3.5 Traffic Safety Measures

3.5.1 Statistics and Analysis of Traffic Accident

1) General

Two main objectives of motorway accident survey are:

(1) To gather traffic violation data of motorway drivers

(2) To collect data regarding the causes of accidents and take safety steps according to 3E's (Engineering, Enforcement, Education) approach to reduce future accidents of similar nature on the motorway

The first objective is geared toward enforcement by traffic police, while the second objective is for the road administrator (KGM). Because of this, only the second objective is further elaborated below.

2) Contents of Motorway Accident Investigation Form (What items should be investigated)

Traffic accidents on the motorway are generally caused by problems related to the vehicle, road environment and human behavior. Accident statistics must be comprehensive to understand the actual event, cause and effect of the accident.

The fundamental items to be investigated are commonly referred to as the 5W's and 1H.

These are:

When - date, time, whether day or night, etc.

Where - location, road conditions and function, safety facilities, traffic regulations, visibility, etc.

Who - vehicle type, name of drivers, sex, age, driving experience, influence of alcohol and drugs, etc.

What - accident type, causalities, etc.

Why - accident causes, violations, etc.

Table Motorway Accident Investigation Sheet

Accident Investigation Sheet

1)Name of Road	2)Main Maintenance Center	3)Maintenance Office
		5)Accident Date Day Month Year
		6)Accident Time Hour Min

4)Name of Entering Officer

7)Day	8)Holiday	9)Location On Mainline	10)Location Off Mainline	11)Direction
1.Sun. 5.Thu. 2.Mon. 6.Fri. 3.Tues. 7.Sat. 4.Wed.	1.Normal 2.Holiday	K.P.	1.Exit Ramp to SA.PA 6.PA.SA 2.Entrance Ramp from SA.PA 7.Petrol 3.Acceleration Lane Station 4.Deceleration Lane 8.Others 5.Tollgate 9.Unknown	1.Northbound 2.Southbound 3.Eastbound 4.Westbound 9.Unknown

12)Weather	13)Wind	14)Period Of Day	15)Lighting	16)Visibility Distance	17)Surface Condition
1.Fine 2.Cloudy 3.Foggy 4.Rainy 5.Others 9.Unknown	1.Strong 5.Others 9.Unknown	1.Dawn 2.Day 3.Dusk 4.Night 9.Unknown	1.On 2.Off 9.Unknown 0.No Lighting	1.Less than 50m 2.50 to 100m 3.100 to 200m 4.Over 200m 9.Unknown	1.Dry 2.Wet 5.Others 9.Unknown

18)Vehicle Type

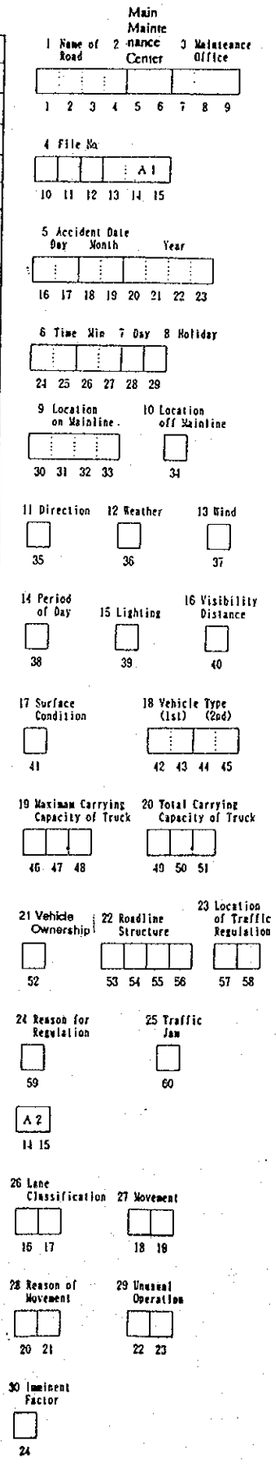
Bus	Trucks	Passenger Car	Motorcycle	Pedestrian
11.Route Bus 13.Other Bus	21.Truck with 2 axles & 4 wheels 22.Truck with 2 axles & 6 wheels 23.Truck with 3 axles 24.Truck with 4 axles 25.Truck with 5 or more axles	31.Site Car 32.Passenger Car 33.Taxi	41.100cc or less 42.Over 100cc	51.Pedestrian(worker) 52.Pedestrian(others) 88.Others 99.Unknown 00.None

19)Maximum Carrying Capacity of truck	20)Overloading of truck	21)Vehicle Ownership	22)Road Line Structure		
			Road Classification	Road Alignment	Other structure
999 Unknown 000 None	999 Unknown 000 None	1.Private usage 2.Commercial usage 8.Others 9.Unknown	11.6 or more lane dual carriageway 12.4-lane dual carriageway 13.2-lane single carriageway	21.Straight 22.Curve	31.Tunnel 32.Toll Barrier on Mainline 33.Bridge 34.Junction 99.Unknown 00.None

23)Location of Traffic Regulation		24)Reason for Regulation	25)Traffic Jam
01.First lane 02.Second lane 03.Overtaking lane 04.Climbing lane 05.Acceleration/Deceleration lane 06.Shoulder 07.Median 08.Ramp	11.Facing Traffic 12.Coordinating Traffic 88.Others 99.Unknown 00.No Regulation	1.Accident 2.Breakdown 3.Construction 4.Worknig on Road 5.Weather Condition 6.Traffic Control 8.Others 9.Unknown 0.No Regulation	1.Yes 2.No 9.Unknown

I. Condition Before Accident / **II. Movement Just Before Accident**

26)Lane Classsfication	27)Movement	28)Reason of Movement	29)Unusual Operation	30)Imminent Factor
01.First lane 02.Second lane 03.Overtaking lane 04.Climbing lane 05.Acceleration(Entrance) 06.Deceleration(Exit) 07.Shoulder 08.Median 09.Emergency Parking Space 10.Opposing lane 88.Others 99.Unknown 00.None	01.Running 02.Braking 03.Stopping 04.Accelerating 05.Decelerating 06.Changing to Right Lane 07.Changing to Left Lane 08.Retreating 88.Others 99.Unknown 00.None	01.Changing lane before Overtaking 02.Changing lane after Overtaking 03.Changing lane for Entrance or Exit 04.Changing lane for other Reason 05.Evasion of Rear-end Collision 06.Evasion of Head-on Collision 88.Others 99.Unknown 00.None	01.Improper Steering 02.Improper Overtaking 03.Improper Steering and Braking 04.Other Steering/ Braking 05.Right-side Moving 06.Left-side Moving 07.Near Missing (Too short safety gap) 88.Others 99.Unknown 00.None	1.Sleeping (Over fatigue) 2.No Looking Ahead 3.Random Glancing 4.Drunk 5.Drug 6.Fear Feeling 8.Others 9.Unknown 0.None



III. Obstruction and Accident Type

31)Detail of Movement	32)Detail of Happenings	33)Objects of Obstruction			
1.Slip 2.Spin 3.Meander 4.Out of Control 8.Others 9.Unknown 0.None	01.Broken Front Glass 02.Loss of Wheel 03.Rush onto road by Person 04.Rush onto road by Animal 05.Flying Stone 06.Slop Slip 07.Water Splash 08.Fallen Gravel 99.Unknown 00.None	01.1st Party 02.2nd Party 03.3rd Party 11.Guard Fence 12.Tunnel Wall 13.Bridge 14.Island 15.Slope 16.Sign 17.Light Pole 18.Others	21.Guard Pence 22.Tunnel Wall 23.Bridge 24.Island 25.Slope 26.Sign 27.Light Pole 28.Others	31.Guard Fence 32.Separation 33.Curb 34.Sign 35.Open Space 36.Others	41.Diverging End 42.Toll Plaza 51.Fallen Goods 88.Others 99.Unknown 00.None
		41)~18 Right-side of Road(Shoulder) 21-28 Left-side of Road(Divided without Median) 31-36 Median			

