passenger Car Per Hour Per Lane

PCU	:	Passenger Car Unit
PFS	:	Pre-Feasibility Study
PHF	:	Peak Hour Factor
PIJF	:	Polythene Insulated Jelly Filled
PPP	:	Public Private Partnership
PPPAC	:	Public Private Partnership Appraisal Committee
PPR	:	Preliminary Project Report
PSV	:	Polished Stone Value
PwD	:	Persons with Disabilities
RAP	:	Resettlement Action Plan
RIS	:	Road Information System
ROE	:	Return on Equity
ROW	:	Right-of-Way
RUCS	:	Road User Cost Study
SA	:	Service Areas
SAM	:	Strain Alleviating Membranes
SCF	:	Standard Conversion Factor
SCRIM	:	Sideway-force Coefficient Routine Investigation Machine
SCTP	:	Steering Committee of Transport Planning
SDP	:	State Domestic Product
SFAP	:	Small Format Aerial Photography
SH	:	State Highway
SO_2	:	Sulphur Dioxide
SOI	:	Survey of India
SPCB	:	State Pollution Control Board
SPV	:	Special Purpose Vehicle
SUE	:	Stochastic User Equilibrium
TL	:	Test Levels
TMC	:	Traffic Management Center

TOR	:	Terms of Reference
TRRL	:	Transport and Road Research Laboratory
UPS	:	Uninterrupted Power Supply
VES	:	Vehicle Enforcement System
VFM	:	Vehicle Fleet Modernization
VGF	:	Viability Gap Funding
VICS	:	Vehicle Information and Communication System
VMS	:	Variable Message Signs
VOC	:	Vehicle Operating Cost
vph	:	vehicles per hour
VR	:	Village Road
WIM	:	Weigh in Motion

GUIDELINES FOR EXPRESSWAYS

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Volume – III: Operations and Management

Volume – IV: Maintenance

VOLUME - III : OPERATIONS AND MANAGEMENT

EXECUTIVE SUMMARY

VOLUME – III : OPERATIONS AND MANAGEMENT

EXECUTIVE SUMMARY

The Document Volume-III: Operations and Management is complementary to other guideline volumes. The objective of this document is to assist the design engineer in project preparation for the identified sections of "National Expressway Network".

The contents of this document are necessarily a compilation on illustrative requirements which are generally not covered by the available documents/practices. The intended users of this document will be the Expressway professionals/engineers.

This document has been structured into 3 (three) chapters as follows:

Chapter – 1 : Toll Plaza Operation

Chapter – 2 : Traffic Management

Chapter – 3 : Service Area Management

Chapter – 1 : Toll Plaza Operation

This chapter provides relevant aspects of toll plaza operations in a holistic manner. The toll plaza at various interchange locations have different toll lane requirements involving various methods of collection viz. Manual, Smart Card and ETC.

For a closed toll system, the collection methodology deliberates ticketing systems, toll collection methods and toll gate operations. Operations in toll plaza cover the aspects and activities at entry and exit; control of over loaded/over sized vehicles along with regulatory authorities for imposing necessary legal/penal measures. Activities for alleviating traffic congestion including measures such as flexible gate opening, capacity enhancement, organizations, and responsibilities along with occasions for surprise checking have been covered.

Traffic safety measures include signage, road markings, safety cushions at gore areas, ETC related safety measures and toll area safety including provisions for utility and turn around provisions for emergency vehicles.

Additional safety measures dealt features (not mandatory but desirable) to enhance safety of toll operators, toll lane inspectors. This include adequate information to drivers/users,

push button / alarm switch inside toll booth, wide signage over toll booth along with flashing spindle, safety ropes and safety bars between toll lanes and provision of air conditioning facilities inside booth. Security at toll plaza mainly deliberates on overall safety of the plaza area.

Audit section describes the general procedures and the frequently met aspects of monitoring toll collection data and associated counter measures.

Counter measures for toll evasion covers measures for control on “ticket exchange” and preventing/minimizing “passing through toll gate without paying (Tailgating)”.

Chapter – 2 : Traffic Management

This chapter has been presented under two broad heads viz. Traffic Control and Incident Management.

Traffic Control section deliberates on (i) Information collection includes emergency communication system; mobile communication system, meteorological data system, automatic traffic counters cum classifiers system, closed circuit television, transmission system and vehicles for route patrol. (ii) Control center which comprises of traffic management center, facility control center and disaster control center which inter-alia include natural disasters. (iii) Information dissemination deliberates on types of information and the medium such as variable message signs, portable VMS – on vehicles, highway advisory radio, internet or mobile services, and Vehicle Information and Communication System (VICS).

Incident Management section covers aspects of (i) traffic accident, (ii) bad weather, (iii) current practices, methods, strategies and technologies.

Chapter – 3 : Service Area Management

The conventional development of road side amenities and rest areas is no longer being considered as free facilities for the toll roads. The current global trend is to commercialize these facilities, and service areas. New developments in this regard are as follows:

- Administration for service area covers on organisation and risk sharing between the expressway authority and the concessionaires. This has been discussed using current Japan scenario for developing under Indian scenario.

- Customer services include provision for high quality services and facilities to the expressway users. This includes traffic information, local tourist information, facilities for Persons with Disability (PwD), and services available for comfortable and enjoyable stay.

- Use of Eco friendly energies such as solar and wind power, recycling of waste water, heat sealed pavement, water retaining pedestrian blocks, garbage recycling including reduction, and rainwater harvesting have been covered.

- Facility planning for profitable service area includes merchandising plans explained based on case study for Connecticut, USA; Japan, and Indian scenario.

As an added tool, Parking Management has been described along with pictorial layout of similar facilities in Japan.

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CHAPTER - 1

TOLL PLAZA OPERATION

CHAPTER – 1

TOLL PLAZA OPERATION

1.1 TOLL COLLECTION METHODOLOGY

Toll plazas are designed to provide a venue for vehicles to stop and pay toll for using the facility (expressway). The specific venue planning is guided by the facilities needed to implement toll operations or toll system. Based on traffic characteristics, revenue requirements, maintenance considerations, site opportunities and constraints, the methodology for toll collection comprises of the following.

1.1.1 *Outline of ticketing systems*

A ticket system at toll collection entails the issuance of a ticket to every vehicle entering the expressway. This ticket shall generally be encoded with the vehicle class, entry toll plaza, date, time, entry toll attendant identification, vehicle registration number and an entry serial number. The ticket is surrendered by the driver at exit and is processed by the exit toll attendant. The exit toll collection equipment encodes the ticket with exit point, and again encodes vehicle class, date, time, attendant identification, vehicle registration number and an exit serial number. All these informations are then electronically stored for subsequent use in the Audit process. The ticketing system can be operated either in attended or unattended fashion using automatic ticket issuing machine. The system requires vehicles to make only two stops: one to pick up the ticket and one to surrender the ticket and pay toll and thus the delay is minimized. Another advantage is that the toll charges can be structured to have very similar “per-kilometer” rates for all movements. Bar code reader is desirable at the entry and exit for efficient use.

1.1.2 *Types of toll collection methods*

Three types of toll collection methods prevalent at present are

a) ***Manual*** – A method of toll collection which involves classifying vehicles, collecting cash, providing change and receipts. The operation is conducted manually by a toll booth attendant. The details of transactions are recorded and stored in the computer.

b) ***Smart Card*** – This method comprises, the system for vehicle identification, barrier and synchronize traffic light and payment through smart card. A smart

card is a plastic card, usually about the same size as a magnetic stripe card that has embedded electronic logic to data and in some cases a chip that can process data. Smart card users have to stop at "Touch and Go" reader at both entry and exit lanes while passing through the toll plaza. The physical components of a smart card system are i) a card; ii) a reader device; iii) a terminal; iv) a host computer and v) the connections which link the components of the system.

c) ***ETC: Electronic Toll Collection*** – This technology relies on two major components: a transponder which is an On Board Unit (OBU); and a communicator which is a road side antenna. OBU assigned to a vehicle replaces cash as the form of toll payment. The communicator is used to identify the transponder automatically and therefore validate the toll payment. A non-stop (regulated speed) cashless ETC, requires a system that remotely identifies a transponder attached to a moving vehicle. Here the communicator (antenna) is connected to a Central Processing Unit (CPU).

Two piece type OBU with multipurpose contactless card is desirable. The card can also be used in Touch and Go system as well as can be used as credit card for other payments. **Fig. 1.01** presents such OBU unit.

Another type of OBU could be with bar code marking for multipurpose use as shown in **Fig. 1.02.** This is currently under considerations for use in Delhi-Gurgaon Toll Plaza.

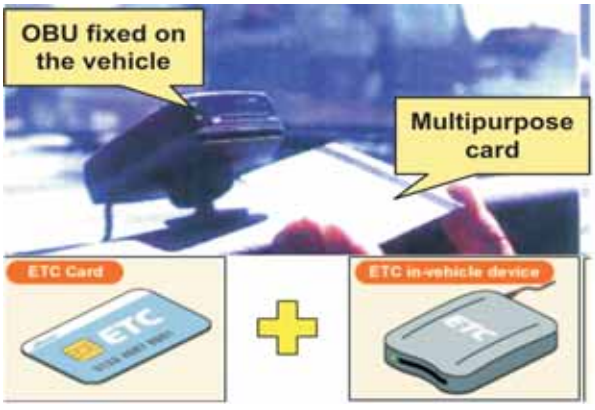


Fig. 1.01 Two Piece OBU with an IC Card

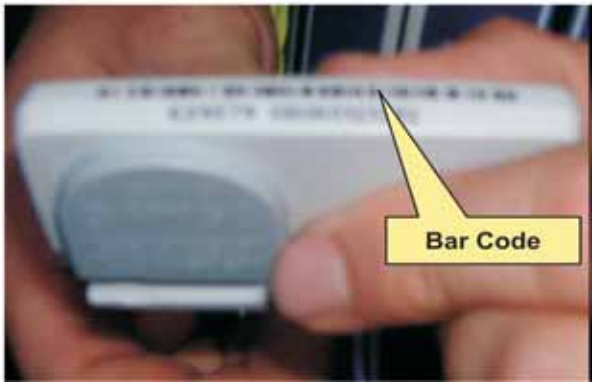


Fig. 1.02 On Board Unit with Bar Code

1.1.3 *Toll gate activities*

As the vehicle enters the toll plaza area, the same is detected by the roadside antenna arrangement of the toll system. Vehicle proceeds to dedicated lane for either Non-ETC cash lane or ETC lane.

a) Vehicle Identification

Automatic Vehicle Identification (AVI) system placed adjacent to toll lane identifies the vehicle for classification and pictures the vehicle registration number. A video image of the vehicle is also taken for record. All these are sent to a Central Processing Unit (CPU) at Traffic Management Center (TMC) for record, processing and subsequent usage.

b) Entry to Expressway (Ticket Issue)

- ***Cash Payment Users***

  At the toll booth, the user receives the ticket from the attendant or the machine kept for the purpose. Once the ticket is issued, the barrier goes up and the vehicle can proceed.

- ***Smart Card (Touch & Go)***

  The user touches the receiver and the vehicle details alongwith point of entry are recoded and sent to CPU.

- ***ETC Users (Smart Card)***

  On dedicated ETC lane, the communicator/antenna (placed roadside or on overhead gantry) looks for a transponder (OBU) and captures vehicle details. The vehicle with valid transponders proceeds further. For a vehicle with invalid transponder, the barrier boom closes the lane and the vehicle is diverted to a non-ETC lane. The information details collected by the roadside antenna are sent to Traffic Management Center (TMC) for further processing and usages. In the absence of transponder or it being or non-valid, “additional collection efforts” will be required and ticket will be issued similar to cash payment procedure.

c) Exit from Expressway (Pay Toll)

Digital display for showing the toll rates to various destinations using LED indicator shall be placed at exit toll booth location. The user has to pay the toll charges and submit the ticket received at the entry. **Fig. 1.03** shows LED display.

Fig. 1.03 LED Display (showing Toll Rate)

- ***Cash Payment***

  The attendant verifies the information on the entry ticket and the toll amount payable is generated by the computer. On payment, the attendant issues the receipt and barrier gate opens for onward passage of the vehicle.

- ***Smart Card (Touch & Go)***

  Once the card touches the receiver, the payable toll amount is generated by the computer based on the entry information and the same is deducted from the card.

- ***ETC Payment (Smart Card)***

  On ETC lane, the toll payment/transaction is done electronically using the On Board Unit (OBU) with smart card or a tag. The transponder, assigned to the customer and/or the customer's vehicle, replaces cash as the form of Toll Payment.

  With Automatic Debiting Systems (ADS), the transponder (OBU) is used to store the balance of fund remaining in the smart card. As the OBU is interrogated by the communicator (antenna), the current balance is read, the toll due deducted and a new balance is written. The transaction becomes a self contained record detailing the location, time and date of journey undertaken.

1.2 OPERATIONS IN TOLL PLAZA

1.2.1 *Broad operations*

a) ***At entry*** – check regularly the ticketing machine and the manual operations,

tickets left out (i.e. not collected by the users). This check will be exercised for one month or for a period as decided by the authority. A regular reconciliation of tickets issued, tickets left out and the total vehicle movement shall be carried out on daily basis.

b) ***At exit*** – supervisor checks all collected tickets and the collections, missing ticket records, incidents involving "additional effort" for recovery of tolls and shall reconcile with the reports of the entry supervisor and the desk supervisors. This shall be carried out on daily basis.

1.2.2 *Control of overloaded/oversize vehicles*

a) **Overloaded vehicles:** These are generally slow in running speed, leads to platoon formation in absence of adequate overtaking situation. In addition, these vehicles cause enormous damage to pavement life. Therefore, overloaded vehicles need to be identified before the toll plaza and guided to proceed to the static weighing area for appropriate penal/legal actions by competent authority. The overload components

(if possible) shall be un-loaded, prior to releasing the vehicle for onward journey.

b) **Other Illegal Vehicles:** On these expressway network, only motor vehicles with minimum 4-wheels are allowed. Two/three wheelers, bicycles or animal drawn vehicles are prohibited. Such vehicles shall be stopped and advised/ directed to take other routes. Another type of illegal vehicle is oversize vehicles. They are nuisance/hazards in traffic stream and affect free flow. At toll plaza, a separate lane with enhanced width and vertical clearance is provided to accommodate the same. Prior to leaving the toll plaza area such vehicles should be trimmed, if possible, to legal/permitted size as per Motor Vehicles Act.

1.2.2.1 Daily checking

For this purpose Weigh in Motion (WIM) system shall be installed on all traffic lanes and

the information shall be recorded. This system comprises Piezo electric sensors and inductive loops as shown in **Fig. 1.04**.

Fig. 1.04 Piezo Electric Sensors and Inductive Loops

1.2.2.2 Special checking with regulatory authority

The static vehicle weighing system with storage facilities for off loading of excess cargo and areas for administrative personnel shall be placed in the toll plaza area. This facility shall be provided one each to cater for each direction of travel.

1.2.3 *Traffic congestion measures*

The toll lanes are provided to meet the peak demand and the facility also shall provide additional standby lanes or dual purpose lanes such as lanes for oversized vehicles to meet the eventualities due to maintenance, excessive traffic and non-functioning of booth.

1.2.3.1 Flexible gate opening

During the entire day, the traffic volumes are of “peak and off peak” nature. Therefore, during off peak period, the number of functioning toll lanes may be reduced in a systematic manner with sufficient measures for traffic guidance (flexible barriers) and

signages. This toll-lane-turn-off period shall be gainfully utilized for servicing, maintenance of booth equipment and cleaning plaza lane.

1.2.3.2 Capacity enhancement

With increase in traffic volume, the demand for number of toll-lane increases. Generally, the toll lanes are constructed to meet the demand for 20 years projected/forecast traffic with provisions kept for phased development. Capacity can be enhanced by increasing number of toll lanes or adopting higher technology i.e. converting Non-ETC lanes to ETC lanes. Adoption of upgraded technology will save space as well as administrative tasks. Cash lanes shall be designed for upgrading to ETC lanes depending on projected ETC usage and traffic.

1.2.4 *Organization and responsibilities*

Routine inspection on 24 hr x 7 day basis shall be carried out. Operation staff, security personnel and officers shall match this requirement alongwith adequate numbers of relieving persons. The organization chart for toll operation is indicated in **Fig. 1.05**:

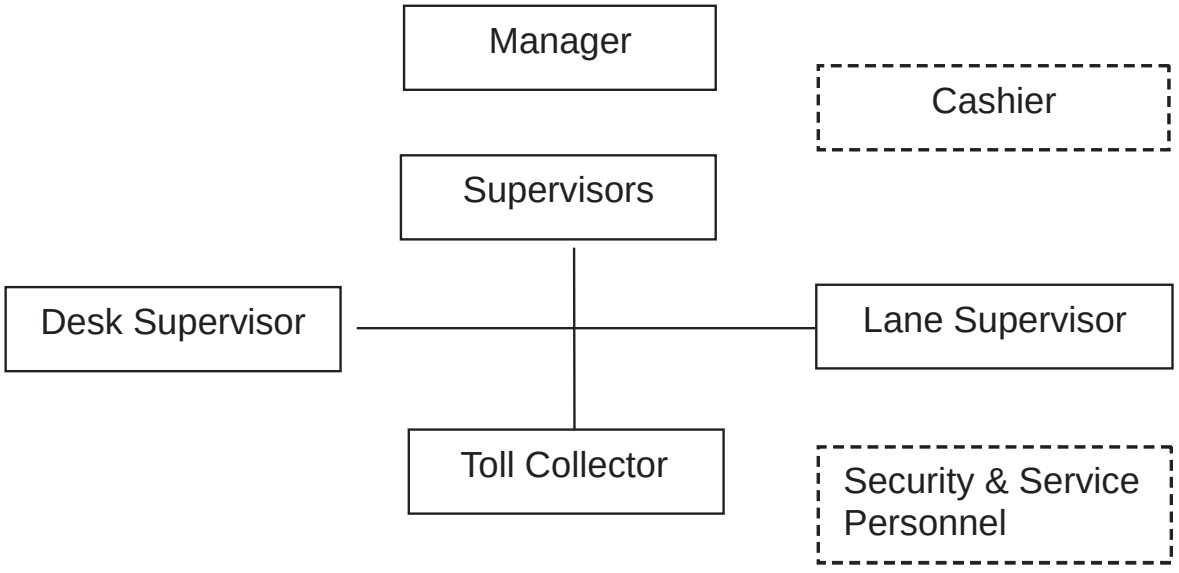


Fig. 1.05 Organization Chart at Toll Plaza

- ***Manager*** – is the chief of the Toll Plaza operation and responsible to higher authorities.
- ***Supervisors*** – are responsible for smooth working of the plaza. They check periodically on site operations. Set all the normal procedures and attend to problems as and when required for any emergency situations.
- ***Desk Supervisor*** – is responsible for overseeing all operations on the toll lane including the activities of the toll operations. Keeps track of all classified vehicle movement record for audit purpose and dispute resolution. One desk supervisor can look after 4-6 lanes (in peak hours) depending upon the computer monitor and traffic volume. They are located in traffic control room with an overview of the lanes.
- ***Lane Supervisors*** – are responsible for attending to any problem on the toll lane as well as functions inside toll booth. One supervisor in peak period may look after 2/3 toll lanes.
- ***Toll Collectors*** – are responsible for toll collection and attending to general queries from customers at exit lane and issuing ticket at the entrance. During peak hours one assistant, placed outside the booth may be required.
- ***Cashier*** – is responsible for visiting the booth at scheduled interval for collection of money and to replenish the likely change (notes and coins of small denominations) as required. Cashier might also have to attend on call from Toll Collector.
- ***Security Personnel*** – are responsible for providing security for the Toll Plaza, administrative area, office, cash section during normal operations. Attend to all eventualities due to any vandalism or accident and assist the lane supervisors and toll attendants to mitigate the unforeseen situations.

Fig. 1.06 A, B and C show illustrations for desktop supervisor, CCTV locations on monitor and traffic control supervisor.

1.2.5 *Surprise checking*

To run the operations efficiently, a team with competent personnel shall periodically check all activities of the plaza include man, machine and other appurtenants. The visit shall be at random without any prior intimation.

1.3 TRAFFIC SAFETY AT TOLL PLAZA

At toll plaza, the signage system on road side and above the toll lanes and lane marking on pavement surface direct the vehicles to the appropriate toll lane.

Fig. 1.06A Desktop Supervisor

Fig. 1.06B CCTV Locations on Monitor

Fig. 1.06C Traffic Control Supervisor (CCTV – Monitor)

1.3.1 *Safety measures at toll plaza*

1.3.1.1 Signages

For expressways closed system is considered, where toll plazas are provided along the main roadway, advance guide signs should be provided at 1 km and 0.5 km in advance of the area. Signs for toll plaza should be in black letters on a reflectorized white background and should carry the message **TOLL GATE 1 km**. **Fig. 1.07A** presents details of traffic signs and toll rates for vehicles **(Fig. 1.07B)**.

Fig. 1.07A Toll Plaza Sign

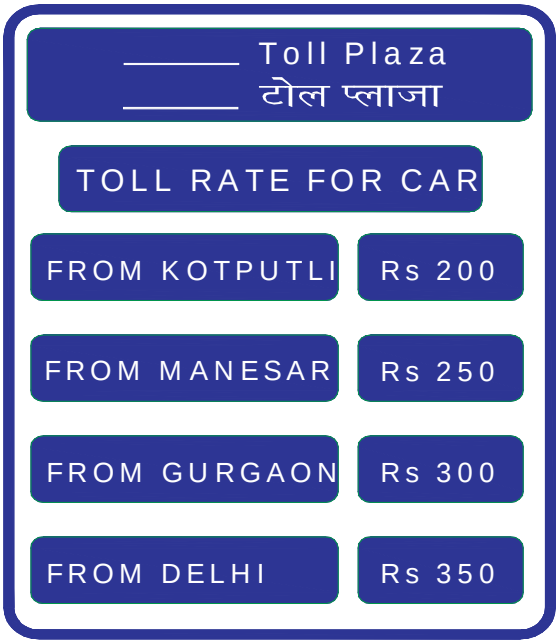


Fig. 1.07B Toll Rate Sign at Exit Ramp
(Assumed Sign Placed at Jaipur)

Stop signs shall always be used in combination with certain road markings such as stop line and the word **"STOP"** marked on the pavement vide IRC:35 "Code of Practice for Road Markings" and IRC:67 "Code of Practice for Road Signs".

1.3.1.2 Road markings

The road markings for the toll plaza area are designed to provide lane markings, diagonal, chevron markings. In the flared portion provided in place of dismantled center median to indicate separation of the traffic in two directions. Single lane is provided at toll gate to demarcate each service lane. Diagonal markings for central traffic island and chevron markings at side traffic island shall be provided to guide the approaching and separating traffic.

Relevant markings are shown in **Fig. 1.08**. The road markings are generally proposed in accordance with the provision of IRC:35, "Code of Practice for Road Markings".

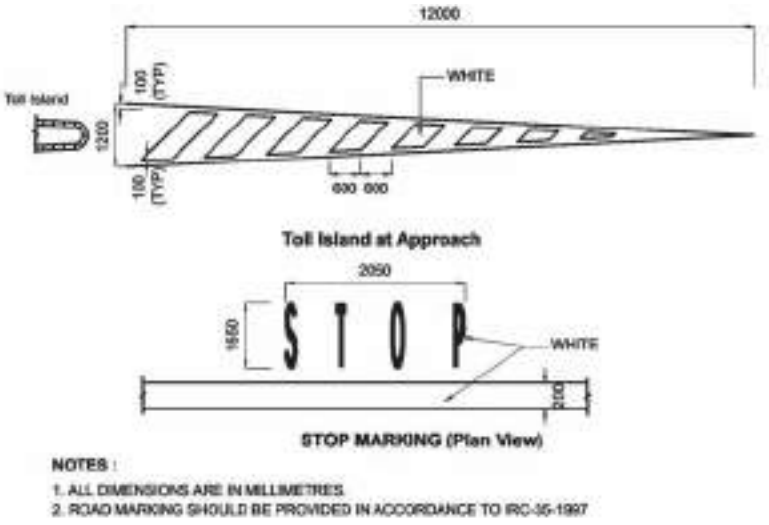


Fig. 1.08 Road Markings in Toll Plaza

1.3.1.3 Safety cushions

Safety cushions shall be placed at the end of raised toll island to protect toll booth and other instrumentation/equipments. **Fig 1.09** shows Typical Safety Cushion.

Fig 1.09 Typical Safety Cushion

1.3.1.4 ETC related safety measures

Signages and Markings

ETC being a non-stop lane would require signages in advance for traffic lane guidance to avoid complex weaving manoeuvre at toll plaza. **Fig. 1.10A** presents Guide sign for ETC.

The ETC lane at the plaza shall have a distinct identification signage adequately illuminated and placed over the dedicated lane. **Fig. 1.10B** presents Guide Sign on Toll Lane Portal.

The portal over the ETC lane shall also have purpose oriented informative features. For easy identification by user, the pavement surface of the ETC lane shall be marked with special type, such as, white chevron marking on blue background and the word ETC is written on the pavement surface. **Fig. 1.10C** presents ETC Lane Marking on the pavement surface.

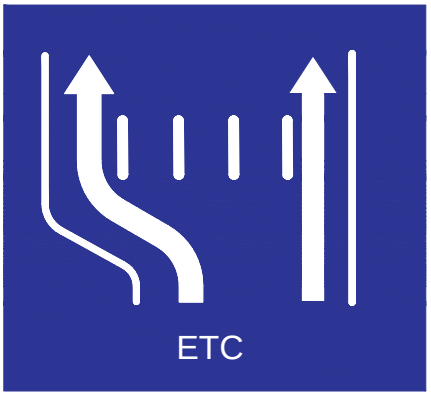


Fig. 1.10A Advance Gantry Sign

Fig. 1.10B Guide Sign on Toll Lane Portal

Fig. 1.10C ETC Lane Marking

Provisions on Segregated ETC Lane

On ETC lane, the communicator (antenna) has to identify the transponder (OBU) for validation. An invalid transponder or a vehicle without transponder need to be diverted to a Non-ETC lane. This would require an additional length of around 30 m between the location of communicator and the lane barrier for diverting the errant vehicle. To effect this diversion, removable barriers are placed between the ETC and Non-ETC lane.

1.3.1.5 For Toll Area Safety

a) Provisions for Toll Booth Utility

The toll booth utility service, connecting the office area to the various toll booths are provided for movement of cash, personnel and providing utility service lines. This provision may be as overpass or underpass depending on site specific conditions and economic considerations. However, the followings may be kept in view.

Fig. 1.11 Typical View Inside Toll Booth

Overpass is preferable compared to underpass (tunnel) due to the followings:

- Dirt and water is likely to gather at underpasses.
- Computer and optical facilities are prone to malfunction in presence of dirt and water/moisture.
- Un-expected heavy rain may flood the underpass.
- Even if we provide pump - power failure may happen.
- Using glass window will reduce the number of offensive attack because other users can see (watch) the overpass.

b) Turn Around Provision

Emergency and patrol vehicles require U-turn provisions for effective mitigation of emergent incident. The actual configuration may be site specific, desirably in close proximity. As such this is being located close to toll plaza and the service area accommodating the emergency facilities. **Fig. 1.12** presents Typical Turn Around.

Fig. 1.12 Typical Turn Around

1.4 ADDITIONAL SAFETY MEASURES AT TOLL PLAZA

The collector at toll booth has to deal with various kinds of customers and not necessarily all are well behaved and nicely co-operating personnel. To deal with such situations, inside the booth, facility in the form of voice communication and push button system shall be provided, which will alert the security to rush in for rescue. To meet eventuality like fire, provision shall be kept for smoke detectors and fire extinguisher inside booth.

The following facilities are expected to enhance performance

1.4.1 Additional safety features

Judicious placement of the following features on selected basis at risk prone locations may improve safety aspects.

a) Data from height/length and axle sensors should match with the classified traffic volumes recorded by the toll operator and desk supervisor.

b) Two CCTV shall be placed on each lane for surveillance of the activities inside booth and traffic movement on toll lane.

c) ID cards for entry to various areas shall be classified conforming to the person's task requirement and responsibilities.

d) Two CCTV (minimum) shall be placed in the utility tunnel to check and record all movements and events inside tunnel.

e) A CCTV in the cash handling section shall be placed to record all transactions and specially look at the entry/exit doors.

f) All the information or images collected by the CCTV will be linked to server for surveillance and auditing by the Manager, Auditor and the senior officials.

g) The roof top shall be designed to guard the blinding effect of sunlight on the monitors during morning and evening hours. Strategically placed flaps or sheds may also serve the purpose.

h) Annual Maintenance Contract (AMC) shall be maintained to ensure prompt service within maximum 30 (thirty minutes) of the call over telephone or internal messaging system.

i) Signal and Spin Light

Large size Open/closed signal along with spin light at the toll plaza gantries should be provided. This will facilitate the user to select the appropriate lane. It shall be operable from the toll booth as well as from the operation office (toll office). **Fig. 1.13** presents Signal and Spin Light.

Fig. 1.13 Signal and Spin Light

j) Safety Rope and Bar

Safety rope and barrier, as shown in Fig. 1.14 may reduce the danger of accident with casualties for lane supervisor

Fig. 1.14 Typical Safety Rope and Bar

k) Shielding Sunlight Glaring

Blocking sunlight, especially in the morning from east and in the afternoon from west by provision of a shield to remove to eliminate reflection of light which improves the visibility of the display panel of the console for toll collectors and of the toll indicator for users. The roof of the toll gate at both ends shall be so designed to prevent the toll gates from sunlight. **Fig. 1.15** presents typical sunray shield at toll booth.

Fig. 1.15 Typical Sunray Shield at Toll Booth

l) Air-conditioning

Air conditioning shall be provided in the booth. This will enhance toll collector's efficiency and reduce the malfunctioning of the computer and other electrical facilities.

1.5 SECURITY AT TOLL PLAZA

The attendant at toll booth has to deal with various kinds of customers and situations. To deal with such situations, security systems are necessary at all the tollbooths, overpass/ underpass, toll office and operation office.

a) Inside the booth
   - Security camera
   - Voice communication facilities
   - Alarm button
   - The toll collector shall be adequately trained for use of these facilities

b) Outside the booth
   - Lane camera
   - Voice communication facilities
   - Armed security personnel

c) Overpass/Underpass
   - Security camera
   - Alarm button
   - Armed security personnel

d) Toll office
   - Security camera
   - Voice communication facilities
   - Alarm button
   - Armed security personnel

1.6 AUDIT

1.6.1 *General procedure*

The toll plaza shall have toll audit system and fraud protection measures. The operations for toll collection, supervision, auditing and money handling shall be done through the qualified trained personnel so that each operation is handled efficiently and appropriately.

The toll audit unit would be responsible for the audit of all toll attendants. Toll attendants must be audited for every hour of duty in order to identify precisely the period of wrong use or misuse. This unit will audit a "seven-day-work" for toll collection within the next five days. It is extremely important that this unit shall not be understaffed. It is anticipated that all information received from the toll plazas would be stored on a central computer for processing. These would contain information entered by toll attendants and independent information recorded by treadles and loops regarding axle counts and transactions. This applies to entry lanes as well as exit lanes. Amounts to be deposited by attendants would be calculated by the equipment at the toll plaza from the information contained on toll tickets processed through the exit lane terminal. The entry-lane audit is as important as the exit lane audit even though no cash is involved.

1.6.2 *Monitoring toll collector's data and counter measures*

Transaction/money and axle counts (vehicle) should be reconciled to the tickets issued to ascertain any misuse/wrong use by the entry attendant. The system must also provide for non-revenue vehicles which are allowed to travel without paying a toll. In these cases, axles and transactions would be counted but toll amount in terms of money would not be entered. These transactions must be handled by a special pass which is processed through the attendant's terminal and identifies the user. The use of non-revenue passes should be reviewed by supervisor periodically, preferably on a monthly basis and / or random basis for any suspicious use.

Effective and credible means of enforcement are essential to the success of any ETC system. Barriers to deny access to customers without a valid form of payment are one alternative for installation on a toll plaza. Transactions at high speeds (greater than 60 kmph) are complex where a barrier requires raising to allow passage. Barrier system such as "to keep a barrier in the raised position until a vehicle attempts to violate the system (gain passage without payment)" is not recommended for expressways in terms of safety.

An increasingly effective method of enforcement being adopted universally is to employ a Vehicle Enforcement System (VES). This captures an image of any violating vehicle's number plate by means of camera or video technology. A summons/challan for non-payment can then be issued to the registered vehicle's address.

1.7 USER SERVICE AT EXIT BOOTH

1.7.1 *Driver's enquiry*

The driver's operating on the route may be a new person traveling for the first time may enquire about the toll rate and subsequent route guidance. This shall be provided by the toll attendant or shall be advised for the appropriate place where the driver can get his desired information.

1.7.2 *Traffic information on incident*

The toll attendant must inform the driver of any incident occurred on connecting highways and shall be advised for necessary precautions. The probable delay which the driver may suffer due to the incident shall also be conveyed to him so that the driver can decide to continue his journey or spend some time in the nearest rest area for clearance of the incident.

1.7.3 *Advertisement*

The advertisement brochures of informative nature may be handed over to the driver for possible information on traffic safety enhancement, important places, tourist information and availability of regional foods, handicrafts and special medical assistance.

1.7.4 *Trouble shooting*

1.7.4.1 Machine trouble

Machine troubles may be of three types i.e. on Hardware, Software and Breakdown

- ***Hardware Troubles***

  Abnormalities in functioning of machine/equipments like video system not working, loop not functioning, exit boom not working, computers not able to access network, keyboard/mouse is not working etc. On noticing such incidents during normal operations, the toll booth operator or lane supervisor shall report to the systems in-charge over internal telephone/communication system and also through a fault report.

- ***Software Troubles***

  Some troubles which are noticed by the toll operator or lane supervisor such as hanging of work stations, virus attacks, application software not responding etc. shall be reported to systems in-charge over internal telephone/communication system and also through a fault report.

- ***Breakdown of the System***

  This may be noticed by the toll booth operator or lane supervisor during normal operation or from extraneous reason (vandalism/accidents), the supervisor shall immediately report over internal communication system as well as through a fault report. Vocal communication system may be used for help and need of the lane supervisor and security personnel.

For all such events, the affected lane shall be closed and the traffic shall be diverted to other operating lanes.

1.7.4.2 Lost ticket

At exit**,** the toll collection process will involve "additional collection effort", provided the vehicle registration number details captured at entry lane can be traced from Traffic Management Center (TMC). If the entry details are non traceable for the vehicle, the user identification card and vehicle images along with vehicle registration number shall be noted and mutually agreed penal amount may be collected based on driver's statement.

Quoted below is a relevant Frequently Asked Questions (FAQ) in Japan.

Q. What if I lose my transit ticket?

A. If you lose your transit ticket, please inform the attendant at the exit toll booth and fill out the necessary paperwork. Customers will be asked about the situation and toll will be charged from the entrance interchange only if that interchange can be confirmed. Otherwise, toll will be charged from the farthest interchange, so please take care to not lose your transit ticket.

(Source: http://global.c-nexco.co.jp/faq/8.html)

Toll collector, the monitoring attendant and lane supervisor must declare the incident in document for each shift. The supervisor must check the detail using recorded data (Vehicle Classification Data – from video recording).

1.7.4.3 ETC error

It may be the failure of transaction due to non-reading/non-communication between the transponder (OBU) and the communicator (Antenna). In such cases, the usable video imaging for vehicle and vehicle registration number details becomes the only source. The "additional collection effort" involving entry identification may become prohibitive. Mutually acceptable amount may be a solution (Using similar procedure as for lost ticket).

a) Vehicle Classification Error

Particular type of vehicles may have been detected as class A instead of class B. In that case, toll office manager has to examine the data and may inform the supervisor to check the equipment along with other measures.

b) Power Failure and Thunderbolt

Power failure and thunderbolt may cause huge damage to information stored. Retrieval of data to the extent possible shall be made with the help of a back-up power generator. However, in between the switchover process, some communicated data may be lost.

c) Human Failure

When lane supervisor or user wrongly operates ETC machine, transaction error may happen.

When the error is noticed, the lane supervisor shall guide the user to the toll office or to a non-operating lane and settle the issue. The supervisor and toll office manager shall check to avoid similar ETC error again.

1.8 TOLL EVASION COUNTER MEASURES

Enforcement by means of manual policing can be an option to be considered. This is generally relied upon as a backup to another means of enforcement. Some heavy vehicle drivers may attempt to gain passage through dedicated "cars only" lanes, but using an OBU encoded with a car classification. This practice is regarded as toll evasion - the offender may be treated in the same way as someone who made attempt – not to pay.

Another aid in enforcement is Automatic Vehicle Classification (AVC). These systems can work with all the classification methods previously described. Axle counting systems are the most well established of this genre, utilising axle sensors mounted on the road surface. Inductive loops buried underneath the road are often used for length based AVC, although increasing use is being made of image processing based systems. The latter can even work via an interface with existing CCTV equipment. The most complicated AVC equipment is that required to determine vehicle type, but this is generally based on high resolution imaging technology.

1.8.1 *Ticket exchange*

This is a typical situation and likely venue would be the Rest Areas. A policing mechanism may need to be adopted.

Attendant placed at the entry gate and will take the Toll Ticket in his custody and will return the toll ticket at the exit gate. At entry, a video image of the vehicle and vehicle registration number will be attached with the toll ticket for return and verification at EXIT.

1.8.2 *Pass through toll gate without paying*

1.8.2.1 Tailgating

The most common form of evasion is that of tailgating. Here a vehicle which is not equipped with a transponder drives nose-to-tail behind a vehicle equipped for valid ETC payment. This form of toll evasion is usually carried out with the two drivers working together, as it requires a fair amount of skill to avoid being distinguished as two separate vehicles without colliding. Tailgating is only practical where passage is at low speeds, *e.g.* when barriers are employed. The use of an effective AVC system coupled with a visible deterrent in the form of VES should prevent such activity.

CHAPTER - 2

TRAFFIC MANAGEMENT

CHAPTER – 2

TRAFFIC MANAGEMENT

2.1 TRAFFIC CONTROL

Traffic management is the application of traffic control measures through information collection on real time basis, processing the same i.e. collation and analysis and finally dissemination of the information to the users and concerned agencies, stake holders and security/legal/law and order administrators.

For safety, the prime importance is to provide real time and precise information to users on road. The entire system shall be based on computerized Highway Traffic Management System (HTMS) incorporating Intelligent Transportation System (ITS).

A system working round the clock shall be established for informing the road users about the road condition, traffic situations/incidents, and weather conditions on the expressway and to make interventions as required for smooth, safe and efficient traffic movement by providing rescue and relief to the users to avoid distress.

The system primarily shall include:

a) Acquisition of data from the various sources such as the road, the users, the maintenance and operation patrol, the ambulance, and the intervention team.

b) Three way communication (i) between the data sources and a Central Control Room, (ii) between the Control Room and the data sources and display units, and (iii) between the maintenance and operation teams, through a transmission system.

c) A Central Control Room collects, collates and processes all data and control the Expressway operation. Data received are also archived for a set period of times.

2.1.1 *Information collection*

This shall consist of (a) Emergency Communication System (b) Mobile Communication System (personal mobile) (c) Meteorological Data System (d) Automatic Traffic Counters cum Classifier System (ATCC) (e) Transmission System (OFC/PIJF) (f) Closed Circuit Television (CCTV) (g) Patrol Vehicle etc.

2.1.1.1 Emergency communication system with loud speaker, micro phone, activation button with LED, indicating conversation is on, shall be housed in a vandal proof casing and operate in full to play mode in noise level of up to 95 decibels with in built diagnostic features for automatic detection in case of damage by any object.

These facilities are installed generally at 2 km interval and on sensitive locations at 1 km interval. Inside the tunnel, it is desirable to place the system at 200 to 500 m interval.

Mobile communication system may comprise the mobile radio base stations and control center equipments as well as Emergency Call Boxes (ECBs). These ECBs are free of charge and may be of dialing for push button type and are meant for the notification of emergencies such as accidents and breakdowns. ECBs will not connect with any other ordinary telephones and these shall be noticeably posted above the dialing system or the push button. However, it shall have provision for connecting to mounted mobile set on ambulances, towing and patrolling vehicles. The system shall have the facility to connect mobile to mobile, mobile to controller, and controller to mobile along with the systems for waiting, holding, and transfer of calls. The system shall use a pair of frequencies to be allotted for the purpose by the Department of Telecommunications.

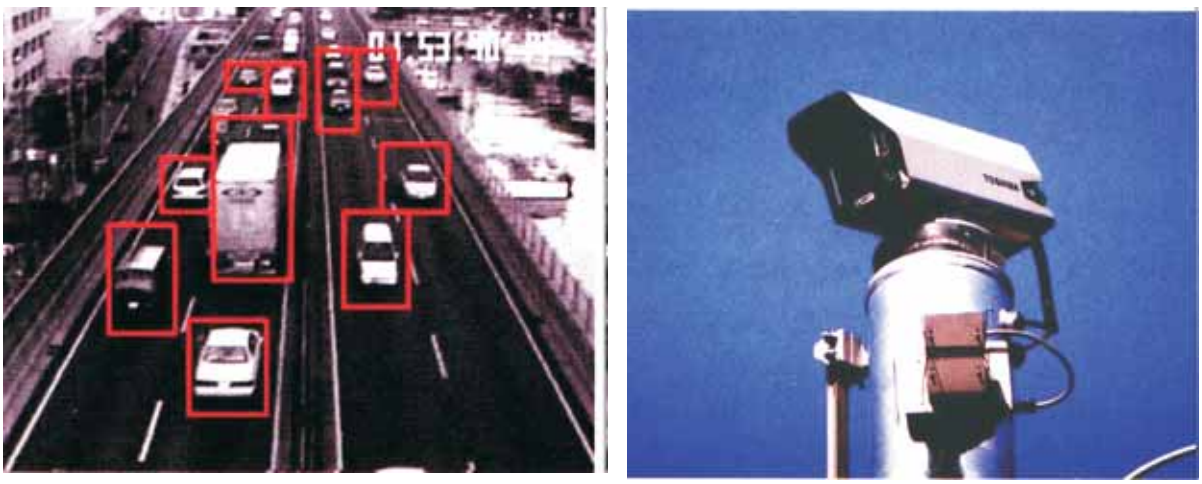
2.1.1.2 Mobile Communication System is commonly available mobile network to enquire for help lines or passing incident information to Traffic Management Center as noted by the users enroute expressway.

2.1.1.3 Meteorological Data System shall comprise thermocouple/pyrometer, humidity meter, anemometer, visibility meter and sensor for measuring pavement surface temperature. They shall be installed on a single pole with a specific attachment and power supply fed from the integrator. They shall have the facility to communicate on Polythene Insulated Jelly Filled copper cables (PIJF)/Optical Fiber Cable. These instrumentation system shall be placed at strategic locations (or at places where the weather is likely to change) to pickup the relevant data and communicate the same to the Traffic Management Center (TMC).

2.1.1.4 Automatic Traffic Counters cum Classifier system (ATCC) shall be capable of detecting and recording all categories of vehicles plying on the expressway based on their speed, length, and number of axles. These shall desirably be located near the toll plaza and the entry and exit locations on the expressway. The system shall be robust and capable of operating with minimum maintenance and may be either piezo-electric or infrared. It should have minimum accuracy level of 99%. The logic units shall be microprocessor based. The system should be able to record and store vehicle data for a

period of at least two weeks with a Daily Traffic Volume up to 100,000 vehicles. The system shall have compatibility to transfer the data on PIJF/OFC by using any of the available communication mode like GSM (Global System for Mobile Communications), landline modem, CDMA (Code Division Multiple Access) depending upon the effective and economic operation of the particular mode available at the site. The system may be electric/solar power operated depending upon the availability of source.

2.1.1.5 Closed Circuit Television (CCTV) generally placed at 1.5 to 2 km interval. CCTV will monitor traffic flow, security aspects, vehicle detection and incidences on the expressway section. Surveillance shall comprise video camera, its housing and pan, and tilt Heads. The video camera shall be mounted at a height so as to cover the target length (generally 2 km of expressway section) of expressway and the housing shall be able to withstand adverse weather conditions. It shall have a 360 degree angular travel in the horizontal plane and a tilt of 90 degrees down from 0 degree horizontal. It shall have zoom lens with minimum power of 30 X, auto iris and infrared filter, infrared compatibility for night operation and remotely selectable operating modes. It shall have compatibility with co-axial cable/ optical fibre cable for transmission of information to TMC. **Fig. 2.01** presents the typical systems.



View transmitted to TMC Typical CCTV

Fig. 2.01 Typical CCTV Information Transmission to TMC

2.1.1.6 Transmission System: This shall consist of a backbone Optical Fiber Transmission system, cable system, interface system, network management system, repeater/amplification system, and power supply system. There shall be 3 or 4 sub-centers

(as appropriate) housing all the interface equipment apart from the Control Center, provided with, as appropriate, cables, interface, terminals (such as optical line terminals and interface, network management system equipment, optical fiber cable interface equipment and control center interface equipment, data acquisition system interface, etc). The cables from ECBs, VMS, meteorological data systems, ATCC shall be Polythene Insulated Jelly Filled (PIJF) copper cables and those from CCTV cameras shall be coaxial cables. Repeaters/amplifiers shall be used to maintain the quality of signals. All the cables shall have at least 20 percent spare capacity to allow for expansion. The interface system shall be capable of handling the composite audio, video and data signals at various interface levels and processing them.