34) Accident Type	35) Final Stopping Position	36)Stopping Condition	37)Reason of Item 29)·02&03 Only
01.Head-on Collision 02.Rear-end Collision 03.Contact Collision 04.Running off 05.Overturning 06.Personal Damage 88.Others 99.Unknown 00.None	01.First Lane 02.Second Lane 03.Overtaking Lane 04.Climbing Lane 05.Acceleration (Entrance Lane) 06.Deceleration (Exit Lane) 07.Shoulder 08.Parking Space 09.Median 10.Opposing Lane 88.Others 99.Unknown 00.None	1.Normal Stopping 2.Roll over Stopping 3.Over thrown Stopping 4.Normal Stopping after Roll Over 5.Fall Down 6.Stopping after Fire 8.Others 9.Unknown 0.None	01.Talking with passenger 02.Looking at Other Vehicle 03.Side Viewing 04.Looking at Accident Site 05.Operating Radio/Stereo 06.Smoking 07.Toll (Money or Payment) 88.Others 99.Unknown 00.None

IV. Detail of Casualties

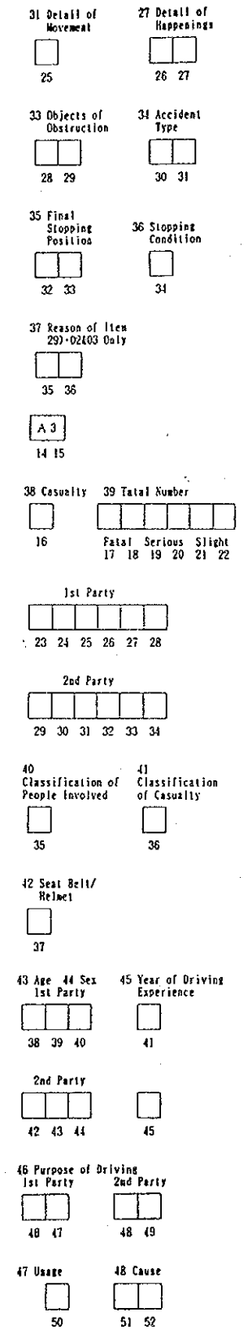
38)Casualties	39)Number	40)Classification of People Involved	41)Classification of Casualties	42)Seat Belt/Helmet
1.Non-casualty 2.Injury Accident 3.Fatal Accident 9.Unknown	1.1st Party 2.2nd Party 3.Total Number	1.Driver 2.Front-seated Passenger 3.Back-seated Passenger 4.Motorcycle 5.Pedestrian 8.Others 9.Unknown 0.None	1.Fatal 2.Serious Injury 3.Slight Injury 0.None	1.Fasten Seat Belt 2.Unfasten Seat Belt 3.No Seat Belt 4.Wear Helmet 5.Do not wear Helmet 9.Unknown 0.None

V. Detail of Driver

43)Age	44)Sex	45)Year of Driving Experience	46)Purpose of Driving	47)Usage	48)Accident Cause
	1.Male 2.Female 9.Unknown	1.Less than 1 year 2.1 to 2 years 3.2 to 3 years 4.3 to 5 years 5.5 to 10 years 6.More than 10 years 8.Others 9.Unknown	01.Commute 02.Business 03.Sight-seeing 04.Private 05.Patrol 88.Others 99.Unknown	1.First Time 2.Several/year 3.Several/month 4.Often/week 5.Patrolling 8.Others 9.Unknown	From the Police Code

Accident Situation Drawing

N



How - positions of vehicles, control of vehicles, sequence of events during accident, etc.

This information is collected and entered into the motorway accident investigation form. This form is divided into three main parts. The first part is general information and is for data on "When" and "Where". The second part is the movements and behavior of the accident and comprises data related to "How" and "Why". The third part is the results of the accident and deals with data on "Who" and "What".

3) Motorway Accident Investigation (How to complete the form)

The motorway accident investigation form is different from the traffic accident record used by traffic police for recording accident data. This investigation form is to be completed by traffic patrol officers with cooperation from traffic police.

This investigation form should be provided with blank cells to enter codes which will respond to questions for data processing by computers.

The investigation form also includes a large cell at the bottom for a sketch of the accident.

The motorway accident investigation form should be completed for every accident on the motorway, even if it only involves property damage.

4) Data Processing of Motorway Accident Investigation Form

It is recommended that the motorway accident investigation from is filled out in triplicate, a copy of which is to be kept at the maintenance office, main maintenance center and KGM headquarters.

The main maintenance center is to be responsible for processing the accident data by computers as well as investigating and analyzing each accident. The results of the analyses, such as monthly reports containing concise accident statistics should be sent to the traffic police and KGM headquarters.

5) Focus of Accident Analysis (What should be analyzed)

A traffic accident is a complex phenomenon whose exact cause is difficult to determine as each accident occurs at a different place, time and under different circumstances. Although complex, it is still possible to analyze general trends and characteristics of accidents using statistical analysis. Based on these analyses, it is possible to find ways to reduce the

probabilities of accidents or to minimize accident damage. Accident analysis can be carried out by two approaches, macro-analysis and micro-analysis.

Macro-analysis is the approach used to investigate the social, economical and regional characteristics of the accident, while micro-analysis is the examination of the occurrence and relationship between the vehicle drivers and the motorway environment. The motorway accident investigation form is used to gather information for the micro-analysis.

Using the reports of the motorway accident investigation forms compiled by each maintenance office, accident statistics are to be processed and analyzed at the main maintenance center. It may be analyzes as follows:

(1) Number of accidents by vehicle action (speeding, unexpected breaking, etc.)

(2) Number of accident by driver action (sleeping, alcohol, etc.)

(3) Number of accidents by type of fixed object (guardrail, etc.)

(4) Motorway sections having high accident rates

These accident statistics should be processed on a monthly, semi-annual and annual basis.

6) Practical Uses of the Analysis

Accident data analysis is indispensable for carrying out effective operations and maintenance on the motorway

A traffic safety section within KGM is necessary to make full use of the results of a traffic safety analysis and to implement traffic safety improvement measures on the motorway. Steps to conduct accident studies on the motorways are shown below:

(1) Investigation of the accident causes, safety measures, improvement plans and cost-benefit analysis for motorway sections with high accident rates.

(2) Study the relationships between geometric design elements and accidents. This is done by analyzing the accident data and motorway elements such as geometric design, road structures and safety devices such as guardrail, lighting, etc.

(3) Study the driver's behavior during accidents.

3.5.2 Traffic Safety Campaign

Traffic safety is a major area of concern in all the highly developed countries. Various efforts have been made to improve the level of safety on motorways. Traffic safety campaign is an example of one such effort.

The underlying purpose of a traffic safety campaign is to reduce the numbers and severity of traffic accidents. An example of a traffic safety campaign is illustrated in Figure 3.5.1.