2.1.1.7 Patrol vehicle: route patrol

Routine patrolling is required to provide on "24 hour and 7 day" basis to assist road users with information feedback, and various alternative functions to be performed. The patrol persons shall be adequately trained in related traffic management aspects, road safety and in primary first aid. The purpose of these patrols is to:

- Provide the users of the highway with basic mechanical help for vehicles that breakdown on the road and also protect other users from such vehicles.
- Quickly identify traffic hazards of whatever nature, such as unauthorized parking, public transport vehicles, debris, stray animals, crops and the like. The operator shall take the necessary measures to remove such obstructions.
- Provide emergency management at accident scenes until such time as the appropriate authorities arrive.
- Provide road user information for the rest of the expressway section (generally for 50 km ahead or next exit whichever is earlier)
- Maintain daily records of assistance provided to road users.
- Observe, record and report – suspicious aspects/objects on the expressway, hazards and incidental damage caused by vehicles, floods, storms or any other random events, such that the highway maintenance records and database are continuously updated.

  a) Patrol Vehicle Equipment and Accessories

A suggested minimum provision may consist of the followings:

- Vehicles capable of negotiating the highway in all-weather conditions, having 2 axles, 2 front seats, 2 back seats, sufficient rear space for equipment storage, fitted with rotating light and hooter, and painted with a unique colour pattern for quick recognition, with the agency name and emblem painted prominently on sides, back and front, together with the Control Center Help line numbers. Vehicle equipment should comprise parking, low beam, high beam, tail, brake, indicator, and interior lights, rear and side view mirrors, screen wipers, spare wheel, and reflector.

- Each vehicle should carry Traffic Management Equipment, such as
  a) Sign boards – "Accident ahead" -3 no, "Lane merging" - 3 no, "Direction Arrows" - 3 no, "Speed Limit" (80/60/40/20) - 3 no, "Keep left/right" – 2 no (all signs 1200 mm size),
  b) Sign Stand set (one for triangular, and other for circular sign)- 6 sets.
  c) Flags, whistle, reflective hand signal,
  d) Traffic cones 500 mm size, min 20 no. or flexible polythene water ballasted barriers – min 5 nos.
  e) Barricades, tape, Stands, Flags of 600 mm by 600 mm made of good red cloth, secured to a 1 (one) meter long staff. Paddles at least 600 mm wide and provided with rigid handle with markings SLOW, STOP

- Each vehicle should also carry the following equipment
  a) Fire extinguisher-1 no,
  b) Gas cutter with protective glass,
  c) Liquid container 2 no., Water container with fresh water with (Funnel Scoops) - 1 no.
  d) Rubber Gloves, Leather Gloves- 1 pair each
  e) Brooms one hard bristle, other soft- 2 no.
  f) Gum boot 4 pairs, Rain coat 4 pairs, Blankets 1.
  g) Torch lights-4 no, Spare Batteries, Flashing light – 1 no
  h) Hydraulic jack, towing chain, Animal hook,
  i) Tool set (With standard set of spanners, pliers, hammer etc)
  j) Digital Camera, measuring tape

k) Paper pad, Forms, pen/pencils, folders

l) First aid kit

As a minimum, each patrol vehicle should carry sufficient communication equipment to render its passengers capable of direct communication with the Traffic Management Center.

b) Patrol Staff

The team which is to be deployed with each patrol vehicle needs adequate training for their tasks, especially in first aid, traffic management at incident site, vehicle maintenance including minor repairs. There shall be sufficient manpower for each patrol vehicle shift. Typical staffing might be:

i) Route Patrol Officer

ii) Assistant Route Patrol Officer, with first aid training

iii) Lane Assistant

iv) Driver, with knowledge of vehicle repairs

2.1.2 *Control center*

2.1.2.1 Traffic management center

The Traffic Management Center (TMC) shall be designed for round-the-clock operations of monitoring, on-line information acquisition and processing the same for decision making. The Main Control Center shall have equipment of central computer, call center, terminal junction box, uninterrupted power supply (UPS), console, operator with monitors and joy sticks, rack accommodation, large display board, line printer and general purpose office computer with monitor, printer, fax and telephone. The system shall also have Network Management System (NMS) or real-time monitoring of Emergency Call Boxes (ECBs) and related network diagnostics.

The TMC shall be the repository of all the data acquired from the field and their processing, storing, and archiving. All the information for real time monitoring of the expressway project shall be generated at the TMC and the relevant information shall be disseminated to the users for appropriate intervention. Another important function shall be the operation management of the TMC itself along with its various sub systems.

Central Control Room (CCR) shall have the following minimum equipment, hardware and

software:

- A Central Computer Server with integrated ATMS and ATMS software.
- A Traffic Manager's Terminal for operation of the integrated traffic management system.
- Call system equipment comprising Operator PC along with sub-systems and digital voice recorder.
- Mobile radio terminal comprising Operator PC and engineering terminal.
- Computers for Network Management System (NMS) for Fiber Optic Communication System, CCTV Console Equipment.
- CCTV Console Equipment.
- Computers for VMS, AVCC, MET, Traffic Control.
- A large size display screen.
- A line Printer.
- An Office Computer.
- A Power back up system (uninterrupted power supply)

Fig. 2.02A and Fig. 2.02B present a typical Traffic Management Center and a close view of the monitoring screen. *(Source: Japan Documents)*

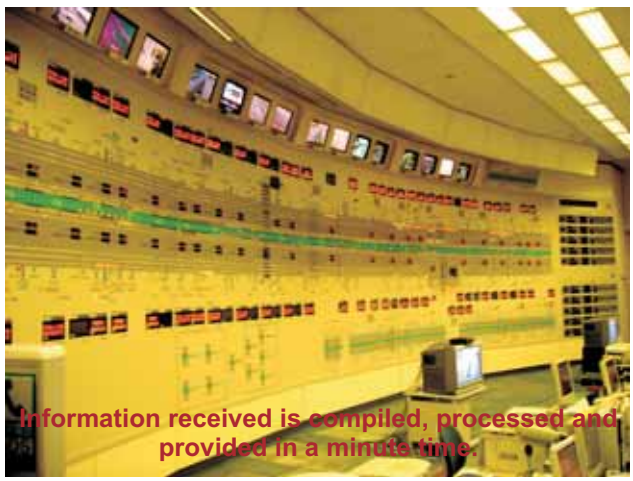


Fig 2.02A Traffic Management Center

Fig 2.02B Close View of Monitoring Screen at Traffic Management Center
(Source: Japan Documents)

2.1.2.2 Facility control center

The facility control center is the nucleus of the system, which operate all facilities on expressways. This center monitors all facilities and supervises for appropriate functioning on “24 hour and 7 day” basis. A modern facilities control center has a centralized configuration which broadly comprises of a) Central monitoring and controlling equipment, and b) Transmitter sending messages to various terminals. The essential elements in the terminals are as follows:-

- Power reception / distribution equipment
- Power generator
- Lighting facilities
- Emergency facilities
- Ventilation provisions
- Mobile communication facilities
- Water supply/drainage systems

- Information boards (including VMS)
- Meteorological equipment

The control center broadly consists of three components:-

a) A set of control desk of a large display monitor / control desk

b) A data statistics desk, and

c) A simulator desk

The above system collects, collates and analyzes data collected from the data sources and transmitting equipment exchanges information with various terminals located at interchanges, tunnels and important structures. In order to increase the efficiency in processing and analyzing the huge data base it would be necessary to have dedicated software development with inbuilt provisions to disseminate guide information in emergency situation. Engineers and operators, on the site, shall have a mobile terminal for direct connection to the facilities center. This provides support to the engineers to carry out the maintenance and inspection of road facilities.

Fig. 2.03A and Fig. 2.03B present Facility Control Center and Operations.

Fig. 2.03A Facility Control Center

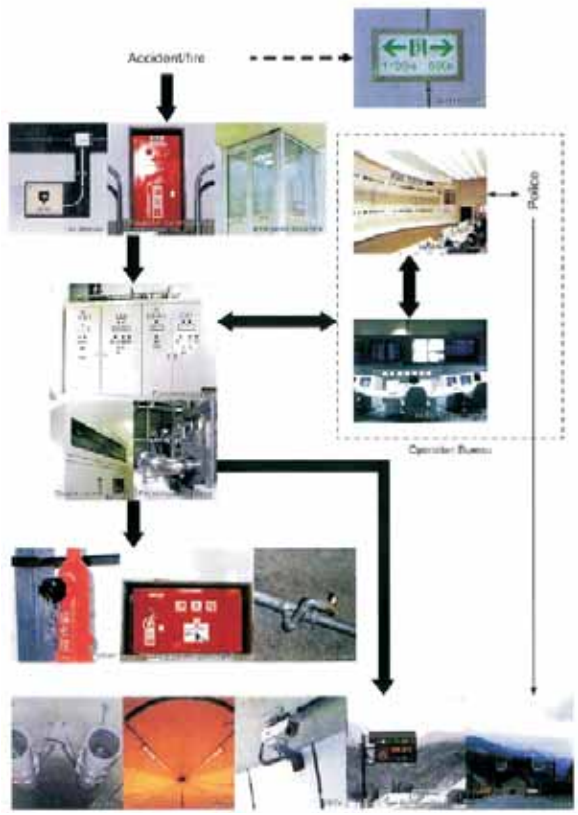


Fig. 2.03B Typical Operations in Facility Control Center
(Source: Japan Documents)

2.1.2.3 Disaster prevention center

The center is primarily engaged in Disaster planning, prevention, preparedness, response, and recovery. All these fall into the category of emergency management. Emergency is defined as any unplanned event that can cause deaths or significant injuries to employees, customers or the public; or that can shut down businesses, disrupt operations, cause potential environmental damage, or threaten a facility's financial standing. Emergency management is the process of preparing for, mitigating, responding to, and recovering from an emergency. **Fig. 2.04** presents typical disaster prevention center in Japan.

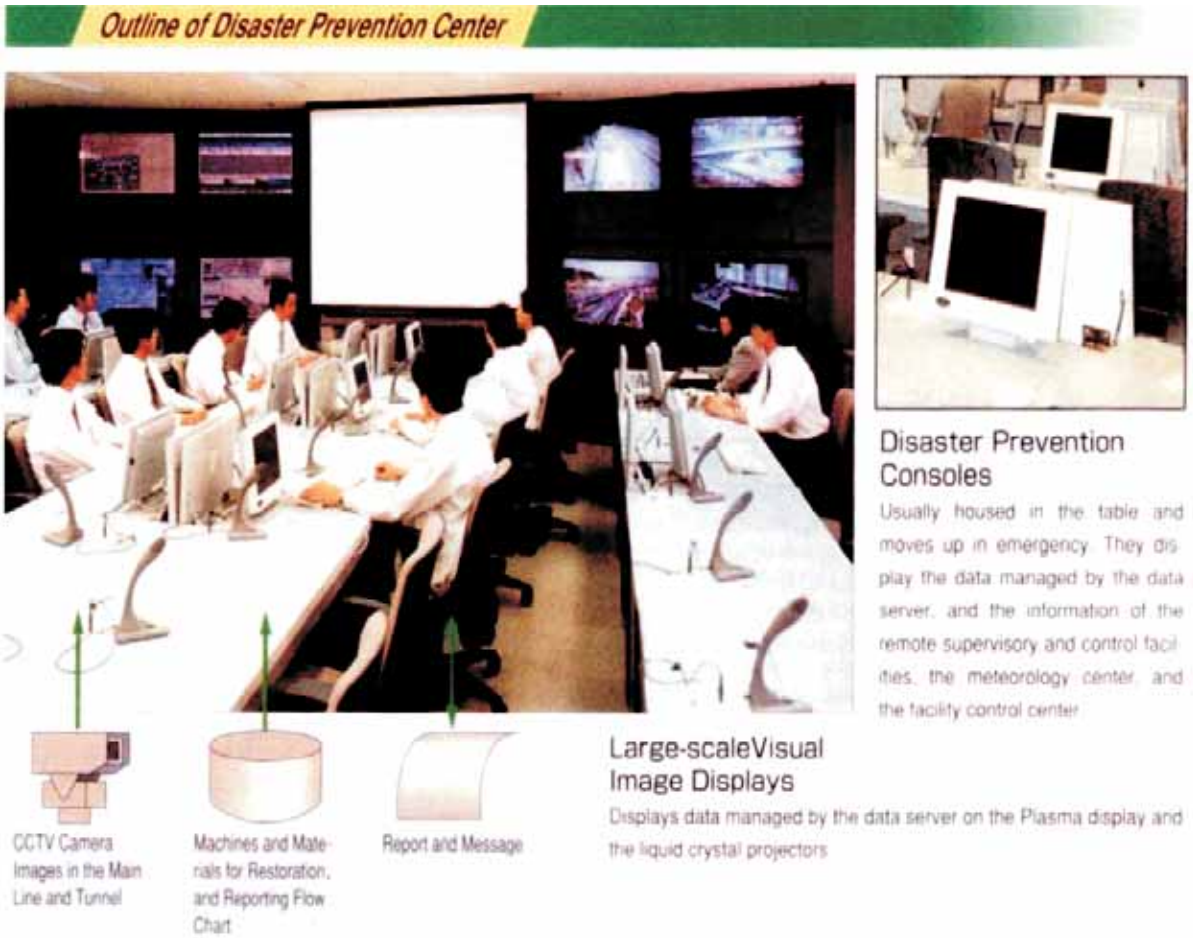


Fig. 2.04 Disaster Prevention Center
(Source : Japan Documents)

Typical disasters occur/happen due to:

Heavy Rainfall: This may cause the erosion of embankment slopes, damage to the drainage structures (including bridges) and landslides (in hilly terrain).

Cyclone: A cyclone is a tropical weather system with winds that have reached a sustained speed of 120 kmph or more. The combination of growing population and development in coastal zones, rising ocean levels, coastal erosion, and changing climatic trends have increased the potential for loss of life and property in coastal regions of the country.

Floods: Most states in India experience some kind of flooding after rains, heavy thunderstorms. Floods can be slow, or fast rising, but generally develop over a

period of days; the exceptions being “flash floods” (which result from intense storms dropping large amounts of rain within a brief period, and can occur with little or no warning), and dam/barrage failures (which can suddenly let loose a gigantic quantity of water).

Earthquakes: An earthquake is a sudden, rapid shaking of the earth caused by the tectonic movement of earth crust. This shaking can cause buildings and bridges / elevated Expressways to collapse, and sometimes trigger landslides and avalanches, all impacting the transportation network.

Wild land Fires: As residential areas expand into relatively untouched wild lands, people living in these communities are increasingly threatened by forest fires. Unpredictable wildfires can wipe out huge sections of landscape and endanger the lives of residents, necessitating evacuations from the threatened locations. Additionally, the smoke from these fires can significantly reduce visibility over a wide area, resulting in reduced speed limits, Expressway closures, and traffic diversions.

Homeland Security: The terrorist attacks have become frequently occurring unfortunate events exact a terrible toll on the country and fundamentally affects the way of life. Surface transportation is also changed, and continues to change in response to the attack.

2.1.3 *Information dissemination*

Information generated at the Control Center shall be disseminated in the following manner:

To the users: By displays on the Graphic information Boards on Streets, Variable Message Signs on expressway and on Streets (Expressway Closed), Travel Time Information Boards, Latest Congestion Warning Boards, Tunnel Warning Display Boards, Emergency Broadcast in Tunnels, Wind Speed Display Boards, Variable Regulatory Speed Signs, Vehicle Information and Communication System, Telephone Services, via internet web pages.

To the Operation and maintenance teams: By mobile phones.

To the ambulances: By mobile phones.

To the Trauma centers: Via ambulances

To the law and order administrators: By mobile phones

The effective dissemination of user information services supports many types of information requests and categories of users, and combines multi-modal information in an effective and timely manner. Information may be provided in a number of ways, including static information and real-time information. Static information comes from such sources as transit schedules, planned work zones, and known road closures. Real-time information comes from a variety of sources including roadway-based sensors, surveillance equipment, and drivers. The information assists users in selecting their mode of travel, route, and departure times – both pre-trip and enroute. **Fig. 2.05** illustrates the possibilities of range of data sources, processing and uses of user information. The figure depicts the various sources of data (left-hand side, and including expressway conditions) which are collected and centrally processed (central part of figure) to yield integrated information about the current and future travel conditions; and which are broadcast or disseminated to users, allowing them to make informed choices about when, where and how to travel.

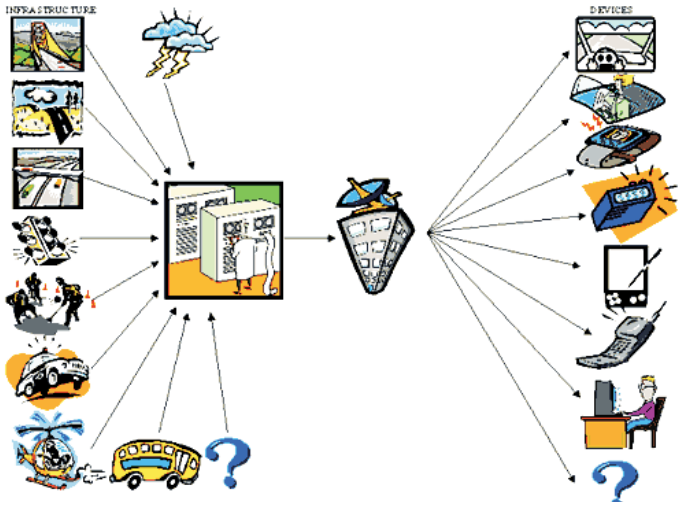


Fig. 2.05 Sources and Uses of User Information
(Source : FHWA Manual)

As shown in the **Fig. 2.05** – the information process extends well beyond the expressway, both in terms of where the information is obtained and how it is distributed. Information on expressway conditions and the dissemination of that information to users should therefore be viewed as part of a broader, region-wide, Advanced Traffic Information System (ATIS).

2.1.3.1 Variable message signs

Variable Message Signs (VMS) are quite useful in conveying the traffic conditions ahead to the drivers on real time basis as well as to display messages to support national road safety campaigns. It may also include the variable traffic speed limit depending upon the requirements.

Variable Message Signs are capable of displaying several messages in a sequence and can be repeated. Such messages can be changed manually, by remote control or by automatic control. Variable Message Signs shall display pertinent traffic operation and guidance information only and not any advertising. Various situations where VMS would be appropriate are as below:

i) Incident signs as accidents, traffic diversions, incident management, monitor road work (men at work), adverse weather and road conditions and operation with lane control signals;

ii) Traveler information such as display of road construction activity in near future, messages for testing of the system and special events that affect the traffic flow;

iii) Public service announcements like messages relating to driver safety campaign.

a) *Locations of VMS*

Variable message signs are used to visually provide expressway users with information about traffic, required time, parking condition, road, weather conditions, etc. in order to ensure that the traffic moves safely and smoothly. These boards are categorized as shown below according to their use remarkably, and congestion occurs frequently, and the images are monitored at a traffic control center or operation office.

Table 2.01 Locations of VMS

Information Provision Device		Overview	Locations
Expressway	Highway information boards at the exit to an interchange	Normally information is provided up to the next five interchanges. Road closure and other information about serious impediments to traffic are provided over wide areas (the time required to pass through a congested section is provided directly upstream from and inside the congested section).	Installed about 200 m upstream from IC off-ramps.
Expressway	Intermediate Highway information boards	Normally information is provided up to the next five interchanges. Road closure and other information about serious impediments to traffic are provided over wide areas (the time required to pass through a congested section is provided directly upstream from and inside the congested section).	Installed half way between two ICs as necessary.
	Wide area information boards	Provided over a wide area with the priority on road closures and other information about serious impediments to traffic.	Installed upstream of system interchange and locations where the weather changes abruptly, so that travelers on the long journeys can use the information in route selection and trip planning.
	System Interchange Information boards	Normally information is provided up to the next five interchanges. Road closure and other information about serious impediments to traffic are provided over wide areas.	Installed at 750 m upstream from system interchange locations.
	System Interchange Pictorial information boards (Optional)	Information about road closures and congestion is provided within a range necessary for route selection decisions on network roads.	Installed just in front of system interchange branches.
	Service/rest area utilization information boards	Congestion at the next two or three service/ rest area are indicated using one of three words, full, partial, and light.	Installed along with guidance boards at 3 km to 4 km before a service / rest area.
	Required time information boards	Provide required times to the next interchanges and up to the next two major ICs	Generally installed at intervals of between 2 and 3 kilometers from an IC
	Pictorial required time information board	Pictorial indications of road closure and congestion information; these provide the time required to major ICs	Installed upstream from sections where congestion frequently occurs at a number of locations
	Tunnel entrance information board.	Basically for emergency for those who use tunnel	About 300 m ahead of a tunnel entrance.
	In-tunnel information boards	Basically for emergency for those who use tunnel.	Inside ‘C’ or higher class tunnels.
	Weather information boards	Basically for weather information use.	Installed where weather conditions are harsh or change abruptly.
Interchange entrances	IC entrance information boards	Normally information is provided up to the next five interchanges. Road closure and other information about serious impediments to traffic are provided over wide areas.	Installed on ordinary highways just before the entrance to an IC.

There should be clear distance between existing sign and VMS. On expressways, the minimum distance between road signs and VMS should be 200 m. On National Highways or other highways, the minimum distance should be 100 m. Fig. 2.06 presents typical locations of VMS.

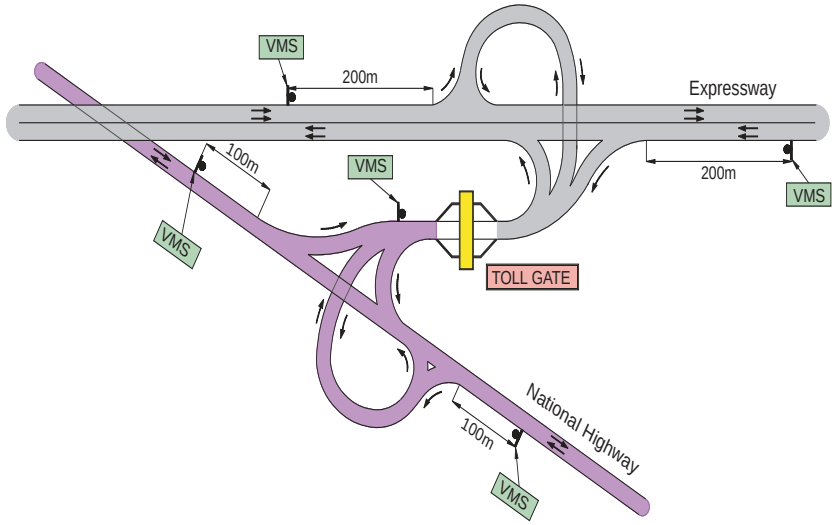


Fig. 2.06 Information Dissemination: VMS at ICs

b) *Technical Requirements*

The system shall use Light Emitting Diodes (LEDs)/High gain trans-reflective Liquid Crystal Displays (LCDs) for outdoor ambient sunlight. The system should comply with European Standard (EN-12966). The minimum height of character shall be 300 mm so that display is legible from a distance of 200 m. The design and provision of Variable Message Signs should be done after careful consideration of its need. Following aspects should be considered;

i) Collection of preliminary data i.e. intended purpose, type of information to be displayed and alternative diversion routes available;

ii) Type of VMS i.e. intended purpose, information to be displayed and technology to be used;

iii) They are visible in all weather conditions including foggy and misty conditions;

c) *Placement of VMS*

Placement should be as below:

i) Fixed VMS shall be mounted on a sturdy and aesthetically pleasing gantry structure whereby the vertical clearance of at least 5.5 m is available from the road. Safety barriers shall be provided at gantry support column (s) for

their protection and for safety of road users. The concrete pedestal for support column should be flushed with ground but in no case should protrude for more than 150 mm.

ii) The signs should be visible from a distance of 300 m. It should not be located on a curvature and on a highway section having grade exceeding 4 percent;

iii) Location and source of power along the road segment if it is not solar power.

d) *Typical Messages*

(Ref.: MORTH Circular No. RW/NH-33044/1/2007-S&R(R) dated 24 October 2007)

Some typical messages "as indicated in *MORTH Circular No. RW/NH-33044/1/2007-S&R(R) dated 24 October 2007"* are given below:

- Accident Ahead, Road Closed, Take Diversion;
- Accident AHEAD, followed by some typical message like 'Expect Delays', 'Merge Right', Merge Left', 'All Traffic Exit' can be displayed;
- Maximum Speed: _____ kmph;
- Speed Limit Strictly Enforced;
- Construction Work, Road Closed;
- Congestion Ahead;
- Bad weather conditions like 'Heave Fog Ahead', 'Poor Visibility Ahead';
- Trucks Use Left Lane;
- Watch your Speed;
- Watch for Falling Rocks; (In the case of landslide prone areas);
- No Mobile When Mobile;
- Drunken Driving Prohibited.

e) *Typical Pictorial Presentations*

Some typical examples of pictorial presentations used in Variable Message Sign (VMS) in Japan Expressway System are presented below along with Events and Traffic flow situations.

Fig. 2.07 Pictorial Presentation in VMS

i) *Events*

Table 2.02 Events

Kinds	Events
Weather	earthquake, fog, rain, snow, gust, heat
Road Surface	wet, flood, freeze, snow, fallen object, pot hole
Traffic	accident, repair work, roadwork, congestion, travel time, car fire
Wayside	wave, slope failure, land slide, shoulder damage, fallen rock, debris, pyroclastic flow
Amenity	occupancy, services
Warning	congestion forecast, roadwork schedule

ii) *Location of Events*

Table 2.03 Location of Events

Kinds	Events
Name of IC	A – B, at A
Location	Near A, B Tunnel
Distance	Ahead, 1 km ahead
Route	A Road, to B

iii) ***Instruction Message***

Table 2.04 Instruction Message

Kinds	Events
Message	Road Closure, Exit Here, No Entry
Speed Limit	80 / 50
Lane Usage	Divert to Right, Divert to Left
Warning	Caution, Slow Down
Lifting	Removal Finished

iv) ***Dissemination Timing***

- Just in front of the location where an event occurred
- In front of IC prior to event location
- At entry IC to expressway where an event occurred

v) ***Information Renewal Cycle***

- Traffic condition : 1 ~ 5 min
- Weather condition : 10 min
- Warning : half day or longer

A location of events differs according to their importance and requirements.

In case of traffic accidents, the location of events is a point on expressway, which may be on a stretch of expressway or as a region. As for example, congestion is on a stretch whereas the meteorological information is applicable for the region.

When a large scale accident blocking the expressway happens, it is required to inform oncoming vehicles to exit at the next interchange. When the number of lane is reduced due to road work, it is necessary to instruct the vehicles to slow down. The different instruction messages, according to the extent and seriousness of the event, shall be placed.

For appropriate actions by the drivers like slowing down or changing road shall be indicated before a few interchanges enabling them to change the travel route or even commencing journey on the expressway. Similarly for lane changing due to road works, the VMS may be placed at or near the incident.

Information on traffic condition should be renewed on real time basis may be at a cycle of one to five minutes, information on weather – which does not change so quickly, can be

renewed at the cycle of ten minutes or so, and information on warning of scheduled work can be renewed on half day basis.

2.1.3.2 Portable VMS – on vehicles

The variable message signs can be fixed or portable. Portable signs can be mounted at the back of the truck or similar vehicle. The portable VMS signs mounted on a truck could be powered by solar energy or battery and show the sign of 'men at work' and/or speed limits in the construction zone. Proper placement of a portable VMS is critical to its effectiveness. The placement must give adequate time to the motorists to react to the message and take corrective action. On Expressways and National Highways placement of these at 2 km prior to the decision points should be done with repetition at 1 km and 500 m. It should provide adequate sight distance (around 300 m) and should not interfere with other traffic control devices. If the portable VMS set up along the roadway and a message was not to be required for a period of next four hours or more, the sign panel should be turned away. **Fig. 2.08** presents the typical portable VMS.

Fig. 2.08 Portable VMS in Operation in a Work Zone
(Source: FHWA Manual and Japan Document)

2.1.3.3` Highway advisory radio

Although not as widely used as VMS, Highway Advisory Radio (HAR) is another means of providing highway users with information in their vehicles. Traditionally, information is relayed to highway users through the AM radio receiver in their vehicles. Upstream of the HAR signal, users are instructed to tune their vehicle radios to a specific frequency via roadside or overhead signs. Usually, the information is relayed to the users by a prerecorded message, although live messages can also be broadcast.

Highway advisory radio (HAR) is an effective tool for providing timely traffic and travel condition information to the public. It has various advantages and disadvantages. It is most important advantage is that it can reach more users, or potential users, than Variable Message Signs (VMS). While VMS reach only those motorists at a particular point, and can only convey a short message, HAR has the advantage of being able to communicate with any persons in their broadcast range. Further, the amount of information that can be conveyed is much greater. Its primary disadvantages are that it is restricted to low power, and this leads quite often to poor signal quality (since it is affected by many outside forces such as weather), and it requires the driver to take an action (i.e., turn on the radio or change the station or both). This can lead to poor listening.

Messages are broadcast in the field from transmitters that play stored messages. These messages are transmitted to the field from a “central” location, which can be a traffic control center or any telephone. In its simplest form, no central system is needed, only an analog phone line to the transmitter so that an operator can record a message in the transmitter for broadcast. This is labour intensive if an agency maintains a number of transmitters, and traffic conditions change throughout the day. Its advantage is that it is inexpensive, and message can be sent to a transmitter from anywhere a phone exists, even from a cell phone. Alternatively, a central message distribution system is used to record new messages, store pre-recorded messages, and distribute messages to the transmitters (simultaneous if necessary). This is typically a PC-based system with security access control.

Deployment strategies

HAR can be broadcast in two ways: Point or Wide-Area coverage.

- In Point broadcast, a single transmitter is used to broadcast over a given area. This is typically used at diversion points of areas of recurring congestion to notify motorists of queues and congestion. This type of implementation is popular with users because the information is specific to them.

- Wide Area Broadcast transmits a signal to a larger coverage area using multiple synchronized transmitters. This is an effective strategy when a single message is applicable to a large coverage area, and the coverage area is sufficiently large for a motorist to hear the longer message length. The fact that a long single message, that is pertinent

to specific users for only a part of the message is indeed a disadvantage.

Portable and Mobile Systems

Portable systems permanently installed on trailers and mobile systems installed on service or maintenance vehicles can be of value in providing timely dissemination of information to motorists during short-term deviations from normal highway conditions. This is particularly true in areas where there is limited or no normal coverage or the permanent transmitter site has failed. These systems can be solar powered, generator powered, or battery powered (**Fig. 2.09**). Portable/mobile systems can be set up at decision points where a route guidance system directs motorist to an alternate route. This will increase motorist comfort level by reinforcing their confidence that they are following the alternate route instructions correctly.

Fig. 2.09 Portable Highway Advisory Radio Station

2.1.3.4 Internet or mobile services

On-Line services to access the Internet represent an additional means to disseminate pre-trip user information. The Internet's effectiveness as a fast and flexible communication medium has spurred explosive growth in all sectors of society. The network is now in daily use by people in all professions.

Several private Information Service Providers also have web sites providing similar information for multiple cities. Many of these sites may provide:

- Real-time traffic flow information via colour-coded maps
- Road closure information (e.g., for construction or maintenance)
- Real time video images (still captures or streaming video)
- Camera selection
- Travel advisory information for route planning
- Links to other web sites
- News and weather

Fig. 2.10 User Information showed in Mobile Phone
(Source: Japan Documents)

2.1.3.5 Vehicle Information and Communication System (VICS)

VICS is a digital data communication system which promptly provides the latest road traffic information to drivers via the car navigation system. The world's first VICS service started in Japan in 1996. VICS, using 5.8 GHz DSRC, can transmit various and large-volume information quickly. Drivers are promptly communicated on network situation and spot information from roadside camera. Drivers are also warned/advised on voice communication.

There are generally three different on-board equipments used in Japan, which supply different depth of information.

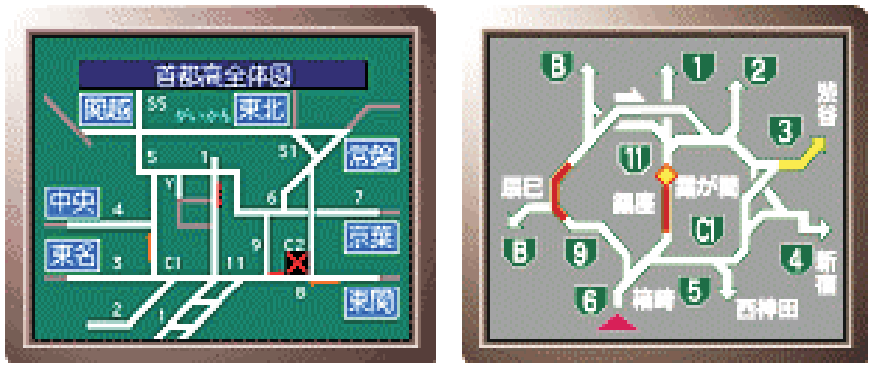
The three levels are described in the following:

Level 1: Information is only displayed in text form on installed devices. **(Fig. 2.11)**

Fig. 2.11 Graphic Display of Information shown on On-Board Equipment

Level 2: Information is shown by simple graphics on the display of installed devices. The released information covers congested routes and driving times.

Level 3: Information is shown in the form of Beacon conveying similar/additional information to Level 2. **Fig. 2.12** shows Level 2 and Level 3.



Level 2: FM-Multiplex Level 3 : Beacon

Fig. 2.12 Inner-City Expressways

2.2 INCIDENT MANAGEMENT

2.2.1 *Traffic accident*

This may be generated due to vehicle collision, fall or spillage of cargo blocking the expressway lane.

2.2.1.1 Information collection

The information on occurrence of such accidents (incidents) is primarily from the route patrol vehicles. The secondary information sources may be cell phone calls from drivers or passengers, CCTV images; calls from maintenance crews and emergency call boxes, police patrols etc.

The next step on receipt of information is to identify the precise location and nature of accident, as well as the display, recording, and communication of this information to the appropriate agencies. Operations center personnel may verify accidents and communicate with incident responders on scene, or provide details to emergency agency dispatchers. These should include:

- Field units (e.g. police) at the incident site
- Closed circuit TV images
- Communication with helicopters operated by police, media or information service providers
- Combining or *fusing i*nformation from multiple cellular calls

2.2.1.2 Information provisions

Reporting information of the accident/incident to all drivers enroute for at least 50 km prior to the incident location.

Motorist information is the activation of a variety of communications media to relay traffic. Dissemination of information is one of the primary services provided by TMCs, and the Techniques may include:

- Commercial radio and television
- Variable message signs (VMS)
- Highway advisory radio (HAR)
- In-vehicle or personal information system
- Internet/on-line services (mobile)

2.2.1.3 On site action

This is the activation, coordination, and management of the appropriate personnel, equipment, and communication links and motorist information media as soon as it is reasonably certain that a traffic incident has occurred. Techniques may include:

- Interagency response planning and mutual-aid agreements
- Intra- and inter-agency communications. This includes voice radio interoperability, data and video links between public safety communication centers, TMCs and Highway operations centers.

- Personnel and logistics support
- Equipment storage sites
- Advanced response vehicles that include a mobile communications platform, GPS and other features to facilitate efficient response

The prime requirement would be i) to send Ambulance at the incident site; ii) Traffic Regulation/Control/Management; iii) Removal of vehicles or cargo involved in the incident; iv) Vehicle Fire Extinguish.

a) ***Ambulance Services***

Ambulances may be parked in the work zone, if necessary. A senior representative as a member of the Management Team shall ensure that a proper record is kept of the activities on scene, and of decisions made.

The first team on the scene of the incident, shall note the details, prioritize patients, aid the injured and place advance warning signs to users.

Where possible, assist the concerned law and order authorities with regard to the following:

i) Ensure that the necessary blood samples are collected by a suitable qualified person where substance misuse is suspected.

ii) Inform concerned authorities, investigation team when the particulars of patients can be collected prior to departing from incident scene.

iii) Assist concerned authorities to complete outstanding patient details after the incident has been cleared, if the particulars of a patient could not be obtained on scene.

iv) Advise concerned authorities of the particulars of the ambulance driver if a patient has died on the highway to a hospital.

In the event of an incident involving hazardous materials:

- Wear protective clothing before entering into a danger zone.
- Remove the victim from the source of exposure.
- Remove all contaminated clothing from both the patient and personnel.

- Obtain the Material Safety Data Sheet from the Fire & Rescue services to determine the requirements and limitations for medical attention after exposure to a specific hazardous material.
- Transport the injured to the nearest suitable hospital(s).
- Ensure that bodies of deceased victims are either placed in body bags or properly covered as soon as possible, especially if members of the public are on scene or driving by.

b) ***Traffic Management***

The application of traffic control measures at the incident site and on facilities affected by the traffic incident. Effective traffic management minimizes traffic disruption while maintaining a safe workplace for responders and reducing the likelihood of secondary crashes. Techniques include:

- Preparation
  - Alternate route planning (consider use of paved shoulder)
  - Availability of cones, flares, warning signs, arrow boards, portable CMS and other traffic control resources
  - Availability of traffic control devices and traffic signals
- Flow management at scene
  - Establish point traffic control at scene
  - Manage Expressway space
- Queue management to actively monitor the end of queue and warn approaching motorists.
- Flow management on alternate routes
  - Establish and operate alternate routes
  - Actively manage traffic control devices
- Reduce long-term traffic incident duration

c) ***Removal of Vehicles Damaged in the Accident***

The Management team shall ensure that the necessary debris has been cleaned-up.

In the event of fatalities, possible reckless driving, and/or where government or military vehicles are involved, the information report shall collect the detailed (to the extent possible) information and shall ensure that evidences are preserved. Authorise and control the removal of vehicles from the scene in conjunction with the concerned authorities investigating officers by determining which vehicles, if any, need to be removed by a tow operator.

Ensure that the following information is made available by the tow operator before a vehicle is towed from the scene:

- the name, address and telephone number of the operator;
- the registration number of the tow vehicle;
- the name, address and telephone number of the owner of the damaged vehicles;
- the registration number of the damaged vehicle; and
- the destination of the damaged vehicle.

Regulations for - Tow, Recovery and Crane Operators

Only one towing vehicle for every stationary vehicle involved in the incident shall be allowed on scene. No additional towing vehicles shall be allowed to stop at the scene of an incident. Park tow vehicle in the parking zone at the fringes of the incident scene. Enter the “work zone” only if authorized by the Management Team.

Towing vehicles that do not conform to the legal requirements laid down will not be allowed to tow, and will be requested to leave the scene of the incident.

Report at the Forward Control Point or in the case of minor incidents to the senior officer on scene immediately after arrival on scene to ensure that the same is noted.

d) *Vehicle Fire Extinguish*

The vehicle may park in the work zone, if necessary. Remove vehicles to the parking zone once they are no longer required as mobile warning signs. A senior representative as a member of the Management Team shall ensure that a proper record is kept of the activities on scene, and of decisions made. Inform Fire & Rescue service in whose jurisdictional area the incident had occurred.

For motor vehicles accidents, carry out all fire-fighting and fire control operations followed by search and rescue operations.

Identify potential hazardous material.

In the event of an incident involving hazardous material, undertake the following:

- Obtain the Material Safety Data Sheet of the vehicle transporting the hazardous material.
- Supply a copy of the Material Safety Data Sheet to the Ambulance personnel on scene.
- Inform to mobilize the necessary hazardous material specialist team(s).
- Prevent or minimize pollution to the environment (paying special attention to fire run-off water).
- Relay the dangers relevant to the hazardous material involved to all members of the Management Team.
- Ensure that the public is warned of potential dangers.
- Prohibit smoking in the immediate vicinity of the incident.
- Effect on-site chemical/gas containment.
- Identify the incident scene pertaining to area of isolation and evacuation.
- If necessary, initiate the necessary evacuation procedures in conjunction with the full Management Team.

2.2.2 *Inclement weather (not conducive to comfortable driving)*

2.2.2.1 Information collection

The effects of weather on expressways differ in areas according to geography, topography (level terrain, mountainous region), and road structure (cut, embankment, bridge). To accurately understand the road weather, which can change within a short distance on the roads, to perform road maintenance, to secure safe and smooth flow traffic by informing road users of the weather conditions, to promote efficient use of the roads etc. all require the installation of various meteorological observation equipment on the expressways.

a) ***Meteorological Information Facilities***

i) Overview

Meteorological information facilities are weather observation instruments installed along roadsides to gather data needed for road management and the execution of snow and ice measures.

ii) Meteorological Observation Facility System Chart

Meteorological items observed are the air temperature, road temperature, rainfall, snowfall, wind direction and wind speed.

Data concerning mist, road surface icing etc. are also gathered according to regional meteorological conditions and road management conditions.

iii) Instrument Configuration

Item	Meteorological Observation Instrument
Air temperature	Thermometer
Rainfall	Rain/snow gauge, precipitation sensor
Snowfall	Rain/snow gauge, CCTV, transmissivity meter, or BS type visibility meter
Mist	CCTV, transmissivity meter or BS type visibility meter
Wind	Anemoscope/anemometer (wind vane type)
Earthquake	Seismograph
Road icing	Road surface tempe rature gauge (underground thermometer)

b) ***Standard Instruments***

i) Thermometers

Thermometers are used to continually measure the exterior air temperature based on the resistance fluctuations caused by the temperature of the platinum temperature resistant body.

ii) Rainfall/Snow Gauge

A rainfall/snow gauge collects rain or snow and automatically weighs it according to the tilt of its tipping bucket to measure the precipitation.

iii) Precipitation Sensors

A precipitation sensor immediately senses the beginning and end of rainfall or snowfall. In this way, it obtains up to the minute information about the beginning of rainfall, a period when road conditions are particularly slippery.

A precipitation sensor can also automatically distinguish between snow, rain, and mist if it is combined with a VI meter or BS meter.

	Output		
Precipitation sensor	O	O	X
V I meter (or B S meter)	X	O	O
Judgment results	Rain	Snow	Mist

iv) Visual Obstruction Sensors

Visual obstruction sensors include transmissometers (VI meters) and Backward Scattering visibility meters (BS meters).

VI meter, which consists of a floodlight and light receiver installed facing each other to measure light transmissivity, is appropriate where the main objective is the measurement of mist.

BS meter, a device consisting of an integrated floodlight and light receiver aimed in the same direction, measures the light scattered backwards from mist or falling snow (reflected light). It is appropriate for use where the principal phenomenon observed is the obstruction of visibility by falling snow.

v) Meteorological CCTV

CCTV system is an appropriate way to provide images confirming that actual conditions on a road conform to values provided by monitoring instruments. It is also a good method to clarify road conditions that are difficult to measure using meteorological observation instruments. (e.g. blowing snow or amount of snow accumulated on the road surface).

vi) Anemoscope/Anemometer

Anemoscope/anemometers that are used to measure the wind speed and its direction are aero vane pane type consisting of a propeller that measures the wind speed and a tail plane.

vii) Seismograph

A seismograph detects the earthquake movement acceleration of two components of horizontal and vertical motion, its processor records the time of the earthquake and its acceleration wave profile and calculates the SI value, measured intensity, maximum acceleration etc.

viii) Road Surface Thermometer and Soil Thermometer

A road surface thermometer and a soil thermometer perform measurements with two thermometers (fluctuation in resistance caused by the temperature of a platinum temperature resistant body) installed at different depth under the ground surface to predict the icing of the surface of a through highway.

2.2.2.2 Information provisions

Analysis of the Meteorological data recorded on site alongwith the weather forecast made by National Meteorological Department, the expressway section specific data, which may affect on expressway, shall be generated and conveyed to drivers for possible precautions to be exercised by them.

Likely heavy rainfall, formation of fog and snow (rare) impedes the vehicle speed, visibility and may develop hydroplaning effect. All these effects need to be conveyed to the drivers through Variable Message Signs, highway radio broadcasting and in vehicle unit (if any).

2.2.2.3 On site action

a) Expressway road section, being at a higher level, the precipitates are drained out by the cross slopes and in sag profile areas adequate drainage facilities are to be provided. The road side drains including chutes shall be kept clean for easy passage of rain water.

b) To prevent hydroplaning effect, the macro structure of the road surface at the probable locations may be enhanced for draining out the water from the contact area between the tyre and pavement. Alternatively, a porous asphalt wearing course may be used.

c) In snowfall areas measures to deal with snow accumulation and icing on expressway include mechanical snow removal and spreading de-icing chemicals on roads. Appropriate storage of materials and the equipment alongwith operators shall be present in nearby operating yard/service areas.

CHAPTER - 3

SERVICE AREA MANAGEMENT

CHAPTER – 3

SERVICE AREA MANAGEMENT

3.1 ADMINISTRATION FOR SERVICE AREA

Service Areas shall be an integral part of an expressway system. The administration for operation and maintenance forms the basic requirement to be a successful service area, satisfying user needs in a best possible way. Security, safety and maintenance are the primary requirement for a service area. From the concepts of wayside amenities providing just the need for the basic minimum services, the present day service areas are providing retail merchandising facility. Therefore, the administration for providing such services will require business management approach.

3.1.1 *Organisation*

The expressway national network are being planned to be implemented as toll roads through Public Private Participation (PPP) process. The concessionaire (single entity or a joint venture) may be a special purpose vehicle (SPV) for the implementation. The Service Area is intended to be a profit making business to supplement the toll revenues. The process may be considered in toll elasticity analysis and the related demand modelling for future traffic.

3.1.2 *Expressway authority and business tenants : risk sharing*

In this context the organizational structure of Japan and in India are presented below:

a) Scenario in Japan

In Japan, the expressways alongwith the wayside amenities were constructed using Government (National) funding, as tollway. Subsequently for operation and maintenance, three private organizations to deal with East, Central and West parts of the expressway were formed. The mandate was for i) Operation and Maintenance of expressway and ii) to payback the Government the investment costs. This leasing system was considered for 45 years as a payback period. The toll rates were fixed by the Government and the entrusted recently formed private organizations were responsible for toll collection as well as associated operation and maintenance. The Government/Agency imposed that private contractor cannot make any profit on toll revenues and the Government would reimburse all the costs incurred by the private organization. This was the basic concept.

Later on, these private organizations, with an aim to earn additional revenue, started creating additional high quality customer facilities by extending around the already built service areas, and originally handed over to the private companies. These extensions of facilities are funded by the private companies from their own resources including construction, operation and maintenance.

Since the private organizations are not permitted to make any profit on the toll revenue, these newly added facilities become the prime revenue (profit) source for the private organisations. The organisation structure and the Agency/Company involvements are schematically shown in **Fig. 3.01** and **Fig. 3.02** presents the distribution of additional facilities created and the original areas based to the private companies.

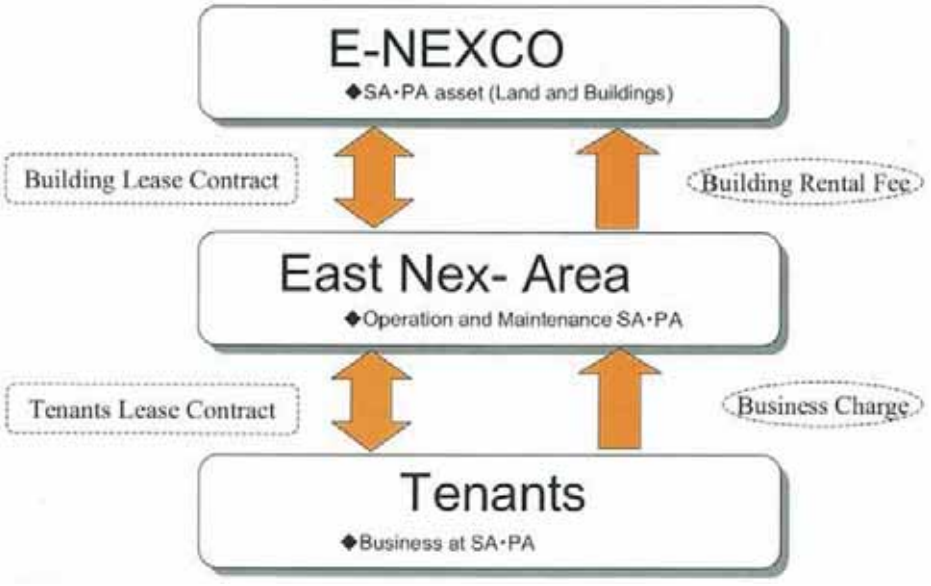


Fig. 3.01 Typical Organisation Structure
(Source: Japan Documents)

b) Scenario in India

In India, the expressway business is yet to pick-up in an organized way and it would require comprehensive planning and developing financing mechanisms and integrating with the regional development. This may provide means for additional resources and generate business acumen of the prospective concessionaires.

For the implementation of National Expressway Network under PPP, the organizational developments need to be defined in the concession agreement. The concessionaire

Types	Green Area etc	Parking and Road	Toilet	Green Area	Business Facilities
Asset Division	Agency	Agency	Agency	Company	Company
Expense Division(Road: SAPA)	100:0	65:35	66:34	0:100	0:100
Responsibility	Road Dep.	Road Dep.	Road Dep.	Business Dep.	Business Dep.

Fig. 3.02 Typical Distribution of Responsibilities between Agency and Company
(Source: Japan Documents)

agreement also shall define the basic requirements of the users and the operation and maintenance norms to be followed by the concessionaire. These norms shall form the basic tools for inspection and monitoring by the Client/Agency/Authority.

The prime issues which need to be addressed for developing service area cum business centers along the expressways are as follows:

- Additional Right-of-Way (ROW)/Area need to be acquired.
- Development right flanking the expressway and on the periphery of the business development area need to be defined.
- The ownership of the area developed for business along the expressway need to be defined beyond the concession period of the expressway.
- The minimum facility provisions/requirement for the users as well as national benefit shall be established.

3.2 CUSTOMER SERVICES

For enhanced attraction of expressway users to the service area, a high quality customer service shall be provided. New England Transportation Consortium (NETC), USA (www.docs.trb.org) – research concluded that service area users value picnic areas, pet

areas, and barbecue grills the least. However, since these services are inexpensive to provide, they could be kept on being offered. A grassy open space may also be important to users/drivers, even if only some people use it and therefore the overall demand is not high. Still, many more may appreciate the aesthetics of a well maintained grill space.

Truck driver rated public telephone as the most essential features of rest areas. However, fast improvements in mobile phone technology and fall in prices for use of mobile phones will probably mean that most users will soon have their own phones and that areas along the new expressways will be covered by the mobile telephone network. All these need to be considered for selecting the items for business development. Currently, there is a wave of commercialization of rest areas sweeping nationwide. It is now possible to find sites that sell tourist related merchandise, hot coffee/tea, cakes/pastries, sandwiches and items of daily use. Vending machines are also becoming common and they dispense cold/hot drinks, ice creams, stationeries, mobile recharging cards, etc. There are even internet kiosks that operate on free services basis and also provide video-games machines at places. Fuel and restaurants services are essential; therefore, service plazas shall consist of gas stations, convenience stores and fast-food franchises.

Some services may be essential for the safety of the people, while other services provide convenience – based assistance to the commuters. Information and tourism are also fast growing segments of the overall economy, and are starting to be the major organisation to use the service areas.

The monotony of driving makes it necessary to stop, relax and rest. The confines of the vehicles also make it necessary for the drivers/users to get out and stretch or walk or stop for sleep, water, and rest room breaks. And well planned customer's services are likely to develop enhanced customers leading to more business. **Fig. 3.03A** and **Fig. 3.03B** present the customer services provided in Japan.

3.2.1 *Traffic information*

The information centre is equipped to provide information on enroute traffic conditions, likely time taken to reach their destination, occurrences of some incidents such as accidents, on going road repair and maintenances, occurrences of avalanches such as land slide, heavy rainfall, formation of fog, mist and snow fall etc. All these provide the customer to take necessary decisions to continue enroute or change their route or stay longer period in Service Area for safe journey. **Fig. 3.04** shows Typical Traffic Information Center.

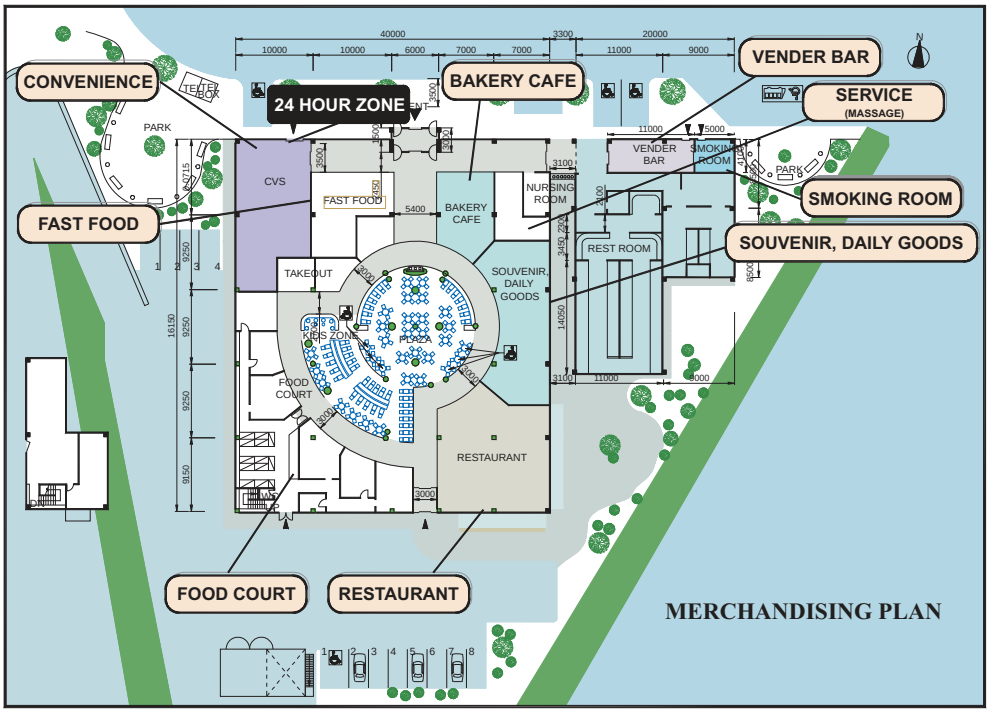


Fig. 3.03A Typical Customer Services Layout
(Source : Japan Documents)

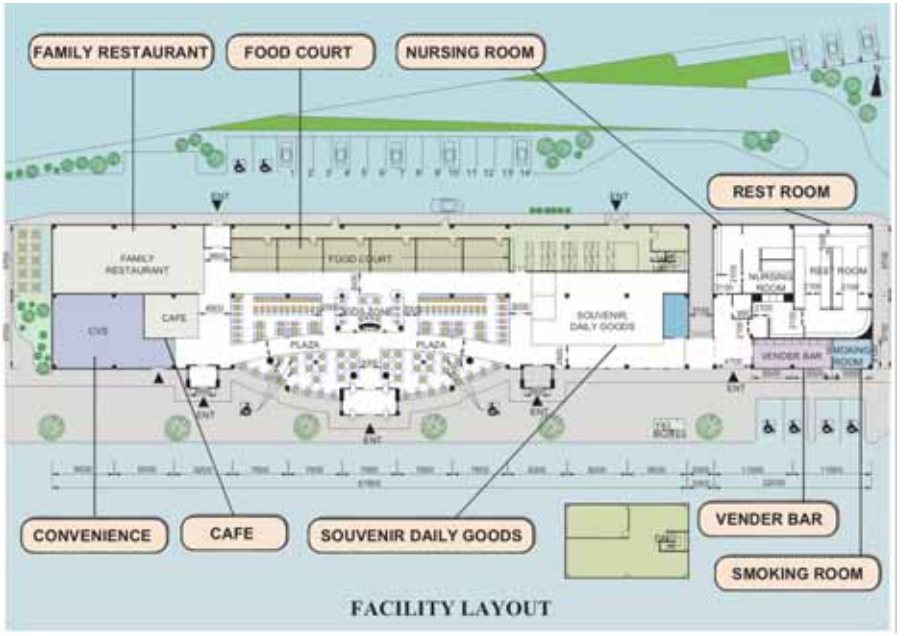


Fig. 3.03B Typical Customer Services Layout
(Source : Japan Documents)

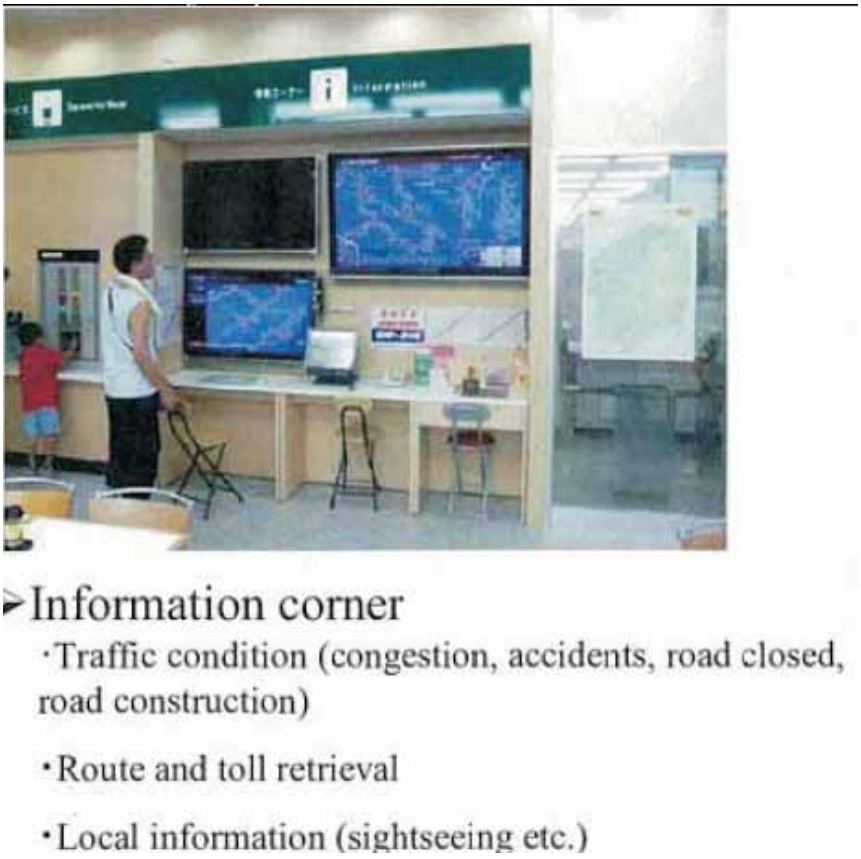


Fig. 3.04 Typical Traffic Information Center
(Source: Japan Documents)

3.2.2 *Local tourist information*

The information centre is also equipped with places of tourist importance with handouts, short video pictures or still photos/images of tourist interests. The centre also shall provide data on travel time road conditions, local customs and the time during which the place is open for tourists.

3.2.3 *Facilities for persons with disabilities (PwD)*

Persons with Disabilities (PwD) special areas shall be kept reserved at most convenient place which is nearest to restaurants, toilets and other utility places. To facilitate their movement "universal design standards" are accepted such as the easily negotiable ramps for wheel chairs, elimination of level differences on their route, special provisions in the designated toilets, reserved places in the restaurant etc. Attendant facilities are available on their requirement. **Fig. 3.05** presents facilities for physically challenged persons.

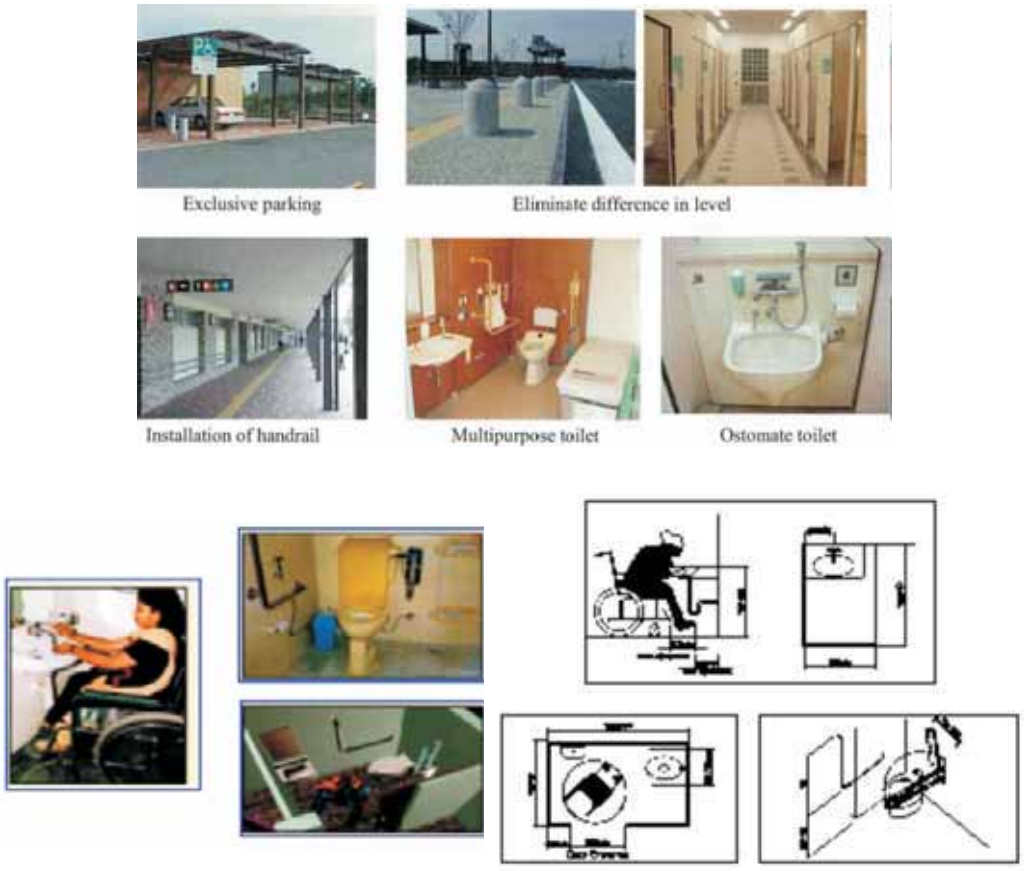


Fig. 3.05 Facilities for Persons with Disability (PwD)

3.2.4 *Facilities for comfortable and enjoyable services*

For stroking and movement of visitors with portable luggage on wheel carriers, all the surfaces are made trolley friendly for easy comfortable towing of the baggage.

For pleasure, the area shall be surrounded by greeneries and provided with green lawns for strolling, children's park, dog walking strips and the entire area is surrounded by the tall green trees, bushes and colourful flowery plants. The concrete walls and similar structures are covered with green creepers. **Fig. 3.06A** and **Fig. 3.06B** present facilities for improving services.

Information provision

Information corner
・Traffic condition (congestion, accidents, road closed, road construction)
・Route and toll retrieval
・Local information (sightseeing etc.)

Area concierge
(33 SA/PA)

Highway Walker
Free magazine with various information (map, recommended restaurants, sightseeing spots etc.)

Fig. 3.06A Information Services
(Source : Japan Documents)

Multipurpose toilet

Eliminate difference in level

Installation of handrail

Exclusive parking for handicapped people

Fig. 3.06B Improved Facilities at Service Area
(Source : Japan Documents)

3.3 ENVIRONMENTAL CONSIDERATION

Any man made development on virgin areas will disturb the environment. Suitable measures shall be considered and provided to adequately compensate the adverse impact on the environment.

3.3.1 *Solar and wind power*

To reduce the energy requirement for providing artificial lighting, heating and other conveniences, the solar and wind energy to be used optimally so long as these are economically beneficial. Standby measures and reliable technology shall be used to reduce the eventualities to a minimum level. **Fig. 3.07** shows Typical Solar and Wind Power for usage as alternative energy source

Solar Power

Solar panel at Yokosuka PA
(usage for lighting in rest room)

Hybrid (Solar & Wind power)

Lighting at Hashie PA
(usage for lighting in emergency)

Fig. 3.07 Typical Solar and Wind Power for Usage as Alternative Energy Source
(Source : Japan Documents)

3.3.2 *Recycling of waste water*

Water is a precious commodity and is required in practically all walks of life. The water used in kitchen, bathrooms, wash basins, floor washing and washing machines shall be collected separately and carried to a treatment plant for purifying these waste waters to a usable one. The treated water may be recycled to bathrooms, washing of clothes, utensils and watering garden, lawns and for irrigation purpose. Typical recycling process is given in Fig. 3.08.

Fig. 3.08 Typical Recycling Process
(Source : Japan Documents)

3.3.3 *Heat sealed pavement and water retaining pedestrian blocks (Figs. 3.09A & 3.09B)*

Walkways are provided with porous water retaining/holding blocks to reduce accumulation of rainwater on the surface in addition to adequately designed drainage provisions and cross slopes.

For the adjoining areas, the restaurants, heat shield pavement surfaces are provided to reduce the ambient temperatures to a lower level, giving the visitors more comfort.

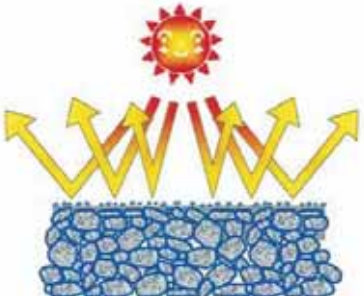


Fig. 3.09A Heat Sealed Pavement

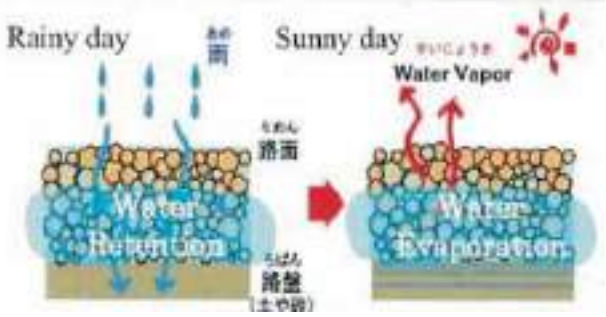


Fig. 3.09B Water Retaining Pedestrian Blocks

3.3.4 *Garbage recycle and reduction*

As key components of cleanliness and public health, the use of waste and recycling receptacles should be encouraged. Design and location are important in reinforcing public attitude towards proper disposal of garbage/trash. These receptacles should be conveniently located near parking, eating areas, gardens and shall be readily visible to users. Their appearance should be attractive and unobtrusive, blending with site aesthetics. Key locations include entrances to main building, at picnic shelters, and near vending machines and snack junctions. **Fig. 3.10** shows typical garbage recycle and reduction.

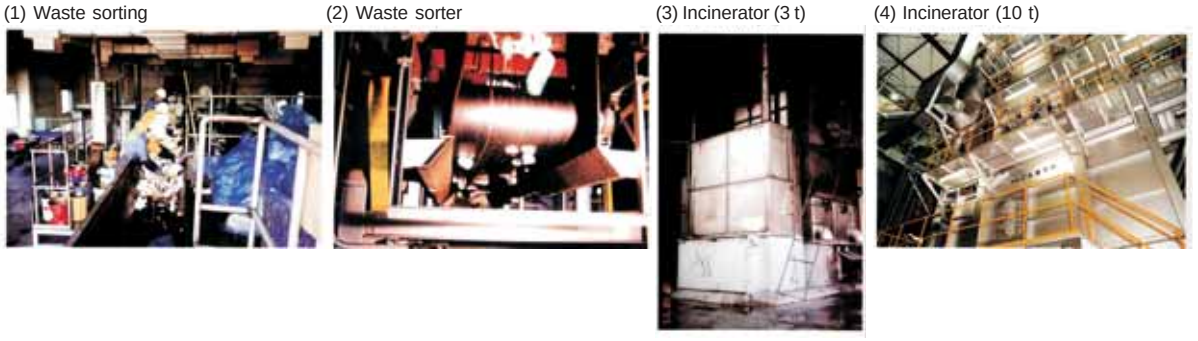


Fig. 3.10 Typical Garbage Recycle and Reduction
(Source : Japan Documents)

The receptacles should be earmarked for glass; plastic and thermodes; metal and papers. The idea is to separate the materials for recycling. The biodegradable wastes such as papers, pruning outputs, leaves and dry flowers etc. can be used for recycling as “compost” for use as bio fertilizers.

3.3.5 *Rainwater harvesting*

Provisions for rainwater harvesting has been made mandatory. The process of collecting the precipitates from roof tops and the water flowing down due to natural topography shall be collected and guided to a well specially design for storage and recharging the acquitters below.

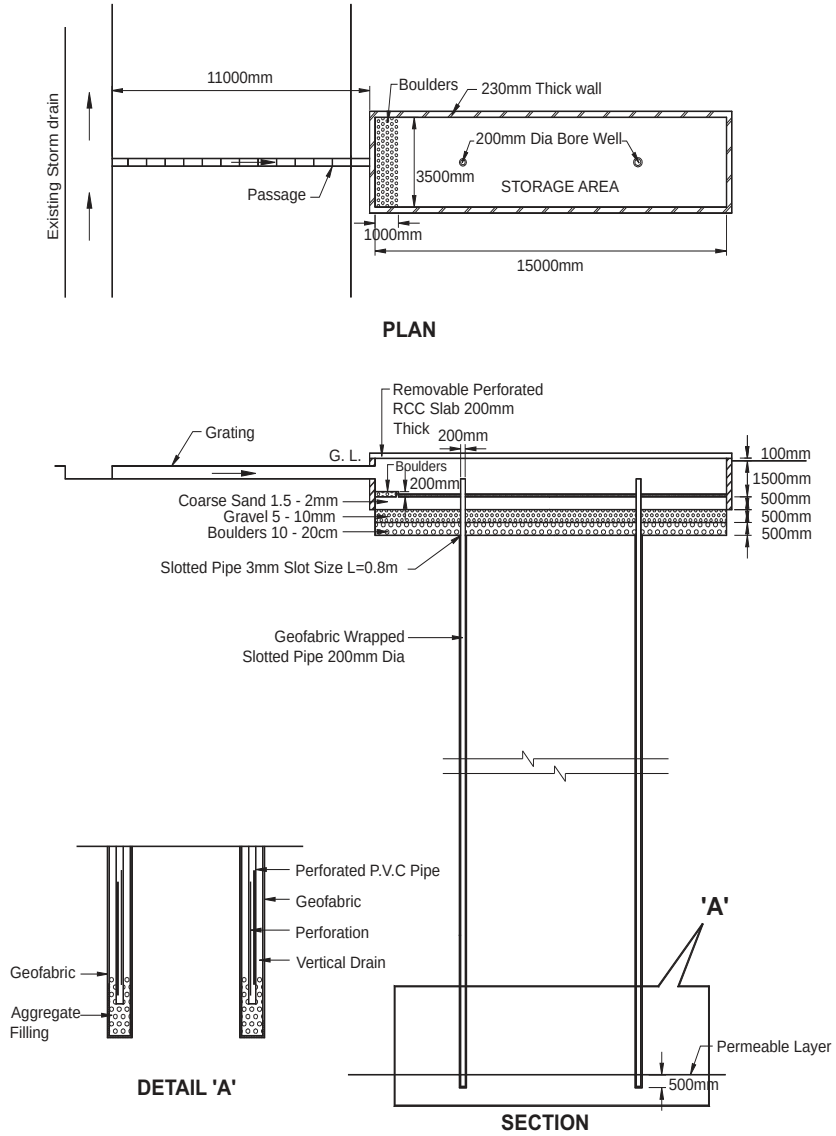


Fig. 3.11 Rain Water Harvesting Arrangement

3.4 FACILITY PLANNING FOR PROFITABLE SERVICE AREA

To attract expressway users for a Service Area requires due diligence business planning and facility provisions.

Business planning involves selection of merchandising materials which can be offered in the service area.

3.4.1 *Merchandising planning*

Selection of eatable items of reputation, local specialties, specialized usable items. Many partnerships and innovative uses have developed out of sheer necessity of market economics. The economic forces include the large market provided by a controlled access expressway and the physical realities of maintaining and operating rest areas. Some of the bigger forces in this game may be chambers of commerce, regional economic development groups, tourist bureaus and private enterprises.

a) Case study for Connecticut, USA

Connecticut has a series of creative practices in order to maximize use of their rest areas. Combined with other commercial facilities, the service areas have also facilities as mentioned below:

McDonald's has a contract to operate 10 sites along I-95 for a total of 20 years starting in 1985. The restaurant agrees to pay a percentage (13 percent to 18 percent) of gross receipts with a guaranteed minimum. The restaurant also operates the facilities and maintains the building (including cleaning restrooms). Mobil Gas has a total of 23 sites on the Connecticut Interstates. The General Transportation Fund receives an 11-cent royalty per gallon delivered to the stations and 5 percent of gross receipts of all other sales (convenience store).

Overall, the Connecticut transportation agency receives in excess of ten million dollars ($10,000,000) per year from these private enterprises. The state treasury also collects their usual sales taxes apart from the amount received from lease/rentals. Overall, DOT does not maintain the buildings and they receive a substantial amount of money from these service areas. Though, it has to be remembered that these facilities were grandfathered and that with present legislation, this concept cannot be duplicated at other locations.

Connecticut also uses rest areas to base DOT personnel and tourism information centers. For example, the Willington rest areas provide a DOT shed and maintenance office on I-84 eastbound (EB), and a tourist information booth on the westbound (WB) side. The WB side also has a fishery that is open year round for trout (supposedly the only one in the state). Overall, Connecticut has many beneficial systems to deal with rest areas by distributing costs.

b) Case Study for Japan

In Japan, the privatized operating and maintenance companies cannot make any profit on the revenue generated from toll collection. In order to increase company's financial base, they have taken up commercialization of the service areas with creation of innovative value added facilities. Beside the leased properties developed by the Government, additional facilities developed on the adjoining land at their own cost. Some of their considerations are mentioned below:

	Before		After
Parking (vehicle)	Up 107 Down138	2 times	Up 208 Down 262
Facility (㎡)	Up 350 Down 350	5 times	Up 2,000 Down 2,000
Sales	¥2.5 mil./day $ 25.1k/day	3 times	¥7.5 mil./day $ 76.7k/day

Fig. 3.12 Typical Business Data in PASAR
(Source : Japan Documents)

i) *SA related business*

In an innovative way, Japan has developed and new brand for the new commodity, eating and drinking facilities which has been aptly named as PASAR, which stands for Parking Area, Service Area and Relaxation. **Fig. 3.14** and **Fig. 3.15** shows the views of Makuhari PASAR.

pasar

PA : Parking Area

SA : Service Area

R : Relaxation

"Market" in Indonesian
"Stop at", "spend time" in Spanish

Fig. 3.13 PASAR
(Source : Japan Documents)

Fig. 3.14 Outside view of Makahari PASAR

Fig. 3.15 Inside view of Makahari PASAR

In the service area the company has leased areas for lease/rent to established eating, drinking companies such as STARBUCKS, SWEET MARCHE, TULLY'S Coffee shops, Natural Bread Bakery local as well as non-regional and European style eating places, established Chinese and American food chains such as McDonald, NanKing etc. They have introduced speciality stores for shopping curios, souvenirs, local mementos, garments with local style as well as speciality and brand varieties. **Fig. 3.16** shows typical arrangements.

Fig. 3.16 Typical Arrangements

(Source : Japan Documents)

- Developed innovative lunch packs which can be takeaways also.

Fig. 3.17 Special lunch box with local cooking ingredients “DORABEN”

(Source : Japan Documents)

- Tourist related merchandise such as hot coffee, domets/pastries, sandwiches, burgers etc. Vending machines which are sophisticated and dispense ice-cream, hot drinks, calling cards and lottery tickets. There are even internet kiosks which operate like videogame machines, internet access.

  - **Hotel Business**

    At some locations hotel business has been started in collaboration with a famous roadside hotel operator. The first hotel, E-Nexco Lodge Sano SA opened in July 2008. One can stay at this hotel without exiting the expressway at reasonable price. **Fig. 3.18** shows an Expressway Hotel in Japan and in India.

Fig. 3.18 Expressway Hotel (in Japan) and Expressway Hotel (in India)

  - **Advertising Business**

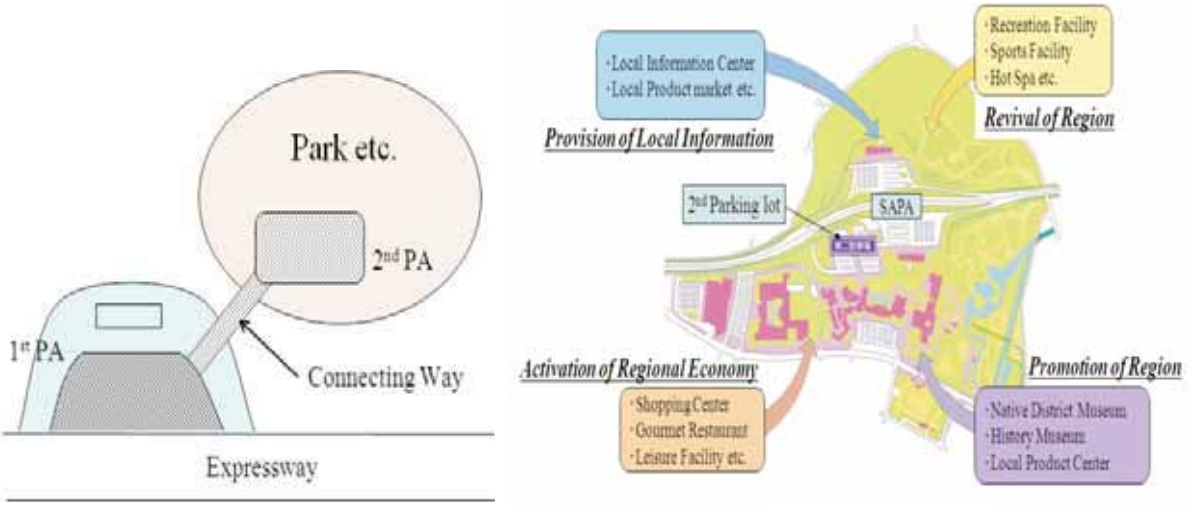
    Advertising on expressway is not desirable from safety considerations. Therefore, advertising business is allowed in service areas. There are generally "Highway Impact," western style advertising panels, Fig. 3.19.

ii) ***Integrated SA with Amusement Parks***

Direct connection to other facilities such as Amusement Parks makes expressways more attractive because expressway users can visit them without exiting expressway network. A typical Arrangement of integrated SA with Amusement Parks is shown in **Fig. 3.20.** Expressway users can access directly to parks through a second parking lot.

Fig. 3.19 Advertising Business

(Source : Japan Documents)



Scheme

Arrangement

Fig. 3.20 Integrated Arrangement SA with Amusement Parks

iii) ***New business other than SA related business are also being developed such as***

- ***Transaction Card Business***

  They offer a money-saving and highly convenient transaction card for customers who use our expressways. This card contains an ETC transaction function, a credit function, and an electronic money transaction function. It also offers an award points program, in which the awarded points can be redeemed for expressway tolls.

- ***Internet Business***

  They have created the Internet portal site, "E-NEXCO Drive Plaza," which provides information needed for a driving journey and support to make the trip more enjoyable.

Fig. 3.21 Internet Business

- ***Business Utilizing Space beneath Overpasses***

  Utilize the space beneath overpasses and elevated roads for parking areas, shops, offices, and other purposes.

Fig. 3.22 Business Utilizing Space beneath Overpasses

(Source : Japan Documents)

- ***Location Service for Outdoor Shooting of Films, Advertisements***

  Offer facilities operated by the company as set locations for movies, TV dramas, commercials, and other film productions.

Fig. 3.23 Locations Service for Outdoor Shooting of Films, Advertisements
(Source : Japan Documents)

- ***Parking Facility Business***

  Operate 24-hour facilities in the important places.

Fig. 3.24 Parking Facility Business
(Source : Japan Documents)

- ***Truck Terminal Business***

  Also operate truck terminals at locations close to expressway interchanges, contributing to the efficiency of truck transport.

Fig. 3.25 Truck Terminal Business
(Source : Japan Documents)

c) Scenario in India

The speciality stores have been introduced on a small scale in service areas. The commercializations of service areas are at low key – possibly the expressways so far developed are short stretches and connect town centers with ample amenities

Fig. 3.26 Typical Rest Area Commercialization in India

Fig. 3.26 Typical Rest Area Commercialization in India

For development of national expressway network, the service areas with more commercialization concept can be planned and developed.

In this connection, recently developed scenario on retail merchandising could be exploited to the maximum. Brief excerpts from a news paper are presented below:

i) The Indian Retail Scenario

The organized retail sector has grown from 0.9 million sq.ft. in 1999 to 28 million sq.ft. in 2007. The growth has been at an annual rate of 75 percent for the last six years and is expected to grow at least 50 percent for the next 4-5 years. Today, retail contributes about 11 percent to GDP.

ii) Mall Boom in India

With no malls in the country a decade ago, today there are 600 malls in India of which 120

are operational. The 'retail boom', 85 percent of which has so far been concentrated in the metros is beginning to percolate down to the emerging cities and towns. The contribution of these emerging cities to total organized retailing sales is expected to grow to 20-25 percent.

iii) Franchiser by Category

- Automotive
- Beauty Saloons and Supplies
- Business Services
- Computer & Internet
- Consultancy
- Consumer Services
- Dealers and Distributors
- Education & Training
- Entertainment
- Financial
- Florists
- Food and Beverages
- Garments
- Health Care & Fitness
- Home Based Businesses
- Immigration
- Interior
- Jewellery
- MLM Businesses
- Others
- Play School & Activity Centre
- Retail
- Travel

With the above preamble, there would be several opportunities to commercialize the Service Areas with judicious business considerations on National expressway network.

3.4.2 *Parking management*

An operation and management plan shall be developed for each service area to ensure that critical activities are appropriately considered as part of on-going operations. To provide effective management and to attract users, the basic requirements, which need to be considered are as follows:

- Provide segregation between large/utility vehicles and small and medium vehicles. **(Fig. 3.27)**
- Provide enough parking spaces in terms of numbers, space for parking as well as movement.
- Provide information on parking area availability (status) on the expressway 2 to 3 km ahead of the service area. **(Fig. 3.28)**
- Adequate traffic control and safety measures shall be arranged through appropriate planning consideration on layout and guide signs in the service area. **(Fig. 3.29)**

Fig. 3.27 Parking Layout for Segregation Between Large and Small Vehicles
(Source : Japan Documents)

Fig. 3.28 Parking Availability Message Sign
(Source : Japan Documents)

Fig. 3.29 Guide Signs in Rest Area
(*Source : Japan Documents)*

3.4.3 *Safety and maintenance of service areas*

It is important to develop a system to maintain current infrastructure and to keep it running at a level which the travelers value. That standard may vary between different types of service rest areas. For example, travelers expect tourist information, hotel reservation systems, etc.

Locating police, service area authorities, maintenance facilities, etc., in connection with service areas make travelers perceive them as safer. To keep track of users' perception of safety is important.

It is imperative that travelers are allowed to sleep or to take a nap at service areas. Fatigue-related crashes cost our society huge amounts in pain and suffering since these crashes are more serious than any other crash causation. Today, especially truck drivers have difficulty finding areas where they legally can sleep. Currently there are time limits - and prohibition of truck entry through developed urban areas/metropolitan cities. There should be areas within the parking lot where drivers are not woken up when stopped. Alternatively, rest rooms for taking a nap, sleeping, washing and bathing facilities shall be available.

Design is also an important part of the service rest area concept. This includes concerns regarding drinking water and sewage systems. But transportation issues are obviously also central to a good design. Vehicle speeds should be maintained low in areas were there is pedestrian activity even if there is no enforcement. Parking spaces should be clearly marked. That typically requires yearly rest ripping. A good pavement quality is an issue which typically is not directly related to traffic safety—rather inversely related when

it comes to travel lanes – but keeping a good pavement standard contributes to the feeling that the rest area is well looked after and therefore safe. Also, uneven pavements can lead to pedestrians tripping and falling down.

To keep a facility operating efficiently, it is important to keep track of its use. A maintenance program should include the collection of utility use, parking occupancy, visitor counts, traffic counts and overall customer satisfaction and comments. This is probably the most important part of an Accountability Process.

Maintenance Concerns

The in-depth interviews carried out by FHWA with travelers show that people value cleaner restrooms more than anything else. And maybe societal economic savings could be found in that area at the same time as the quality of cleanliness is improved. In service area, people with disabilities who may otherwise have limited employment opportunities provide day-to-day maintenance of rest areas through Local Community Rehabilitation Programs. Such a policy could be brought to India as well.

Suggested Priorities

It is important to make travelers feel comfortable with the service areas where they travel. Foremost, it is a safety and security issue. A sleepy driver needs to feel like he can stop and take a nap almost immediately. It is therefore imperative that some parts of service areas are open 24 hours a day, and that restroom facilities are open the entire period. But it is not only a safety issue, well maintained rest areas make the region look good. That is important not least for tourism, which may be an essential economic industry in several parts. To keep service areas safe and attractive, the priorities of maintenance should be:

- hourly cleaning of restrooms in the daytime, every 2-4 hours at night (preferably, there are at least three restrooms, so that both men and women always have facilities available to them)
- snow removal/sanding as needed to keep parking lot and paths safe
- 2-3 times per day, cleaning up of other indoor facilities and the grounds near trash bins, picnic areas, parking lot, and around restrooms
- regular emptying and cleaning of trash receptacles, as frequently as needed
- daily cleaning of pet areas

- daily, check indoor and outdoor lights, telephones and signages
- daily, collect comment cards and make sure cards are available
- weekly, thorough cleanup of entire grounds, mowing of grass, pruning of bushes and trees
- monthly, landscaping during season, trimming and planting as needed
- sweeping of parking lots and paths as needed,
- annual land marking of parking lot
- annual survey of users to assess maintenance quality
- as needed, building maintenance/painting to keep facility in excellent condition
- paving according to need, to keep facility in excellent condition.

Welcome Centers and Tourist Information Centers may have even higher maintenance needs than regular service areas.

Whether service area maintenance is done by the concessionaire or by separate contractors, it is obviously less important than how it is done. However, quality control and ensuring hygienic conditions are necessity, no matter to which entity the work is entrusted.

VOLUME-IV : MAINTENANCE

EXECUTIVE SUMMARY

VOLUME – IV: MAINTENANCE

EXECUTIVE SUMMARY

The document Volume-IV: Maintenance shall be read along with the other volumes of the Guidelines to appreciate the various considerations on design, operations and management aspects for the expressways along with all the appurtenances. The expressway maintenance requires a systematic approach to preserve, repair and restore its elements to its design or accepted configurations. Its system elements include carriageway surfaces, shoulders, road verges and slopes, drainage facilities, bridges, tunnels, signs, markings, lightings, fixtures, toll plaza, service areas etc.

Maintenance shall also take care to offset the effect of weather, environments, growth of vegetation, deterioration, traffic wear and damages on asset due to vandalism. Deterioration would include effects of ageing, material failures and fatigues, design and construction faults.

Maintenance and repair of building, stock piles and equipments are essential to preserve the expressway asset.

This document intends to provide basic information for maintenance engineers to formulate appropriate maintenance, inspection and reporting system, which will in turn enable better expressway management in terms of planning, manpower and budgeting.

Document has been structured into 8 (eight) chapters as follows:

Chapter – 1 : General

Chapter – 2 : Maintenance Management

Chapter – 3 : Inspection

Chapter – 4 : Maintenance Works and Repair

Chapter – 5 : Maintenance Operations

Chapter – 6 : New Maintenance Practices

Chapter – 7 : Preventive Maintenance

Chapter – 8 : Disaster Prevention

The first and second chapter deliberates on general requirement and maintenance management, which inter-alia covers “base data collection” and relationship between inspection & maintenance.

Chapter-3 deliberates on the essential requirements of maintenance – “Inspection”. This comprehensively presents the type, frequency and inspection targets. The inspection work also covers Inspection Program & Operation, Assessment and Inspection Reports. Typical ranking of inspection for maintenance dealing with various item of maintenance and its assessment for ranking (AA, A, B, C, OK, E) has been presented in tabular forms to aid maintenance engineers in formulations of work programs.

Maintenance Works and Repair as provided in Chapter-4, deliberates on the various items broadly in two sections (i) maintenance works, and (ii) maintenance repair. Each section covers brief description of the various items associated with maintenance to retain functional and structural integrity of the expressway asset.

Chapter-5 : Maintenance Operations – has been provided with the essential considerations for carrying out the maintenance activities such as work zone safety, environmental protection, inspection and assessment, defect treatments along with consideration and options. This chapter also highlights the mechanization and equipment necessary to provide due diligence to the maintenance operations on high volume, high speed expressways.

Chapter-6 : New Maintenance Practices, deliberates on the current scenario as followed in other countries for similar services. This chapter comprehensively deals with equipment for data collection for roadways; bridge and structures; service areas and other appurtenances. For functional improvement of road surfaces in wet weathers, use of porous asphalt and micro surfacing along with improvement in drainage has been briefly mentioned. The other aspects considered are (i) rigid pavement milling and overlaying, (ii) waterproofing and repair of structures, (iii) protection against corrosion and salt damage, and (iv) special road marking for night visibility. This chapter also indicates on formation of – Maintenance Company for leasing of maintenance vehicles.

Preventive Maintenance as briefly mentioned in Chapter-7, includes (i) necessity for “applying the right treatment to the right pavement at the right time”, and (ii) necessity of preventive maintenance has been broadly linked to “inspection assessment”.

Damages occurring due to natural calamities like heavy floods, sand storms, cyclones,

earthquakes to any element or system of the expressway shall be rectified and restored. All such activities require exhaustive deliberation. However, this Chapter-8 presents a cursory glance to essential aspects. This chapter broadly covers (i) pre-event preparedness measures, (ii) policy and organization for repair, (iii) emergency measures, (iv) classifications of works, (v) slope protections against disaster, and (vi) protection against earthquake disaster. A disaster restoration work flow and typical damages suffered by the various components have been presented in pictorial form with short illustrations.

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CHAPTER - 1

GENERAL

CHAPTER – 1

GENERAL

1.1 INTRODUCTION

This Volume-IV: Maintenance is intended to be followed for various maintenance operations for the Greenfield Inter-urban Expressway projects. The activities broadly comprise of various features (such as main road, service roads, cross-roads, intersections, interchanges, underpasses, overpasses, bridges and structures, etc) and *Project Facilities* (such as, toll plaza, wayside amenities, etc), all within the right-of-way (ROW) of the project expressway.

The basic intention is to provide uniform systems for expressway maintenance management adopted throughout the expressway network presently under consideration. In general, the maintenance management comprises of basic elements of planning, scheduling and evaluating etc. following general management principles to perform in an efficient manner to serve the users.