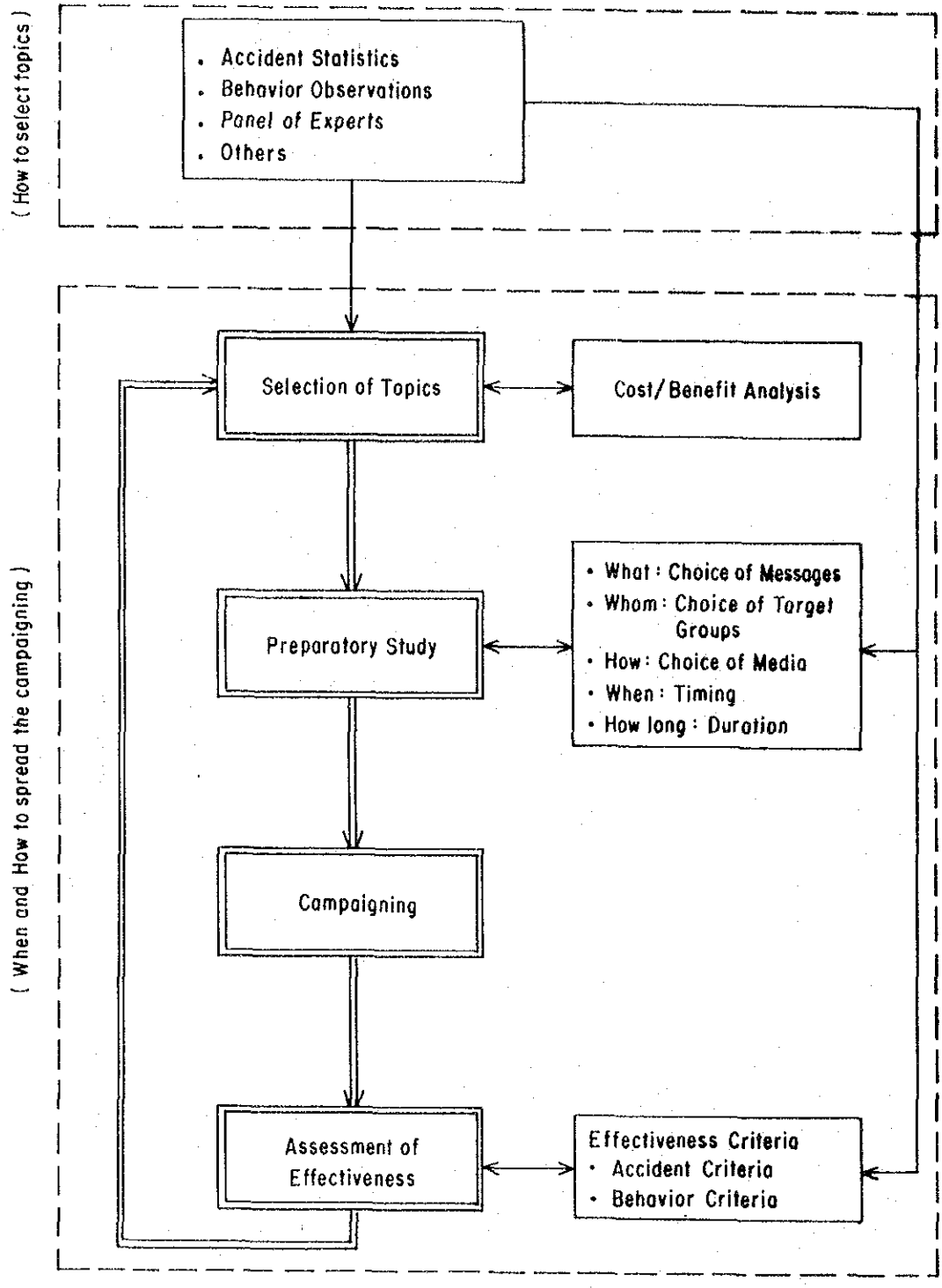


Figure 3.5.1 Flowchart of a Motorway Safety Campaign

3.6 Methods of Handling Hazardous and Hard-to-dispose of Materials

Various kinds of hazardous goods are transported on motorways. When vehicles carrying these materials are involved in accidents, such materials can be spilled and damage the road surface or structures, and could become sources of fire or explosions which would affect the smooth operation of traffic on the motorways.

3.6.1 Hazardous and Hard-to-dispose of Materials

Accidents involving overturned vehicles where the contents have been spilled on the motorway would require special measures to prevent further accidents that might be induced by the spilled materials.

Effective and safe disposal of such materials, particularly if they are harmful or hazardous, require precise knowledge of their chemical characteristics, dangers, neutralizing agents, etc.

1) Dangerous and Flammable Substances

Among dangerous substances there are those that will ignite at normal temperatures, while others may explode if combined with water. The ability of the traffic management staff to recognize such substances and the knowledge for disposing of them safely are important. Some of the common dangerous and flammable substances by types and makes are listed in Table 3.6.1. Flammable gases and liquids are shown in Table 3.6.2.

Table 3.6.1 Example of Flammable Substances

Category	Group	Examples
A.	Flammable at normal temperature in liquid form	- Petroleum - Alcohol - Ester Acetate - Chloro Benzol
B.	Flammable at normal temperature in solid form	- Yellow Phosphorous - Phosphorous Sulphide - Sulpher - Calx - Red Phosphorous

C.	Oxidizing Agents	- Chlorates - Peroxides - Nitrates
D.	Dangerous when contact with water	- Potassium - Sodium - Carbide - Quicklime
E.	Self Oxidizing Compound	- Celluloid - Ester Nitrate - Nitro Compound

Table 3.6.2 Example of Explosive Substances

No.	Examples
1.	Acetylene
2.	Oxygen
3.	Hydroxides
4.	Carbon Monoxide
5.	Acetone
6.	Butane
7.	Propane
8.	Turpentine
9.	Benzene
10.	Dynamite
11.	Nitroglycerine
12.	Hydrogen Cyanide

2) Poisonous Substances

Besides flammable substances, there are other liquids or gases which can catch fire easily. There are also substances which emit poisonous gases when burned or are injurious to human skin. There are over 100 substances of this nature. Some examples are:

1. Yellow Phosphorous
2. Acidic Salts
3. Acetic Acid
4. Nitro-benzene
5. Aldehydes
12. Ammonia
13. Potassium Hydroxide
14. Lead Monoxide
15. Carbon Disulfide
16. Phenol

6. Hydroxides
7. Sulfuric Acid
8. Sodium Compound
9. Uric Peroxide
10. Barium Salts
11. Bromide Compound
17. Mono-chloro Acid
18. Lead Phosphate
19. Aniline
20. Sodium Oxalide
21. Chloroglycerine

3) Hard-to-dispose-of Surfaces

There are substances which are not dangerous but are difficult to dispose of. If such substances are left unattended on the motorway, they may pose a danger to on-coming traffic. Examples of such hard-to-dispose-of substances are:

1. Flour (wheat, corn, etc.)
2. Sugar (honey, etc.)
3. Asphalt or Tar
4. Animal or Chemical Glue
5. Rubber Latex
6. Oil (cooking oil, crude oil, etc.)
7. Animals (chickens, etc.)

4) Stabilizing Agents

There are various kinds of stabilizing or neutralizing agents or absorbent materials for the removal of chemicals or oil spills from the motorway pavement surface. These include pellet-form or felt-form oil absorbers, liquid-form oil-disintegrating agents, perlite, etc. The large number of dangerous and hard-to-dispose-of substances as discussed above require many specific and exclusive chemicals for their safe and effective disposal. It is important that the maintenance office prepare a list of chemical suppliers or disposal specialists so that they can be contacted if their services are needed.

3.6.2 Procedures during Accidents

The basic procedures for handling hazardous materials during an accident are depicted in Figure 3.6.1. The traffic control room, maintenance office and patrol car units are the three main elements that form the basic organization framework in dealing with hazardous materials. Besides these three elements, an information exchange, directories and other activities ensure that proper traffic management measures are being carried out.

Although it is the responsibility of the persons who directly caused an accident to clean the motorway of spilled loads or fallen objects, it is the responsibility of the traffic management personnel to manage it so that such materials are promptly disposed of to prevent further damage to motorway users and structures and to eliminate any dangers that may affect the surrounding areas or residents nearby.