Road Maintenance is defined as the preservation, upkeep and restoration of the roadway facilities as nearly as possible in the condition to which they were originally constructed or subsequently improved. Roadway facilities encompass all physical components within the ROW of the project expressway, for example:

- Pavement for the carriageways and shoulders
- Other paved/unpaved areas including median, footpath and island
- Embankment and cut slopes and other areas within the ROW
- Surface and subsurface drains including drainage appurtenances
- Traffic safety and control devices (road signs, markings, barriers, signals, etc)
- Structures (bridges, culverts, retaining structures, etc)
- Protective works (erosion control structures, etc)
- Plantation and Landscaping
- Other road furniture (distance stones, boundary pillars, etc)
- Project facilities (toll plaza, rest areas, parking areas, etc.)

Road maintenance also includes associated facilities and services to provide comfortable, high speed and safe highway transportation. The followings are also included in road maintenance:

- Wayside amenities, service areas, rest areas, toll plaza, etc
- Special safety devices, traffic signals, Illumination system
- Highway patrol and assistance
- Emergency operations (lane closure, traffic diversion, etc)

1.2 BASIC MAINTENANCE OBJECTIVES AND POLICIES

1.2.1 *Basic objectives*

The maintenance engineer/personnel shall make themselves fully aware of the Project Site with regard to the existing features of the site (such as, location, layout, geometry, right of way, intersecting roads, existing access points, etc), all physical assets with their inventory and condition (for example, pavement, traffic signs, etc), weather conditions that are expected to prevail, and also the constraints at the site (such as, limitation of right of way, existence of adjoining property, utilities, etc), if any. He shall plan and prepare a detailed programme for carrying out maintenance activities to comply with the Inspection Reports and recommendations for respective activities.

Any project report and other information provided by the Authority (Employer) shall be used by the Maintenance Organization only for reference purpose. The Maintenance Organization shall also assume full responsibility for undertaking all the activities, which are necessary, but not limited to:

- Planning and programming;
- Development, updating and maintenance of database;
- Field inspections, measurements, investigations and condition assessment;
- Material mix-design and testing;
- Determine appropriate type of treatment;
- Construction planning including traffic management, safety to the users and abutting property holders, safety for workers, etc;

- Measurements of work done/ materials used;
- Keeping track of intervention levels and respond within the allowable time;
- Actual repair and maintenance works; and
- Reviewing its performance, especially if the contract is performance-based.

1.2.2 *Policies for maintenance implementation*

The maintenance engineer/personnel (responsible for maintenance activities) shall take effective measures to overcome the physical and operational constraints, if any, and operate and maintain the Project Highway using appropriate methods, management techniques and technologies. General considerations shall, without being limited to, be as follows:

a) ***Traffic Control and Safety***

Safe and effective traffic control is vital to the safety of the traveling public. It is also essential to protect maintenance and utility workers whose work places them near high speed traffic and other unsafe conditions. The Concessionaire shall prepare and implement appropriate traffic control plan and also make sure that its supervisors and maintenance workers understand the need for safety and the ways safety can be enhanced. This aspect has been discussed in details in Chapter-2:Traffic Management of Volume-III:Operations & Management.

b) ***The Constraints***

The maintenance engineer/personnel should be aware of any constraint that might affect his performance and if there is any constraint, he should take appropriate measures to eliminate the cause, if possible, or reduce its damaging effect, or avoid disruption of traffic and other undesirable condition.

c) ***Durability***

It is intended that the Expressway be durable besides being safe. This would mean that the deteriorating effects of climate and environment (for example wetting and drying, freezing and thawing, if applicable, temperature differences, aggressive environment leading to corrosion etc) in addition to the traffic shall be duly considered in determining the most cost-effective treatment in order to preserve durability of the Expressway.

d) *Mitigating Disruptive Effects of Construction*

The operation and maintenance of the Expressway should be planned and taken up in such a way that the construction of Expressway does not have adverse impact on the environment and does not disrupt the lives and business activities of the people living close to the Expressway. Activities such as, painting, sanding, anti-icing, herbicide application, mowing and brush control, landscaping and maintaining drainage, etc can raise environmental objections. All material handling can have environmental safety implications for the maintenance workers and the general public as well.

e) *State and Local Laws and Conditions*

The maintenance engineer/personnel should be aware of the laws, bylaws, rules and regulations, acts, circulars, etc of the State Government and Local bodies, especially those related to disposal of surplus materials, handling of materials, maintaining water bodies, landscaping with native plants, etc. The Maintenance Organization should also be aware of local conditions including weather.

f) *Utility Service Providers*

A utility corridor of 2 m width on each side of the expressway has been kept reserved. The maintenance engineer/personnel shall be aware of the utilities present along and across the expressway including the name, address and contact telephone numbers of the utility providers. Any fault or development within this corridor shall be intimated to the respective utility providers.

CHAPTER - 2

MAINTENANCE MANAGEMENT

CHAPTER – 2

MAINTENANCE MANAGEMENT

2.1 INTRODUCTION

Maintenance of Expressways includes various services such as maintenance of carriageway, bridges, tunnels, and other structures; cleaning and inspection for ensuring the safety of road users; maintenance of information system for providing traffic information on a continuous basis; as well as cleaning of service areas and wayside amenities.

The road maintenance engineers are required to keep expressways always in good condition, at the same time improving the efficiency of maintenance system.

Under the circumstances, extensive expressway maintenance program may need to be considered alongwith construction of expressway network. This may be broadly classified as:

- Maintenance Works (Routine Maintenance): This covers inspection, renovation, cleaning of road and associated facilities including recovery of traffic accidents, etc.
- Maintenance Repair: This covers pavement repair (all types of distresses), bridge surfacing renovation and painting of metallic and concrete surfaces to maintain the traffic requirements.
- Improvement: This covers improvement of serviceability as well as structural efficiency of the pavement, structures and environment, and
- Disaster prevention: This covers the emergency measures/works to mitigate the adverse effects of earthquakes, storms, and floods alongwith man made casualties.

The objectives of these maintenance works are to:

- Assure driving comfort and safety on expressway.
- Preserve road and appurtenances, associated facilities with the purpose of providing upgraded functional qualities.
- Meet current social needs.

All these requirements are presented in **Fig. 2.01**.

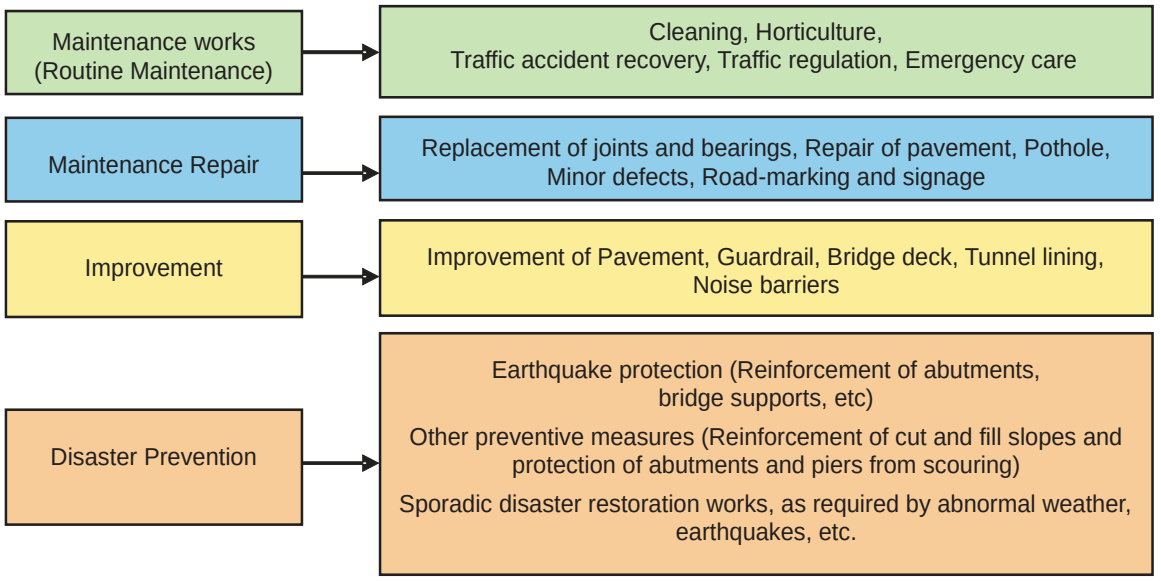


Fig. 2.01 Types of Maintenance Activities

2.2 BASE DATA COLLECTION

At the commencement of the Maintenance activities, all historical data, reports, and "As-built" drawings on construction and maintenance of the project, shall be available for planning of necessary inspection, survey and investigation.

The data set may comprise:

- Traffic census data
- Accident data
- Inventory and "As-built" drawings of:
  - main road and services roads;
  - surface and subsurface drains;
  - bridges, culverts and other structures;
  - traffic safety and control devices; and
  - project facilities, such as toll plaza, service areas/rest areas etc.
- Pavement construction and maintenance history containing detailed information on:

- time-series data on construction (both original and subsequent rehabilitation) of each layer of pavement, thickness and characteristic properties of the pavement layers and foundation as obtained from test results (including test dates) ;
- time-series data on pavement visual distress condition and ride quality;
- time-series data on pavement strength; and
- time-series data on pavement maintenance treatment carried out including salient properties of materials used

- Structures construction and maintenance history containing detailed information on:
  - time-series data on construction of each member of a structure, dimensions, characteristic properties of material used as obtained from test results (including test dates);
  - time-series data on high flood levels and occurrence of drainage problems;
  - time-series data on condition of structures; and
  - time-series data on maintenance treatment carried out including salient properties of the materials used
- Time-series data on maintenance of surface and subsurface drains
- Time-series data on maintenance of traffic safety and control devices
- Time-series data on maintenance of project facilities

2.3 RELATIONSHIP BETWEEN INSPECTION AND MAINTENANCE

Maintenance Operations are continuous in nature and requires round the clock supervision with the following objectives.

- To find the defects quickly, ensure road safety, and prevent the damage/ discomfort to the user as well as third party (if any)
- To understand/appreciate the distress mechanism to plan and execute long term / short term measures.
- To provide riding comfort to the users.

Fig. 2.02 presents typical maintenance cycle.

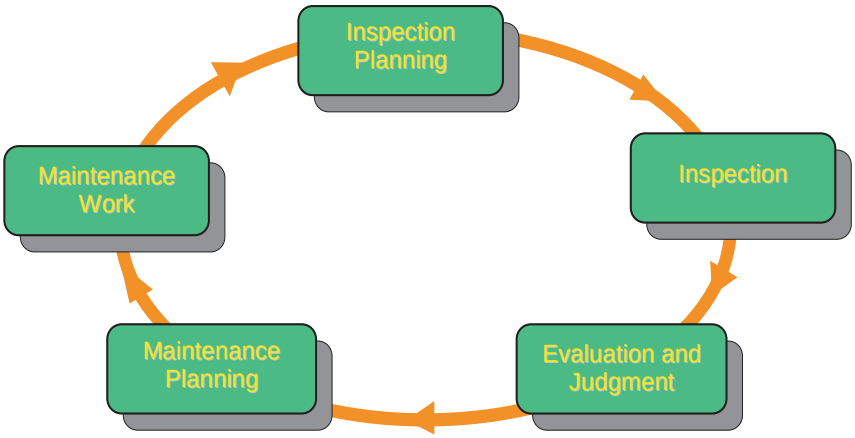


Fig. 2.02 The Typical Maintenance Cycle

At the initiation of the maintenance operations, it would be necessary to study the secondary data collected from the concessionaire and to plan inspection followed by evaluation and judgment leading to maintenance planning of activities and finally performing the maintenance work. There are a number of factors which influence the manner and effectiveness of the activities at the various stages. Many of these factors are subject to a wide range of variables. The factors include:

- Distance of work sites from the base of operations and the time and expenses to transport personnel, materials, and equipment to work sites.
- Weather conditions that can influence whether a repair can be made or the nature of the materials and equipment that will be required.
- Availability of skilled personnel, proper equipment and materials.
- The size and grouping of each work package and whether it is within the scope of resource availability and will it result in a high unit cost because of transportation distance. In such a situation, the preventive maintenance measures may also be included.
- Influence of unanticipated events, etc.
- Traffic conditions at different time periods.
- Possible outside influences such as labour contracts, local disturbances, scarcity of suitable materials, etc.

Typical Maintenance Flow diagram inter-linking the various broad activities are shown in **Fig. 2.03.**

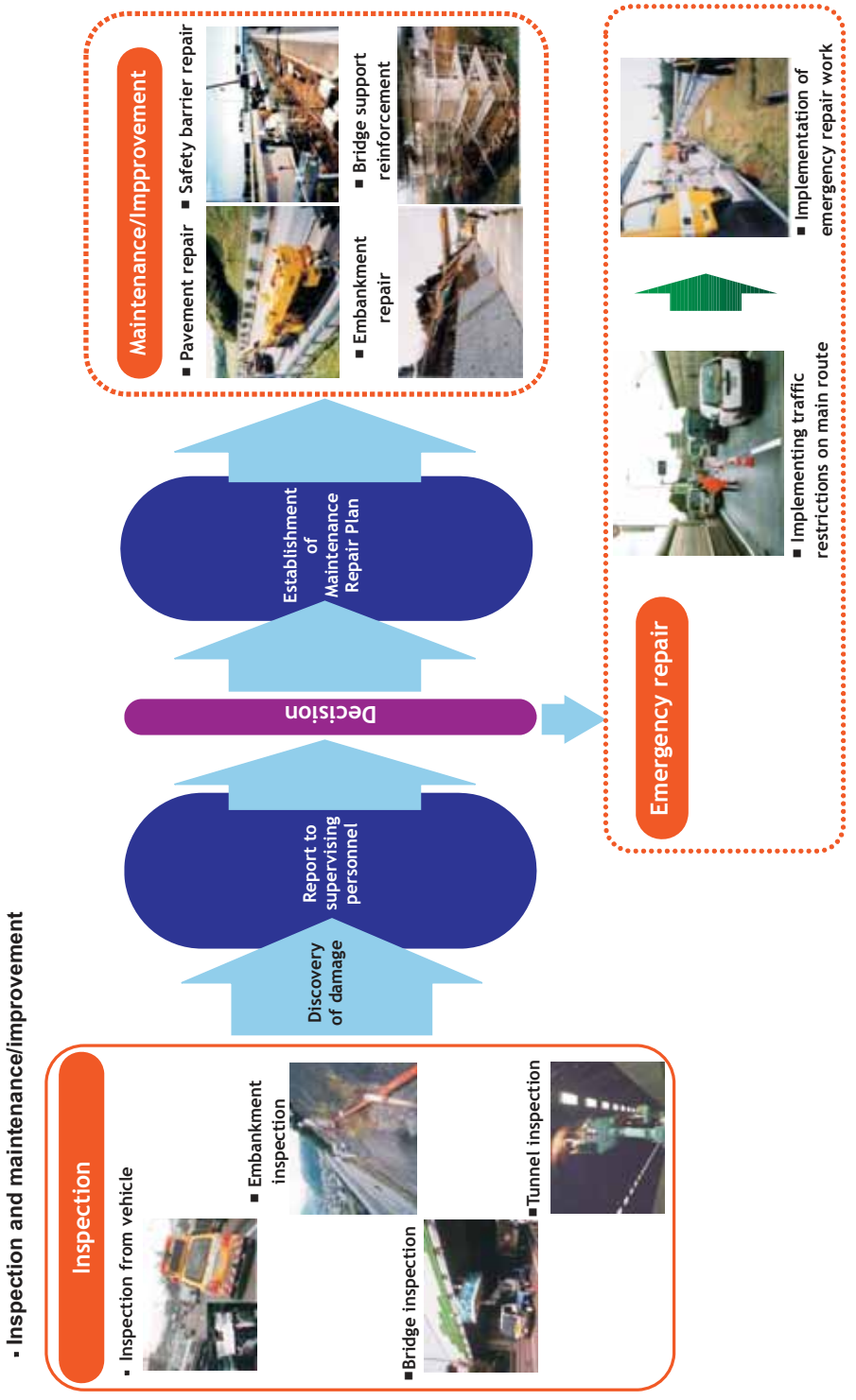


Fig. 2.03 Maintenance Flow

CHAPTER - 3

INSPECTION

CHAPTER – 3

INSPECTION

3.1 INSPECTION

Adequate and regular inspection is the key to success of a maintenance project. Soon after collection of the historical as-built and maintenance data, appropriate plan for inspection shall be prepared.

3.1.1 *General*

All inspection and surveys that are required for planning and designing with regard to operation and maintenance of the expressway shall be carried out in accordance with

- IRC:SP:19–2001 : Manual for Survey, Investigations and Preparation of Road Projects
- IRC:SP:35-1990 : Guidelines for Inspection and Maintenance of Bridges
- IRC:SP:54-2000 : Project Preparation Manual for Bridges
- IRC:SP:52-1999 : Bridge Inspector's Reference Manual
- MORTH: Guidelines for Maintenance Management of Primary, Secondary and Urban Roads and best industry practices. Inspection and Survey include topographic survey, traffic survey, hydraulic and drainage survey, road and bridge inventory and condition survey, material survey and pavement investigation.

This Guideline explains the Inspection Process in a comprehensive manner.

All data generated from these inspections shall be properly referenced, compiled, validated and presented in easily comprehensible forms, such as those prescribed in the publications referred to above.

3.1.2 *Types of inspection*

Types of inspection are divided into the following three (3) categories:

i) *Routine Inspection:*

Routine inspection is carried out on daily/weekly basis to identify road conditions and traffic conditions. It shall be a visual inspection carried out from a moving

inspection vehicle with the occasional need of the observation on foot. It usually consists of a team of two inspectors.

Routine Inspection

ii) *Periodic Inspection:*

Periodic Inspection is primarily designed to carry out more detailed periodic investigation of the relevant structures such as bridges and slopes on foot. Close Inspection (with simple measuring tools and rebound hammers) of the structure shall be done partially as full visual inspection is not possible in some cases

Close Inspection

a) The lower part of an expansion joint cannot be inspected during Daily Inspection as it is carried from a moving vehicle. However, if some damage is detected on the joint surface, the entire joint should be inspected to ascertain the level or extent of damage and its cause.

Inspection with Rebound Hammer

b) Daily inspection for slopes may be carried within a visible range from a moving vehicle. However if some distress/failure is detected, full/detail inspection should be carried out to ascertain its stability or further imminent failures.

Structures within the ROW shall be inspected overall by an inspection group consisting of engineers and technical staff.

Inspection of Structure

iii) *Special/Emergency Inspection:*

Special Inspection is defined as the supplementary inspection in addition to the daily/weekly inspection and periodic inspection, for example, in the occasional cases such as storm and heavy rain.

Inspection of Slope

3.1.3 *Frequency of inspection*

Frequency of inspection is as follows:

i) Routine inspection once a day or a week.

ii) Periodic Inspection once a year/once every three (3) or six (6) months.

iii) Special Inspection in case of necessary/additional/ad-hoc requirements/ situations.

Examples of the frequency of inspection are given in **Table 3.01.**

Table 3.01 Typical Content of Inspection Report

Item	Type of Inspection	Description	Reporting
1)	Routine inspection	Routine inspection to evaluate road and traffic condition. Coarse Visual Inspection (CVI) to assess overall health of the asset as a whole. Any defect notic ed shall be highlighted identifying locations.	Daily
		Road user facilities and amenities including Service Area s, Rest Area s, Toll Plazas, Truck Parking Areas, etc.	Weekly
2)	Periodic inspection	Detailed Visual Inspection (DVI) periodically especially identified in CVI, structures, slope protection or embankment, safety measures, etc. – with diagnostic and prescriptive content.	Monthly, commencing from the date of construction
		Pavement Condition Assessment – functional and structural.	Yearly (Preferably after monsoon)
		Mechanical and Electrical (Toll, emergency telephone, street light, traffic signage)	Quarterly
3)	Special inspection	• Unusual emergency cases impeding the service facility, due to storm, rain, landslide, earthquakes and simila r natural avalanches. • Major accidents, spillage of liquids requiring lane closure.	Immediately on occurrence and on compliance with necessary activities

3.1.4 *Inspection targets*

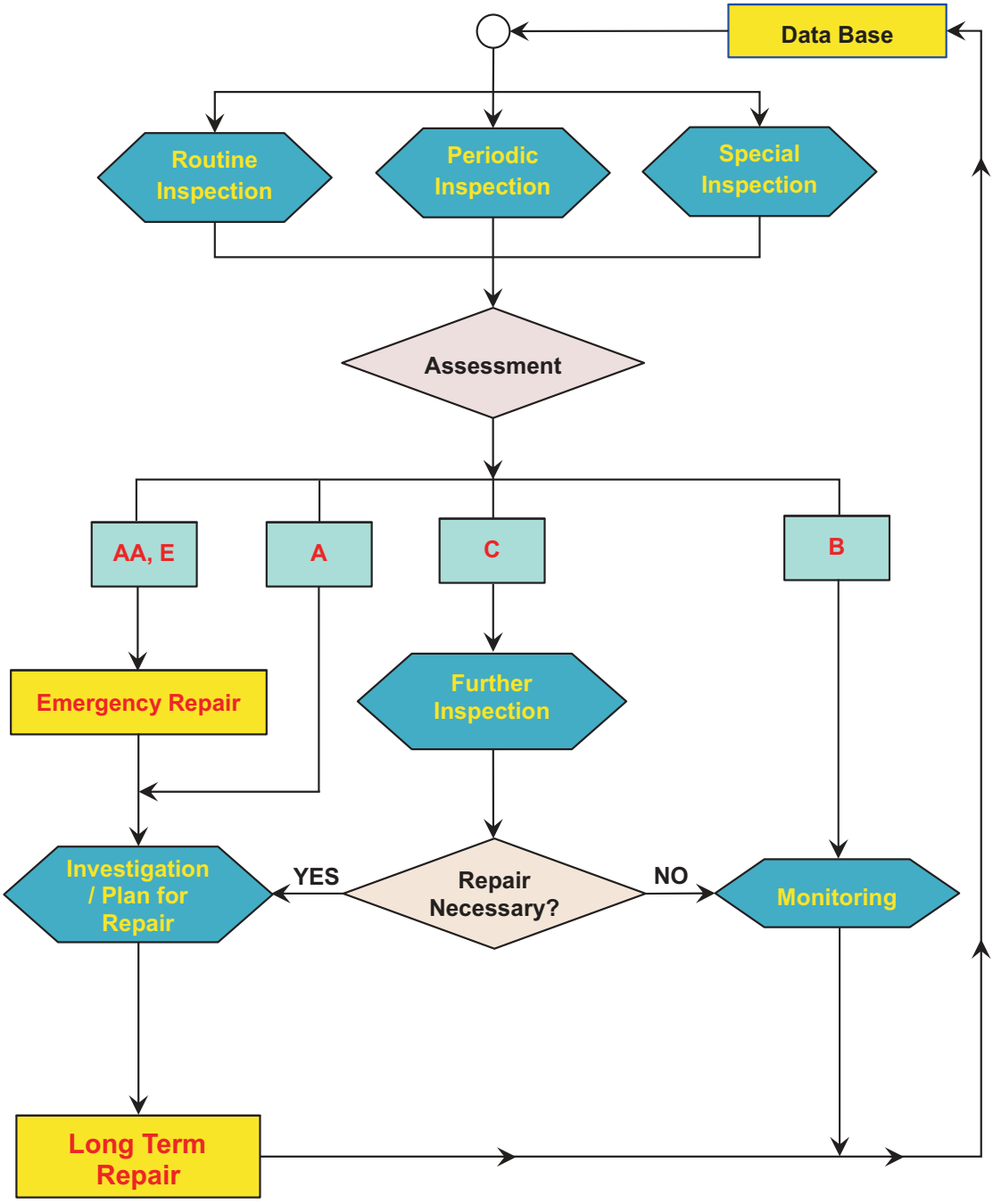
Table 3.02 indicates the inspection targets for each type of inspection works

3.2 INSPECTION WORKS

The various processes for each inspection works are illustrated in **Fig. 3.01**. It is important to establish this process to ensure that each inspection is followed up with appropriate action systematically. Any damages or defects detected during these inspections will be recorded and assessed according to the specified ranking criteria.

Table 3.02 Inspection Targets

Functional Category	*Component*		*Routine Inspection*	*Periodic Inspection*		*Special/ Emergency Inspection*
				Every 6 months	*Every year*	
Road Surface (flexible/rigid)	Pavement & shoulder surface		O		O	In case necessary
	Expansion joint (rigid pavement)		O			
	Road kerb		O			
Drainage Facility	Road Surface and Roadside	Shoulder	O	O		
		Median	O	O		
	Slope / embankment		O	O	O	
	Bridge		O		O	
	Adjacent Area			O		
Slope	Vegetation on slope		O	O		
	Specially treated slope		O	O		
	Masonry / Rubble		O	O		
	Retaining Wall		O	O		
Bridge and Viaduct	Concrete super structure				O	
	Concrete sub-structure				O	
	Steel structure				O	
	Slab				O	
	Painting				O	
	Shoe				O	
	Railing and kerbs		O		O	
Culvert	Concrete Box				O	
	Concrete Pipe / Slab				O	
	Corrugated Metal Pipe		O		O	
Tunnel	Concrete Lining		O		O	
	Entrance (portal)		O		O	
	Lining		O		O	
	Ceiling Panel		O		O	
	Drainage Facility		O		O	
Traffic Safety Devices	Traffic Barrier and Guardrail	Shoulder	O	O		
		Median	O		O	
	Anti-Glare / ROW Fencing	Shoulder	O	O		
		Median	O	O		
	Anti-falling Objects fence	Shoulder	O	O		
		Median	O	O		
Traffic Control Devices including retro-reflectance	Traffic signs and Gantries		O		O	
	Road markings		O			
	Delineators		O			
	Kilometer Stones/Markers		O			
Others / Miscellaneous	Noise Barriers		O		O	
	Lighting		O		O	
	Landscaping		O	O		
	Toll Plaza		O	O		
	Service Areas/Rest Areas		O	O		
	Operation Facilities		O	O		



Ranking Criteria (Refer Table 3.03)

Fig. 3.01 Process of Inspection, Assessment and Repairs

3.2.1 *Inspection programme and operation*

3.2.1.1 An inspection programme shall be set up before carrying out any periodic inspection. The inspection programme shall contain the following items:

i) Types of inspection

ii) Objects/components and items

iii) Time schedule and inspection route

iv) Members of inspection team

v) Inspection methods

vi) Tools and equipments

vii) Inspection Record

3.2.1.2 The details of Inspections shall be recorded in a systematic way using typical forms used for recording the inspections observations.

3.2.1.3 Inspectors have to select and carry appropriate tools and equipments. The following tools are usually carried by the inspector in the inspection vehicle:

i) ***Daily Inspection and Special Inspection***

Tools and equipments: camera/ video camera, binoculars, compact measuring tape, test hammer, measuring tape, survey pole, black board, chalk, torch light, maps, etc.

ii) ***Periodic Inspection***

Tools and equipments: camera/ video camera, binoculars, magnifying glass, calipers, clearance gauge, test hammer, measuring tape, survey pole, black board, chalk, spade, rope, torch light, maps, etc.

In addition, traffic safety equipments such as safety cones and a flag should be arranged.

3.2.2 *Assessment*

The inspection findings/results will be assessed based on the ranking criteria as given in **Table 3.03**.

Table 3.03 Typical Ranking of Inspection

Ranking		Typical Condition
Functional deterioration (including visual structural distresses)	**AA**	Has severe damage/deformation. **Requires immediate repair to recover its functionality**
	A	Has damage/deformation and functional deterioration. **Requires repair but not immediately**
	A1*	Does not require immediate repair, but has functional deterioration which is expected to worsen rapidly. **Estimated to require repair within 2 years**.
	A2*	Does not require immediate repair, but has functional deterioration which is expected to worsen gradually. **Estimated to require repair within 5 years**.
	A3*	Has functional deterioration but the speed of deterioration is slow. **Requires monitoring continuously or after 5 years' time, and determining the timing of repair accordingly**.
	B	No sign of functional deterioration albeit damage/ deformation. **Requires continuous monitoring of damage/deformation**
	C	**Requires investigation** in order to assess its functionality
	OK	**No or only slight sign of damage/deformation**
Affect Traffic Safety	**E**	Has risk of affecting the safe traffic condition. **Requires immediate attention.**

* The ranking of "A" is further classified into A1, A2 and A3 except for the safety inspection during the routine inspection. The inspection assessment shall also include "Structural Deterioration".

For ranking 'AA' and 'E' shall be considered for maintenance activities.

For ranking 'A', 'B' and 'C' shall be noted and informed to the following inspection group for appropriate actions.

Note: ***Intervention period is illustrative, subject to change.***

The examples of inspection item and ranking criteria for pavement, slope and structures are given in **Table 3.04.**

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures
(Source : NEXCO - Inspecion and Maintenance Manual)

[Pavement]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1.	Pothole, patching, scaling	Over 20 mm in depth and over 20 cm in diameter	Less than 20 mm in depth or less than 20 cm in diameter	
2.	Faulting	Over 20 mm	10 mm to 20 mm	
3.	Rutting	Over 25 mm	15 mm to 25mm	
4.	Cracking	Over 20 percent of Cracking Ratio	10 percent to 20 percent of Cracking Ratio	
5.	Longitudinal surface roughness, corrugation		Uncomfortable driving, More than 30 mm	Vertical displacement 10 mm to 30 mm
6.	Stripping of surface thin layer		Stripping	
7.	Stagnant water		stagnant water observed whenever it rains	
8.	Joint breakage		Joint break	
9	Skid resistance *	Less than 0.25 μ(V)	0.25 μ(V) to 0.3 μ(V)	
10.	Roughness (IRI)	IRI over 3.5mm/m		
11.	Damage to kerb	Extreme breakage or lifting	Heavy Breakage or lifting of precast kerb Heavy damage to asphalt kerb and losing drainage function	Breakage of lifting or precast kerb Damage to asphalt kerb

Refer Table 3.03 for Ranking Criteria

* ***Fixed slip method using Komatsu Skid Trailer is used for Friction and Skid Measurement***

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Road Surface Drainage]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to the facility	Shoulder drainage in embankment: Damage causing overflow or slope failure Lid : Being off or damage causing remarkable functional lowering	Shoulder drainage in embankment: Remarkable functional lowering Lid: Being off or damage causing functional lowering	
2)	Bad connection	Water leakage causing embankment failure	Water leakage scouring base or side	Water leakage scouring base or side slightly
3)	Silting	Loss of drainage function causing water logging	Remarkable lowering of drainage function Stagnant water on surface	Lowering of drainage function Temporary stagnant water

Refer Table 3.03 for Ranking Criteria

[Asphalt/Precast Kerb]

Sl. No.	Item	Assessment		
		AA/E	A (A1, A2, A3)	B, C, OK
1)	Damage to kerb	Remarkable breakage or lifting	Breakage or lifting of precast kerb Damage to asphalt kerb causing loss of drainage function	Partial scaling of precast kerb Partial damage to asphalt kerb

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Vegetation Slope]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Fall (rock & debris)	Slope was collapsed and continue to be collapsed	Slope was collapsed slightly with less possibility of continuing	
2)	Crack, swelling, depression	Cracks, swelling or depression which will cause slope collapse	Slight c racks, swelling or depression which may not cause slope collapse	
3)	Descaling, gully erosion	Wide range descaling or gully erosion which will grow	Descaling or gully erosion which may not grow	
4)	Seepage water	Seepage water with increasing water volume during heavy rain which will cause slope collapse	Seepage water with increasing water volume during heavy rain which is unlikely to cause slope collapse	Seepage water which may not cause slope collapse
5)	Fallen trees	Fallen or inclined trees which will cause slope collapse	Fallen or inclined trees which may not cause slope collapse	Very thickly grown trees
6)	Vegetation damage		Covering rate of vegetat ion is less than 30 percent	Covering rate of vegetation is between 30 percent and 70 percent
7)	Silting	Silting causing slope drainage function	Silting which does not affect drainage function	Small Silting
8)	Flaking stones, boulders	Very unstable flaking stones or boulders on slope which may fall on the carriageway	Unstable flaking stones or boulders on slope	

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Concrete block / Cast in place Crib Slope]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks, stripping	Substantial crack or stripping which will fall	Wider spread crack or stripping	Partial crack or stripping which is unlikely to grow
2)	Looseness, bulging, subsidence	Substantial looseness, bulging, subsidence resulting in falls or collapse	Looseness, bulging, subsidence with less possibility of growing	
3)	Drainage, seepage	Large seepage from joint or stuffed drainage pipe resulting in falls or collapse		Seepage from joint or stuffed drainage pipe which may not result in falls or collapse

Refer Table 3.03 for Ranking Criteria

[Mortar/Concrete Spraying Slope and Concrete Lining Slope]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks, stripping	Substantial crack or stripping which will fall	Wider spread crack or stripping which will grow	Partial crack or stripping which is unlikely to grow
2)	Looseness, bulging, subsidence	Resulting in falls or collapse	Less possibility of growing	
3)	Cavity			Possibility of cavity
4)	Drainage, seepage	Large seepage from joint or stuffed drainage pipe resulting in falls or collapse		Seepage from joint or stuffed drainage pipe which may not result in falls or collapse

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Falling stone Prevention Net / Fence]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to net /fence	Breakage or fall off of net / rope, inclination of column, resulting in loss of function	Wide-spread damage to net, rope or column	Damage to net, rope or column
2)	Damage of accessories	Stopper, anchor bolts for lift stopping or set bolts: substantial breakage		Stopper, anchor bolts for lift stopping or set bolts: cracks or looseness
3)	Corrosion		Wide-spread corrosion	Partial corrosion
4)	Damage to foundation	Lifting of anchor, scour around foundation resulting in damage to net / fence proper	Lifting of anchor, scour around foundation	Partial lifting of anchor, scour around foundation

Refer Table 3.03 for Ranking Criteria

[Concrete Block/Stone Masonry]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks, looseness, bulging	Substantial crack, looseness or bulging resulting in falls or collapse	Wider spread crack or stripping which will grow	Partial crack or stripping which is unlikely to grow
2)	Settlement, displacement, inclination	Substantial settlement, displacement or inclination resulting in falls or collapse	Settlement, displacement or inclination which will grow	Partial settlement, displacement or inclination which is unlikely to grow
3)	Joint gap	Substantial joint gap resulting in falls or collapse	Substantial joint gap which will grow	Partial joint gap which is unlikely to grow
4)	Scouring	Substantial scour around foundation or behind block resulting in falls or collapse	Scour around foundation or behind block resulting in falls or collapse which will grow	Partial scour around foundation or behind block which is unlikely to grow
5)	Drainage, seepage	Large seepage from joint or stuffed drainage pipe resulting in falls or collapse		Seepage from joint or stuffed drainage pipe which may not result in falls or collapse

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

Concrete retaining walls (Reinforced Concrete)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks, corner failure	Substantial cracks into reinforced bars resulting in falls	Cracks into reinforced bars	Partial Cracks
2)	Stripping		Large stripping	Partial stripping
3)	Exposure and corrosion of reinforcement		Steel is remarkably exposed and corroded	Steel is partially exposed
4)	Joint gap	Substantial joint gap resulting in falls or collapse	Substantial joint gap which will grow	Partial joint gap which is unlikely to grow
5)	Settlement, movement, Tilting	Substantial settlement, movement, Tilting resulting in falls	Settlement, movement, Tilting which needs investigation	Small Settlement, movement, Tilting
6)	Scour	Substantial scour around foundation	Scour around foundation	Partial scour around foundation or behind block which is unlikely to grow
7)	Leakage	Substantial leakage		Leakage

Refer Table 3.03 for Ranking Criteria

[Concrete retaining walls (Non Reinforced Concrete)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks, corner failure	Substantial cracks resulting in falls	Large cracks or corner failure which will grow	Partial cracks or corner failure which is unlikely to grow
2)	Joint gap	Substantial joint gap resulting in falls or collapse	Substantial joint gap which will grow	Partial joint gap which is unlikely to grow
3)	Settlement, movement, Tilting	Substantial settlement, movement, Tilting resulting in falls	Settlement, movement, Tilting which needs investigation	Small Settlement, movement, Tilting
4)	Scour	Substantial scour around foundation	Scour around foundation	Partial scour around foundation or behind block which is unlikely to grow
5)	Leakage	Substantial leakage		Leakage

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Slope Drainage]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to the facility	Drain ditch, vertical ditch damage causing overflow or slope failure	Drain ditch, vertical ditch damage resulting in remarkable functional lowering Lid is off or damage causing functional lowering	
2)	Bad connection	Water leakage causing slope failure		Water leakage which is unlikely to cause slope failure
3)	Silting	Silting resulting in loss of drainage function which will cause slope failure	Silting resulting in stagnant water on the slope surface	Silting which will not affect drainage function
4)	Weeds	Grown weeds resulting in loss of drainage function which will cause slope failure		Weed which will not affect drainage function

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Steel Structures (Girder, Plate deck, Pier, Cross beam)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks	Substantial cracks	Cracks	
2)	Deformation	Heavily deformed which affects load strength	Deformed	Partial deformation of member
3)	Loss or looseness of high tensile bolts		Two or more bolts missing at each joint part	Bolt missing
4)	Loss or looseness of rivet		Two or more rivets missing at each joint part	Rivet missing
5)	Corrosion	Entirely and remarkably corroded which affects load strength	Widely corroded which affects load strength	Corroded
6)	Unusual noise and vibration		Unusual noise vibration caused by shaking, creaking or impacts by vehicle	Unusual noise and vibration
7)	Surface painting		Wide spread damage by crack, Swelling, pitting or rust	Partial damage by crack, Swelling, pitting or rust
8)	Water leakage stagnant water		Main structural member: widely corroded due to water leakage Inside of box girder: widely corroded due to stagnant water	Partial corroded due to water leakage Inside of box girder : partially corroded due to stagnant water
9)	Inadequate clearance under deck		Insufficient clearance	

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Concrete Superstructures]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks	Substantial cracks	Cracks	
2)	Stripping		Large stripping	Partial stripping
3)	Exposure and corrosion of reinforcement		Steel reinforcement is remarkably exposed and corroded	Steel reinforcement is partially exposed
4)	PC steel breakage	PC steel is cut off	Attachment of PC steel is cracked or rust	
5)	Air void, honeycomb		Remarkable air voids or honeycombs	Air voids or honeycombs partially
6)	Deflection, unusual vibration		Unusual water stagnation on bridge deck recurs Excessive deflection observed Abnormal vibrations observed	
7)	Unusual noise and vibration		Unusual noise vibration caused by shaking, creaking or impacts by vehicle	Unusual noise and vibration
8)	Water leakage		Continuous water leakage	Water leakage during rains
9)	Surface colour change		Colour change with cracks	Partial colour change
10)	Rust fluid		Substantial Rust fluid	Partial rust fluid
11)	Inadequate clearance under deck		Insufficient clearance	

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Abutments and Piers]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks	Substantial cracks near bearing	Cracks into reinforced bars	Partial cracks
2)	Stripping		Large stripping	Partial stripping
3)	Exposure and corrosion of reinforcement		Steel reinforcement is remarkably exposed and corroded	Steel reinforcement is partially exposed
4)	Air void, honeycomb		Remarkable air voids or honeycombs	Air voids or honeycombs partially
5)	Rust fluid		Substantial Rust fluid	Partial rust fluid
6)	Settlement, movement, tilting		Damaged due to Settlement, movement, tilting	Partially damaged due to Settlement, movement, tilting
7)	Scouring	Substantial scour around foundation	Scour around foundation	Partial scour around foundation or behind block which is unlikely to grow

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Steel Bearings]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage of structure	Heavy damage of main structure	Upper, lower bearing: restricted function of rotation or movement due to breakage, settlement or tilting	Upper, lower bearing: cracks or tilting
2)	Damage of accessories		Stopper, anchor bolts for lift stopping or set bolts: breakage	Stopper, anchor bolts for lift stopping or set bolts: cracks or looseness
3)	Corrosion	Heavily corroded affecting load strength	Remarkably corroded reducing load strength	Partially corroded affecting function of rotation or movement
4)	Damage of bearing pedestal concrete, nearing pedestal mortar, protection mortar	Remarkably corroded affecting load strength	Bearing pedestal concrete: widely cracked Bearing pedestal mortar : air voids or cracks	Protection mortar : cracks or spalling
5)	Inadequate clearance	Loss of load strength	Rotation or movement of girders: completely restricted	Rotation or movement of girders: restricted
6)	Unusual noise		Large and unusual noise	Unusual noise
7)	Silting		Buried in accumulated soil and dust	Accumulated soil and dust around bearings

Refer Table 3.03 for Ranking Criteria

[Rubber Bearings]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Deterioration of Rubber	Heavily deteriorated affecting load strength	Crack, blister	Partial crack, blister
2)	Damage of bearing pedestal concrete, nearing pedestal mortar, protection mortar	Remarkably corroded affecting load strength	Bearing pedestal concrete: widely cracked Bearing pedestal mortar: air voids or cracks	Protection mortar : cracks or spalling
3)	Silting		Buried in accumulated soil and dust	Accumulated soil and dust around bearings

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

Joints]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to joint	Damage to welding part or lifting of face plate Missing anchor bolt	Breakage of face rubber	
2)	Damage to secondary material		Opening between secondary material and joint Cracking	
3)	Faulting	Over 20 mm	10 mm to 20 mm	
4)	Abnormality in spacing		Closed spacing and possibility of bad influence to the bridge structure Abnormal opening of spacing and abnormal sound	Abnormally narrow spacing Wide opening of spacing
5)	Water Seepage		Water seepage from joint which affect s other bridge members	
6)	Abnormal sound		Abnormal sound on vehicle passage	

Refer Table 3.03 for Ranking Criteria

[Groove Joints]

Sl. No.	Item	Assessment		
		AA	A	B
1)	Damage to joint		Opening	
2)	Damage around joint		Hollow or lump : over 1 m in length over 5 cm in width and over 5 cm depth	
3)	Water Seepage		Water seepage from joint which affect s other bridge members	
4)	Abnormal sound		Abnormal sound on vehicle passage	

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)

(Source : NEXCO - Inspecion and Maintenance Manual)

[Railing and Kerb (Steel Railing)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1.	Damage		Deformation or cracks in wide area	Deformation or cracks in limited part or falling of bolts
2.	Corrosion		Corrosion in wide area	Corrosion in limited part

Refer Table 3.03 for Ranking Criteria

[Railing and Kerb (Concrete Railing)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Crack	Substantial cracks resulting in falls	Cracks into reinforced bars	Partial Cracks
2)	Stripping		Large stripping	Partial stripping
3)	Exposure and corrosion of reinforcement		Steel reinforcement is remarkably exposed and corroded	Steel reinforcement is partially exposed
4)	Free lime		Free lime causing corrosion	Partial free lime
5)	Water leakage		Continuous water leakage	Water leakage during rains
6)	Surface colour change		Colour change with cracks	Partial colour change
7)	Rust fluid		Substantial Rust fluid	Partial rust fluid

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Bridge Drainage (Catch basin)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to the facility	Damage causing overflow during rains	Damage affecting drainage function	
2)	Damage to the lid	Lid is off or remarkable damage		Damage causing functional lowering
3)	Silting	Silting resulting in overflow	Silting resulting in lowering of drainage function which causes stagnant water	Temporary stagnant water

Refer Table 3.03 for Ranking Criteria

[Bridge Drainage (Joint drain)]

Sl. No.	Item	Assessment		
		AA/E	A (A1, A2, A3)	B
1)	Damage to the facility	Damage causing overflow during rains	Damage affecting drainage function	
2)	Silting	Silting resulting in overflow	Silting resulting in lowering of drainage function which causes stagnant water	Temporary stagnant water

Refer Table 3.03 for Ranking Criteria

[Bridge Drainage (Drainage Pipe)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to the facility	Damage causing overflow during rains	Damage affecting drainage function	
2)	Bad connection	Water leakage affects bearing or other bridge members		
3)	Silting	Silting resulting in overflow	Silting resulting in lowering of drainage function which causes stagnant water	Temporary stagnant water

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Tunnel (Lining)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks, corner failure	Substantial cracks resulting in falls	Cracks: more than 0.3 mm wide and progressing	Cracks: more than 0.3 mm wide and not progressing
2)	Stripping	Substantial concrete stripping	Thick concrete stripping	Thin concrete stripping
3)	Leakage, free lime	Substantial leakage, free lime		leakage, free lime
4)	Abnormality in a joint		Discrepancy, gap or difference with expanding	Discrepancy, gap or difference without expanding

Refer Table 3.03 for Ranking Criteria

[Tunnel (Portal)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks, corner failure	Substantial cracks resulting in falls	Cracks: more than 0.3 mm wide and progressing	Cracks: more than 0.3 mm wide and not progressing
2)	Stripping		Substantial stripping	Partial stripping
3)	Exposure and corrosion of reinforcement		Steel reinforcement is remarkably exposed and corroded	Steel reinforcement is partially exposed
4)	Settlement, movement, tilting	Progressing settlement, movement, tilting Bad influence to upper slope	Small settlement, movement titling	
5)	Abnormality in joint		Discrepancy, gap or difference with expanding	Discrepancy, gap or difference without expanding
6)	Scour		Surroundings, of footing, body and wing; remarkably scoured	Surroundings, of footing, body and wing; scoured
7)	Drainage, spring water		Abnormal spring water from a joint resulting in stagnant water	Leakage from a joint

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Tunnel (Interior wall)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to the wall		Breakage or separation in wide area Remarkable dirt wholly	Breakage or separation in a part
2)	Damage to the accessories		Fittings, bolts: breakage, lost, remarkable rust Possibility of fall of wall	Fittings, bolts: breakage, lost, remarkable rust

Refer Table 3.03 for Ranking Criteria

[Tunnel (Ceiling slab)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to the slab		Remarkable Breakage or separation	Breakage or cracks
2)	Damage to the accessories		Suspenders, fittings, bolts: breakage, lost, remarkable rust	Suspenders, fittings,: breakage, rust

Refer Table 3.03 for Ranking Criteria

[Tunnel (Drainage)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage to the drainage facility	Remarkable damage due to the lateral or vertical stress affecting drainage function	Damage due to the lateral or vertical stress affecting drainage function	
2)	Silting	Silting resulting in overflow	Silting resulting in lowering of drainage function which causes stagnant water	Temporary stagnant water

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Culverts (Reinforced Concrete Box]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks	Substantial cracks resulting in falls	Cracks into reinforced bars	Partial Cracks
2)	Stripping		Large stripping	Partial stripping
3)	Exposure and corrosion of reinforcement		Steel reinforcement is remarkably exposed and corroded	Steel reinforcement is partially exposed
4)	Air void, honeycomb		Remarkable air voids or honeycombs	Air voids or honeycombs partially
5)	Leakage, free lime		Substantial leakage, free lime causing corrosion	leakage, free lime
6)	Settlement, scour		Stagnant water in a water channel or in a culvert Bump at the connection to an approach road Remarkable scour around wing	Functional lowering of water channel Scour around wing
7)	Abnormality in a joint		Fallen cut -off plate because of discrepancy, gap or difference	Discrepancy, gap or difference

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Culverts (Reinforced Concrete Pipe]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Cracks	Substantial cracks resulting in falls	Cracks into reinforced bars	Partial Cracks
2)	Stripping		Large stripping	Partial stripping
3)	Exposure and corrosion of reinforcement		Steel reinforcement is remarkably exposed and corroded	Steel reinforcement is partially exposed
4)	Settlement		Remarkable lowering of drainage function Stagnant water	Lowering of drainage function
5)	Damage of joint		Discrepancy, gap, breakage Leakage	Discrepancy, gap
6)	Silting		Remarkable lowering of drainage function Stagnant water	Lowering of drainage function

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Culverts (Other Type Culvert]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage of culvert		Large deformation or remarkable cracks	Deformation or cracks
2)	Corrosion		Remarkable corrosion in wide area	Corrosion in a part
3)	Settlement		Remarkable lowering of drainage function Stagnant water	Lowering of drainage function
4)	Damage of joint		Discrepancy, gap, breakage Leakage	Discrepancy, gap
5)	Silting		Remarkable lowering of drainage function Stagnant water	Lowering of drainage function

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Traffic Safety Facilities (Guard Fence)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage of fence	Remarkable breakage, fall	Breakage, deformation, bending or tilting in wide area	Breakage, deformation, bending or tilting in a part
2)	Damage of accessories	Fittings, bolts: fall, breakage, cutting Possibility of fall or breakage of fence		Fittings, bolts: break age, deformation, looseness
3)	Corrosion		Remarkable corrosion in wide area	Remarkable corrosion in a part
4)	Damage of foundation	Base anchor: fall, cutting, looseness Scour around foundation Possibility of damage to fence		Base anchor: breakage Scour around foundation Less possibility of damage to fence

Refer Table 3.03 for Ranking Criteria

[Traffic Safety Facilities (Anti-dazzle Facilities)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage of anti-dazzle facility	Net, plate, support: breakage, deformation or tilting in wide area		Breakage, deformation, bending or tilting in a part
2)	Damage of accessories	Fittings, bolts: fall, breakage, cutting Possibility of fall or breakage of fence		Fittings, bolts: breakage, defor mation, looseness
3)	Corrosion		Remarkable corrosion in wide area	Remarkable corrosion in a part

Refer Table 3.03 for Ranking Criteria

Table 3.04 Inspection Items and Ranking for Pavement, Slope and Structures (Contd...)
(Source : NEXCO - Inspecion and Maintenance Manual)

[Traffic Management Facilities (Traffic Signs)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage of sign	Plate, support: Remarkable breakage, deformation or tilting	Plate, support: breakage, deformation or tilting Reflecting sheet: peeling, dirt Blurred paint Difficulty of reading a sign	Plate, support: Remarkable breakage, deformation in a part Reflecting sheet: peeling, dirt Blurred paint
2)	Damage of accessories	Fittings, bolts: fall, breakage, cutting Possibility of fall or breakage of fence		Fittings, bolts: breakage, deformation, looseness
3)	Corrosion		Remarkable corrosion in wide area	Remarkable corrosion in a part
4)	Damage of foundation	Base anchor: fall, cutting, looseness Scour around foundation Possibility of damage to fence		Base anchor: breakage Scour around foundation Less possibility of damage to facility

[Traffic Management Facilities (Traffic Markings)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	
1)	Damage of traffic paint		Continuous blur, vanishing, cracks or discoloration	Partial blur, vanishing, cracks or discoloration

[Traffic Management Facilities (Delineator)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage of delineator proper		Continuous fall, breakage or dirt	Partial fall, breakage or dirt

[Traffic Management Facilities (Kilometer Post)]

Sl. No.	Item	Assessment		
		AA	A (A1, A2, A3)	B
1)	Damage of marker proper		Continuous fall, tilting, breakage or dirt	Partial fall, breakage or dirt

Refer Table 3.03 for Ranking Criteria

3.2.3 *Inspection report*

Reports on inspection findings/results are very important for identifying road conditions and preparing repair and rehabilitation plans. These inspection reports shall also include the assessment by the respective inspector.

Reporting forms for the various inspections shall be furnished and completed and the data are further recorded in a computer data base. The various report forms shall be generated based on the objective of the organization.

3.2.3.1 Daily inspection report

This report summarizes findings/results of the daily inspection which has been conducted. Where necessary, it reports the detail damage detected with sketches or pictures/ photographs.

3.2.3.2 Monthly summary report

This report summarizes the daily inspection results/findings on a monthly basis in suitable format.

3.2.3.3 Periodic or special inspection report

The reporting form used will be similar to that of daily inspection form as it reports periodic or special inspection results. It reports the periodic or special inspection results/findings.

3.2.3.4 Annual summary report

This report summarizes the daily, periodic, and special inspection results/findings once a year in suitable format.

CHAPTER - 4

MAINTENANCE WORKS AND REPAIR

CHAPTER – 4

MAINTENANCE WORKS AND REPAIR

4.1 INTRODUCTION

In this Guideline, road maintenance is categorized as routine, periodic and emergency, as already explained in **Fig. 2.01** Chapter-2. For ready reference, it is reproduced here:

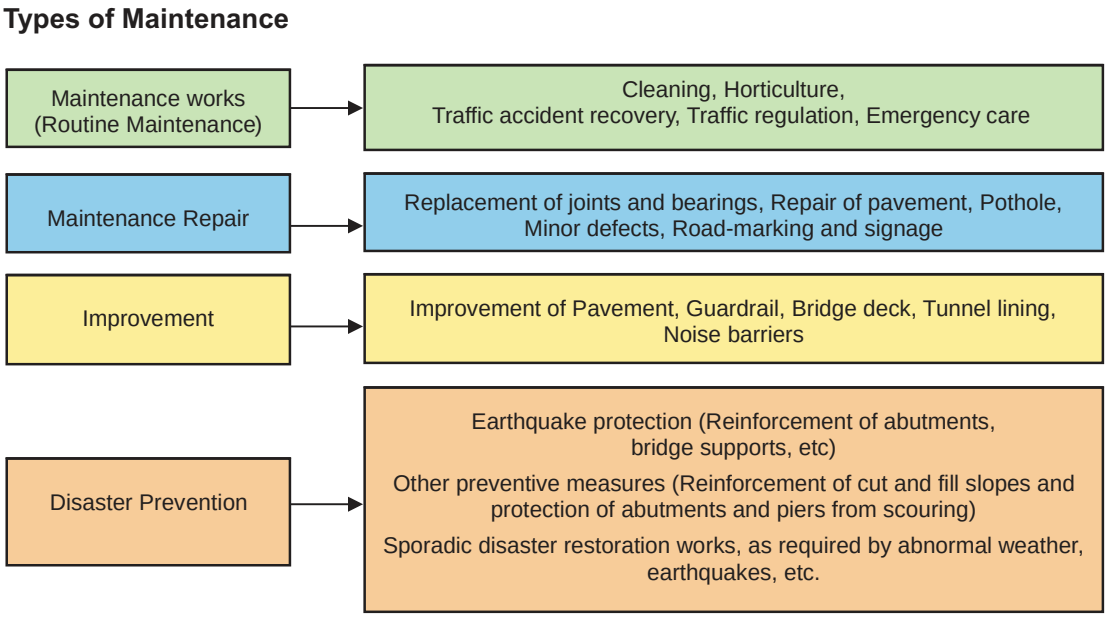


Fig. 2.01 Types of Maintenance Activities

4.2 MAINTENANCE WORKS

Clearing works are classified in areas (Carriageways, shoulders, rest areas, road appurtenances)

4.2.1 *Cleaning works*

Classification

Cleaning works are designed to relieve roads of litter, soil, dust, etc. to allow them to perform normal functions, preserve road and roadside environmental amenities, and maintain ideal landscape, as classified below:

Classification	Sub-classification	Working method		Coverage
Surface cleaning	Type A cleaning	Cleaning by sweeper		Main line and ramp way shoulders and their peripheries
	Type B cleaning	Washing by sprinkler truck		Main line and ramp way shoulders beyond reach of sweeper
	Type C cleaning	Manual cleaning to supplement type A or B cleaning		Mostly, road surfaces
	Type D cleaning	Manual cleaning of roads not covered by type-A or B cleaning		Road surfaces
Interchange and area cleaning	Type A cleaning	Manual cleaning		Service and parking areas (road portions)
	Type B cleaning	Manual cleaning		Service and parking areas (garden portions)
	Type C cleaning	Manual cleaning		Interchanges (garden portions)
Associated facilities cleaning	Lavatories	Manual cleaning		Lavatories in service/parking areas and bus stops (windows, floors, washrooms, stools and bowls, etc.)
Cleaning of road attachments, etc.	Crash barriers	A	Manual cleaning	Guardrails
		B	Manual cleaning	Handrails
	Traffic signs	A	Manual cleaning	Delineators, distance markers, emergency telephone signs
		B	Manual cleaning	Overhead traffic signs
		C	Manual cleaning	Signs on the shoulder
		D	Manual cleaning	Traffic control, warning and other signs installed on the shoulder
	Drain pipes	A	Mechanical cleaning	Underground drain pipes (150-300 mm dia)
		B	Mechanical cleaning	Underground drain pipes (350-1200 mm dia)
		C	Mechanical cleaning	Circular waterways
	Gutters	A	Manual cleaning	Rolled gutters
		B	Manual cleaning	Uncovered gutters
		C	Manual cleaning	Covered gutters
	Median strips (inlets)	Manual cleaning		Median strip (inlets)
	Catch basins	A	Manual cleaning	Catch basins
		B	Mechanical cleaning	Catch basins
	Joints	A	Mechanical cleaning	Joints on the two-lane (each way) highway
		B	Mechanical cleaning	Joints on the three-lane (each way) highway
	Catch basins or highway bridges	A	Manual or mechanical cleaning	Catch basins on bridges and viaducts
		B	Mechanical cleaning	Cleaning of catch basins and drain pipes of bridges and viaducts to assure smooth flow
	Tunnel side walls	A	Mechanical cleaning	Cleaning of tunnel side walls (interior boards, etc.) with tunnel washer and sprinkler truck
		B	Mechanical cleaning	Cleaning of tunnels side walls (interior boards, etc) with multi-purpose wet cleaner and sprinkler trucks
		C	Mechanical cleaning	Cleaning of tunnels side walls (interior boards, etc) with multi-purpose dry washer

Note : Generally, cleaning work on highways requires traffic control. It is, therefore, hazardous since cleaning vehicles move slowly.

Accordingly, the roadwork should be performed under full safety provisions.

Surface Cleaning

i) Type A Cleaning

This involves road surface cleaning by sweeper, removing, sand and litter using brush or vacuum type sweeper. Areas cleaned include main lines and ramp way shoulders and their peripheries. Cleaning frequency is determined based on the traffic volume of the areas involved.

Type “A” cleaning (surface)

Note: a) In northern snow countries, roadside soil and sand deposits often fly up in early spring as a cloud of dust during cleaning works. Since this can obscure visibility, roads are often sprinkled to keep dust down.

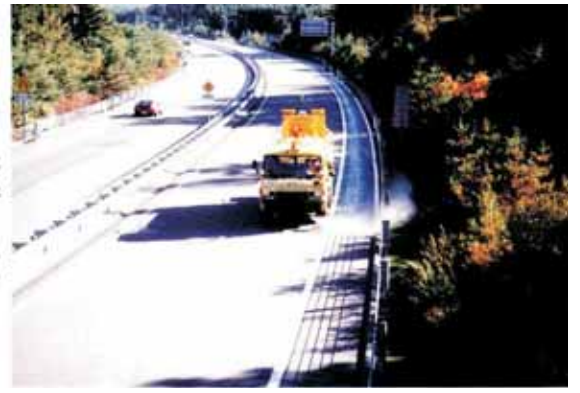
b) Soil, sand, etc. are dumped in compliance with legal restrictions as non-industrial wastes.

ii) Type-B Cleaning

In this operation, sprinkler trucks are used to blow off soil, sand, etc. with the pressure of water flushed through the sprinkler nozzle.

Note: a) Careful attention should be paid at sites where expressways overpass highways.

b) Cleaning work should be suspended at locations where “No snow dumping” signboards are installed.



Type “B” cleaning (surface)

iii) Type-C Cleaning

In this cleaning, litters, and other scattered obstacles such as cargoes slipped off from running vehicles and wastes are removed manually by workers. For this operation, 2 to 4

ton capacity trucks are used.

Note: Since the cleaning truck stops and starts anywhere on the road to pick up litter, and this action is repeated often, there is a hazard that passing vehicles can hit the service truck while stopped for a pick-up. Therefore, swift pick-up with appropriate safety precautions is required.

Type “C” cleaning (surface)

iv) Type-D Cleaning

This involves manual cleaning of roads not covered by type A and B cleaning. Soil, sand, litter, etc, scattered on the surface within 1.5 m from road edge, dropped cargoes, wastes and other obstacles scattered on the road are removed manually. Trucks of 2 to 4 ton capacity are usually used for this purpose.

Note: Refer to Type-C cleaning (road surface).

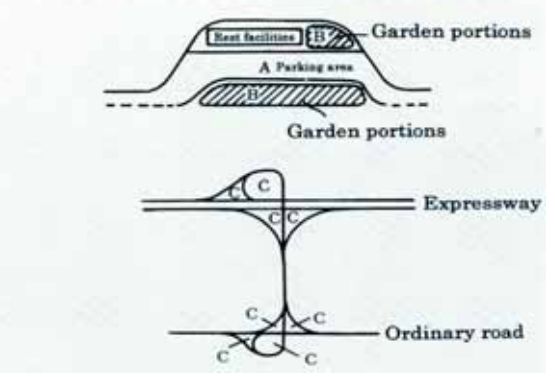
Type “D” cleaning (surface)

Interchange and rest area cleaning

This involves manual cleaning of rest facilities (parking areas and garden portions) and interchanges (garden portions).

Classification:

- Type A cleaning: Rest facilities (parking place and road surface)
- Type B cleaning: Rest facilities (garden portions)



Types of cleaning in interchange and rest area

- Type C cleaning: Interchanges (garden portions surrounded by looped ramps)

Litter collected is carried by 2 to 4 ton capacity trucks.

- Type A cleaning: Manual cleaning of rest facilities (parking place and road surface)
- Type B cleaning: Manual cleaning of service and parking areas (garden portions)
- Type C cleaning: Manual cleaning of interchanges (garden portions)

Interchange area cleaning

Lavatory cleaning

This involves cleaning of toilets in the service and parking areas, focused on 1) window, 2) floors, 3) wash basin rooms, 4) stools and 5) walls, using detergents.

Note: a) Perform cleaning works during non-rush hours.

b) Place work signs outside the lavatory being cleaned.

c) Carefully clean the lavatory avoiding water splash.

Lavatory cleaning

Crash barrier cleaning

This involves manual and mechanical cleaning of guardrails and handrails using detergents to upgrade driving environment and improve delineation. Tunnel cleaner is used for this cleaning work.

Note: Pre-check nearby streams to assure that no waste water flows into fish nurseries, etc.

Manual Cleaning of Guardrails

Machanical Cleaning of Guardrails

Cleaning of traffic signs

This involves detergent-applied manual cleaning of 1) traffic guide, regulatory and warning signs, etc. and 2) delineators, etc. for better visibility from vehicles on highways.

High overhead signs are cleaned by crane trucks.

Note: a) Carefully wash high overhead signs so as not to splash water to passing vehicles.

b) If damaged on the surface, traffic signs lose power of reflection. Wipe them off with soft cloth.

c) In cold, snowy locations, delineators are easily spoiled or stained. They should be cleaned as often as required.

- Type A cleaning : This involves manual cleaning of delineators, kilometer posts and emergency telephone signs.

- Type B cleaning : This involves manual cleaning of overhead traffic signs using crane trucks.

Type “B” cleaning (traffic sign)

- Type C cleaning: This involves manual cleaning of traffic signs installed on the road shoulder.
- Type D cleaning: This involves manual cleaning of regulatory, warning, and other signs installed on the shoulder.

Type “C” cleaning (traffic sign)

Cleaning of drain pipes

This involves removal of soil, sand and dust deposits from underground drain pipes, gutters and round-shaped drains. In this operation, high-pressure washer or sprinkler trucks are used to flush deposits to catch basins by means of powerful hydraulic pressure.

Where soil, sand, etc. is coagulated beyond the capacity of hydraulic pressure, workers take part in manual cleaning.

Note: Thorough patrol inspection and cleaning is essential before rainy and typhoon seasons come.

Cleaning of drain pipes (manual)

Cleaning of drain pipes (high-pressure water)

Cleaning of gutters

This involves manual removal of soil, sand and trash deposits from U-drains and rolled gutters installed on the shoulders, median strips, longitudinal drains on the slope, slope toes and berms. Branches of trees and grass over drains and gutters should be cut off or pruned.

Soil, sand, etc. should be carried to designated or remote dumps to ensure they do not flow back into these drains or gutters.

Type "A" cleaning (gutters)

Note: Thorough patrol inspection and cleaning is essential before rainy and typhoon seasons come.

- Type 'A' cleaning (gutters): Manual cleaning of rolled gutters

- Type B cleaning (gutters): Manual cleaning of uncovered gutters

Type "B" cleaning (gutters)

Type C cleaning (gutters): Manual cleaning of covered gutters

Cleaning of median strip inlets

This involves manual removal of soil, sand and dust deposits accumulated at rainwater drainage inlets installed on the median strip.

Note: a) Thorough patrol inspection and cleaning is essential before rainy and typhoon seasons come.

b) Preferably, gutters should be cleaned to remove soil and sand deposits concurrently with the above cleaning.

Cleaning of median strip inlet

Cleaning of catch basin

This involves removal of soil, sand and dust deposits from catch basins either manually or mechanically using a vacuum sweeper attached with a mud sucker.

Note: a) Thorough patrol inspection and cleaning before rainy and typhoon seasons come is essential.

b) The catch basin should be tightly covered after cleaning to avoid hazard of accidents.

c) Where soil and sand deposits are coagulated, soften them by hand to ease mud suction.

- Type A cleaning: Manual cleaning of catch basin

Type “A” cleaning (catch basin)

- Type B cleaning: Mechanical cleaning of catch basin

Type “B” cleaning (catch basin)

Cleaning of Joints

This involves manual or mechanical (using high pressure washer) removal of soil, sand and dust deposits in the drainage system and pipes of steel comb-type expansion joints installed on bridges and viaducts.

Note: a) Start cleaning at the higher end of a slope

b) Keep joints well maintained to prevent corrosion or damage as well as enable them to retain good drainage.

c) Clean joints carefully so as not to splash over people passing under the bridge with mud.

- Type A cleaning: Cleaning of joints on the two-lane (each way) highway

- Type B cleaning: Cleaning of joints on the three-lane (each way) highway

Type "A" cleaning (Joint)

Cleaning of catch basin on highway bridges

This involves manual or mechanical (with high pressure washer truck) removal of soil, sand and dust deposits in catch basins and drain pipes of bridges and viaducts.

Note: a) Thorough patrol inspection and cleaning before rainy and typhoon seasons come are essential.

b) The basin should be tightly covered after cleaning to avoid accidents.

- Type A cleaning: This involves manual or mechanical (with high-pressure washer truck) cleaning of bridges and viaduct.

Type "A" cleaning (catch basin)

- Type B cleaning: This involves manual cleaning of catch basins and drain pipes of bridges and viaducts with a high pressure washer truck.

Cleaning of tunnel side-walls

This involves manual and mechanical (with washer truck) cleaning of tunnel side-walls in dry or wet modes, using a sprinkler truck for washing.

Note: a) As a cloud of dust is raised during the dry cleaning, take safety precautions for passing vehicles.

b) The drain system should be prechecked to inhibit outflow of foul cleaning water.

c) Adjust the cleaning brush to the desired contact pressure to prevent damage to interior boards in the tunnel.

d) Pay attention to ITV, delineators, etc.

Type “A” cleaning (tunnel)

e) Use manual cleaning to make up for unevenness from mechanical cleaning.

f) Preferably, clean inspection galleries, handrails, etc. at the same time.

- Type A cleaning: This involves washing of tunnel side walls (interior boards, etc) with a sprinkler truck after cleaning by a washer truck.

- Type B cleaning: This involves washing of tunnel side walls (interior boards, etc) with a sprinkler truck after cleaning by a multi-purpose washer truck.

- Type C cleaning: This involves mechanical cleaning of tunnel walls (interior boards, etc) by a multi-purpose dry cleaning truck.

Type “B” cleaning (tunnel)

4.2.2 *Horticultural activities*

4.2.2.1 Type of plantation work

Plants are nursed as follows:

i) Trees: Care of independently planted trees and shrubs and maintenance of hedges and row-planted trees. (1) Pruning, (2) Manuring, (3) Insecticide spray, (4) Weeding, (5) Weed-vine clearing, (6) Irrigation, (7) Other maintenance (renovation of tree props, protection of trees from snow and wind, mulching, nursing of injured, sickly, fallen or decayed trees).

ii) Forests: Nursing of existing forests and saplings to form new forests in the future. (1) Weeding cutting, (2) Supplementary planting, (3) Root treading,

(4) Fertilization, (5) Raising up fallen trees, (6) Thinning, (7) Weed-vine clearing, (8) Insecticide spray, (9) High branch cutting, (10) Branch cutting.

iii) Nursing of turfs: Turfs in the median strips, in the loops interchanges and service/parking areas and lawns around buildings (1) Herbicide spray, (2) Manual weeding, (3) Lawn mowing, (4) Insecticide spray on turfs, (5) Lawn fertilization, (6) Top dressing, Aeration.

iv) Nursing of planted slope: This involves nursing of plants on cut or embankment slopes close to the ramps of the main lines, interchanges and service/parking areas, and maintenance of verge shoulders. (1) Slope fertilization, (2) Herbicide spray on the slope, (3) Grass cutting, 4) Removal of rough weed, 5) Protection of plants from harmful insects, 6) Felling shrubs, 7) High branch cutting, 8) Thinning.

v) Gardening fixtures: Promenades, benches, outdoor tables, pergola, water fountains, etc.

4.2.2.2 Pruning

This is the manual or mechanical cutting off of limbs and twigs of trees for better shape. Pruning time varies with the species of trees planted. Commonly, autumn (October through November) is the best season for pruning coniferous trees. For evergreen trees, the ideal season for pruning is late spring to early summer (May through June) when new buds halt growth after sprouting, and early autumn (September through October) when summer shoots and long shoots stop growing up after second growth. For deciduous trees, July through August (the pre-typhoon season) when fresh green leaves have matured into solid leaves, and November through March when leaves fall off the trees, are optimum season for pruning.

i) Pruning (manual): Manual trimming, cutting off and thinning of limbs and twigs of trees.

Pruning (Manual)

ii) Pruning (mechanical) : Mechanical trimming, cutting off and thinning of limbs and twigs of trees.

Pruning (Mechanical)

iii) Pruning (with multi-purpose vehicle): This involves pruning with a special vehicle attached with trimmer.

Pruning with multi-purpose vehicle

4.2.2.3 Plant fertilization

Providing trees with manures

i) *Plant fertilization (with solid manures)*

This involves providing trees with solid manures. Ideally, trees should be manured during

December through March or during June through September, except for summer when the soil is dried up or winter when the ground freezes. Flowering plants should be manured before flower bud differentiation and after petal fall-off.

Plant fertilization (with solid manures)

ii) ***Plant fertilization (with manure piles)***

Manure piles are used to fertilize trees during the same period as by solid manures above

Plant fertilization (with manures piles)

4.2.2.4 Insecticide spray on trees

Insecticides are sprayed on trees to purge them of harmful insects.

Note: a) Timely discovery of trees infested with harmful insects through patrol inspection.

b) Consult experts for right chemicals to be applied to trees infested with the insects.

c) Carefully spray chemicals ensuring that no worker inhales or contracts sprayed chemicals.

Insecticide spray on trees along the median strip

Insecticide spray on trees planted in service facilities

4.2.2.5 Weed-vine clearing

Weed vines climbing trees are cut off manually. Merely cutting off vines halfway is not enough as it would permit their re-growth. Vines should be uprooted or eradicated using herbicides. For this operation, the best time of the year is early summer (June through July) when vines are running out of their stored nutrients and not ready yet to restore new ones.

Weed-vine cleaning

4.2.2.6 Irrigation

Water is supplied to soil by sprinkler truck. Soil should be irrigated during the dry summer season and during the prime growth period of plants and before they stop growing up.

Note: a) In summer, irrigate trees in the early morning or in the evening, but not under direct sunlight during daytime.

b) Summer irrigation should not be suspended halfway, but continued until substantial rainfall.

Sprinkler truck

4.2.2.7 Renovation of props and supports

Tree props and supports are renovated for the purpose of protecting trees from falling, inclination, ruptures and consequent damages or accidents. Another aim is to maintain better roadside environment.

Removal of props

4.2.2.8 Removal of props

Though it varies with the species involved, trees get firmly rooted with their trunks becoming solid and stable, about 6 to 10 years after planting. As props are no longer required at this time, remove them, beginning with rotten ones.

Removal of props

4.2.2.9 Removal of decayed or damaged trees

Decayed or damaged trees not only spoil a scenic view but may also result in spreading trees infested with harmful insects. Left unattended, they could fall off by themselves spontaneously. Potentially, they can threaten the health of local people and damage nearby facilities, too. For this reason, they should be immediately uprooted.

Removal of damaged trees

4.2.2.10 Weed cutting

This involves manual cutting of weeds growing thick around young trees, preferably during June through July when they lose regenerative power. Spread weeds cut off around trees. It is effective for curbing growth of other weeds, keeping soil dry, protecting surfaces soil and making it more fertile.

Note: Cut down after September, a season when weeds have stored nutrients and trees are exposed to cold wind should be avoided

Weed cutting

4.2.2.11 Felling of deal trees

Felling of selected trees, including thinning of forests and cutting obstructive trees where no obstruction exists around the trees worked, they are cut down at the base and branches are removed. On the other hand, where there is any obstruction around them, trees are hung on the wrecker and cut off at the base, or manually suspended from the pulley with branches to be removed first, followed by the trunks which are to be cut by 1 to 2 meters from the tip downward.

Felling of dead trees

4.2.2.12 Lawn mowing

Mechanical mowing of turfs to renew stem leaves, check growth of weeds and preserve scenic view. Turfs should be mowed during July through September, which is their prime growth season. Lawn mowers are commonly utilized in large turfed areas besides interchanges, service and parking areas and median strips.

Mowing turfs

4.2.2.13 Fertilizing turfs

It is more effective if turfs are manured during March through May, concurrently with placement of top dressing soil. Select manures to be used depending on the season and frequency involved.

Fertilizing turfs

Note: a) Preferably, turfs should be fertilized when wetted with rainfall or morning dew.

b) Avoid fertilization in a dry season.

c) Avoid or carefully use liquid fertilizer or readily water soluble fe

rtilizer since it can injure turfs.

d) Avoid fertilization when ground is frozen.

4.2.2.14 Manual weeding

This involves manual weeding of ground around trees and turfed gardens. It is more effective if weeding is done during May through June for spring and summer grass and during July through August for autumn and winter grass to prevent inhibiting growth of trees and turfs, harmful insects and malfunctions to safety equipment.

Manual weeding

Note: Weeds should be uprooted including cpillary roots

4.2.2.15 Chemical spray

Chemicals are sprayed to curb growth of weeds in a germinating phase and kill them in a growing phase. It is more effective if chemicals are sprayed during April through May for spring and summer grass, during July through August for summer and autumn grass and during September through October for autumn and winter grass.

Chemical spray

Note: a) Consult experts for the right chemicals suited for the weeds to be uprooted.

b) Carefully spray chemicals to avoid contact with human bodies. In the event of contract, wash them away immediately.

4.2.2.16 Insecticide spray on turfs

Chemicals are sprayed on turfs for prevention and purging of harmful insects, preferably during April through October when harmful insects are active.

Note: a) Consult experts for the right chemicals suited for grass infested with insects.

Insecticide spray on turfs

b) Carefully spray chemicals to avoid contact with human bodies. In the event of contact, wash them away immediately.

4.2.2.17 Top dressing

Soil is filled up on the turfed ground to level grass surface and curb overgrowth of turf buds. It is effective if top dressing is applied during March through May concurrently with fertilization. Sandy soil is ideal for top dressing. It should be filled up thick enough (3 to 6 mm) to cover the crest of buds, followed by roller finish or irrigation.

Top dressing

4.2.2.18 Grass cutting

This involves manual and mechanical mowing of part of grassy area on the road shoulder and roadside cut or embankment slopes.

Note: a) Weeds cut off should be neatly packed into containers.

b) Weeds left uncut after mechanical mowing should be neatly cut off by hand.

c) Weeds should be cut off at any time as they can be a possible menace to traffic safety, cause fire, spoil visibility of delineators or exert adverse effect on nearby environment.

d) Mechanical mowing can cause pebbles, metal fragments, etc. to fly at work sites. Therefore, remove them before mowing the area.

i) Grass cutting (with shoulder-suspended grass cutter)

This involves mowing with a shoulder-suspended grass cutter.

A Shoulder - suspended grass cutter

ii) Weeding (with self-driven slope grass mower)

This involves mowing roadside slopes with a self-driven, remote-controlled grass mower.

Self-driven slope grass mower

iii) Weeding (with multi-purpose weeding vehicle)

This involves mowing roadside slopes with a general-purpose weeding vehicle.

Multi-purpose weeding vehicles

4.2.2.19 Slope fertilization

Roadside slopes are manured in the spring season. Where a slope is bare of plants, it is more effective to spray seeds together with manures.

4.2.3 *Traffic Accidents Recovery Works*

Traffic accident recovery works shall generally provide:

- A 365 days response system
- Immediate response and an understanding of all the actions and measures necessary to recover traffic as soon as possible and prevent secondary damage to the surrounding environment

Slope fertilization

Accidents can occur in a variety of locations, so high level of experience and know-how, as well as immediate response is required.

Accident recovery works are classified in six categories:

i) Replacement of crash barriers

ii) Replacement of boundary fences

iii) Replacement of anti-glare screens

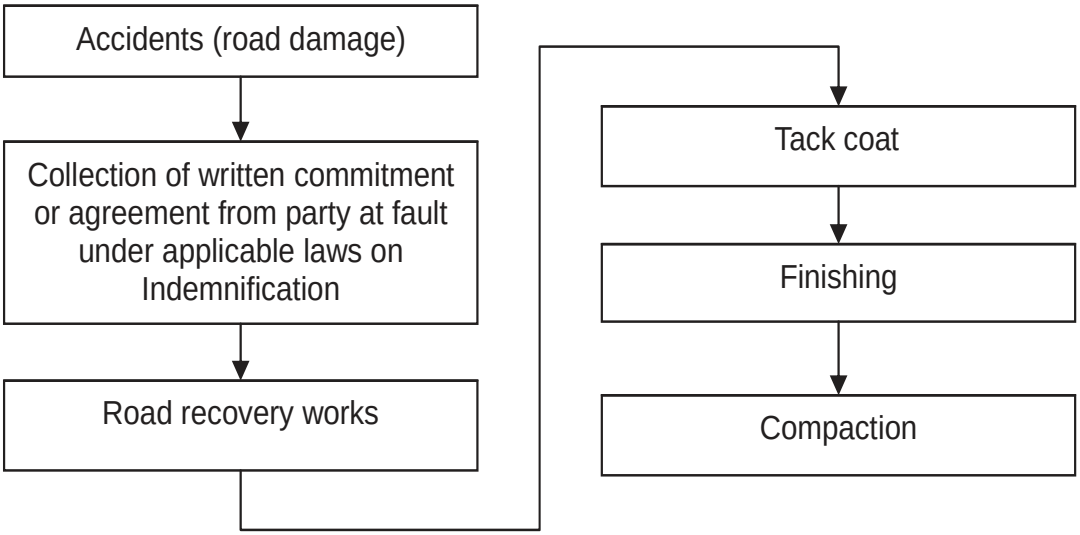
iv) Replacement of delineators

v) Replacement of kilometer posts

vi) Replacement of traffic signs

In addition to the above, extra works may be involved, depending on the properties damaged.

Procedures for indemnification.



4.2.3.1 Replacement of crash barriers

i) *Guardrails*

This involves replacement of damaged guard rails (rails, posts and wing rails) with new ones.

Guardrails (damaged)

Guardrails (mended)

ii) ***Replacement and restraining of guardrails***

This involves replacement (including connection) of damaged guard cables and posts and restraining loose cables.

Guard cables (damaged)

Guard cables (mended)

iii) ***Replacement of box beams***

This involves replacement of damaged box beams and posts.

iv) ***Straightening titled posts***

This involves straightening inclined posts and struts.

v) ***Replacement of guard cable terminal posts***

This involves replacement of posts of damaged guard cable terminals or intermediate terminals.

4.2.3.2 Replacement of boundary fences

This involves replacement of damaged posts, struts and wire nets.

Boundary fences (damaged)

Boundary fences (mended)

4.2.3.3 Replacement of anti-glare screens

i) Replacement of anti-glare screens (expansion metals)

Damaged expansion metals or posts are replaced with new ones.

Damaged screens

After replacement

ii) Replacement of anti-glare plates

Damaged anti-glare plates are replaced with new ones.

Damaged screens

After replacement

iii) Replacement of anti-glare nets

This involves replacement of damaged nets and posts, and terminal post ropes with new ones.

4.2.3.4 Replacement of delineators

This involves replacement of reflector plates and posts of damaged delineators with new ones.

Delineators (damaged)

Delineators (after replacement)

4.2.3.5 Replacement of kilometer posts

Damaged road posts are replaced with new ones

Before replacement

After replacement

4.2.3.6 Replacement of traffic signs

Damaged traffic signs are replaced with new ones.

Before replacement

After replacement

4.3 MAINTENANCE REPAIR

4.3.1 *Replacement of bridge bearings and expansion joints*

4.3.1.1 Bridge bearings

MORTH - Specifications for Road and Bridge Works published by IRC specifies the different types of bearings generally used in structures such as steel bearings, elastomeric bearings, and pot bearings. These specifications aptly provide details for execution and maintenance of the bearings.

4.3.1.2 Expansion joints

MORTH - Specifications for Road and Bridge Works published by IRC provides the details regarding provisions, execution and maintenance of expansion joints. However, the followings as practiced in Japan are presented for illustration.

Current expansion joints are classified into three types as follows:

i) Elastomeric joint

It features a combination of elastomer with steel for application to concrete bridges. It is further classified into four types: elastomer-surfaced joint, steel-surfaced joint, butt joint non-load bearing, and load bearing joint.

ii) Steel finger joint

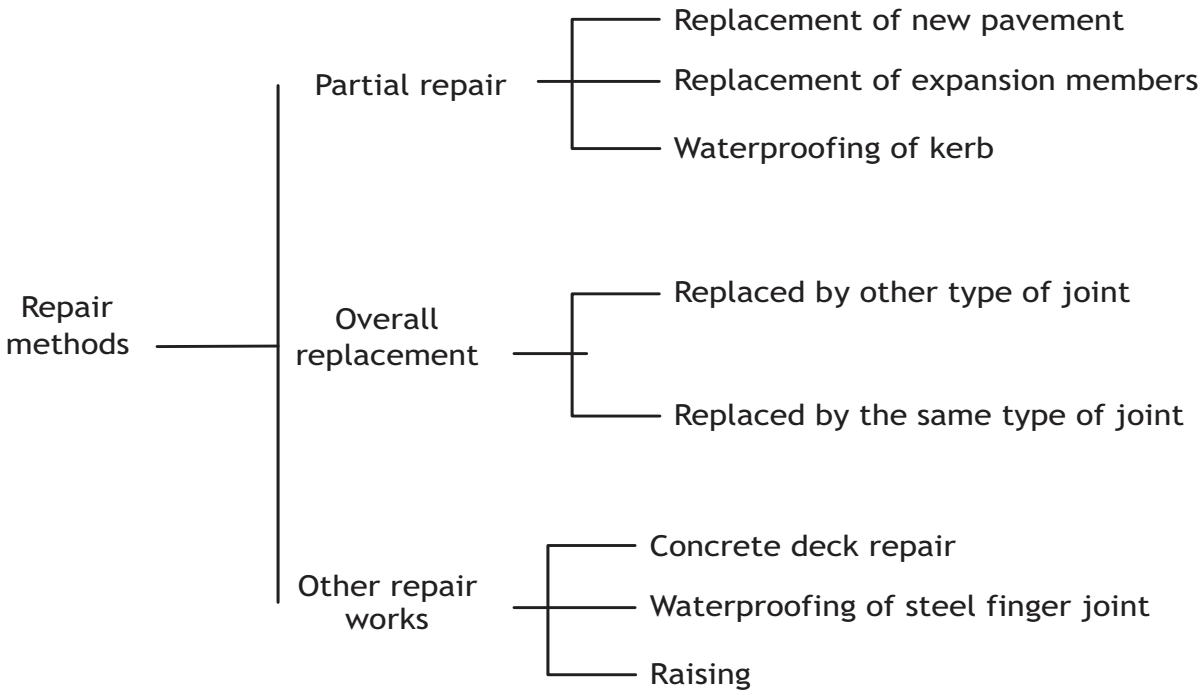
It represents a comb-type expansion joint capable of directly bearing tyre load, as applied to steel bridges and concrete bridges with highly expandable beams.

iii) Buried joint

Expansion joint composed mainly of pavement materials, etc. having properties similar to those of neighbouring pavements, commonly applied to concrete simple girder (on the fixed side) of a bridge.

Repair methods for expansion joints

Repair methods are classified as follows:

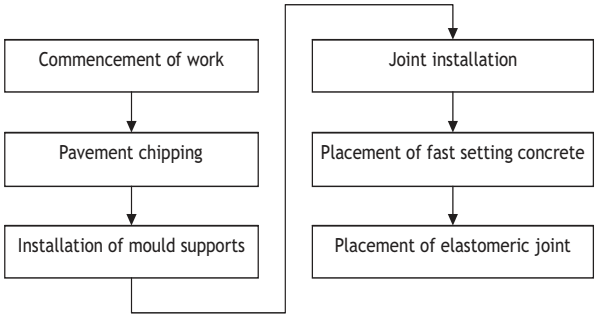


Note:

- Repair them as soon as possible
- Repair them properly after tracking the cause of damage
- Develop a detailed work plan in full consideration of traffic regulations to be imposed
- Preferably, repair damage to concrete deck damages concurrently with joint renovation

4.3.1.3 Replacement of Elastomeric Joint

Work Flow:



Commencement of Work: Assess the severity of damage involved and mark the cut position along the contour of existing joint pavement before inserting a cutter with care to avoid hurting the deck.

Commencement of work

Pavement Chipping: Carefully remove pavements in order not to damage concrete deck and anchor members with breaker, etc. When breakers are used for removal, pay extra care not to scatter concrete fragments, etc. onto the road.

Pavement chipping

Installation of mould supports: After thorough cleaning of concrete face following pavement chipping, place mould supports.

Installation of mould supports

Joint installation: After installing joints with setter (angle), fix them with anchor bolt and insert reinforcing bars.

Joint installation

Placement of fast setting concrete: Clean the surface where concrete is to be placed with air compressor and place concrete. Be careful not to produce difference in grade or gap between existing expansion system and pavements. After placement, spray film curing agent to set concrete, but no curing by water spray should be applied.

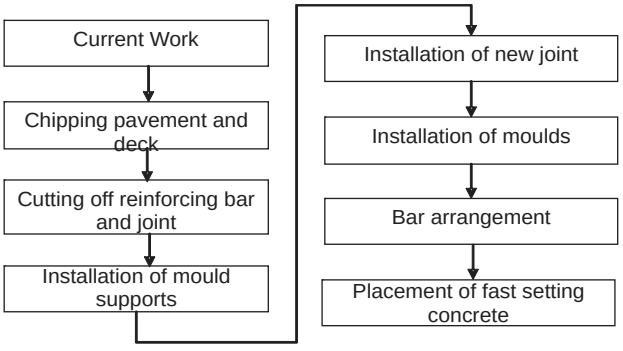
Placement of fast setting concerete

Placement of Elastomeric joint: After concrete has set, install elastomer joints.

Placement of Elastomeric joint

4.3.2 *Replacement of steel finger joint*

Work Flow:



Cutting and removal of reinforcing bars and old joints

Installation of new joints and bar arrangement
Reinforcing bars are placed for tight connection as required

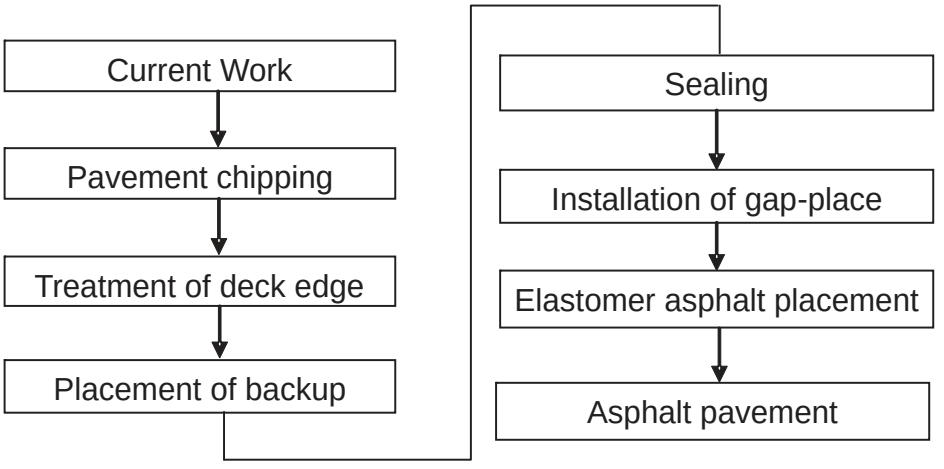
Placement of fast setting concrete

Clean the surface where concrete is to be placed with air compressor and place concrete. Be careful not to produce difference in grade or gap between the existing expansion system and pavements. After placement, spray film curing agent to set concrete.

Placement of fast setting concrete

4.3.3 *Replacement of elastomer with buried joint*

Current Work



Pavement chipping

Limit pavement chipping to a minimum required. Remove chipped pavements carefully to ensure that they do not fall into joint gaps.

Pavement chipping

Treatment of deck edge

Finish concrete face as smoothly as possible. Where excessively large gaps are created due to replacement of rubber joint with buried joint, correct such gaps concurrently with touch-up and reinforcement of concrete faces.

Treatment of deck edge

Backup material placement

Coat joint gaps with adhesives and fill in after sufficient precompression.

Backup material placement

Sealing

Clean concrete face and evenly spread sealant about 1 cm in excess of gap plate width.

Sealing

Gap plate installation

Install gap plate in tight contact with elastic sealant before sealant cures.

Gap plate installation

Elastomer asphalt placement

Pour in enough elastomer asphalt to cover the top of gap plate.

Elastomer asphalt placement

Asphalt pavement

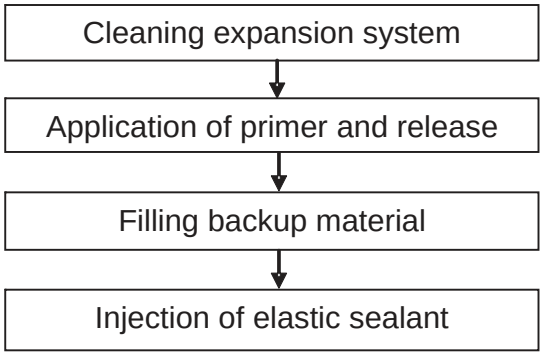
Apply tack coat before asphalt paving and preheat the existing pavement along the cut line with burner so as to enhance adhesion with the new pavement.

Asphalt pavement

4.3.4 *Waterproofing of steel finger joint*

Waterproofing of steel finger joint is based on the following process:

Work Flow:



Cleaning of expansion joint

Clear expansion joint of sand, soil, etc. before cleaning. Remove rust and stains from flume surface to enhance primer cohesion

Cleaning of expansion joint

Application of primer and release agent

Coating joints with small gaps with primer is an awkward job. Make sure that no part of any joint is left uncoated.