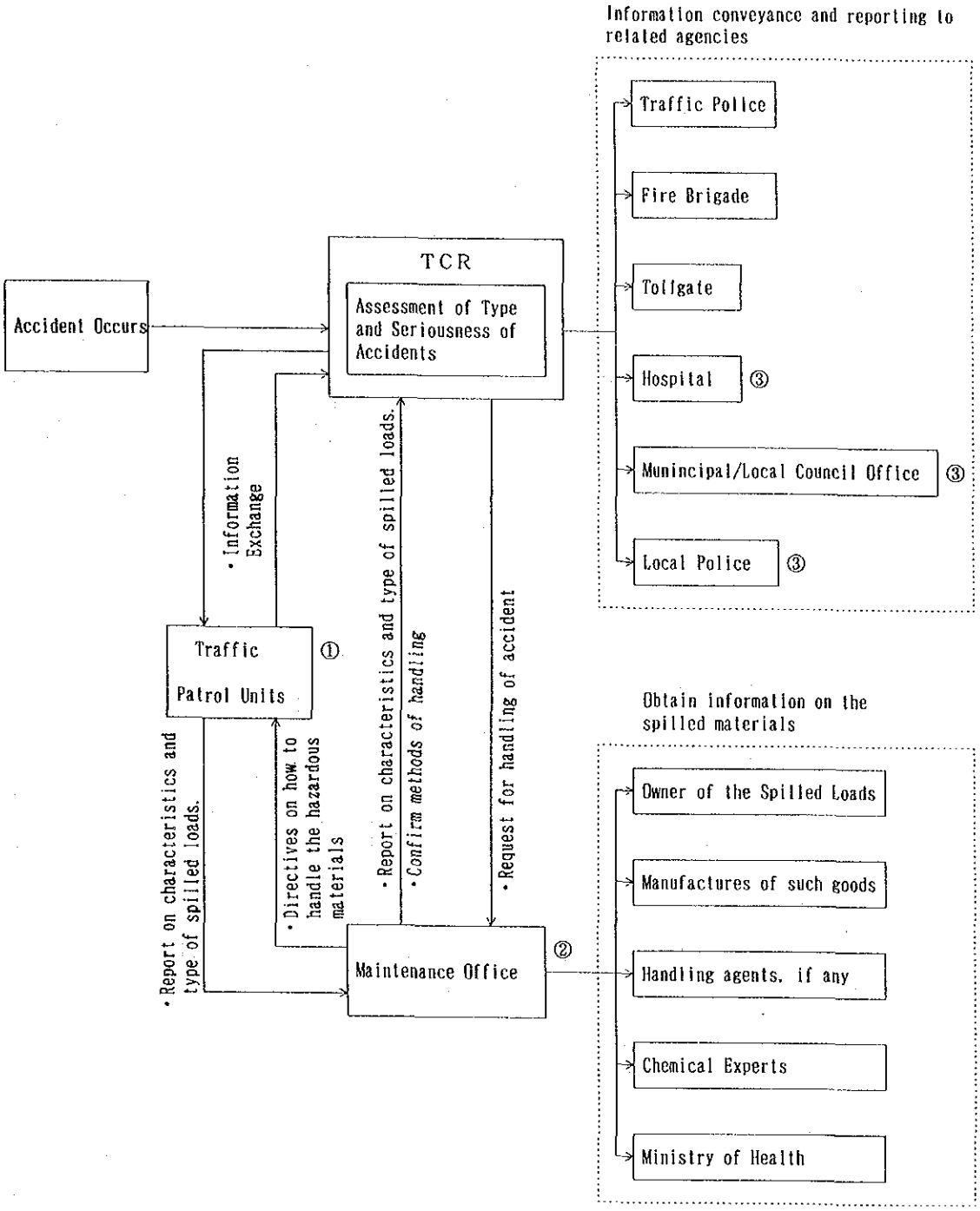
3.6.3 Preparation of a Dangerous Materials List

It is imperative that a list of dangerous materials, their characteristics, effects on health, and methods of handling be prepared and distributed to various related agencies and maintenance office. Such efforts will contribute to strengthening the organization when handling hazardous materials during emergencies. Such listings should be carried in the patrol car for reference during emergencies. A listing of companies specializing in transporting and handling of hazardous materials and their telephone numbers is also indispensable for the operation.

3.6.4 Related Laws and Regulations

Traffic control and management personnel are required to familiarize themselves with the prevailing laws and regulations regarding the handling of hazardous or poisonous materials, such as:

- Regulations on fire-fighting
- Regulations on explosives
- Regulations on liquefied gases
- Regulations on poisonous materials
- Others



Note:

1 - To contain the affected areas, put out fires and report to TCR. Avoid contact with third parties and wait for directive from TCR.

2 - Obtain cooperation from police and fire brigade for handling the hazardous materials.

3 - Contact if the need arises.

Figure 3.6.1 Procedures in Handling Hazardous Materials

3.7 Data Processing and Management

3.7.1 General

Various data are needed for the planning of traffic operations, maintenance and management activities on the motorways. Some of the basic data required are:

1) Traffic volumes and related data
2) Traffic accident data
3) Vehicle breakdown / incident records
4) Obstacle records
5) Weather data
6) Adverse weather and disaster records
7) Traffic regulation records
8) Traffic congestion / road closure records

These data are collected by each maintenance office in the form of output from computer generated data or daily activity records (patrol records, incident record, etc.). The data are forwarded to the main maintenance centers and division office for data processing. The processed data are then forwarded to headquarters for planning and decision making, and also to be published in monthly and annual reports.

3.7.2 Traffic Volumes and Related Data

1) Importance of Traffic Statistics

Traffic volume data are the most fundamental and indispensable data needed for traffic management. It is not only for the planning of daily traffic control and management measures but is also essential for setting standards for traffic safety measures, disaster measures, emergency traffic control regulations and others.

Depending on the usage, different formats for data analysis are necessary. Generally, all traffic volume data are summarized in units of one hour or larger units.

Vehicle running speeds are another statistic for the planning of traffic safety measures. Running speeds (particularly that of heavy trucks) must be obtained so that measures can be taken to avoid large speed differences on the motorway. Vehicle running speeds are also used as an indicator of traffic congestion when monitoring traffic flow on the motorway.

2) Traffic Related Data Required

(1) Annual Average Daily Traffic (AADT)

Daily traffic volumes gathered by traffic detectors installed at representative spots along the motorway network are collected and processed to determine an annual average figure in units of vehicles and PCU's. These AADT values form the basis for comparing levels of usage between motorway sections. AADT values are also used for traffic volume projections and to determine the traffic management levels of each section (which determines the types of equipment or facilities needed to meet the traffic demand).

(2) Entering and Exiting AADT at Each Interchange

These data are collected at toll collection offices. Similar to the above, they are processed in the AADT format by analyzing the annual changes of such traffic. These data are essential for the planning of interchange improvements, for example.

(3) Monthly Average Daily Traffic (MADT)

The analysis of average daily traffic volumes by month enables traffic management officers to determine when traffic is lowest for conducting maintenance and repairs to minimize their effects on traffic flow. Months with high traffic demands (such as holidays) may require careful personnel scheduling to respond to the more probable occurrence of incidents.

(4) Monthly Average Daily Traffic Volumes at Interchanges (entering and exiting traffic)

For reasons similar to the above, daily traffic volumes at each interchange are analyzed to determine the monthly fluctuation of traffic demand.

(5) Daily Maximum and Minimum traffic Volumes

Daily traffic volumes are arranged in descending order over a year to reveal the maximum and minimum daily volumes and the data on which they occurred.

(6) Daily Maximum and Minimum Traffic Volumes at Interchanges (entering and exiting traffic)

Similarly, the daily traffic volumes at each interchange (entering and exiting) are arranged in descending order to obtain the maximum and minimum traffic volumes and dates on which they occurred.

(7) Weekly and Monthly Traffic Volumes Indices

The weekly traffic volumes index for each motorway section is used to determine the traffic variation by day of the week and is obtained by:

$$\frac{\text{Average daily traffic volume by day of week}}{\text{Weekly average daily traffic volume}}$$

Similarly, the monthly traffic volume index is used to determine the traffic variation by month of the year.

$$\frac{\text{Average daily traffic volume by month}}{\text{Annual average daily traffic volume}}$$

These indices are useful in analyzing traffic volume fluctuations along section of the motorway.

(8) Daily Traffic Volume Indices

Daily traffic volumes over a year (for each section) are arranged in descending order as described in (5) above.

To obtain the indices, these volumes are divided by the AADT.

(9) Traffic Volumes by Vehicle Type

Traffic volume data breakdowns by vehicle type can be obtained from the following three sources:

- Traffic census data
- Traffic detector data
- Toll unit data

Vehicle classification data from these sources may differ due to their respective needs. The data collection and analysis from each source have to be carried out independently.

(10) IC Pair Traffic Volumes

Traffic volumes by vehicle type between IC pairs can be determined by using toll tickets that show the entry and exit points. These data are useful in learning trip length and behavior of vehicles for planning the future motorway network.