Application of primer and release agent

Filling backup material

Urethane foam is injected into the drainage flume of the expansion system and hard urethane foam (in-site foamed) is injected to secure design thickness of elastic sealant injected.

When filling in backup material, make sure primer-applied surface has been kept dry. Use extra care for edge treatment.

Filling backup material

Injection of elastic sealant

Prior to injection of elastic sealant, apply masking tape to finger plate surface to protect it against dirt or stain, and pour in the sealant after primer has dried, taking care to provide edge portions with intended injection thickness.

Injection of elastic sealant

4.3.5 *Minor renovation of pavements*

4.3.5.1 Pot holes

This involves repair of local pot holes occurring on pavement due to aging of mixtures. Pot holes can be repaired as follows:

- Patching: Pot holes are repaired by filling material (cold or hot mixed materials)
- Local replacement of pavements

Before renovation

Completed

4.3.5.2 Crack seal

This involves mending of pavement cracks by injecting asphalt, filler, etc. Pavement cracks should be repaired as early as possible to prevent rainwater infiltration into base or subgrade, leading to damage to overall pavements. Cracks should be well cleaned and dried before filling.

Before renovation

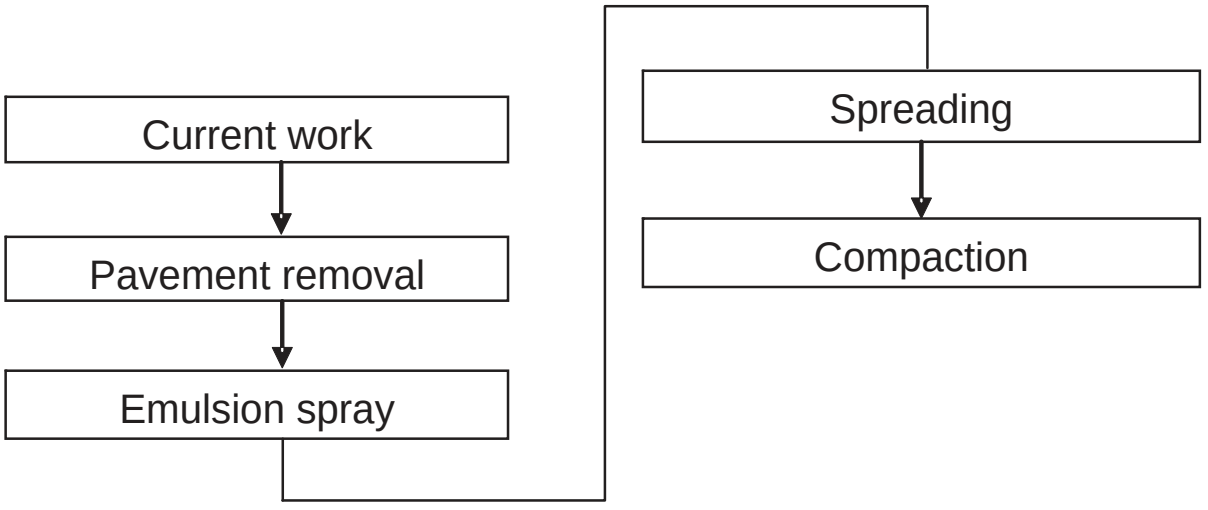
Completed

4.3.6 *Local replacement of pavements*

4.3.6.1 Conventional

This involves removal and replacement of damaged pavements, base or subgrade in cases where pavement cracks and subsidence have progressed to damage base or subgrade. In this mending work, probable causes of damage such as cracks, subsidence, etc., should be traced and countermeasures taken.

Work flow:



Cutting and Chipping

After cutting existing pavements with concrete cutter, the damaged portion of pavement within the cut line is removed by chipping machine.

Pavement cutting

Pavement Chipping

Emulsion spray

Asphalt layer is crushed by rock-drill and removed by backhoe before intensive cleaning and emulsion spray.

Emulsion spray

Spreading and compaction

Mechanical rolling compaction tends to fail to cover corners and edges. Use extra care for even compaction over the entire surface.

Levelling

Rolling

4.3.6.2 New generation road repair

In new generation of road repair, surface defects are repaired by recycling the existing pavement material using the latest technique such as infrared technology to create a quickly, seamless and longer-lasting repair.

Typical all in one vehicle

In the process a thermo-bond is created between the repair area and the existing bituminous surface. The work is performed in four steps as follows:

Step 1 : The portable infrared heater is positioned over the defect and heats the surface area to approximately 160-170°C.

Step 2 : The existing surface is re-worked. The heat generated by the infrared heater creates a strong thermo-bond between the new material and the existing surface, reducing potential future weak points.

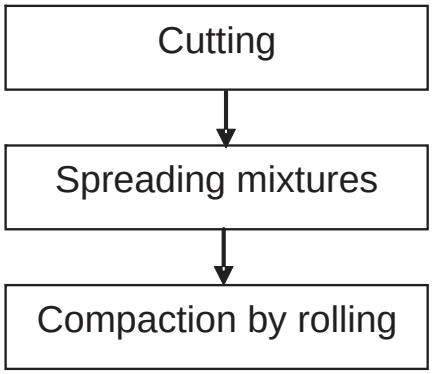
Step 3 : A suitable rejuvenating materials added to the defective area.

Step 4 : A small amount of material from the on-board 'hot box' in the vehicle may be added as required. Because the existing material is rejuvenated and reused, the amount of new material needed is minimised. The area is then raked and compacted by a portable plate vibrator transported in the vehicle to create a seamless joint.

4.3.7 *Correction of difference in grade*

Where there is a difference in grade between structure mixtures is partially overlaid to level them.

Work flow:



Pre-construction phase

Perform pre-construction survey and determine the scope of work, considering a difference in grade between structure and embankment section and paying attention to smooth connection.

Pre-construction survey

Cutting

In order to improve the workability of new asphalt mixture, scarify the pavement to a certain depth.

Cutting

Spreading asphalt mixtures

In order to improve adhension with existing pavement face, provide tack coat before spreading new asphalt mixture.

Spreading asphalt mixtures

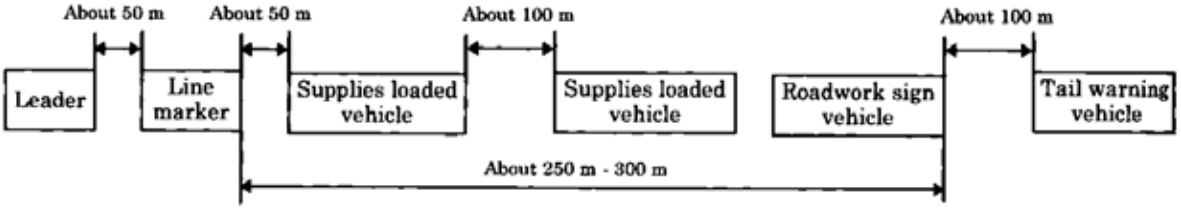
Compaction by rolling

Compact new asphalt pavement with vibratory roller. Normally, pavement is limited to relatively small area; careful attention should be paid to the method of rolling, temperature upon compaction, etc.

Compaction by rolling

4.3.8 *Road marking*

This involves renewal of obscured road markings. Standard vehicle team-up of edge and center line markings is as follows:



Marking of edge and center lines

Marking of paint lines on the road with a line marker

Marking of edge line

4.3.9 *Partial replacement of bridge decks*

This involves removal of existing pavements and decks and arrangement of reinforcing bars on the mould laid beneath the decks.

Where urgent construction is involved, use fast setting concrete. Confirm concrete strength after curing.

Damaged concrete deck

Joint between the old and new floorings is a weak point in that it tends to permit water leakage. Accordingly, apply waterproofing works to cover overall joints including parts where decks are replaced.

Photo shows liberated lime and trace of water leakage beneath the concrete decks of the steel bridge.

Chipping of the concrete deck

Chipping of the concrete deck

Arrangement of reinforcing bars

Arrangement of reinforcing bars

CHAPTER - 5

MAINTENANCE OPERATIONS

CHAPTER – 5

MAINTENANCE OPERATIONS

5.1 OPERATIONAL CONSIDERATIONS

5.1.1 *General*

The Operation and Maintenance of the Expressway shall be decided to ensure safety and comfort at high speed travel as envisaged in design. All maintenance operations should be planned in such a way that traffic movement is least affected.

The following areas need proper understanding and planning for maintenance :

- Work Zone Safety
- Environmental Protection
- Inspection and Assessment
- Defect Treatment
- Proper equipment

The above points are explained hereafter.

5.1.2 *Work zone safety*

The following are the principles to enhance motorist and worker safety in maintenance work areas:

- Development of a comprehensive traffic control strategy that can be implemented at the work site. Evaluation of the work operation, site, and traffic conditions should determine the traffic control measures to be applied. Refer to "*Highway Safety Code (IRC: SP: 44)"* and "*Guidelines for Safety in Construction Zones (IRC: SP: 55)*." Typical traffic regulation as practiced in Japan is shown in **Fig. 5.01** and **Fig. 5.02**:

The purpose of traffic regulation is to achieve safe maintenance work as well as causing least disturbance to drivers. In case of accident, heavy snow or fog it may be necessary to have traffic control. The traffic regulation activities are carried out in consultation with police and the road administrator. Depending on the degree of necessity, the traffic regulation may be lane control, closing the shoulders, and diversion of all traffic to one lane.

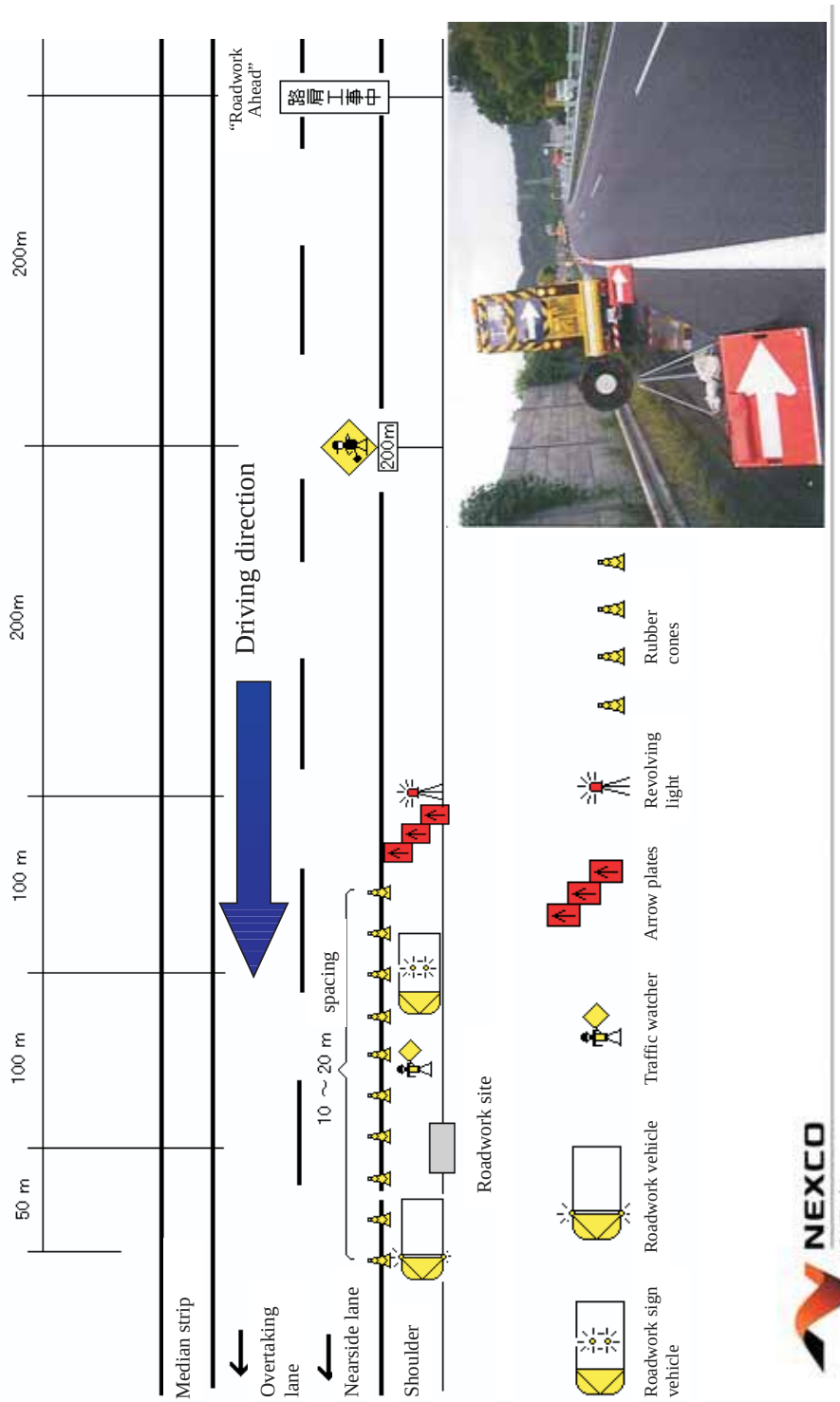


Fig. 5.01 Traffic Regulation on Shoulders

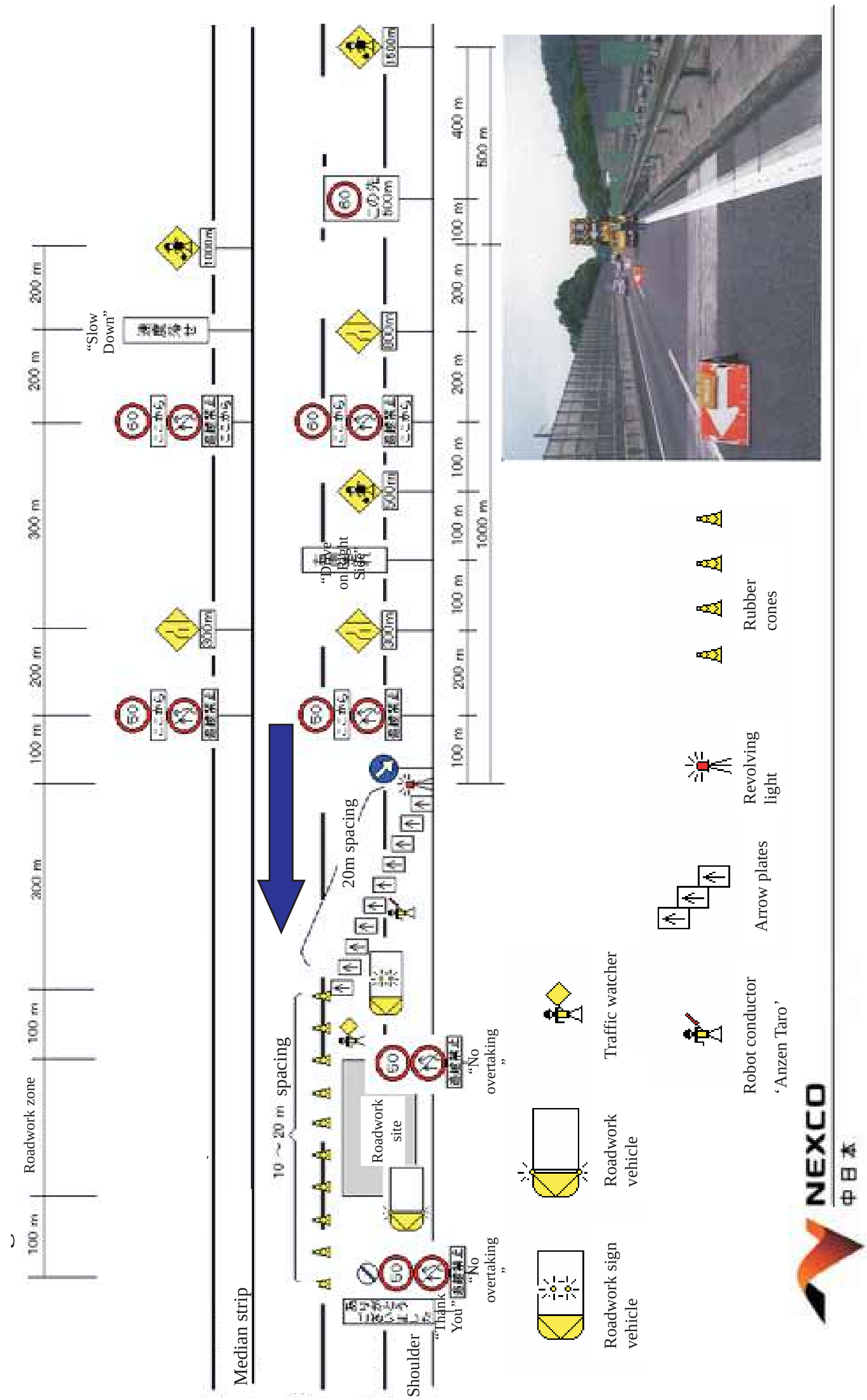


Fig. 5.02 Traffic Regulation on near Side Lanes

5.1.3 *Environmental protection*

The Concessionaire shall take utmost care to avoid damage or degradation to the environment during maintenance activities. The term “environment” as used in this Guidelines refers to the natural surroundings including soil, water, air, plant & animal life, and archaeological and historical resources.

The maintenance engineers, technicians and operating crew must be aware of the requirements for environmental protection in the performance of their duties. An environmentally sensitive area may not be easily identifiable and may not appear to be so obvious to untrained persons.

Some maintenance operations have potential for damaging or destroying archaeological, historical, and sensitive biological resources, as well as culturally sensitive resources, such as Native Plant gathering areas and sacred/holy sites.

Contamination of underground water supplies by hazardous substances (such as gasoline, diesel, oil, and solvents), leaking from underground and above ground sources should be promptly addressed with preventive measures.

Exhaust and crankcase emissions from vehicles and equipment running on petroleum fuel are a prime source of the air contaminants: carbon monoxide, nitrogen oxides, and hydrocarbons.

Some of the Best Environmental Management practices are:

- Use of environmentally sensitive cleaning and releasing agents eliminating diesels and others solvents.
- Adoption of appropriate water pollution control measures.
- Arrangement of adequate erosion control supplies (e.g. diapers, kitty litter, shovel, etc) to keep materials out of water bodies.
- Disposal of excess materials at the designated site.
- Performing surface works in dry weather to minimize runoff of potentially hazardous materials.
- Controlling of the width of cleaning/grading, where applicable, to minimize disturbance of vegetation to control erosion.

- Locating mixing plant at a distance of minimum 500 m from residences or as per local statutory requirements.
- Preparation of an adequate spill plan for running of hot-mix plant and materials for spill containment.
- Stabilisation of disturbed soil permanently using appropriate plants, seeding or mulching.
- Using protection measures, such as turfing, stone pitching, gabions, etc on areas prone to erosion .
- Preparedness to meet any eventuality arising out of heavy rains and flood.
- In critical locations/ flood prone areas, making arrangements for necessary materials and tools (e.g. sand, gunny bags, shovel, rope etc.) to meet emergency requirement.
- Using pesticides according to manufacturer's recommendations.
- Ensuring no contamination to the active flowing stream
- Using water based paints that are more environment-friendly.

5.1.4 *Inspection and assessment*

Inspection report forms the base document for all maintenance operations. The effectiveness and justification of the measures decided has to be evaluated and whether further considerations are required or not, shall be decided prior to implementation.

5.1.5 *Defect treatments – considerations and selection*

The following are the major points to be considered while selecting a treatment for a defect:

- The prime cause of the defect.
- Area/magnitude and severity of the defect
- Suitability of the treatment selected based on:

- prevailing climatic condition
- expected life of treatment
- interference with traffic
- material, plant and crew requirement

- requirement of special material, equipment, or expertise
- complexity of the process
- safety requirement

• Treatment or major maintenance is more appropriate to correct the problem.

• Whether other major maintenance / repair / rehabilitation is already scheduled for the area of the defect.

• Whether the treatment requires any design and trial (for example, application rates of binders, mix designs, etc)

• Priority of work with respect to safety.

• Response time as per Inspection assessment.

5.1.6 Defect – treatment options

Any visible evidence of an undesirable condition in expressway asset is referred as a Defect.

It is advisable that the maintenance works are taken up based on the priority mentioned below:

1) **Safety and Legislative** – All treatments, which are needed to restore safety or correct defects that are legally unacceptable or required to fulfil obligations as part of the works, may be given the highest priority. The treatments in this group are also required to comply with the mandatory legislations.

2) **Preventive** – All treatments, which prevent further deterioration/degradation, may be given the second highest priority.

3) **Usability/Appearance** – All treatments, which are needed for maintenance of time related usability or appearance defects or the defects which do not fall into either of the above two categories mentioned, may be given the lowest priority.

A set of nine tables has been included as illustration and information (ready reference). **Table 5.01** presents activity wise summary of inspections along with possible/current technical options to remedy the defects and are by no means meant to be “exhaustive and unique” solutions.

However, for detailed maintenance treatment options, relevant latest IRC standards shall be considered.

Table 5.01 Defect – Treatment Options

01. Bituminous Pavement			
SN	**Defect**	**Summary inspections**	**Treatment Options**
1)	Isolated Depressions and Bumps	• Isolated depressions and bump which causes noticeable riding discomfort • Ponding of water hazardous to traffic may occur.	• Surface Correction • Pavement Repairs • Thin Bituminous Overlay • Profile Correction
2)	Ruts	• Maximum depth of depression measured vertically using straight edge and wedge, placed laterally • Ponding of water may cause hydro-planing and hazardous to traffic.	• Surface Correction • Slurry Seal • Scarify and reshape • Thin Bituminous Overlay
3)	Shoving	• Depth of depression measured vertically using straight edge and wedge, placed laterally • Ponding of water hazardous to traffic may occur.	• Pavement Repairs
4)	Hungry Surface (Isolated Sections)	• Loss of bitumen fines dislodged bigger aggregates in position	• Slurry seal • Surface Correction • Heavy Patching • Scarify and Reshape • Thin Bituminous Overlay
5)	Potholes	• Any surface break /formation of holes may aggravate	• Pothole Patching • Heavy Patching • Emergency Pavement Repairs
6)	Alligator Cracking	• Inter connected cracks, prone to moisture entry in the pavement.	• Scarify and Reshape Existing Pavement • Crack Sealing / Treatment • Pavement repairs with Strain Alleviating Membranes (SAM)
7)	Surface Cracks, General	• Individual wide cracks or prone to moisture entry in the pavement.	• Fill Cracks • Surface Strip Treatment of Cracks • Seal Coat • Surface Enrichment • Slurry Seal
8)	Edge Break	• On edge of paved shoulder, width of distress measured parallel to carriageway • On edge of earthen shoulder	• Edge Repair with appropriate materials
9)	Edge Rollover (paved shoulder)	• Rollover vertical deviation measured at the edge using a straight edge	• Surface Correction
10)	Edge Rollover (earthen shoulder)	• Rounding at the edge is damaged / eroded	• Surface Correction including protection measures
11)	Flushing/ Bleeding	• Fatty surface causing vehicle tyre slippage	• Patch with dry sand • Seal Coating • Reseal • Slurry Seal
12)	Ravelling or Stripping	• Isolated stripped patches, loose aggregates	• Surface enrichment with bitumen • Slurry Seal • Seal Coating • Thin Bituminous Overlay

Table 5.01 Defect – Treatment Options (contd…)

01. Bituminous Pavement			
SN	**Defect**	**Summary inspections**	**Treatment Options**
13)	Loose Stones on Roadway	• Debris build-up is likely to be hazardous to traffic, **or** obstruct sight distance visibility • Unpleasant appearance	• Surface Sweeping • Roadside cleaning
14)	Dead Animals on Roadway	• May cause safety problem .	• Dead animal clearing and disposal
15)	Rough Manhole Covers and Grates	• Beyond tolerance in relation to surrounding surface	• Premix surface work

02. Rigid Pavement (plain jointed concrete)			
SN	**Defect**	**Summary inspections**	**Treatment Options**
1)	Cracks (diagonal, block, transverse, corner cracks, longitudinal, meandering and surface cracks)	• Individual wide cracks, **or** • Excessive cracking and moisture is prone to penetrate the pavement.	• Crack seal treatment (epoxy) • Stitch- treat Cracks and seal
2)	Spalling of Joints-Concrete Pavement	• Evidence of spalling of concrete occurring adjacent to slab joints.	• Repair Joint and place sealant
3)	Joint Sealant Defects in Concrete Pavement	• Sealant is missing or hardened with cracks	• Replace Joint Sealant.
4)	Potholes in Concrete Pavement	• Evidence of potholes in concrete pavement	• Concrete Pothole Patching
5)	Sunken Concrete Pavement slab	• Difference in height to adjacent slabs	• Jacking of Concrete Slabs (slurry injection)

Table 5.01 Defect – Treatment Options (contd…)

03. Earthen Shoulders			
SN	**Defect**	**Summary inspections**	**Treatment Options**
1)	Loss of materials (including turfing and erosion protection)	• Substantial loss of material which may aggravate erosion.	• Rebuild to original
2)	Wheel Ruts	• Ruts / depressions caused by vehicles	• Formation Grading
3)	Shoving	• Depth measured vertically from crest to sag of shove using a straight edge placed laterally, may be safety hazard	• Formation Grading
4)	Potholes	• Hole size and depth may be safety hazard	• Repair / Fill the pot hole
5)	Insufficient Crossfall	• May lead to surace water accumulation.	• Formation Grading • Resheeting
6)	Excessive Crossfall	• Steeper Crossfall – prone to cause erosion	• Formation Grading • Resheeting
7)	General Defects (e.g. windrows of material, undulations, scour channels, corrugation soft slippery areas, coarse surface texture, loose material)	• Safe travelling speed may be hindrance	• Formation Grading • Formation Resheeting
8)	Scour Channels (Rain Cuts) in Unsealed Shoulder	• Any	• Shoulder Grading • Shoulder Resheeting • Restoration of Earthen Shoulder
9)	Shoulder Edge Drop Off	• Any	• Shoulder Grading • Shoulder Resheeting • Restoration of Earthen Shoulder
10)	Hazardous Dry Loose Shoulder Material	• Loose shoulder material is a potential traffic hazard	• Removal of loose materials • Restoration of Earthen Shoulder

Table 5.01 Defect – Treatment Options (contd…)

04. Drainage System			
SN	**Defect**	**Summary inspections**	**Treatment Options**
1)	Surface Drain Defects (blockage, silting, etc)	• Insufficient grade or silted, water accumulation or any erosion channels in the surface drain. • Drainage endangering adjacent private property	• Install Unlined Surface Drain • Install Lined Surface Drain • Clean Surface Drains • Repair Unlined / lined Surface Drains • Repair or install Scour Blocks
2)	Subsoil Drain Defects (blockage, silting in the system including flush points and outlets, and other defects)	• Any blockage that is retaining moisture in the road formation, **or** • Any non-functional element e.g. hidden, missing **or** unserviceable marker post **or** damaged flush points **or** outlets **or** outlet scour **or** damaged **or** inlet structure corrosion.	• Install Subsoil Drains • Repair Subsoil Drains • Inspect and/or Clean Out Subsoil Drains
3)	Culvert, Pipe, Pit and Floodway Defects, Other	• Waterway obstructions: Over 50% of the entry/exit obstructed or significant erosion or movement of rock protection or weed growth in inverts which will significantly impede water flow. • Scoured Inlet/Outlets: Erosion is likely to affect the structural integrity of the drainage installation (including aprons and cut off walls) or Structural Damage or rust over the concrete surface is such that structural damage affects the integrity of the structure. • Damaged stone pitching apron and batter protection: • The structural integrity of the structure is affected, and there is an unacceptable risk of failure.	• Install Culverts and Pipes • Clean Culverts, Pipes and Pits • Repair Culverts, Pipes and Pits • Repair Steel Drainage Structure • Repair Inlet and Outlet Scour • Replace or Install Cut Off Walls

Table 5.01 Defect – Treatment Options (contd…)

05. Horticulture			
SN	**Defect**	**Summary inspections**	**Treatment Options**
1)	Grass not in Sight line	• Where action is required to control drainage or elimination of local fire hazards • Lack of watering / fertilizer / pesticides	• Tractor Slashing • Tractor Treatment, Chemical • Roadside Burning Off • Arrange for necessary actions
2)	Unwanted Trees and Shrubs / weeds	• **Medians** Trees and shrubs with potential for safety hazard **Other Areas** Previously cleared areas where re-growth Is evident	• Tractor Slashing • Herbicide Spraying • Clearing • Hand Mowing
3)	Large Trees and Shrubs close to Roadway	• **Medians** Trees and shrubs with potential for safety hazard • **Other Areas** Previously cleared Areas where re-growth is evident	• Clearing • Other Vegetation Control Works
4)	Declared Obnoxious Harmful Plants	• Any	• Herbicide Spraying • Herbicide Spot Spraying
5)	Trees or Limbs Likely to Fall on Roadway	• Any	• Clearing
6)	Grass, trees and shrubs in sight line, in drains, or obstructing roadside furniture	• Unacceptable situations prone to traffic safety	• Tractor Slashing • Herbicide Spraying • Clearing
7)	Landscaping Defects	• Considerable loss of asset	• Seeding or Planting • Maintain Landscaped Shrubs • Mulching • Landscape Planting
8)	Dead/Decaying Trees	• Any	• Uproot and replace

Table 5.01 Defect – Treatment Options (contd…)

06. Roadside Defects (Including encroachment)			
SN	**Defect**	**Summary inspections**	**Treatment Options**
A	Unauthorised Signs	• Any	• Remove Unauthorised Signs
B	Unstable cut slopes or missing bank materials	• Potential safety Hazard	• Address Stability Problems and Repair
C	Damaged Concrete or Paving Blocks	• Potential functional hazard	• Repair or Replace Concrete or Paving Blocks, and Kerbs
D	Earth, Rock blocking Sight Line	• Any	• Clear and establish Visibility
E	Litter on Road Reserve	• Any environmentally sensitive locations	• Roadside Litter Collection and removal
F	Graffiti	• Locations that are highly visible to the public and/or the content is considered offensive	• Graffiti Removal
G	Scoured Areas on the Road Reserve	• Scour is likely to affect adjoining property or endanger structural safety or is likely to cause environmental damage	• Repair Roadside Appurtenances • Installation and Removal of Erosion • Maintenance of Erosion and Sediment Control Measures
H	Abandoned Vehicles	• Any abandoned vehicle in the road reserve. (Notify Local Authority)	• Removal of abandoned vehicles
J	Damaged Fencing	• Live stock or pedestrians likely to gain unauthorised access to the road reserve	• Repair Roadside Fencing
K	Damaged Noise Barrier	• Any panel missing or damaged	• Repair Noise Barriers
L	Damaged or Unserviceable Bus Shelters	• Facility is not functional	• Service Passenger Facilities • Repair Passenger Shelters • Replace Passenger Shelters
P	Emergency Phone Defects	• Any	• Repair Emergency Roadside Phone

Table 5.01 Defect – Treatment Options (contd…)

07. Road Furniture and Appurtenances			
SN	**Defect**	**Summary inspections**	**Treatment Options**
1)	Missing or Defective, Regulatory, Warning or Hazard Sign	Any missing sign or dirty sign face, or if, after cleaning, sign is not clearly legible at night with lights on low beam or sign is beyond repair.	• Install New Signs Excluding Guide Signs • Cleaning Signs etc. • Repair Signs (excl. Guide Signs)
2)	Missing or Defective Guide Sign	• Dirty Sign Face • Sign requires structural repair (includes all sign components including reflective surface sheeting) • Damaged supporting structure (i.e. posts, fitting etc.)	• Cleaning signs • Repair Guide Signs • Install New Guide Signs
3)	Sign Misalignment	• Sign is reflecting glare from vehicles head lights at night, or • The sign is leaning beyond sight angle	• Restore back
4)	Guide Post or Delineator Defects	• Any missing guide posts in a hazardous location • The post is leaning beyond sight angle, **or** • There is an inability at night to see at least two delineators ahead	• Replace guide posts • Restore support Post • Install New Guide Markers • Clean and/or Paint Guide Markers
5)	Reference Marker Defects	• Wording on the marker is not legible when viewed from the side of the roadway	• Repair or Replace Guide Markers
6)	Guardrail, Fencing and Concrete Barrier Structural Defects	• Damaged guard rail or components (eg. terminal sections) are a potential hazard to traffic, **or** • Rail is bent and out of alignment, **or** • Facility has a loss of structural integrity. • The barriers structural integrity or alignment is impaired	• Repair or Replace Guardrail, Barrier Furniture • Repair Guardrail, Barrier Furniture • Replace Guardrail, Barrier Furniture • Repair crash barriers • Repair Impact Barrier Furniture
7)	Kerb or Dyke Defects	• Defects or missing in noticeable length	• Repair or Replace Concrete or Paving Blocks, Kerbs and Dykes • Other Roadside Work
8)	Guardrail, Fencing and Concrete Barrier Appearance Defects	• Visibility at night is significantly impaired by accumulation of dirt, peeling paint, etc.	• Clean and/or paint Guardrail, Barrier Furniture
9)	Raised Pavement Marker Defects	• Loss of markers on curves, or any consecutive markers are missing.	• Reinstall Raised Pavement Markers

Table 5.01 Defect – Treatment Options (contd…)

08. Bridge and Miscellaneous Structures			
SN	**Defect**	**Summary inspections**	**Treatment Options**
1)	Bridge Defects General	• Any reported Defects likely to affect the usability of the bridge component	• Routine Bridge Servicing • Repair Spalled and Cracked elements • Replace Deck • Repair Minor Damage • Clean Out Vent Holes in Superstructure • Clean Bearings, Bearing Sills, deck drains • Clean Out Abutment and Wing Wall Weep holes
2)	Failed Bridge Joints	• Any reported. Joints non functional.	• Repair/Replace Expansion Joints • Clean Out Expansion Joints and Associated Drains
3)	Scouring Around Bridge Piers	• Structural integrity of the structure is likely to be affected	• Routine Bridge Servicing
4)	Debris on Bridge	• Any potential blockage to bridge deck drainage	• Remove blockage and restore
5)	Cracked/Scoured Abutment Protection	• Any Reported	• Repair/Replace protection measures
6)	Damaged Handrails, crash barriers and Posts	• Any Reported	• Replace the affected parts
7)	Peeling Paint on Bridge Structural Elements	• Any significant loss of paint which would lead to the element's ability to carry out its functional purpose being significantly affected.	• Routine Bridge Servicing
8)	Approach Slab General	• Any Reported	• Replace/Repair
9)	Bridge Waterway Obstruction	• Major obstruction of the waterway . Significant erosion or movement of rock protection around bridge elements.	• Clean Out Waterways and repair protection measures
10)	Corrosion Steel Elements	• Any significant degree of corrosion which would lead to the element's ability to carry out its functional purpose being significantly affected.	• Clean-Repair Steel Elements • Clean Aggressive Contamination from Steel Girders

Table 5.01 Defect – Treatment Options (contd…)

09. Project Facilities			
SN	**Defect**	**Summary inspections**	**Treatment Options**
A	Project Facilities, General Defects (Toll Plaza, Service Area, Rest Area, Bus Bays, Truck Lay Bye)	• Any	Routine Maintenance of Toll Plaza/ Rest Area/ Bus Bays/ Truck Laybyes • Cleaning open, paved and unpaved areas, floors, walls, ceiling, roof, sheds, drainage appurtenances, furniture, equipment, electrical accessories, internal signs, decorative items, etc • Disinfecting toilet facilities • Waste Collection and Disposal • Checking and servicing/ repairing sewerage and drainage system, water supply lines, storage tanks, tube wells, pumps and accessories; electrical lines and accessories, telephone lines and accessories; and furniture • Repairing of paved/unpaved areas including crack sealing, patching, surface sealing, regravelling and regrading, as required. Repair of concrete and masonry items limited to crack sealing, patching, plastering and painting • Removal of graffitti • Maintenance of gardens, landscaping

5.1.7 *Mechanisation and equipment*

5.1.7.1 Introduction

For expressway maintenance, it is a sine–quo-non to use mechanized activities to deal with high speed, high volume traffic. The mechanized arrangement involves fewer disturbances to the traffic and requires less number of associated safety measures.

5.1.7.2 Equipment for maintenance

Maintenance equipment requirement will vary from region to region as well as geographic areas surrounded by the expressway.

Table 5.02 *(Source: AASHTO Maintenance Manual)* presents a common list of equipment required for performing various possible tasks of maintenance. These are of informative as well as illustrative nature.

Table 5.02 Mechanized Methods and Equipment (AASHTO)

	Maintenance Operation	**Equipment Used for Alternate Methods**
A.	**Surface Routine**	
I)	Blading and Dragging a) Soil Surfaces	(a-1) Motor Grader (a-2) Truck or Wheel Tractor and Tow Grader (a-3) Truck with Underbody Blade (a-4) Wheel Tractor with Rear Leveling Blade
	b) Bituminous Surfaces	(b-1) Heater Planer (b-2) Milling Machine
II)	Patching a) Soil Aggregate 1) Aggregate Supply	(1-1) End Loader and Trucks
	b) Bituminous Surface 1) Removal of Old Material	(1-1) Surface Heater, Compressor, Pneumatic Breaker, Backhoe End Loader, and Truck
	2) Aggregate Supply	(2-1) End Loader and Truck
	3) Bitumen Supply	(3-1) Small Distributor or Bituminous Kettle
	4) Mixing	(4-1) End Loader and Small Bituminous Mixer (4-2) Motor Grader (4-3) Small Bituminous Mixing Plant (4-4) Central Bituminous Mixing Plant
	5) Sealing	(5-1) Small Distributor
	6) Consolidation	(6-1) Gasoline or Pneumatic Tamper (6-2) Small Flat-Wheel Roller (6-3) Pneumatic Tyred Roller
	c) Portland Cement Concrete 1) Removal	(1-1) Compressor, Pneumatic Breaker, End Loader or Backhoe, Concrete Saw, and Truck (1-2) Concrete Saw, Pavement Breaker, Loader, and Truck
	2) Replacement	(2-1) End Loader, Truck, Mixer, Mechanical Float and Vibrator (2-2) Truck Mixer, Mechanical Float, Vibrator
III)	Sealing Joints and Cracks a) Cleaning	(a-1) Joint-Cutting and Cleaning Machines, Compressor
	b) Sealing	(b-1) Small Bituminous Kettle and Pouring Pot (b-2) Crack-Sealing Machine (b-3) Distributor and Hand Hose

Table 5.02 Mechanized Methods and Equipment (AASHTO) (contd...)

	Maintenance Operation	Equipment Used for Alternate Methods
B.	**Surface Special**	
I)	Dust Palliatives	
	a) Chlorides	(a-1) Truck and Spreader
		(a-2) Truck, Spreader, and Grader
		(a-3) Truck, Spreader and Stabilizing Mixer
	b) Bituminous	(b-1) Bituminous Distributor
		(b-2) Bituminous Distributor and Grader
		(b-3) Bituminous Distributor and Stabilizing Mixer
II)	Surface Replacements	
	a) Soil Aggregate Supply	
	1) Aggregate Supply	(1-1) Loader and Truck
		(1-2) Dozer, Loading Chute, and Truck
		(1-3) Shovel and Truck
		(1-4) Tractor and Scraper
		(1-5) Tractor, Pan, Loading Chute and Truck
	2) Spread	(2-1) Truck and Motor Grader
		(2-2) Trucks, Spreader, and Motor Grader
	3) Consolidate	(3-1) Tractor and Pneumatic Tyred Rollers
		(3-2) Tractor and Sheepsfoot Rollers
		(3-3) Flat Steel Rollers
	b) Bituminous Surface Treatment	
	1) Aggregate Supply	(1-1) Power Shovel and Truck
		(1-2) Loader and Truck
		(1-3) Storage Bins and Truck
	2) Bituminous Supply	(2-1) Tank Car, Tank Car Heater, and Distributor
		(2-2) Tank Truck and Distributor
	3) Cleaning	(3-1) Power Broom and Blower
		(3-2) Truck or Tractor and Broom
	4) Bituminous Application	(4-1) Distributor
	5) Aggregate Application	(5-1) Chip Spreader and Broom Drag
	6) Consolidation	(6-1) Steel-Wheel Roller, Pneumatic Tyred Roller
	c) Bituminous Penetration Surface	
	1) Aggregate Supply	(1-1) Power Shovel and Truck
		(1-2) Loader and Truck
		(1-3) Storage Bins and Truck
	2) Bituminous Supply	(2-1) Tank Car, Tank -Car Heater, and Distributor
		(2-2) Tank Truck and Distributor
	3) Cleaning	(3-1) Power Broom and Blower
		(3-2) Truck or Tractor and Broom
	4) Aggregate Application (First Course)	(4-1) Coarse Aggregate Spreader and Heavy Steel Wheel Roller
	5) Aggregate Application (Cover Course)	(5-1) Chip spreader and Broom Drag
	6) Bituminous Application	(6-1) Distributor
	7) Consolidation	(7-1) Heavy Steel-Wheel Roller

Table 5.02 Mechanized Methods and Equipment (AASHTO) (contd…)

	Maintenance Operation	Equipment Used for Alternate Methods
	d) Bituminous-Mixed-In-Place Surface	
	1) Aggregate Supply	(1-1) Power Shovel and Truck (1-2) Loader and Truck (1-3) Storage Bins and Truck
	2) Bitumen Supply	(2-1) Tank Car, Tank-Car Heater, and Distributor (2-2) Tank Truck and Distributor (2-3) Tank Car, Tank-Car Heater, and Tank Truck
	3) Cleaning	(3-1) Power Broom and Blower (3-2) Truck or Tractor and Broom
	4) Aggregate Application (First Course)	(4-1) Truck, Coarse Aggregate Spreader and Windrow Proportioner
	5) Aggregate Application (Cover Course)	(5-1) Truck and Light Spreader
	6) Bitumen Application and Mixing	(6-1) Distributor and Grader (6-2) Distributor, Rotary Tiller, and Grader (6-3) Tank Truck and Travel-Mix Plant
	7) Spreading	(7-1) Motor Grader (7-2) Chip Spreader
	8) Compaction	(8-1) Heavy Steel-Wheel Roller (8-2) Pneumatic-Tyred Roller
	e) Pre-Mix Surface	
	1) Cleaning	(1-1) Power Broom and Blower (1-2) Truck or Tractor and Broom
	2) Priming	(2-1) Distributor and Tank Car or Tank Truck
	3) Mixing	(3-1) Central Plant
	4) Material Supply	(4-1) Truck
	5) Spreading	(5-1) Bituminous Paver
	6) Compaction	(6-1) Heavy Roller
	f) Cement Concrete Surfaces	
	1) Removal	(1-1) Compressor, Pneumatic Pavement Breaker, Concrete Saw, End Loader, and Truck (1-2) Gasoline Hammer, End Loader, and Truck (1-3) Concrete Saw, Pavement Breaker, End Loader, and Truck
	2) Replacement	(2-1) End Loader, Truck, Mixer, and Mechanical Float (2-2) Truck Mixer and Mechanical Float

Table 5.02 Mechanized Methods and Equipment (AASHTO) (contd...)

	Maintenance Operation	Equipment Used for Alternate Methods
III)	Reprocessing	
	a) Soil Aggregate Surface	
	1) Scarify and Shape	(1-1) Motor Grader with Scarifier Attachment
		(1-2) Tractor, Ripper, Disc Harrow, and Grader
	2) Aggregate Supply (Additional Material Only)	(2-1) Loader and Truck
		(2-2) Dozer, Loading Chute, and Truck
		(2-3) Power Shovel and Truck
	3) Mix and Shape	(3-1) Motor Grader
		(3-2) Rotary Tiller and Motor Grader
	4) Consolidate	(4-1) Pneumatic - Tyred Roller
	b) Bituminous Surface	
	1) Scarify and Pulverize	(1-1) Tractor, Ripper, Motor Grader, Rotary-Tiller, Milling Machine, Loader, and Crusher
		(1-2) Tractor and Heavy-Duty Mechanical Ripper and Rotary-Tiller
	2) Aggregate Supply	(2-1) Loader, Truck Spreader, and Windrow Proportioner
		(2-2) Shovel, Truck, Spreader, and Windrow Proportioner
		(2-3) Storage Bins, Truck Spreader, and Windrow Proportioner
	3) Bituminous Supply	(3-1) Tank Car, Tank-Car Heater, and Distributor
		(3-2) Tank Truck and Distributor
		(3-3) Tank Car, Tank-Car Heater, and Tank Truck
		(3-4) Tank Truck
	4) Bituminous Application and Mixing	(4-1) Distributor and Grader
		(4-2) Distributor, Grader, and Rotary-Tiller
		(4-3) Travel Plant and Grader
		(4-4) Travel Plant
	5) Spreading	(5-1) Motor Grader
		(5-2) Bituminous Spreader
	6) Compaction	(6-1) Pneumatic-Tyred Roller
		(6-2) Heavy Flat Steel-Wheel Roller
IV)	Mud-Jacking	
	a) Drilling	(a-1) Compressor, Truck, and Pneumatic Drill
		(a-2) Tractor-Mounted Compressor and Drill
	b) Jacking	(b-1) Slurry Mixer and Pump (Mudjack), and Truck
V)	Bituminous Under sealing	
	a) Drilling	(a-1) Compressor, Truck, and Pneumatic Drill
		(a-2) Tractor-Mounted Compressor and Drill
	b) Application of Bitumen	(b-1) Distributor and Hand Hoses

Table 5.02 Mechanized Methods and Equipment (AASHTO) (contd...)