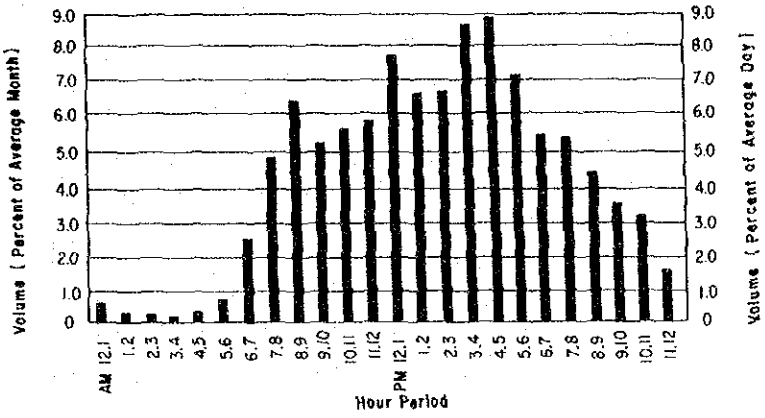
(11) Weekly and Weekend Hourly Traffic Volumes

Using data collected by traffic detectors, average weekday and weekend hourly traffic volumes can be analyzed. These data will show hourly traffic fluctuations on weekdays and weekends.

(12) Running Speeds at Selected Locations

Using traffic detectors, running speeds of traffic can be analyzed with speed distribution curves.

Some example of traffic volume analysis are given below.



3.7.1 An Example of Hourly Traffic Variation Pattern

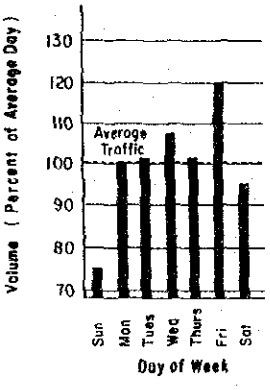


Figure 3.7.2 An example of daily Traffic Variation Pattern

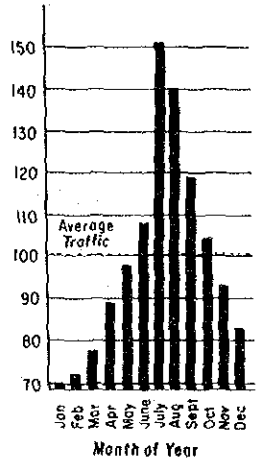


Figure 3.7.3 An Example of Monthly Traffic Variation Pattern

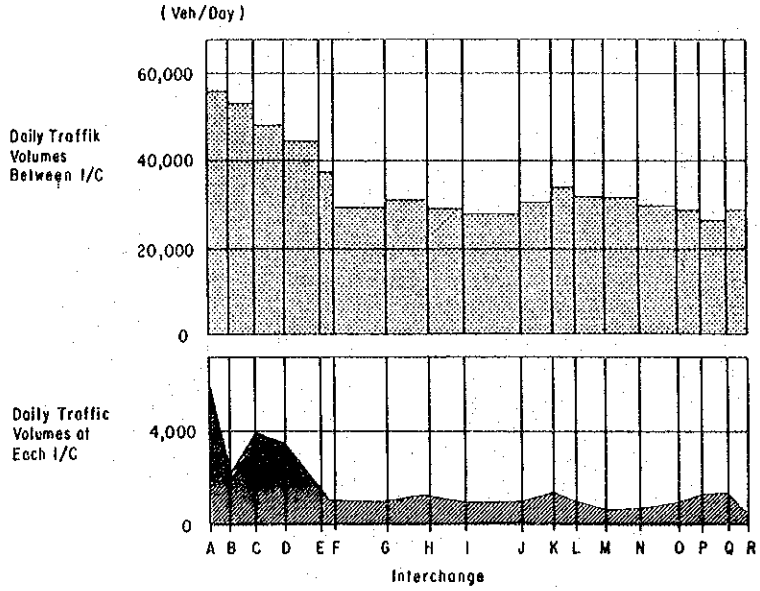


Figure 3.7.4 Examples of Daily Traffic Volume Variations between IC and At IC

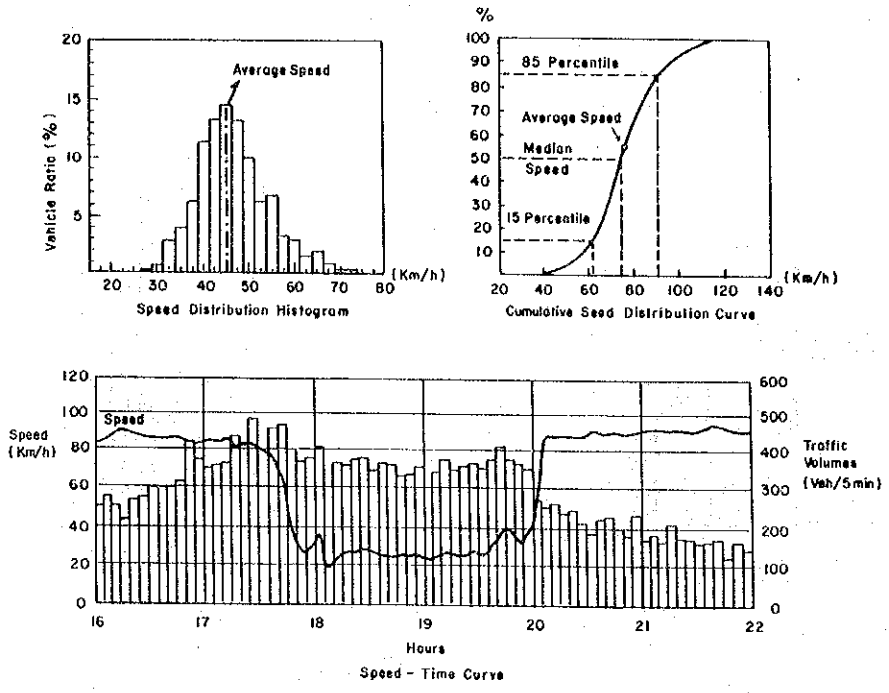


Figure 3.7.5 Examples of Vehicle Running Speed Analyses

3.7.3 Motorway Accident Data

1) General

Motorway accident statistics are essential for understanding the type of motorway accidents occurring in each motorway section. This may help in identifying problem area or sections of the motorway requiring more stringent traffic safety measures.

Motorway accident data are obtained from the "Motorway Accident Investigation Forms" prepared by the traffic patrol personnel as described in Section 3.5.

2) Accident Statistics

(1) Number of Accidents by Motorway Section and Accident Rate

Accident data are processed by number of accidents in each section of motorway. For comparative analysis between the sections, accident rates are used.

Accidents rates are obtained by dividing the total number of accidents for that motorway section by the total annual vehicle kilometers driven in that section (in number of accident / hundred million vehicle • km).

These data should be compiled on an annual basis to show a year-year fluctuation pattern. The number of accidents should be separated into facilities, personal injury, property damage, etc.

(2) Monthly Accident Statistics

The number of accidents by motorway section are to be analyzed in terms of monthly variation to determine if there is any particular pattern.

(3) Types of Accidents by Section

For selected sections (those sections having high accident rate), the accidents are analyzed by accident type.

The data may help to determine the causes of accidents.

(4) Accidents by Vehicle Type

The accidents by motorway section are also analyzed by types of vehicle. This analysis may help determine a vehicle type of target groups.

(5) Accident Distribution Analysis

Accidents can be further analyzed in terms of their distribution over every one km of motorway (depending on the density of accidents). For accidents of the off-mainline, they are to be classified in S.A, P.A. or IC.

(6) Accidents by Day of Week

Accidents for each motorway section can be further analyzed according to the days of the week.

(7) Accidents by Direction and Hour

Accidents for each motorway section can be further analyzed by the direction of travel, i.e. northbound, southbound, eastbound or westbound and by the hour of the day.