	Maintenance Operation	Equipment Used for Alternate Methods
VI)	Aggregate Production	
	a) Crushed Stone	
	1) Drilling	(1-1) Compressor and Wagon Drill (1-2) Compressor and Pneumatic Drill
	2) Loading and Hauling	(2-1) Loader and Truck (2-2) Power Shovel and Truck
	3) Crushing and Screening	(3-1) Crushing and Screening Plants
	4) Storage and Handling	(4-1) Conveyors and Storage Bins (4-2) Conveyors, Stock Piles and Power Shovels
	B) Crushed and Washed Gravel	
	1) Loading and Hauling	(1-1) Power Shovel and Truck (1-2) Dozer, Loading Chute, and Truck (1-3) Loader and Truck
	2) Washing, Crushing, and Screening	(2-1) Washing and Screening Plant (2-2) Washing, Crushing, and Screening Plant
	3) Storage and Handling	(3-1) Conveyors and Storage Bins (3-2) Conveyors, Stockpiles, and Power Shovels
C.	**Shoulders and Approaches**	
I)	Patching a) See Surface Routine, Patching (A-II)	
II)	a) Seeding	(a-1) Truck, Harrow, Fertilizer Spreader, Seeder, and Light Roller
	b) Sodding	(b-1) Truck, Sod Cutter, and Roller
	c) Mulching	(c-1) Truck, Harrow, Rotary-Tiller, Hydro-seeder/Mulcher, and Light Roller
III)	Blading and Rolling	
	a) Soil Aggregate	(a-1) Motor Grader (a-2) Truck or Wheel Tractor with Tow Grader (a-3) Truck with Underbody Blade (a-4) Truck with Maintainer or Drag (a-5) Wheel Tractor with Maintainer or Drag
	b) Turf	(b-1) Roller, Motor Grader, Loader, and Trucks (b-2) Roller Tractor and Pull Grader, Loader, and Truck
IV)	Mowing	(IV-1) Tractor and Mower Attachment
V)	Bituminous Treatment and Retreatment a) See Surface Special (B-1) and Surface Replacement (B-11).	

Table 5.02 Mechanized Methods and Equipment (AASHTO) (contd...)

	Maintenance Operation	Equipment Used for Alternate Methods
D.	**Roadside and Drainage**	
I)	Cuts Fills, and Washouts	(I-1) Motor Grader (I-2) Tractor with Tow Grader (I-3) Small Dozer (I-4) Excavator and Truck
II)	Drainage Channels	
	a) Ditches, etc.	(a-1) Grader and Truck (a-2) Grader, Loader, and Truck (a-3) Tractor, Grader, and Truck (a-4) Tractor, Grader, Force-Feed Loader, Excavator, and Truck
	b) Catch Basin and Storm Drains	
	1) Catch Basin	(1-1) Light Crane with Orange-peel Bucket and Truck (1-2) Hydraulic Cleaning Equipment
	2) Storm Drains	(2-1) Sewer Pumps (2-2) Sewer Cleaning Equipment
	c) Stream-Bed Cleaning	(c-1) Truck-Mounted Dragline, Dozer, End Loader, and Truck
III)	Roadside Mowing and Cleaning	(III-1) Tractor with Mower Attachment (III-2) Refuse Truck (III-3) Truck-Mounted Suction Loader (III-4) Refuse Shredder and Truck
IV)	Reseeding and Resodding	
	a) Seeding	(a-1) Truck, Harrow, Fertilizer Spreader, Seeder, and Light Roller (a-2) Seed-Spraying Equipment
	b) Sodding	(b-1) Truck, Light Tractor, Harrow, and Roller
V)	Tree and Shrub Maintenance	
	a) Spraying	(a-1) Truck or Trailer-Mounted Sprayer
	b) Trimming	(b-1) Truck with Ladders, Lines, Tools, etc.
E.	**Traffic Service**	
I)	Signs	
	a) Transportation	(a-1) Sign Truck
	b) Erection	(b-1) Pneumatic Post Driver (b-2) Power Earth Augers (b-3) Sign Truck with Pneumatic Post Driver (b-4) Sign Truck with Earth Auger
	c) Shop Reconditioning	
	1) Cleaning	(1-1) Sand Blast Machine
	2) Reprocessing	(2-1) Vacuum Applicator (2-2) Silk Screen Stencil (2-3) Compressor Paint Spraying Equipment (2-4) Compressor, Paint-Spraying Equipment, and Baking Oven

Table 5.02 Mechanized Methods and Equipment (AASHTO) (contd...)

	Maintenance Operation	Equipment Used for Alternate Methods
II)	Pavement Markings	
	a) Preliminary Marking (Spotting)	(a-1) Preliminary Marking Truck
	b) Marking	(b-1) Truck-mounted Marking Machine (b-2) Truck-pushed Marking Machine (b-3) Self-propelled Marking Machine
	c) Protecting Painted Line	
	1) Placing Protectors	(1-1) Truck (1-2) Marking Machine
	2) Retrieving Protectors	(2-1) Truck (2-2) Truck and Mechanical Retriever
III)	Guardrail	
	a) Repair Protectors	(a-1) Truck, Guardrail Straightener, Small Generator (a-2) Truck and Earth Auger (a-3) Truck, Earth Auger, and Small Concrete Mixer
	b) Painting	(b-1) Spray-Painting Equipment and Supply Truck
IV)	Signals and Lighting	
	a) Cleaning Luminaries and Lenses, Lamp replacement, and Trouble Shooting	(a-1) Truck (a-2) Truck with Ladder (a-3) Truck with Hydraulic Lift
	b) Painting	(b-1) Compressor and Spray-Painting Equipment (b-2) Truck-Mounted Compressor and Painting Equipment
V)	Surface Cleaning	
	a) Street Sweeping	(a-1) Street Sweeper
	b) Street Flushing	(b-1) Truck-Mounted Tank Flusher
	c) Metallic Pick-Up	(c-1) Truck-Mounted Compressor and Painting Equipment
F)	Snow, Ice, and Sand Control	
I)	Drift Control	
	a) Snow Fence Erection	(a-1) Truck, Compressor, and Pneumatic Hammer
	b) Snow Ridging	(b-1) Dozer or Motor Grader
II)	Snow and Ice Control	(II-1) Truck and Chloride Spreader
III)	Snow Removal	(III-1) Truck and Displacement Plough (III-2) Motor Grader and Displacement Plough (III-3) Tractor and Displacement Plough (III-4) Motor Grader and Rotary Plough (III-5) Rotary Plough (III-6) Tractor and Rotary Plough (III-7) Truck, Displacement Plough, Loader, and Haul Truck (III-8) Rotary Plough and Haul Truck
IV)	Ice Removal	(IV-1) Motor Grader with Scarifier and Saw-Tooth Blade (IV-2) Truck and Underbody Blade (IV-3) Truck and Chloride Spreader

Table 5.02 Mechanized Methods and Equipment (AASHTO) (contd...)

	Maintenance Operation	Equipment Used for Alternate Methods
V)	Sanding	
	a) Material Supply	(a-1) Storage Bins or Building
		(a-2) Loader
		(a-3) Chloride Storage Tank
	b) Spreading	(b-1) Truck and Sand Spreader
		(b-2) Special Sanding Truck Bodies
VI)	Sand Removal	(VI-1) Truck, Broom, and Loader
VII)	Opening Frozen Waterways	
	a) Culverts	(a-1) Truck-Mounted Steam Boiler
	b) Ditches	(b-1) Steam Boiler
	c) Catch Basins	(c-1) Steam Boiler
G.	**Structures**	
I)	Repair	
	a) Concrete	
	1) Removal and Preparation	(1-1) Compressor, Pneumatic Tools, and Acetylene Cutting Torch
	2) Replacement	(2-1) Loader, Mixer, and Truck
		(2-2) Transit Truck (Plant (Mix))
		(2-3) Gunite Machine
	b) Steel	(b-1) Truck, Power Drills, Compressor, and Riveting Hammer
		(b-2) Truck, Arc-Welder, and Power Generator
		(b-3) Special Bridge-Repair Truck with Mounted welder, Generator, etc.
		(b-4) Acetylene Cutting Torch
	c) Wood	
	1) Pile Replacement	(1-1) Truck, Pile Driver, Power Crane, Power Saws, and Hydraulic Jack
	2) Deck and Wood Member Replacement	(2-1) Truck Compressor, and Pneumatic Tools
		(2-2) Truck, Generator, and Power Saw
	d) Stream Channel	
	1) Clean and Remove Bars, Fill Scour Pockets	(1-1) Dozer
		(1-2) Dozer, Power Shovel, and Truck
		(1-3) Dredge and Barge
	2) Replace Riprap	(2-1) Power Shovel, End Loader, and Truck
II)	Cleaning	(II-1) Compressor, Pneumatic Cleaning Tools, Truck
		(II-2) Compressor, Sand-Blast Equipment, and Truck
		(II-3) Generator with Power Buffer, Truck
		(II-4) Special Bridge Maintenance Truck with Compressor, Generator, etc.
		(II-5) Steam Cleaner, Truck
		(II-6) Flame-Cleaning Equipment
III)	Painting	(III-1) Compressor and Paint Gun, Truck
		(III-2) Special Bridge Maintenance Truck with Compressor, etc.

Table 5.02 Mechanized Methods and Equipment (AASHTO) (contd...)

	Maintenance Operation	**Equipment Used for Alternate Methods**
H.	**Administration and Interdepartmental Operation**	
I)	Maintenance Administration a) Field Engineers b) Patrolmen and Foremen	 (a-1) Automobiles (b-1) Pick-Ups
II)	Interdepartmental Use a) Field Engineers b) Small Crews c) Large Crews	 (a-1) Automobiles (b-1) Pick-Ups (c-1) Station Wagons or Vans

CHAPTER - 6

NEW MAINTENANCE PRACTICES

CHAPTER - 6

NEW MAINTENANCE PRACTICES

6.1 EQUIPMENT FOR DATA COLLECTION

6.1.1 *Introduction*

Ministry of Road Transport and Highways, Guidelines for Maintenance Management of Primary, Secondary and Urban Roads – Published by IRC, New Delhi in year 2004 is a comprehensive document. This covers (i) database requirement for MMS; (ii) equipment for data collection; (iii) man-power requirement; and (iv) equipment operations, calibration periodicity of updating besides data base development, data analysis, organizational requirement, intervention criteria and maintenance strategies.

In this Guideline, the aspects covered by the above document have not been reproduced and it is expected that the maintenance engineer is aware of the contents. The following narrations are expected to be additional guideline for the decision making as well as to be in line with the international practices.

6.1.2 *Data collection*

Different types of data are required for maintenance of the road infrastructure.

- Inventory data describe the physical elements of a road system.
- Condition data describe the condition of the elements that can be expected the change over time.

There is a wide range of technologies available for measuring attributes of the road network. The challenge is to select the appropriate equipment, given local condition and the way in which the data are expected to be used.

6.1.3 *Types of pavement evaluations*

Pavement evaluations record pavement characteristics that influence pavement performance. The key pavement characteristics considered in an evaluation are usually:

- Roughness
- Texture

- Skid resistance
- Mechanical/structural properties
- Surface distress; and
- Geometry

6.1.4 *Pavement data collection equipment*

MORTH Guidelines for Maintenance Management of Primary, Secondary and Urban Roads (published by IRC in year 2004) – presents data collection equipment for pavement evaluation.

Pavement evaluations are performed in the field through manual surveys or using specialized equipment. Evaluated characteristics of the pavement are quantified by means of indicators or condition indices.

Table 6.01 presents typical data collection equipment used to evaluate pavement characteristics in the field. Equipment are classified in terms of their precision and survey method.

Table 6.01 Pavement Data Collection Equipment

Pavement Characteristic	Equipment Class
Roughness (as defined by the World Bank)	Class-I : Precision Profiles - Laser - Manual
	Class-II : Other Profilometer Methods
	Class-III: IRI Estimates from Correlations
	Class-IV: Subjective Ratings
Microtexture	Static
Macrotexture	Static
	Dynamic
Mechanical Properties	Falling Weight Deflectometer
	Deflection Beam
	Dynamic Cone Penetrometer
Surface Distress	Video Distress Analysis
	Visual Surveys
	Transverse Profilers
Geometry	GPS
	Inertial Navigation Units

Examples of the different types of equipment available are given in Bennet et al. (2006). Company profiles and brochures are available at www.road-management.info.

6.1.5 *Bridge evaluations*

Bridge structures suffer structural and functional deterioration as a result of structural damage or material degradation. For this reason, bridge structures should be inspected periodically, at time intervals dependent on the scope of the particular type of inspection.

6.1.6 *Bridge inspections and data collection equipment*

On bridge inspection and maintenance IRC (Indian Roads Congress) have published the following documents, which cover inspection, data collection and evaluation.

- IRC:SP:35-1990 (reprinted 2007) Guidelines for Inspection and Maintenance of Bridges
- IRC:SP:52-1999 (reprinted 2005) Bridge Inspector's Reference Manual

Bridge data collection varies depending on the bridge component being surveyed. Visual inspections are normally used for all bridge components, but other applicable physical inspection techniques vary with the material of bridge components. **Table 6.02** summarizes the requirements.

6.1.7 *Use of data collection equipment*

6.1.7.1 Data collection for road surface conditions

In addition to the contents in the Ministry Maintenance Manual published by IRC in 2004, the following equipment presented are being used in Japan and other countries. These instruments are used for investigation and appreciation/assessment of pavement surface. It can be used for inspection of cracks and other failures, including their progression, on the pavement surface. For quantitative analysis of the pavement surface, these vehicles check the roads for skid resistance, ruts, cracks and other surface distresses and produce images of the same. The use of laser beam enables the vehicles to work in night and operate around a speed of 60 kmph.

The CRRI has recently acquired an Accelerated Pavement Testing Facility for structural evaluation of pavement on fast track basis with the support of Dynatest Technologies, with the necessary know-how from CSIR, South Africa. The personnel of CRRI are being trained for running and operation of this facility. This will help the concessionaires in quacker prediction of pavement deterioration and taking timely remedial measures.

Table 6.02 Bridge Data Collection Equipment

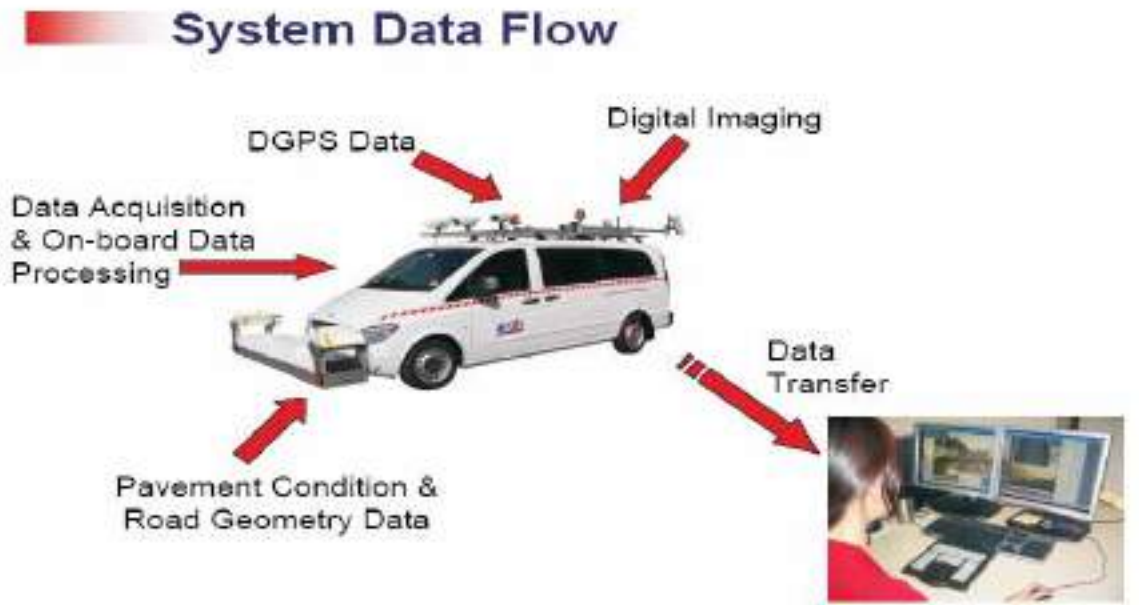
TECHNOLOGY	EQUIPMENT TYPE
Bridge Access Technologies	Hydraulic lifts
	Snooper-type trucks
	Boat or Barge
	Scaffolds
	Diving equipment
Concrete Non-destructive Testing	Strength
	Sonic
	Ultrasonic
	Magnetic
	Electrical
	Nuclear
	Thermography
	Ground Penetrating Radar
	Radiography
	Visual Surveys (Manual or Digital)
	Transverse Profilers
	GPS
Steel Non-destructive Testing	Inertial Navigation Units
	Radiography
	Magnetic particle
	A.C. Wet
	A.C. Dry
	Eddy Current
	Dye Penetrants
	Ultrasonic
	Visual Surveys (Manual or Digital)

Japan – Data Collection Equipment

Skid Resistance Test Vehicles

Rut and Crack Survey Vehicles

ARRB – Data Collection Accessories



ARRB Vehicle

Similar other data collection vehicles used in India are "**ARAN**" and "**ROMDAS**".

ARAN Capabilities:

Photo-log: Single or Multiple Cameras,

Panoramic, 640 x 480 pixel, 1300 x 1030 pixel

Geometry and Spatial: POS LV, curve sta
centerline.

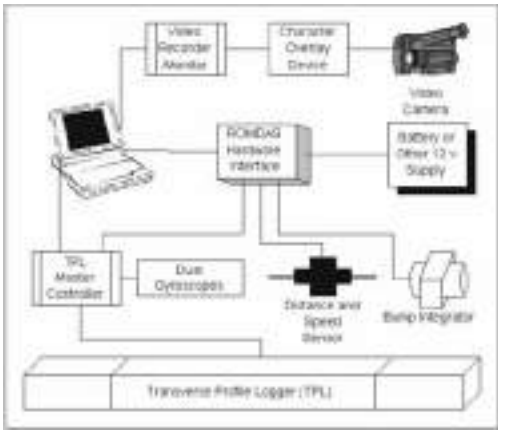
Pavement: Roughness, texture, rutting, cracki

Assets: Type, location, offset, height and wid
poor).

ARAN Vehicles

ROMDAS Capabilities:

ROMDAS is unitized vehicle contains various modules which can be upgraded as and when required.



ROMDAS Modules

6.1.7.2 Data collection for structures and road appurtenances

Specialized equipment for inspection and data collection for structures used in Japan are presented below:

Bridge Inspection Vehicles

This is a truck mounted inspection vehicle which is used for inaccessible places from the bridge deck. The cantilever portion assist in inspection of under deck structures, bearings, expansion joints, and top portion of the supporting sub-structures.

Bridge Inspection Vehicles

Special Maintenance Trucks

These are essential for inspection and cleaning of road facilities and structures, which includes truck mounted bucket and lift trucks.

Lift Truck

Truck Mounted Bucket

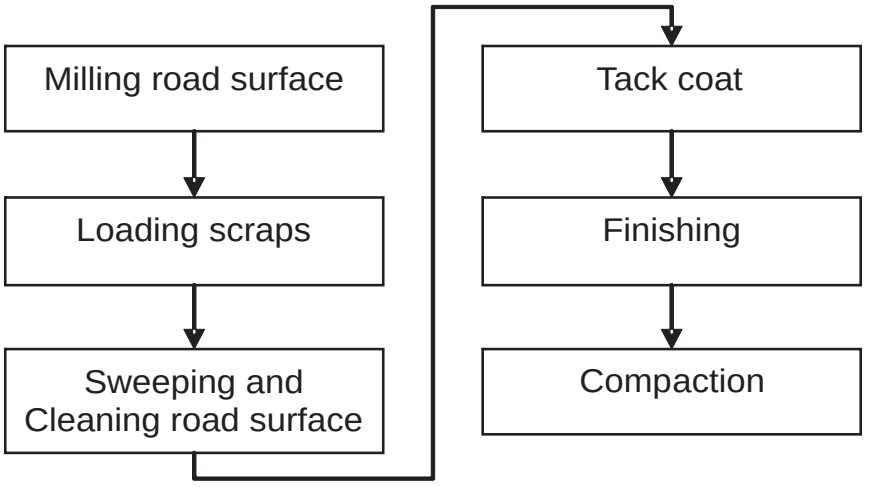
6.2 BITUMINOUS PAVEMENT MILL AND OVERLAY (including recycling)

Globally due to scarcity of good quality aggregates for bituminous work, recycling of the existing distress pavement materials are being considered using various technologies. Recycling process is generally categorized into in-situ recycling (where processing takes place on site), and central plant recycling (where reclaimed material is processed off site). The process can be further divided into hot and cold processes.

6.2.1 *In-plant mix recycling*

Work Flow

The steps for mill and overlay are presented below.



Pavement is milled using either a heated or a cold process.

The cold process is generally employed using heavy cutting machines. Road scraps are loaded directly into a dump truck.

Milling the road surface and loading scraps

Loading of the road scraps into the dump truck is followed by intensive cleaning with a sweeper and/or compressor, to ensure that no scraps are left on the road surface.

Sweeping Cleaning Road Surface

Tack coat is applied after sweeping and cleaning to enhance the adhesion between the new asphalt mixture and the existing pavement surface. Additional care shall be taken in applying tack coat on the milled vertical face.

Track Coat Application

Finishing

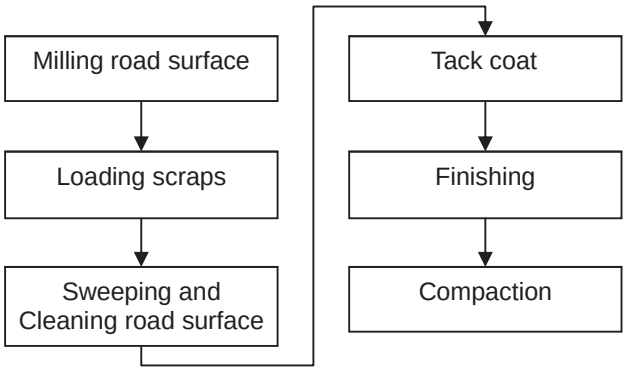
Compaction

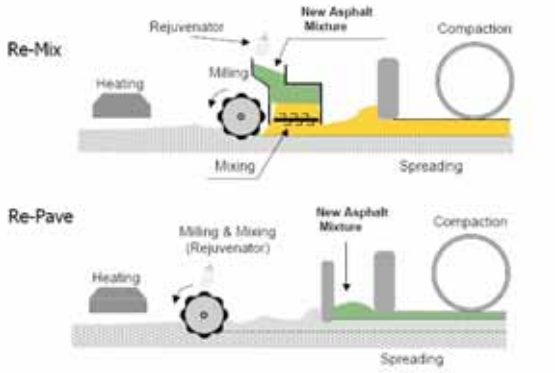
Final finishing and compaction shall be carried out at the earliest using appropriate paver and roller combination, true to design line and level.

6.2.2 *In-situ recycling*

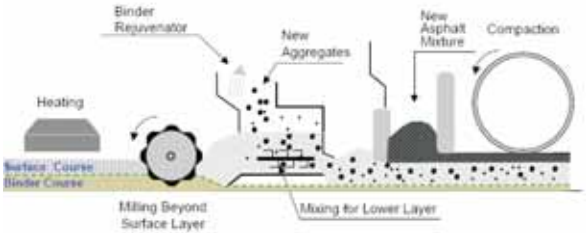
Work Flow

The steps for in-situ recycling are presented below.





In-situ recycling of wearing course



In-situ recycling and strengthening overlay

Typical fleet of equipment for in-situ recycling

The process is similar to plant mix – recycling except loading the scrap in a truck the same is loaded in a Rejuvenator unit where additional bitumen and new aggregates is added and remixed.

6.3 POROUS ASPHALT PAVEMENT

6.3.1 *Introduction*

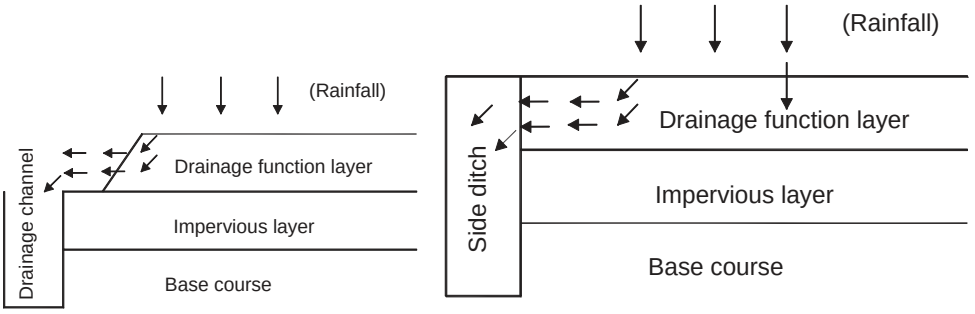
Porous asphalt or open-graded asphalt is the result of **advanced technology** in pavement design. It is used in the top layers, usually has an air void content of 20 percent or greater, due to higher proportions of coarse aggregates and lower sand and filler content. As a result of this composition, interconnected voids are created which, in wet weather, allow the surface first to absorb water, preventing accumulation on the road surface, and then leading it away, like a series of micro pipes, into a drainage system. Porous asphalt is used in many countries and offers a number of solutions to pavement problems. It is appreciated for its benefits in noise reduction and **improved safety** under wet conditions. **Fig. 6.01** demonstrates the reduction of splash and spray in a porous asphalt pavement in Japan

Fig. 6.01 Typical Porous Asphalt on Expressway

Along with the environmental benefits (road – tyre noise is less on porous asphalts surface compare to bituminous surface), porous asphalt can suffer from problems, which can affect both its performance and service life. The open structure exposes a large surface area to the effects of air and water, leading to rapid aging of the binder which in turn leads to loss of adhesion and particle loss. Over the passage of time the interconnected pores (meant for drainage of surface water) are prone to be blocked by the dirt, sand and other extraneous materials such as spillage of chemicals and POL etc." This will need maintenance.

6.3.2 *Drainage*

The structure of porous asphalt pavement should drain water to the drainage facilities (drainage canal and side ditch etc.) as soon as possible, securing the inclination and smoothness of the surface of the impervious layer. In addition to this, if necessary, an underground drainage system should be installed). Typical drainage arrangement is shown in **Fig. 6.02.**



(A) Drainage through shoulder (A) Drainage through side ditch

Fig. 6.02 Typical Drainage Arrangement

6.4 MICRO SURFACING – SPECIAL TREATMENT

Thin micro surfacing comprises of a coating over the pavement surface with a thin layer of synthetic resin tightly bounded on the surface. This is formed with special aggregates such as emery or alumina sand. Besides the places of high superelevation and steep down grade micro surfacing is also applied at locations where the possibility of inadequate surface friction is suspected.

Under construction work

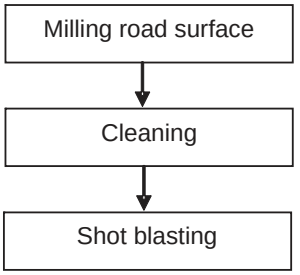
Completed

6.5 RIGID PAVEMENT MILLING AND OVERLAYING

6.5.1 *Pavement milling*

Where concrete pavement develops heavy rutting, unacceptable on serviceability consideration, the distress sections are milled using heavy cutting machine, cleaned and shot blasted in order to prepare the surface for overlaying.

Work Flow:



A large, heavy milling vehicle with very hard cutter bits capable of cutting concrete pavement evenly is used. Careful attention must be paid to bit wear, as streaks may appear in the surface being milled which increases in severity with that of the bit wear.

Milling road surface and loading scraps

Water is sprayed to cool off milling bits due to heat generated during milling. The water sprayed on the bits turns pavement scraps into sludge, therefore, road must be cleaned neatly.

Cleaning road surface

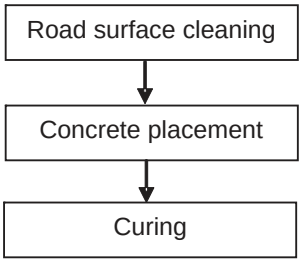
Shot blasting removes loose pebbles, dust, mud, etc. on the milled surface.

Shot blasting

6.5.2 *Concrete pavement overlaying*

To repair worn-out or rutted concrete pavement, a thin layer of new concrete is overlaid on the existing pavement surface. In some cases, worn-out or rutted concrete pavement is milled and removed before overlaying.

Work Flow :



Concrete is generally placed mechanically to a thickness of 40 to 50 mm

Sufficient curing must be provided to prevent shrinkage cracks

6.6 WATERPROOFING BRIDGE DECKS

As a practice, the specifications for wearing course over concrete bridge deck includes a layer of mastic asphalt as waterproofing membrane. However, in Japan a waterproofing layer in the form of plastic sheet of 0.8 mm thickness is placed over bridge deck. This waterproofing layer is suitably placed and rounded on the corners and along the joint with raised footpath (if any) to prevent infiltration of water leaking in bridge face. This waterproofing work shall be integrated along with the bridge drainage work.

Waterprofing Bridge Decks

6.7 REPAIR OF STRUCTURES WITH EPOXY RESIN

Sealing of cracks in structures has been specified in the MORTH - Specifications for Road and Bridge Works published by IRC. This covers the materials, activities, equipment for injection along with testing and acceptance procedures.

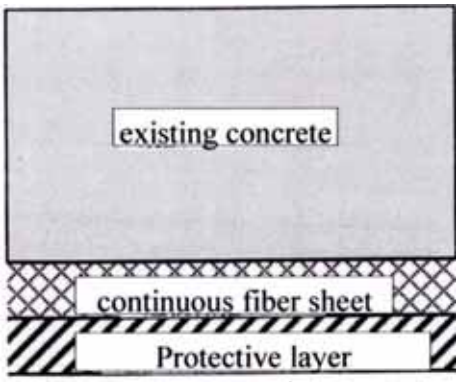
Repair of Structures with Epoxy Resin

In Japan permeative and adhesive synthetic resin is pressure injected into cracks in concrete members.

6.8 PROTECTION AGAINST SPALLING OF CONCRETE

6.8.1 *Spray coating*

Spalling of concrete is mostly from the bottom of the structures and generally is a result of corrosion aggravation in coastal areas and by the pollutants in the industrial areas. The repair process involves cleaning and chipping of the loose concrete, removal of scalling (including rusting and flaking), applying anticorrosive paint on the exposed reinforcement surface, placing mesh reinforcement (chicken net) and grouting / injection of cement slurry. A spray coating of anticorrosive properties may be applied as an additional protection measure. Typical protection against spalling is shown below:



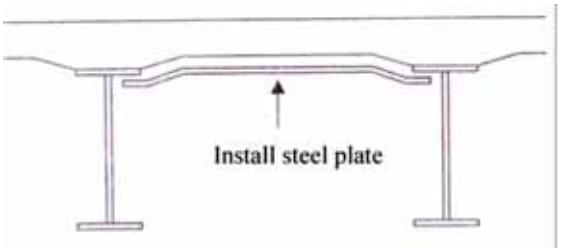
Spray Coating

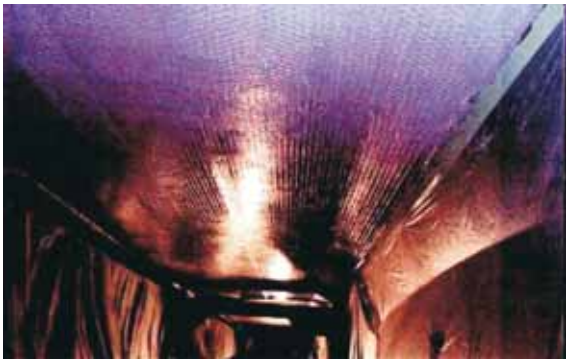
6.8.2 *Installation of steel plate*

Step-1: Attach a continuous fiber sheet which adheres strongly to the existing concrete which can conform to the deformation of the concrete surface.

Step-2: Steel plate is installed over the part of concrete slab at the soffit.

Step-3: Application of a protective layer which may be of concrete slurry or anti-corrosive paint.





Steel Plate Installation

6.9 PROTECTION AGAINST CORROSION AND SALT DAMAGE

Corrosion and salt damage is prevented by surface coating, surface coating after rehabilitation of damaged sections, and cathodic protection, each of which is designed to impede the progression of corrosion.

Infiltration of salinity into concrete structures may come from exposure to a coastal/marine environment or the use of sea sand or chemical admixtures containing a large quantity of chlorides, etc. Corrosion of steel in concrete can result in cracks, loss of adhesion with reinforcing bars, surface float, stripping, etc. For corrosion prevention, monitoring and remedial measures IRC:SP:80 may be followed.

Concrete Cracks by Corrosion

Severity of damage: The photo shows concrete cracks triggered by infiltration of salinity on concrete face, and by corrosion and dilatation of internal reinforcing bars, illustrating the presence of liquefied rusts.

Rust proofing chipped portions: If the internal reinforcing bars are entirely corroded, they are purged of rust and coated with a rust proofing agent. Additional reinforcing bars are added as required.

Exposed Steel Reinforcement

Mending: Mortar is injected after moulds have been placed on chipped parts.

Moulds Injection

Protective Coating

The material for coating shall be effective for "total corrosion control". This shall offer:

- Easiest way to control corrosion
- Measurable reduction in corrosion currents
- Effective against all forms of corrosion – chlorides, carbonation, sulphates
- Deep penetrative, reactive and permanent treatment
- Re-creates protection layer around reinforcement -

6.10 SPECIAL ROAD MARKING FOR IMPROVED DAY/NIGHT VISIBILITY

6.10.1 *Introduction*

Much of the visual information needed by a driver to navigate roads safely in a variety of condition, including day/night, darkness, and adverse weather, is provided by pavement markings. Visibility during wet and night conditions is of particular concern. The retroflectivity, or amount of light reflected back to the source, of conventional pavement markings is degraded under these conditions; water scatters light instead of returning it, making the marking less visible. This reduced visibility renders the driving task more challenging because drivers have less tracking information.

6.10.2 *Materials*

Horizontal road marking materials which are fully visible in day light, can also guide road users in the dark, due to the presence of glass micro beads on the surface.

The road marking materials are a mixture of glass aggregate and glass micro beads with

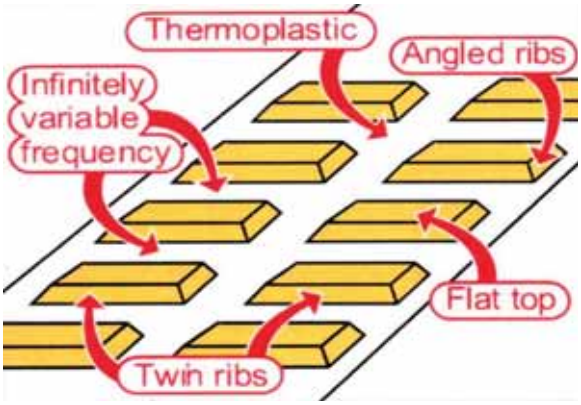
the road marking paint. Micro beads are coated with the hardener and ensure the polymerization of the resin and retroreflection, which means that the marking technique shall be open to any type of machine.

6.10.3 *Applications*

The thermoplastic materials with high visibility is applied using screed technique using a special mechanism which has a control shutter to create the distinctive rib pattern of the marking as illustrated below:

The diagram is schematic only and is intended to give indicative shape.

Because of the protruding shape even during wet night time, it does not lose visibility. With its rumble shapes, when the vehicles over ride the marking a sensible and audible impulses are transmitted to the driver. These impulses alert the driver and increase the safety in driving.



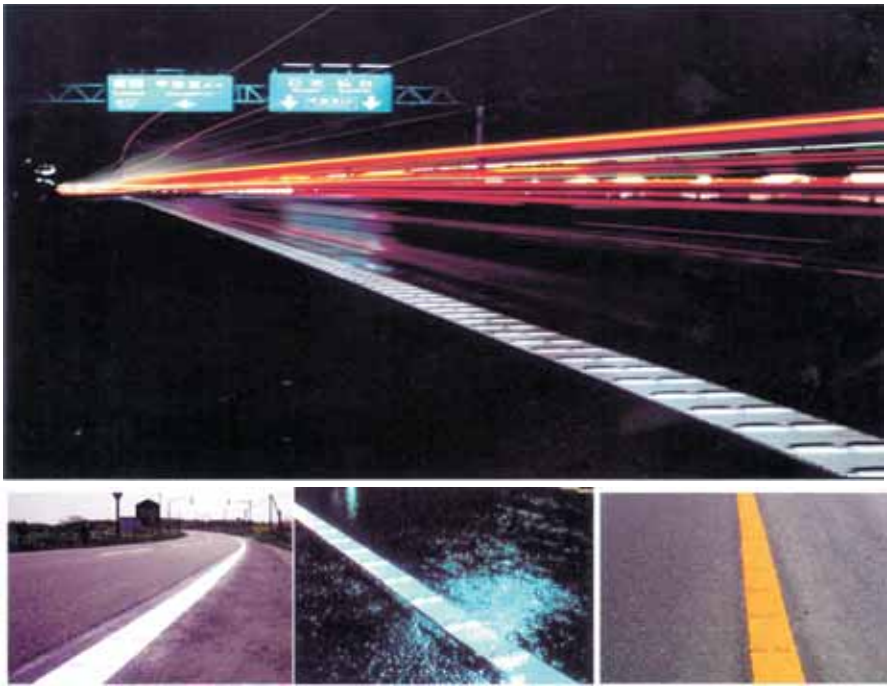


Fig. 6.03 Typical Road Markings for Improved Day/Night Visibility

6.11 TUNNEL MAINTENANCE

6.11.1 *Inspection*

The inspection of tunnels is broadly divided into two categories:

i) The inspection of civil engineering structures such as lining, portals, interior boards, ceiling slabs, and drainage facilities; and

ii) Checking and maintenance of facilities including ventilation system, machines and equipment, and the communication system. Salient major aspects generally considered are as follows:

Inspection of Civil Engineering Structures

- ***Routine Inspection:*** the condition of the road and how it is being used is routinely checked at a range recognizable from a car.
- ***Periodical Inspection:*** inspection at close range by a staff on foot. In the case of tunnels, checking from the inspection gallery is the rule. If the need arises, inspection from a lift car is carried out by restricting traffic (once a year).
- ***Emergency Inspection:*** to supplement daily and periodical inspection, emergency inspection is made as the occasion demands (whenever required).

Inspection/ Maintenance of Facilities

- ***Routine Inspection*** machines and equipments in working condition are checked from outside for any abnormality, using the experienced inspector's judgment and within the range of built -in measuring instruments. Simple mending and cleaning are also carried out.
- ***Periodical Inspection:*** more detailed checking than daily inspection in performed periodically on machines and equipment to ensure there is no abnormality. Cleaning, occasional functioning tests, and detailed measurement using special measuring instruments are carried out.
- ***Emergency Inspection:*** inspection is performed if serious damage is caused to machines or equipment of the facilities by fire or accident or if any problem is foreseen (as and when required).

6.11.2 *Maintenance/improvement work*

Since, tunnels are closed structures, maintenance is necessary in view of disaster prevention. To keep pace with technical progress, emergency facilities have always been modified or updated as frequently as possible. To prevent accidents, measures such as

improving lighting equipment, paving in brighter colours, and visual guidance for improved visibility shall be adopted.

Tunnel-related maintenance work includes cleaning surface, cleaning attachments to the road such as interior boards and tiles on the side walls of inspection gallery, and cleaning drainage facilities and tunnel lighting facilities. The frequency of cleaning depends on the traffic volume. Various inspection and maintenance data shall be comprehensively examined, and the timing of re-inspection and detailed investigation shall be decided while immediate solving of an urgent problem involving accidents, machine breakdowns, etc. need to be considered in order to ensure safe travelling in the tunnel.

The tunnels being an enclosed area with arrangements for lighting, ventilation, wall finishes and safety measures need special considerations. Cleaning of tunnel walls, ventilation and lighting system need use of chemical solvents (specially for soots), pressurized heated water and mechanical devices. All these require skilled maintenance technicians.

Moreover, maintenance in tunnel is difficult under high speed traffic conditions or partial lane closures which may cause severe traffic congestion and may become prone to accidents. Maintenance of tunnel must be accomplished with minimal time spent in tunnel.

For expressway tunnels, to maintain speed and safety mechanized cleaning and maintenance is a necessity. NEXCO practices using various machines are presented as follows:

Remote Controlled Tunnel Wall Cleaning

Mechanized and Manual Tunnel Wall Cleaning

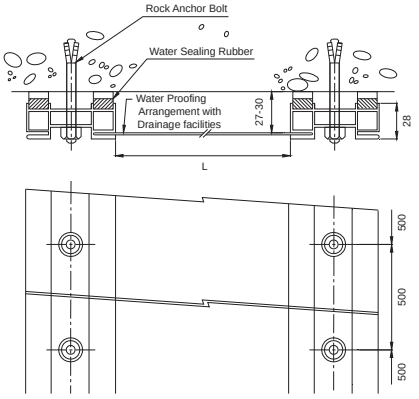

Inspection and Cleaning of Lighting Fixtures


Cleaning of Drains with Hot Water Jet Inspection and Cleaning of Jet Fan

6.11.3 *Tunnel water leakage*

The water leakage inside tunnel is generally through the joints of precast concrete segments, faulty/cracked shotcrete, rock bolt connection, seepage through concrete lighting from rock/earth overburden. The water leakage treatment can be broadly grouped as (i) joint treatment for tunnels with lining and (ii) random treatment for tunnels without lining. A typical tunnel repairing in Japan is shown below :

Joint Treatment for Lining



Typical Repair Arrangement on Leakage Area

Treatment of Sprayed Concrete
Fig. 6.04 Typical Repair Arrangement on Leakage Area

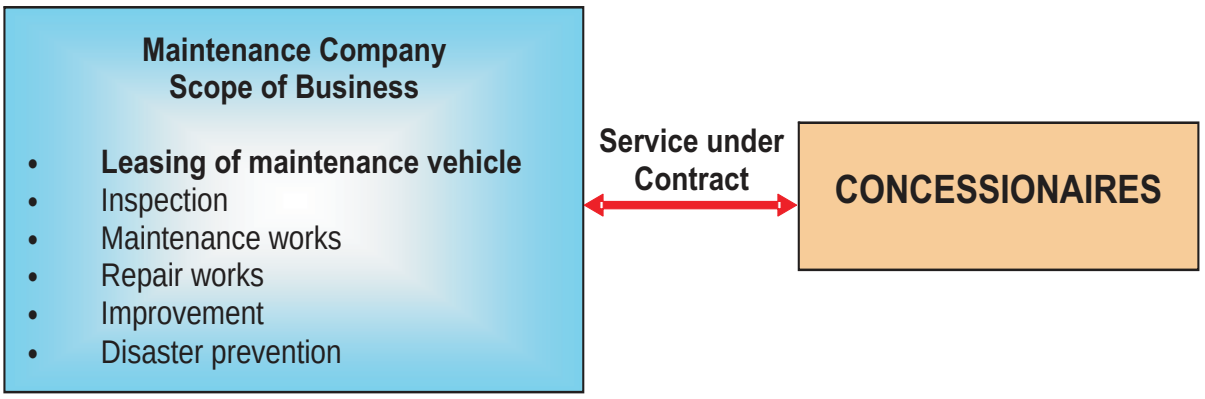
6.12 LEASING OF MAINTENANCE VEHICLES (MAINTENANCE COMPANY)

6.12.1 *Introduction*

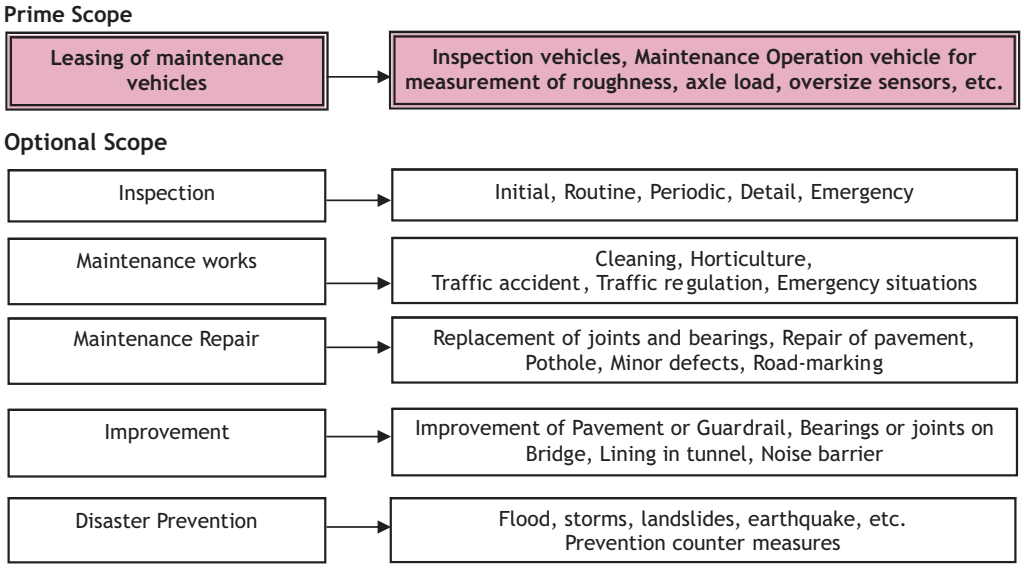
To meet the requirement of specialized equipment for maintenance of Expressway, the concessionaire may not have or may not like to have the required fleet of equipment. These maintenance equipment are capital intensive and are generally of less frequent usage for data collection which may lead to considerable idle time, and maintenance operation is prone to become expensive. For economic use of the maintenance fleet of equipment, it may be prudent to form a separate expressway maintenance company which may serve multiple concessionaires (i.e. for longer sections of expressways) in a coordinated manner.