(8) Accidents by Type of Offense

Accidents by motorway section can also be analyzed by the type of traffic offense:

- *Mishandling of steering*
- Overtaking without signaling
- Following too close to the preceding car
- Overtaking from the right, etc.

3.7.4 Breakdowns

1) General

The number of vehicle breakdowns on a motorway can be expected to be greater than the number of accidents. Responses to calls from breakdowns are similar to those for accidents in which the responses can prevent secondary accidents and minimize the impact on traffic flow.

It is therefore imperative to know the location, cause and extent of the breakdown to know what response should be taken.

Statistics of breakdowns should be compiled and analyzed using data from the emergency telephone records at the TCR.

2) Statistics of Breakdowns

(1) Number of Breakdowns, and Rates of Breakdowns by Section

The number of breakdowns are processed by motorway section and the rates (number of breakdowns / 100,000 veh.km) should be computed for comparative analysis between sections.

(2) Breakdown Causes

The number of breakdown by selected sections (sections with high breakdown rates) and the overall motorway can be analyzed by the cause of the breakdown:

- Overheating
- Faulty sparkplugs
- Engine or other mechanical malfunctions
- Running out of fuel
- Combustion system malfunction
- Flat tires or others

3.7.5 Obstacles on the Motorway Surface

1) General

Typical obstacles found on the motorway surface are fallen objects, truck loads, or carcasses.

Statistics for obstacles are compiled using data from the daily patrol records from each maintenance office. The data are further analyzed at headquarters.

2) Statistics on Obstacles

(1) The number of obstacle incidents are analyzed by motorway section and the type of obstacles:

- Wood / Timber
- Tire, rubber products
- Cloth, clothing, other apparels, shoes
- Boxes or crates made of cardboard, other products
- Animal carcasses
- Others

(2) Statistics for Obstacles by Month

The number of incidents caused by obstacles on the motorway can be further analyzed by motorway section and by month.

3.7.6 Traffic Restrictions During Motorway Maintenance Activities

1) General

Among the various traffic restrictions affecting traffic management, those related to motorway maintenance work should be compiled and analyzed.

2) Statistics on Traffic Restrictions During Motorway Maintenance Activities

Number of occurrences of traffic restrictions by motorway section and type of work:

- Cleaning
- Vegetation control work
- Repair / Improvement work
- Restoration work due to accident
- New facility / Construction
- Restoration work due to disaster

If the number of occurrences for repair / improvements by type of work are high, further classification may be necessary.

It is also good practice if major road repair can be video recorded for detailed analysis and study.

3.7.7 Traffic Congestion and Road Closures

1) General

Data on traffic congestion and road closures are compiled at the TCR when carrying out traffic control and management measures. The data should be analyzed for comparative studies.

2) Statistics on Traffic Congestion and Road Closures

(1) Traffic congestion data

Traffic congestion data should be compiled into:

- Annual number of instances of congestion by motorway section
- Annual number of instances of congestion by time
- Annual number of instances of congestion by cause (recurrent, accidents, roadwork, etc.)

(2) Road Closure Data

Data for road closures should be analyzed similarly to congestion data. The causes of road closures are accidents, roadwork, traffic congestion, adverse weather and road damage.

3.7.8 Weather Conditions and Disasters

1) General

Weather condition data along the motorway are available from observation stations strategically located. Weather data should be recorded and compiled, showing weather patterns for 1 year, 5 years, 10 years or more.

Records for disasters showing the locations, types, extent of damages, etc. should be recorded at each maintenance office and compiled at the main maintenance centers.

2) Statistics for Weather Conditions and Disasters

(1) Annual average rainfall by motorway section
(2) Annual average daily rainfall by motorway section
(3) Annual rain days by daily rainfall accumulation by motorway section
(4) Annual rain days by hourly rainfall accumulation by motorway section
(5) Annual occurrence of strong winds by month, motorway section and wind velocity
(6) Disaster statistics

Statistics for disasters are to be compiled by the main maintenance center based on records kept by the maintenance office. Disaster statistics should be prepared based on number of cases by type (fallen structures, fires, landslides, flood, fallen rocks, etc.), by cause (heavy rain, strong wind, heavy snow, etc.) and by the extent of damages. The measures taken by KGM against the disaster must be recorded.

3.7.9 Publications

Various types of data and statistics should be published in annual reports by each division office. These publications should be made available for planning and research projects by other division offices, main maintenance centers, maintenance offices and also other government agencies and departments.

Examples of such publications in their contents are given below.

1) Annual Traffic Statistical Reports

This is an annual report, which should be prepared by the Chief Traffic Engineer in each division office.

Sample of Contents

Outline of Management Reports

(1) Traffic Volumes

(a) Yearly changes of Annual Average Daily Traffic (AADT)
(b) Yearly changes of Annual Average Daily Traffic by Interchange
(c) Entering and Exiting Traffic Volumes by direction by Interchange
(d) Monthly Average Daily Traffic Volumes by Motorway Section
(e) Monthly Average Daily Traffic Volumes by Interchanges
(f) Monthly Average Daily Entering and Exiting Traffic Volumes by Direction by Interchange
(g) Maximum and Minimum Traffic Volumes by Motorway Section
(h) Maximum and Minimum Daily Entering and Exiting Traffic Volumes by Interchange
(i) Monthly and Weekly Average Daily Traffic Index by Motorway Section
(j) Average Daily Traffic Volumes in Descending Order by Motorway Section
(k) Traffic Volumes by Composition
(l) IC Pair Traffic Volumes
(m) Weekend and Weekday Hourly Traffic Variations
(n) Traffic Variations by Day of Week
(o) Traffic volume Variations on Surrounding Roads

(2) Traffic Accidents

(a) Yearly Changes of Accident Rates and Number of Accidents
(b) Number and Type of Accidents by Year
(c) Number and Type of Accidents by Month
(d) Number and Type of Accidents by Motorway Section
(e) Number and Type of Accidents by Vehicle Type by Motorway Section
(f) Black Spot Analysis by Year
(g) Number of Accidents by Day of Week by Motorway Section
(h) Number of Accidents by Hour by Direction by Motorway Section
(i) Number of Accidents by Type of Offense by Motorway Section
(j) Accidents Statistics for Temporary Completed Motorway Section
(k) Accident Statistics During Festive Seasons
(l) Accident Statistics During Holiday Seasons

2) Annual Traffic Control and Management Statistical Report

This annual report should be prepared and published by each TCR at the main maintenance center.

Sample of Contents

1) Traffic Incident Statistics by Year by Motorway Route
2) Comparative Tables of Accidents and Traffic Volumes with Previous Years
3) Monthly Statistics from Accident Verification Records
4) Accident Graphs by Month
5) Accident Statistics on On-Mainline and Off-Mainline
6) Accident Statistics by Type of Accident and Motorway Section
7) Accident Statistics by Type of Offense by Motorway Routes
8) Accident Statistics by Types of Vehicles by Route
9) Vehicle Breakdown Statistics by Reason by Vehicle Type
10) Obstacle Statistics by Type by Month and by Route
11) Statistics on Measures Taken for Obstacles by Type of Obstacle
12) Number of Emergency Telephone Calls by Month
13) Number of Emergency Telephone Calls by Content by Route
14) Road Closure Statistics
15) Highway Fire Incident Statistics
16) Fire Engine Dispatch Statistics
17) Ambulance Statistics
18) Tow Truck Dispatch Statistics / Company / Route

3.8 Task Manual (Traffic Management Personnel) by Case Study

This section describes the responsibilities and tasks of the traffic management personnel, those in the traffic control room and those on site, by the use of case studies. The former include tasks carried out by the chief of TCR and his traffic control officers. The latter are tasks carried out by traffic patrol unit personnel and traffic police patrols on site.

3.8.1 Setting of the Case Study

To describe various detailed tasks and activities of the traffic management personnel, a case study of a traffic accident involving two vehicles on the motorway is assumed.

1) Accident Scenario

A white car suddenly moves out of the right lane to overtake another car without checking for vehicles following behind. As a result, a green car from behind smashes into the rear of the white car.

Both parties suffer injuries. Both cars are disabled and blocking the center lane and part of the right lane.

Location : West-bound between Sekerpinar IC and Gebze IC at 44.0 kilopost

Nature : Rear end collision accident

Time : Weekday, 10:25 AM

2) Emergency Call

A passer-by notifies the TCR, using the emergency telephone. The message is received by a traffic control officer at the TCR in the Tutunciftlik main maintenance center.

3) Traffic Conditions

The motorway section has fairly high traffic volumes. Therefore, there is the danger of a secondary incident.

This scenario is illustrated in Figure 3.8.1 which shows the accident location, interchange and other motorway related facilities.

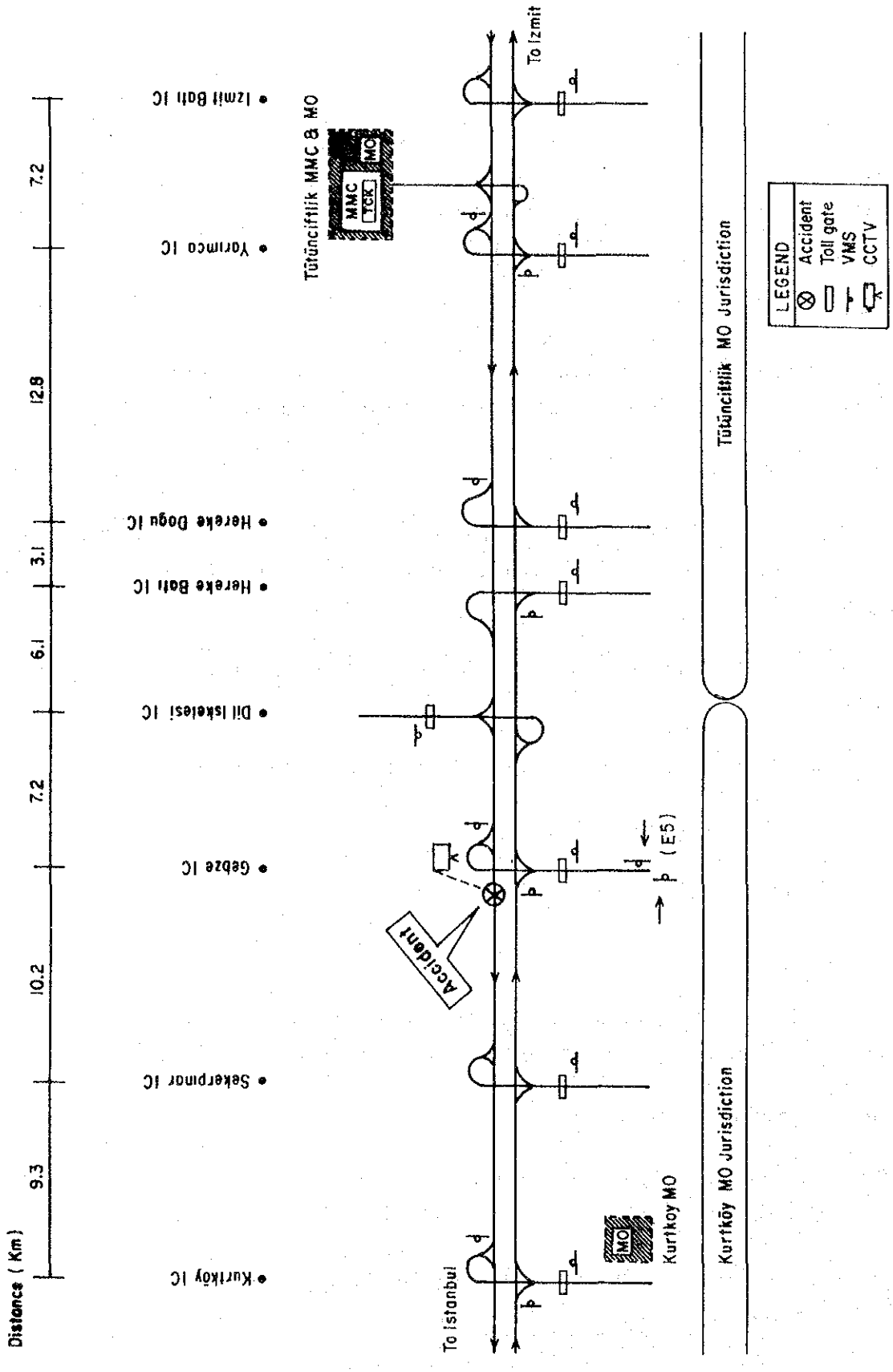


Figure 3.8.1 Location of Accident and Related Facilities

3.8.2 Traffic Control Officer Tasks

1) General

When a distress call is received, either from a patrol car or emergency telephone, the traffic control officer at the traffic control room has to perform a series of tasks that includes contacting patrol units on-site using wireless and activating variable message signs (VMS).

In this section, the traffic control officer's is tasks are explained using a case study.

2) Task Manual

The proposed team of three traffic control officers at the traffic control room are assigned different responsibilities. One officer is responsible for receiving emergency and distress calls and transferring such calls to the management office if necessary. The second officer is responsible for contacting the various agencies such as the hospital, fire department, towing company, etc., during an emergency. The third officer is responsible for activating variable message signs and monitoring CCTV, etc.

(1) Response to the Emergency Telephone Calls

When the call is received, the officer must first record details of the call, preferably on a standard form which should include the following items:

(a) Emergency telephone code numbers

Even though it is possible to know at the TCR which telephone the caller is using, confirmation from the caller is necessary. After confirming the telephone location, the code number (such as "2871") should be recorded.

(b) Location of the accidents

- Northbound or southbound
- eastbound and westbound

In this case, record as "west-bound".

If the caller cannot distinguish which direction they were traveling, the officer must ask for further directional indications, e.g., from Izmit to Istanbul.

- Kilopost

Ask for the kilopost location nearest the caller. Record as "44.0 km" of this example.

(c) Motorway section

- Name of interchanges

In this case, use "Sekerpinar IC - Gebze IC"

(d) Injuries

- Number of injured persons : 1 person
- Seriousness of injuries : very serious
- Fatalities : No
- Anyone trapped in vehicles : No

(e) Vehicles

- Number of vehicles involved : 2
- Type of vehicles : Passenger cars
- Type of accident : Rear end collision
- Property damages (median, guardrail, etc.) : No
- Vehicles on fire : No

(f) Effect on traffic

- Where are the accident vehicles : On the motorway
- Are they blocking traffic : Yes

(g) Spilled load /debris

- Spilled load : No
- Debris, broken parts from accident vehicles : Broken license plates and vehicle bumpers

(h) Time of call : 10:25 am

(2) Response

Since the accident happened during the daytime when the chief of the TCR and the traffic control officers are stationed in the same room, they are all made immediately aware of the emergency call and the nature of the accident. The traffic control officers have to respond to the call quickly and accurately, following the steps below.

(a) Dispatch patrol units

- Using the exclusive telephone on the console, the officer is to contact Kurtkoy maintenance office immediately and order the dispatch of traffic patrol units to the accident site.
- Using wireless, contact any traffic patrol cars which are on duty on the motorway nearby and order them to directly proceed to the accident site.
- Traffic police patrol units should be requested to dispatch a patrol to the accident site, simultaneously.

(b) Surveillance with CCTV

Since the accident occurred at a location within the range of CCTV installed at the Gebze IC, the officer should focus the camera on the accident scene and monitor it visually. The nature of the accident is confirmed. The officer notices that a queue of vehicles is building up, because the accident vehicles are blocking the carriageway.

(c) Activate VMS

- Activate Mainline VMS
- Next, activate toll gate VMS at Sekerpinar IC, Gebze IC an Diliskelesi IC
- Next, activate access road VMS to divert traffic towards Gebze IC

At this time, VMS are activated to show "Accident, Caution xx km Ahead" only. These messages can be changed later after receiving reports from traffic patrol cars from the site.