6.12.2 *Possible scope of "business outline"*

Possible Scope of "Business outline" is shown below:



Scope of Business outline for the Maintenance Company: The prime scope of work will be “Leasing of Maintenance Vehicle”. This leasing will also include experienced operators and necessary other accessories. Therefore, Maintenance Company will have necessary equipment for training technicians and operators for inspection, maintenance operations.



6.12.3 *Essential equipment for maintenance of expressways*

Table 6.03 Equipment List for Maintenance

1*	Road patrol car	**11**	**Milling machine**
2*	Fleet of Trucks for Maintenance	**12**	**Recycling machine**
3	**Portable Lift on Truck**	13*	Patching & pothole repair machine
4	**Mountable signboard arrows, etc.**	14*	Bituminous and concrete plant
5*	Towing vehicle	15*	Aggregate crusher and accessories
6	**Road Sweeper**	16*	Dozer and rippers
7	**Self propelled cleaning machine for drainage**	17*	Tipper Trucks
8	**Watering machine for horticulture**	18*	Transportation truck
9	**Jet water cleaner**	**19**	**Road marking equipment**
10	**Tunnel wall cleaning machine**	20	Cranes

Equipment List for Inspection (Coarse & Detailed)	
1	**Bridge inspection vehicles**
2	**Road surface survey vehicle**
3	**FWD, Benkelman Beam, Skid**
4	**Tunnel wall survey machine (Laser type)**

The "*" marked equipment are expected to be available with the BOT concessionaire whereas the other equipment shall be available on lease basis from the Maintenance Company.

6.12.4 *Conclusion*

Formation of Maintenance Company will have the following explicit benefits for expressway concessionaires to deal with high speed vehicle and high volume of traffic. Such organization with appropriate and adequate number of equipment and trained manpower will also ensure:

- Appropriate inspection
- Expeditious maintenance
- Appropriate traffic regulation
- Increasing traffic safety level
- A fleet of appropriate machines
- Adequate number of employees for day and night operations

Typical equipment used by maintenance companies in Japan are presented in **Fig. 6.05A through Fig. 6.05Q.**

Fig. 6.05A Road Patrol Car

Fig. 6.05B Fleet of Trucks for Maintenance

Fig. 6.05C Portable Lift on Truck

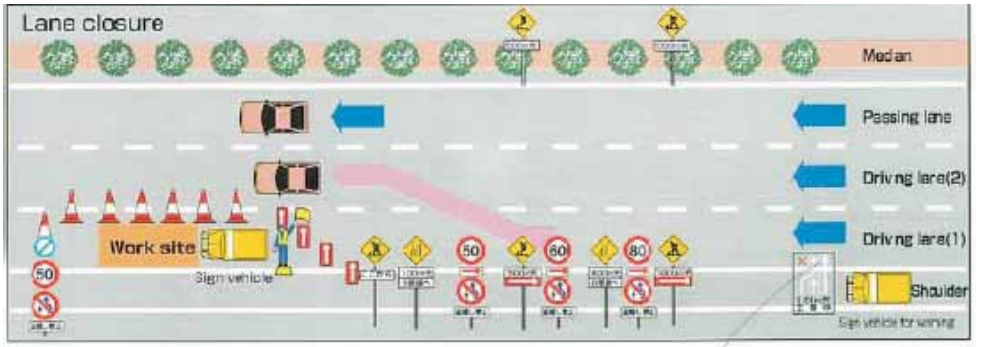


Fig. 6.05D Mountable Signboard Arrows, etc.

Fig. 6.05E Road Sweeper

Fig. 6.05F Self Propelled Cleaning Machine for Drainage

Fig. 6.05G Watering Machine for Horticulture

Fig. 6.05H Jet Water Cleaning

Fig. 6.05I Tunnel Wall Cleaning Machine

Fig. 6.05J Milling and Recycling Machine

Fig. 6.05K Patching & Pothole Repair Machine

Fig. 6.05L Road Marking Equipment

Fig. 6.05M Bridge Inspection Vehicle

Fig. 6.05N Road Surface Survey Vehicle

Fig. 6.05O FWD and Benkelman Beam

Fig. 6.05P Skid Test Vehicle (for Skid Resistance)

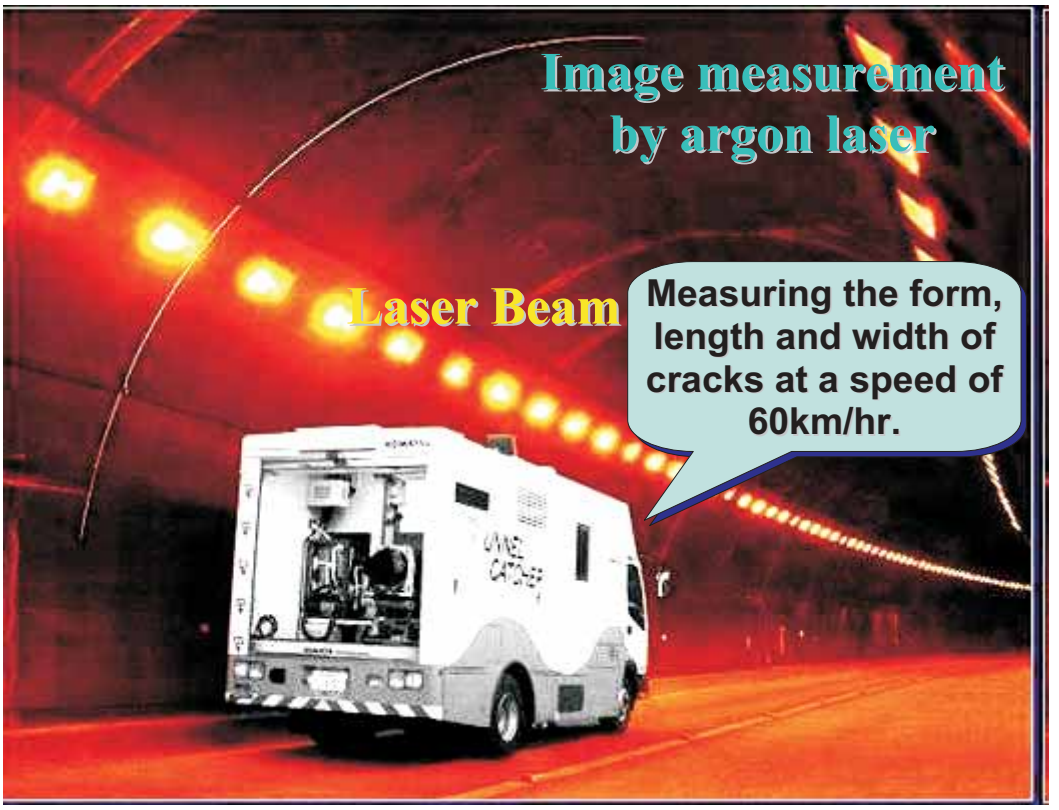


Fig. 6.05Q Tunnel Wall Sruvey Machine (Laser Type)

CHAPTER - 7

PREVENTIVE MAINTENANCE

CHAPTER - 7

PREVENTIVE MAINTENANCE

7.1 INTRODUCTION

For high speed Expressway maintenance, there is need for a planned strategy of cost-effective time saving treatments for the roadway system and its essential appurtenances which preserve the system, retards future deterioration, and maintain or improve the functional conditions of the system (without substantially increasing structural capacity but deferring potential major rehabilitation).

AASHTO's observations on preventive treatment were summed up quite nicely by defining the preventive maintenance as "applying the right treatment to the right pavement at the right time". **Fig. 7.01** presents the trigger levels of preventive treatment and likely rehabilitation level on conceptual basis.

Preventative Maintenance takes a proactive approach in maintenance of the expressway network reducing time-consuming rehabilitation and reconstruction and the associated traffic disruptions. Timely preservation can ensure improved mobility, reduced congestion and safer, smoother, long lasting expressway network.

The key is to apply the treatment when the pavement is still in relatively good condition and no structural damage.

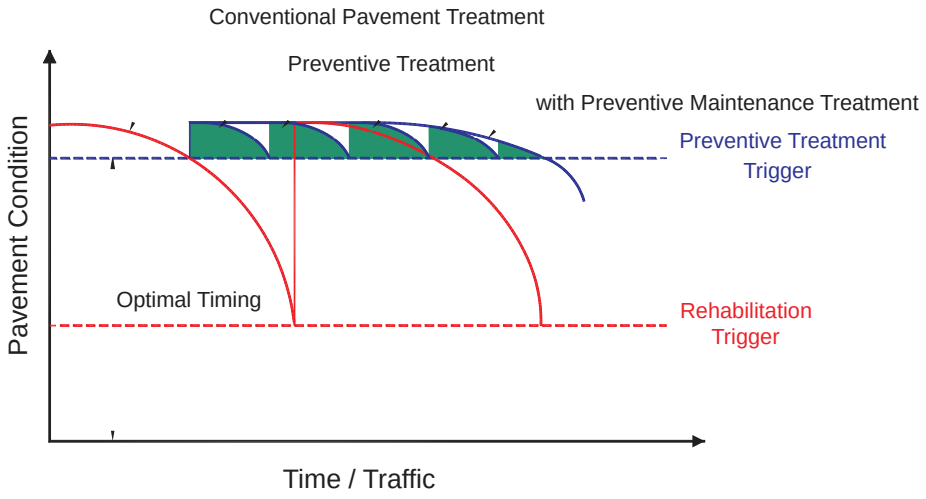


Fig. 7.01 Preventive Maintenance – Conceptual

Fig. 7.02 presents the thematic relations on the various aspects of comfort and pleasure of the users on expressways.

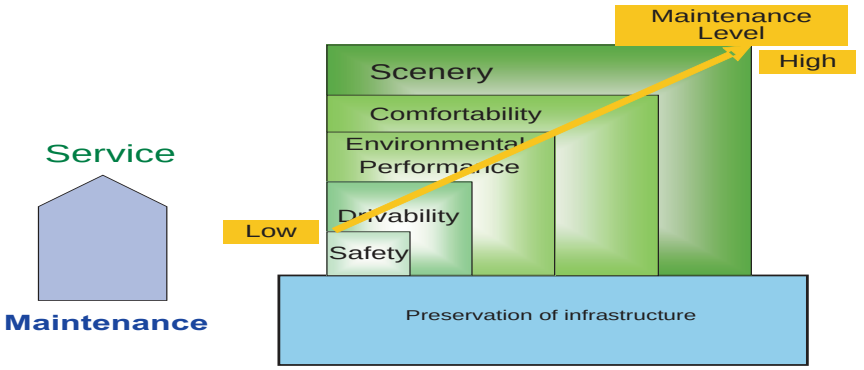


Fig. 7.02 Thematic Relations – Maintenance Level and Users Satisfaction

7.2 NECESSITY OF PREVENTIVE MAINTENANCE

Inspection is the key element in maintenance and triggers all the necessary activities, consequently prepares the resource requirement. Preventive maintenance will emerge from inspection evaluation as follows:

Maintenance	Corrective intervention	Inspection assessment ranking 'AA'
	Preventive intervention	Inspection assessment ranking 'A', 'B', 'C'

Refer Table 3.03 : Typical Ranking of Inspection in Chapter-3.

Inspection Assessment ranking 'A', 'B', and 'C' will form basis for preventive maintenance

- By detecting an early symptom of deterioration
- And checking the development pattern of deterioration
- It is possible to find an optimal intervention level to arrest the deterioration

These will assist in planning a mid/long – term maintenance strategy

7.3 BENEFITS OF PREVENTIVE MAINTENANCE

The benefits associated with preventive maintenance, both perceived and documented, vary from place to place and depend on the strategic objectives. The following benefits are obtained:

- Pre-planned maintenance
  - Maintenance intervention time is known
  - Optimal usage of workforce, machine, spare parts and equipment
- Optimal maintenance level (most cost effective treatment)
  - Best intervention timing and type to treat the deterioration
  - Planning of grouping interventions which will minimize disturbance to traffic

7.4 CONCLUSIONS

A preventive/preservative or proactive approach entails the application of a series of low cost maintenance treatments which are expected to last for a few years. The key is to apply the treatment when the subject element is still in relatively good condition and no structural damage.

The end result will be an extension of the service life of the expressway network instead of having to rehabilitate / reconstruction. And, this translates into savings in resources. It is important to realize that no pavement lasts for ever, and preventive activities do not stop a pavement or appurtenances from eventually deteriorating. These are intended to reduce the rate of deterioration and to make expressway maintenance more cost effective and to cause less disturbance to the users.

CHAPTER - 8

DISASTER PREVENTION

CHAPTER – 8

DISASTER PREVENTION

8.1 GENERAL

Disaster reduction measures to prevent or reduce impact of natural disaster to roads and their time phases are given in **Fig. 8.01.**

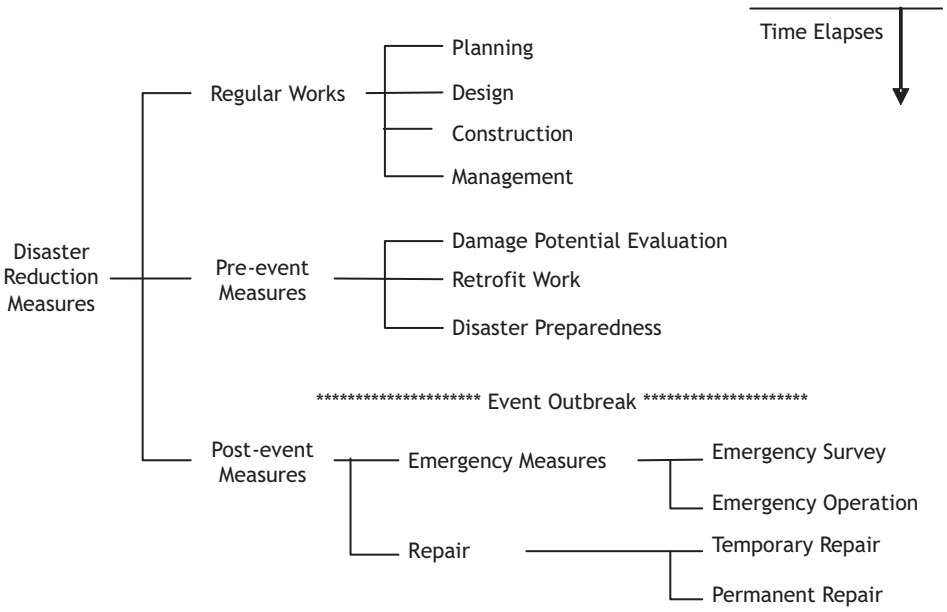


Fig. 8.01 Disaster Countermeasures and Time Phases [1, 2]

Overall measures can be grouped into three phases: regular work, pre-event measures and post-event measures. First, consideration of disaster reduction in the regular work consisting of planning, design, construction, and management is most crucial for mitigating natural hazards to roads.

Pre-event measures include damage potential assessment, retrofit work, and disaster preparedness.

Post-event measures consist of emergency measures (emergency survey and emergency operation) and repair work. Emergency survey is a quick survey to understand the nature and degree of damage to roads and facilities, with objectives of responding to the needs of emergency operation and repair. From the emergency survey, the management staff should obtain an outline of all concerned damage.

Emergency operation may consist of disaster relief aid for rescuing and searching for victims, and also actions for avoiding successive hazards which often follow the original event. Activities to close and restrict the use of damaged roads and to install temporary supports for preventing complete collapse or partial damage to structures are typical emergency operations. The emergency survey and emergency operation will often be conducted consecutively as emergency measures.

8.2 PRE-EVENT PREPAREDNESS MEASURES

Vulnerability of Road Network: In addition to damage potential assessment, pre-event preparedness measures are also very important.

Road management offices should thoroughly understand the vulnerability of road networks in the region concerned and availability of detours. Future additions of road networks should be considered for areas where most roads, including detours, are likely to seriously suffer from hazards.

Road Management Systems: Road offices should improve management systems with consideration of the following factors:

i) Collection of road damage information
ii) Needs for emergency measures and repair
iii) Cooperation with construction and materials delivery industries
iv) Consultation with disaster experts
v) Storage of construction materials and equipment for emergency use
vi) Duty staff to be on call in case of emergency

Education, Training and Exercises: Road maintenance staff should be aware of possible results of road damage and the effects on society and on economic activities. Training exercises that assume a hypothetical disaster are effective in getting the staff accustomed to disaster situation. In these exercises, emphasis should be placed on actions to be taken just after road damage, and on procedures for communicating disaster information among the road office staff.

8.3 POLICY AND ORGANIZATION FOR REPAIR

Procedures for Repair Work: When a hazardous event causes serious damage to roads

and related facilities some of the following measures should be taken, based on the type and magnitude of the disaster.

i) Call of staff members
ii) Setup of emergency organization system
iii) Emergency survey and emergency operation
iv) Road closures and traffic restrictions
v) Temporary repair
vi) Permanent repair

Emergency Organisation: For smooth repair of damaged roads, it is effective to set up a special organization which copes exclusively with the repair work. When establishing a special system to cope with a serious road disaster, the following factors should be carefully considered.

i) Assignment of each staff member's role
ii) Sufficient number of staff members for field teams
iii) System for instruction and information collection
iv) Portable communication system between responsible staff members
v) Consultation with experts and supervisors
vi) Cooperation with specialized companies
vii) Good care of staff health

Repair Plan and Repair Priority: In planning repair of damaged roads, the degree of the entire disaster, characteristics of the affected area, traffic demand, and repair priority should be considered.

Traffic Management: Traffic management should be adequately enforced, taking into account the pattern and degree of road damage. Appropriate control should be selected from different traffic control measures such as (a) complete closure, and (b) partial restriction in kind or weight of vehicles, time of opening, driving speed, lanes to open, or alternating one-way use.

Information Communication and Public Relations : For smooth implementation of repair work, it is essential to have a good system for accurate information communication. In

communicating with related organization immediately after a serious disaster, public telephones may not be available. In such cases, disaster priority telephones, radio phones, or wireless phones may work effectively. Availability and effectiveness of these emergency communication media should be checked during normal times.

It is also important to work on public relations and provide local residents with updated information on road damage and repair prospects. Mass media such as newspaper, radio and television may be effectively employed for this purpose.

8.4 EMERGENCY MEASURES

Emergency Survey: Emergency survey is to obtain an outline of all the damage to road networks. In addition, it is crucial to identify damaged portions which have high potential for subsequent complete collapse.

From the emergency survey, the necessity to close roads or restrict their use should be judged in view of the relation between degree of road damage and road traffic use. An outline of damage to important structures such as long bridges should also be obtained. It is also essential to transmit the results of the emergency survey to the Director at the headquarters office as soon as possible.

Emergency Operation: When serious road damage happens and causes accidents and injuries, the road management office should undertake first aid operations to rescue and search for victims, in cooperation with emergency aid organizations such as police and fire stations.

When damaged portions likely to result in complete collapse are found from the emergency survey, emergency operations such as closure and restrictions of road use, identification of dangerous areas, and warnings to road users should be executed promptly. In this way, subsequent hazards can be avoided.

8.5 CLASSIFICATION OF WORKS

- Slope protection (collapse, rockfall, landslide and fire)
- Earthquake protection
- Reinforcement of substructures against earthquakes
- Snow-work (avalanche, snow drift and falling snow)
- Disaster restoration
- Others (protection from high winds, tidal waves, debris flow and scouring)

To forestall damage from natural disaster such as heavy rain fall, snow fall, land slide, fire, etc. routine inspection and maintenance are essential. Timely discovery and remedy through an expert's eagle eyes is essential. **Table 8.01** presents specific remedies for various problems.

Table 8.01 Specific Remedies for various Failures in Case of Disaster

Classification of failures	Classifications	Mending methods
Collapse	-	Concrete block (piled in parallel cross)
		Replacement
		Re-cutting
		Soil reinforcement
		Mat gabion
		Cast-in-place concrete frame and anchors
		Concrete block frame
		Stone pitching
		Cast-in-place concrete frame and holding piles
		Drain crate
Cracks and swelling	-	Mat gabion
		Concrete block frame
		Knit fence
Descaling and gully erosion	-	Concrete spray
		Grillage frame
Spring water	-	Concrete block frame
		Replacement
Withered vegetation	-	Soil improvement and spreading vegetation mats
Flaking and boulders	Extra territorial slope	Rock fall net, wire rope and net cover
Scouring	-	Wire cylinder and mat gabion

(2) Special Slopes

Classification of failures	Classifications	Mending methods
Cracks or descaling	Concrete block frame	Cast-in-place concrete frame and holding piles
Loose or settled ground	Concrete block frame	Reinforcement with packed cobbles
		Vegetation plus Mat gabion
Scouring	Concrete block frame	Pouring concrete into block frame
Cracks or descaling	Concrete spray	Concrete and mortar spray
Collapse	Concrete spray	Cast-in-place concrete frame and anchors
		Re-cutting and cast-in-place concrete frame
Steel wire corrosion	Rock fall net	Cracked, loose or swollen ground
Soil deposits behind rock fall net	Rock fall net	Concrete spray

(3) Masonry

Classification of failures	Classifications	Mending methods
Cracks, loosen or swelling	Concrete block masonry	Cast-in-place concrete frame and holding piles
		Reinforced concrete wall
Subsidence, displacement and collapse	Concrete block masonry	Concrete block (piled in parallel cross)
Cracks, loosen or swelling	Stone masonry	Lock bolt
		Cast-in-place concrete frame and anchor
		Concrete block masonry
Scouring and settlement	Stone masonry	Foot protection concrete block
Steel wire corrosion	Mat gabion	Rockfall net
Transformation	Vegetation plus Mat gabion	Cast-in-place concrete frame and anchor

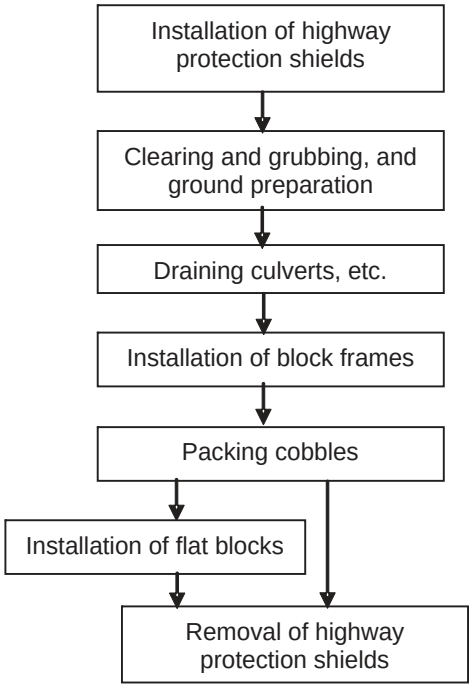
8.6 PROTECTION OF SLOPES AGAINST DISASTER

8.6.1 *Concrete block frame*

This is to provide the slope with protection against erosion and weathering by rainwater, and against gully erosion. It is also used in areas where soil is not suitable for vegetation

but has to be planted for environmental considerations.

To protect slopes from the fire hazard generated from passing vehicles, concrete block frame (filled with flat blocks or cobbles) is applied to slope toes to a height of about 2 m from road surface, providing non-combustible protection. This method cannot withstand earth pressure, and it is expensive compared to vegetation cover/turfing. As a result, its application is subject to careful studies.



i) Concrete block frames should be applied only to gentle slopes with a gradient of over 1V:1H in consideration of workability and potential degeneration of packed cobbles.

ii) The standard thickness of concrete frame members is 15 cm for open-cut section and in a range of 10-12 cm for embankment.

iii) It is preferable to avoid the use of these concrete block frames in snow belts where the soil can freeze and degenerate frame members. Even in unavoidable cases, its application should be limited to gentle slopes with a gradient of 1.2V:1H or more.

iv) For water springs, it is necessary to install an underground drainage system across the slope, along with other steps necessary to dispose of spring water, prior to the installation of concrete block frames.

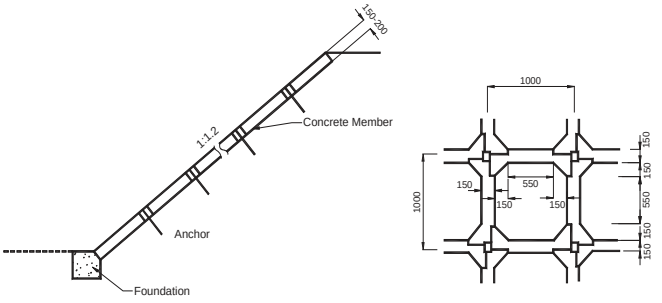
Before installation of concrete block frames. Photo shows collapse of slope surface due to gully erosion caused by spring water.

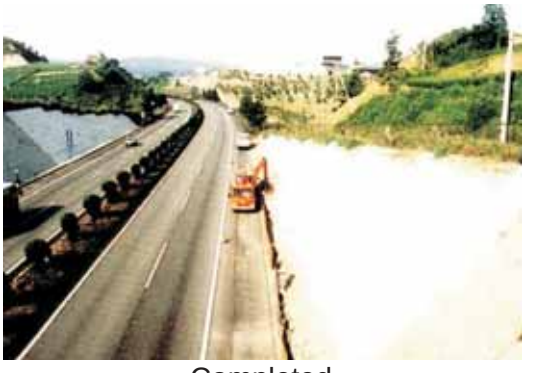
Before Construction Work

Concrete block frame work in progress. Installation of concrete block frames on the slope with a crane on the shoulder.

Under Construction Work

Completion : Open-cut slope (example)





Completed

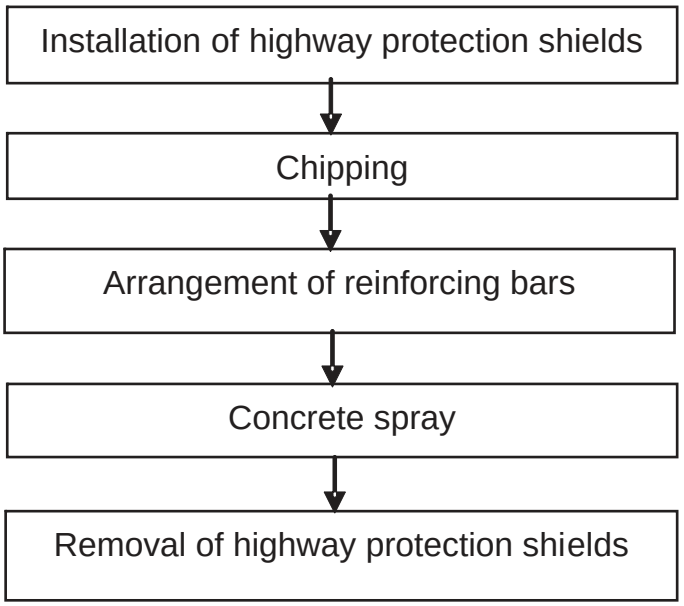
8.6.2 *Concrete (mortar) spray*

Concrete and mortar spray is applied to rocky slopes free of spring water which are subject to weathering (including descaling due to weathering) and to slopes which have many cracks and joints, a potential rockfall hazard, or is not suitable for vegetation.

Though the severity of aging varies with the mix design when constructed, time sprayed, geological conditions (spring water, etc.) weather conditions, etc., sprayed slopes are subject to aging, such as cracks, upheaval, exfoliation, etc, and loss of initial properties over a prolonged period.

This can pose a problem with road operation, especially when peeled concrete fragments drop over road surface. Aged concrete can be cured by overspray or respray.

Work Flow:



Before renovation

Cracks, exfoliation, etc. are seen on slopes due to the deterioration of the sprayed concrete.

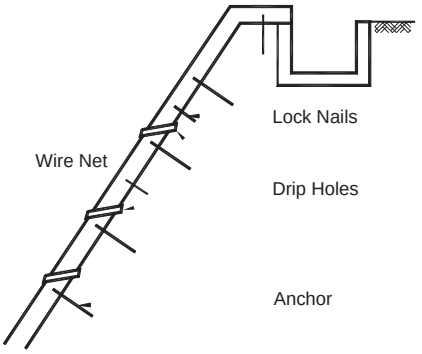
Before Renovation

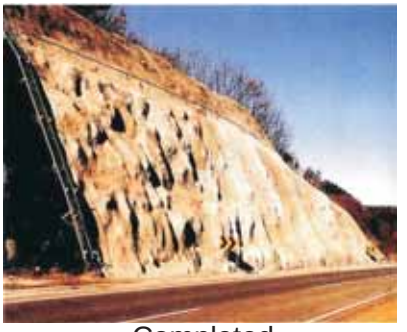
Concrete spraying

Deteriorated concrete spray is chipped-off by the breaker. After the arrangement of reinforcing rhombic wire net, the slope is resprayed with a concrete sprayer up to a thickness of 10 to 20 cm.

Concrete Spravina

Completed





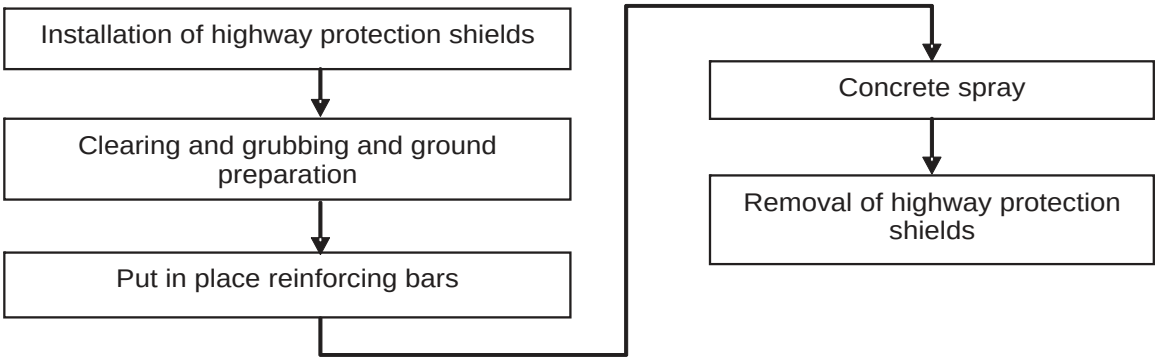
Completed

8.6.3 *Concrete sprayed frame*

This work is applied to rugged, cracked, rocky slopes which need immediate renovation. This method provides easy work and is suited for rugged, uneven slopes, using frames of various shapes which adapt to specific surface contours.

This working method employs a variety of techniques, which should be selected flexibly to meet special on site requirements by changing the size of members, or by the combined use of anchors

Work Flow:



Before renovation

Deformation of natural ground in front of an abutment

Before Renovation

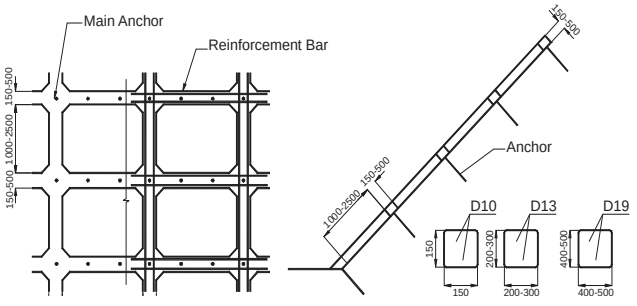
Concrete spraying

A slope is sprayed by concrete sprayer after putting in place reinforcing bars.

Concrete Spraving

Completed

Consolidation of Foundation

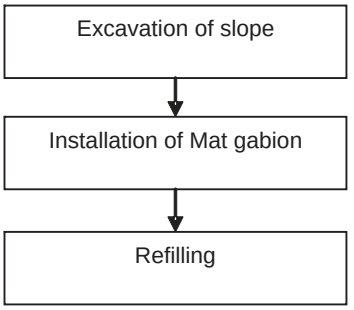


Completed

8.6.4 *Installation of gabion mat*

The purpose of Gabion Mat installation is to rehabilitate portions of a slope which have collapsed due to sediment runoff caused by spring water.

Work Flow:



Before renovation

Slope face degenerated by spring water

Before Renovation

Installation of Gabion Mat

Manual installation of gabion mat, packing cobbles and driving lock piles

Gabion Mat

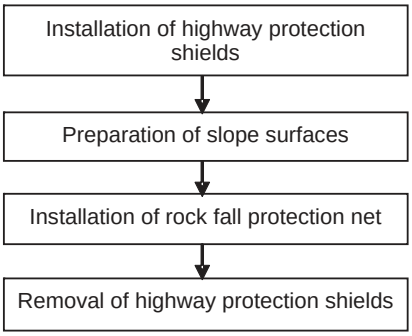
Completed

Completed

8.6.5 *Installation of rock fall protection net*

The rock fall protection net is designed to forestall rock fall and guide fallen rocks to slope toes without allowing them to hit the highway. The protection net is often installed on slopes of rock mixed with gravel and pebbles. Slopes are covered with wire net after the removal of withered and decayed grasses and boulders.

Work Flow:

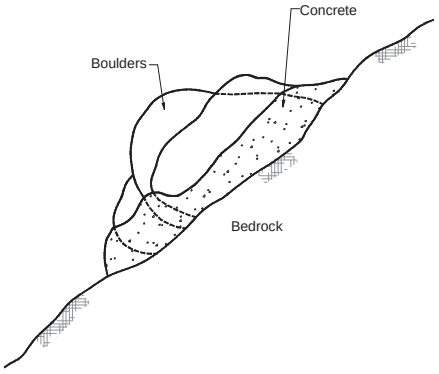


Rock fall Protection Net

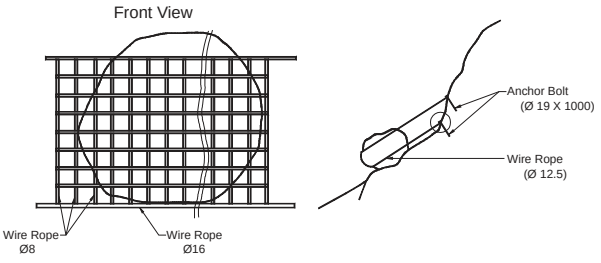
8.6.6 *Treatment of boulders*

Typical Location of a Boulder

Rock fall protection work involves the crushing of rocks and gravel, consolidation of the foundation, the setting of wire ropes, etc. An appropriate countermeasure should be selected based on a detailed field survey of the slope topography and geology, the growth of vegetation, and on pre-assessment of workability, durability and maintainability. In steep areas such as mountain roads, inspection outside of road area should be conducted to prevent rock fall from non-administered areas.



Consolidation of Foundation

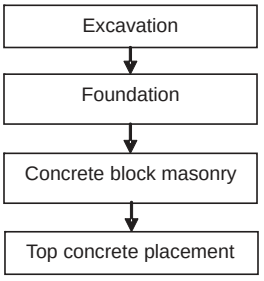


Wire Rope Cover

8.6.7 *Concrete block masonry*

This work is designed to protect bank and open-cut slopes and prevent minor collapse of the base of slopes, applied to a case where earth pressure is low since bedrock behind the slope is solid.

Work Flow



Before Concrete Work

Foundation

Concrete frames are set for concrete placement following ground excavation.

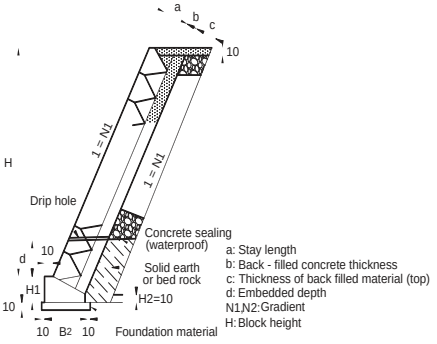
Foundation

Concrete block masonry

Concrete blocks are laid on the slope with manual concrete-filling and back-filling. In filling concrete, concrete must be tightly compacted to avoid the occurrence of gaps near edges or joints.

Concrete Block Masonry

Completion of concrete block masonry

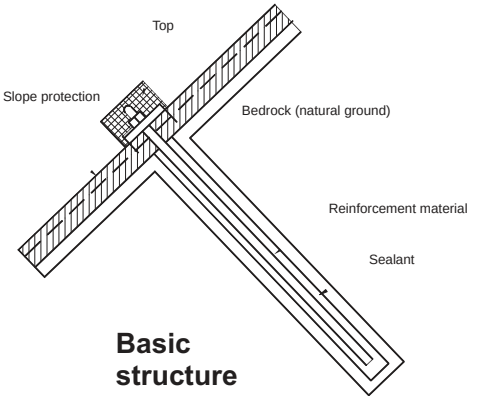


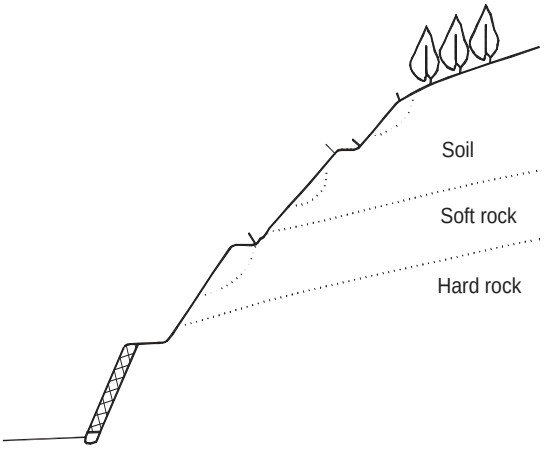
Slope Toe of Embankment

Completed

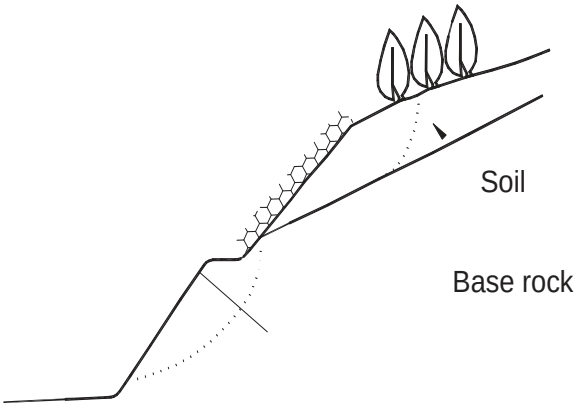
8.6.8 *Earth reinforcement*

This work involves the insertion of many short reinforcing bars and lock bolts into the bedrock together with sealant, through holes drilled into the bedrock. The purpose is to reinforce natural or bank slopes and to integrate embankments with bedrock into an integrated structure.

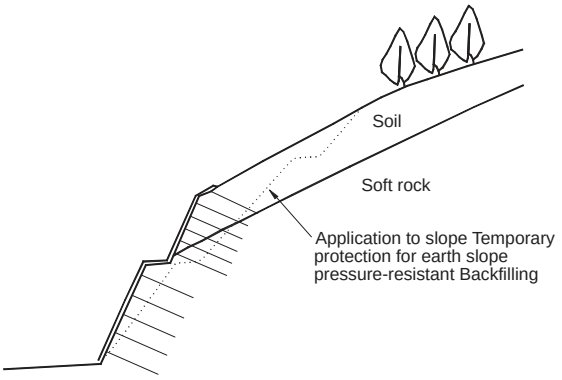




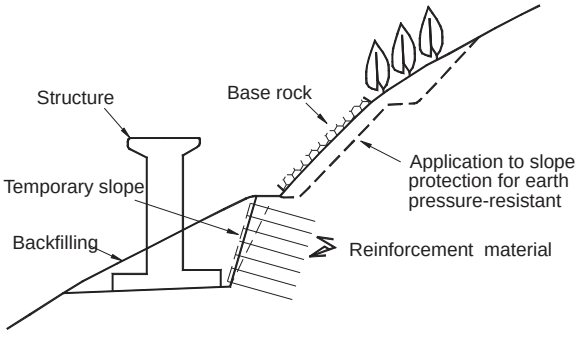
Application to slope protection for earth pressure-resistant



Application to slope protection for medium-scale collapse



Application to steep open-cut slope



Application to temporary slope for structure construction

8.7 PROTECTION AGAINST SEISMIC DISASTERS

8.7.1 *Edge expansion and girder linkage*

Girder linkage: This work is designed to prevent bridge fall down by way of a chain connection of abutments with girders, or making the girders jointless.

Girder Linkage

Edge expansion: This work is designed to prevent bridge fall down by expanding the width of the piers, etc.

Edge Expansion

Floor slab connection to prevent bridge fall down: Floor slabs are connected by steel bars to prevent from fall down.

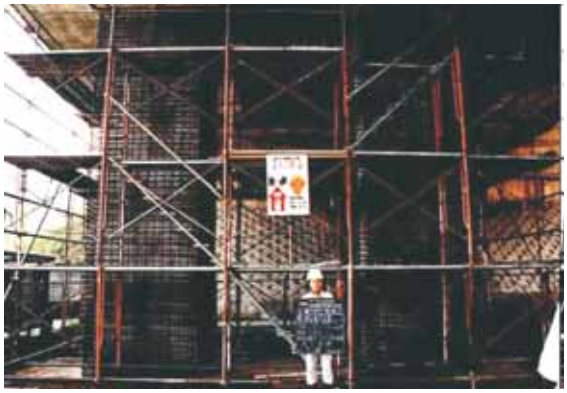
Floor Slab Connection

8.7.2 *Reinforcement of piers*

Bridges have been reinforced in substructures to withstand earthquakes of an intensity equal to that of the Hyogoken Nanbu Earthquake, precluding the possibility of heavy damage to road functions. Piers can be reinforced by RC lining, steel plate lining, CFRP lining, extra foundation piles, etc. In addition, cofferdam work using sheet piles has been introduced in order to curb displacements in abutments and back-fills as a result of quake-triggered ground slide. An optimum construction method should be selected after analysis of ground conditions, potential impact on the main line, bridge structure, etc.

i) ***RC Lining***

Before the work



Work in progress

Completed

ii) ***Abutment Cofferdam***

Work in progress

Completed

iii) *Steel Plate Lining*

This method is designed to allow steel plates to work as tie hoops and main reinforcements by lining existing piers with steel plates, thereby enabling the piers to withstand seismic force.

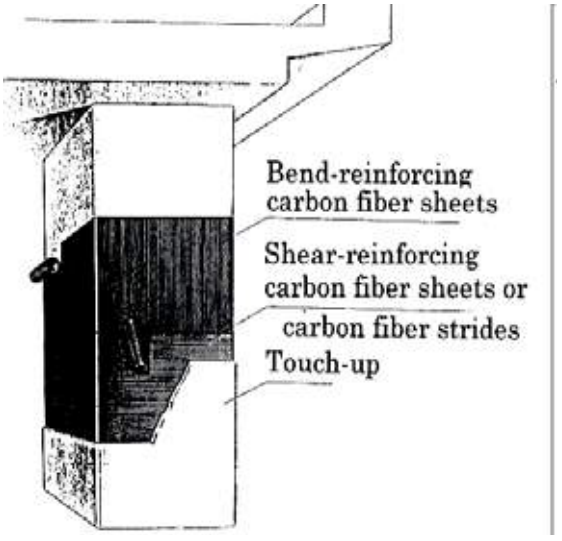
Before Steel Plate Lining

Completed

iv) *Carbon Fiber Reinforced Plastics (CFRP) Lining*

This method is designed to strengthen the main reinforcing bars in terraced parts by bonding and lining the glass gloving cloth (carbon fiber sheet) to existing piers with synthetic resin.

Conceptual View



Before CFRP lining

Work in progress

Completed

v) *Driving Extra Foundation Piles:*

This method employs extra foundation piles to assist the existing piles in bearing increased loads of support on ground which can liquefy in the event of an earthquake.

Exposing reinforcement bars at the head of newly constructed piles

Concrete casting of new piles in progress

8.8 DISASTER RESTORATION

In the event of a natural disaster, maximum effort should be made to minimize secondary damage to third parties and to bring prompt recovery of traffic and transportation.

Disaster restoration measures cover:

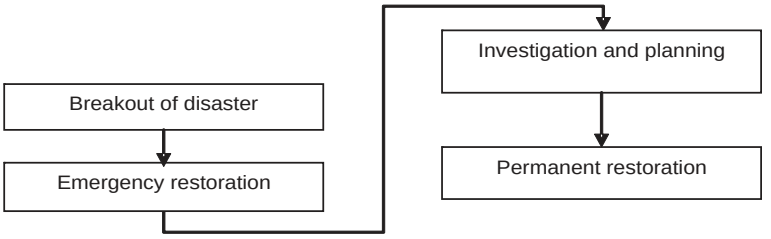
i) Temporary restoration directed to safeguard people against secondary disasters and to recover traffic through emergent restoration of highways, and

ii) Permanent restoration: implemented after the in-depth analysis of causes of the collapse, and investigation of neighbouring areas as well as the location which suffered.

Restoration of disaster stricken slope (Example)

In rain and cyclone season, heavy rainfall can cause slope to collapse. To forestall such accidents, routine inspection and maintenance is essential.

WorkFlow:



Damages Suffered

Slope collapsed due to heavy rainfall

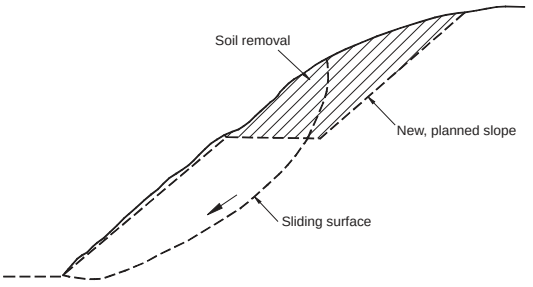
Collapsed Slope

Emergency Restoration

Remove sediment runoff from the collapsed slope and protect it with vinyl sheets and sheet pile wall.

Emergency Restoration

Completion of permanent restoration



Earthquake Damages

Completed