(d) Request ambulance

- The officer is to check the hospital listing and see which is the nearest hospital with an ambulance.
- Request an ambulance from the nearest hospital which is capable of treating the injured persons.

(e) Receive reports from traffic patrol car on-site

Patrol cars have arrived on-site. After investigation, one of the patrol car personnel reports to the officer using the wireless set in the traffic patrol car.

- Actual conditions at the accident site, such as:
  - accident vehicles are seriously damaged
  - persons seriously injured
  - tow trucks needed to remove vehicles
  - vehicles are blocking one direction of the motorway
  - traffic queue is creating serious congestion

The traffic police patrol car has arrived on the site and after making a preliminary investigation, a "Two-lane closure" is deemed necessary. He reports back to the traffic control officer at TCR, stating that a two-lane closure is necessary.

(f) Reports to the chief of TCR

If the accident occurs at night, the traffic control officer has to report this information to the chief using an electronic pager or a mobile phone. The chief should be informed regarding the nature of the accident and what steps have been taken.

In the example case, since the accident occurred at 10.25 am, the chief is already aware of the situation. The chief must then report the incident to the head of MMC.

(g) Request tow trucks

The officer should request two tow trucks by telephone (officer is to refer to list of towing companies and call the nearest one to the accident site).

(h) Monitor the accident management

The officer shall carefully monitor the rescue process, removal of damaged vehicles, etc. by using wireless to maintain contact with personnel on-site. He also should use CCTV to observe the accident scene and monitor traffic congestion.

(i) Switch off VMS display

After the accident vehicles and barricades have been removed and traffic returns to normal (confirmation from patrol cars on-site), the officer should switch off the VMS display.

(j) Reporting

After successful handling the accident, the officer at the TCR should record the accident information and the measures that were taken. This information should be complied as a report.

- Description of the incident and conditions
  - Date, location of incident
  - Conditions
  - Consequences (death / injury / damages / etc.)
- Type of communications
  - Emergency telephone
  - Wireless telephone
  - Exclusive phone
- Agencies contacted
- Measures taken
- Etc.

3.8.3 Chief of TCR

1) General

The chief of the TCR is responsible for the overall response to incidents. His direct involvement is necessary, especially if it is a serious incident with serious injuries or death.

In this case study, the two-lane closure lasts only about one hour. But in cases longer than two hours, the chief of TCR has to inform related authorities.

The chief of TCR has to monitor the entire accident management process.

2) Task Manual

(1) Instruct / Advice the Traffic Control Officer

The chief must make sure that the officer is taking the correct and appropriate steps in response to the emergency call. If any measure is not appropriate, the chief should correct and advise him accordingly.

(2) Communicate with Other Related Agencies

If the incident is serious, the chief must report the incident, its nature, and the steps taken to the head of MMC. He should keep the head of MMC informed of the progress in handling the accident. If he encounters any problems, he must consult with the head of MMC.

(3) Request for Further Assistance

When the patrol unit personnel on-site cannot handle the situation, the chief should request other traffic patrol units from other maintenance offices for assistance.

(4) Monitor Traffic Flow

The chief is also responsible for ensuring smooth traffic flow at and around the accident site as far as preventing any secondary incidents. He should observe and monitor the accident scene using CCTV.

(5) Confirm Accident Responses

The chief should confirm the various responses taken by the officer at TCR.

- Rescue / assistance to injured persons
- Removal of accident vehicles
- Removal of any spilled loads or debris
- Lifting of traffic control and regulations
- Traffic flow conditions

(6) Confirm and Check the Accident Response Report Prepared by the Officer

3.8.4 Traffic Patrol Units

1) General

Traffic patrol units which are either patrolling the motorway or on standby at the maintenance office (MO), after receiving an order from the traffic patrol chief or a traffic control officer at TCR, will proceed to the accident site.

2) Task Manual

(1) Approaching the Accident Site

After receiving the order to dispatch from the traffic control officer at TCR, the traffic patrol units are to promptly move to the accident site. For this case study, traffic patrol units coming from Kurtkoy IC must make a U-turn at Gebze IC to reach the accident site.

(2) Report to TCR

Upon arrival at the site, the traffic patrol units have to quickly report the site situation to the traffic control officer at TCR. After traffic control measures have been established, the traffic patrol units should report the progress to TCR.

(3) Implementing Traffic Control

Once the traffic police patrol has decided to implement traffic control in a two-lane closure to facilitate the removal of accident vehicles, the traffic patrol units (each patrol unit is staffed with two persons) must set up barricades, etc. to stop the traffic, following the abovementioned procedures (refer to section 3.2)

(4) Assist Traffic Police in Accident Investigations

(5) Inspect Safety Facilities for Damages

The traffic patrol units must check for damages to safety facilities at the site which may have been caused by the accident vehicles. They also must record the extent of the damages.

(6) Remove any Spilled Loads and Debris

Any spilled loads or broken vehicle parts should be swept away after the vehicles are removed.

(7) Removal of Barricades

Once the vehicles are removed and pavement is cleared of obstacles, the barricades are removed starting from the rear.

(8) Reporting to TCR

After the barricades have been removed and traffic has returned to normal, the traffic patrol units must report back to TCR to remove the traffic control regulations and VMS displays.

(9) Accidents Reports

After returning from the site to the maintenance office, the patrol personnel are to complete the motorway accident investigation form.

3.8.5 Traffic Police Patrol Units

1) General

When the emergency call is received at Tutunciftlik TCR, the traffic control officer should immediately telephone Kurtkoy MO to request the dispatch of traffic police patrol units stationed at the MO.

The traffic police patrol unit chief, aware of any traffic police patrol units near the accident site, will contact them via wireless and order them to proceed to the accident site.

2) Task Manual

(1) Approach to the Accident Site

Generally, all the traffic police patrol units should approach any accident site from upstream from the same side of the motorway.

In the case where there is a traffic police patrol car nearby but traveling in the other direction, the patrol car must first stop near the accident site. The police officer should then cross over to the accident site while the patrol car makes its U-turn at the next interchange. The disembarked police officer should quickly take action to prevent any further accidents by the use of smoke pots to warn on-coming vehicles.

(2) Motorway Traffic Control Measures

- When arriving at the site, if it is obvious that a lane closure is necessary, one traffic police officer must first contact and inform the traffic control officer at TCR while the other carries out initial traffic control upstream.

- When the traffic patrol units have arrived, the traffic police are to cooperate and assist them in setting up barricades.

(3) Accident Investigations

- Accident and crime investigations are the responsibility of the traffic police. The investigations are conducted to find the cause of the accident.

- For investigations, the traffic police must ensure that the site is preserved, i.e. vehicles are not moved. Confirmation from witnesses of the accident are sought to help the investigation.

- Various essential facts must be confirmed during the investigation, such as the location, the position of the accident vehicles, type and extent of the damages (pictures are to be taken as evidence), any broken vehicle parts, and so on. These are to be carefully recorded to assist in establishing the cause of accidents.
  - Date and time of accident
  - Weather conditions
  - Parties involved (names, sex, age, address, occupation, drivers physical state e.g.. under influence of alcohol, fatigue, etc.)
  - Type of accident (rear end collision, side swipe, etc.)
  - Damages
  - Cause of accident
  - Sequence of events (witness accounts, location of vehicles, point of collision, damages, etc.)
  - Evidence (tire marks, broken glass, spilled loads, blood marks, oil spills, location of vehicle parts, etc.)

(4) Lifting of Traffic Control Measures

- After the accident investigation and all other tasks required of the traffic patrol personnel have been completed, the traffic patrol police will confirm that it is safe to remove the traffic control measures and report back to TCR.

(5) Accident Reporting

- The traffic patrol police have to record all investigated facts on the traffic accident record form and assist the traffic patrol units in completing the motorway accident investigation form.

4. Motorway Maintenance and Operations Manual

This maintenance and operations manual should be continuously updated and revised in the course of the accumulation of KGM's own experience.

4.1. System to Operate Motorway Maintenance

Motorway maintenance and operations covers various activities related to inspections, maintenance and repairs, which require quick response and appropriate treatments to keep the motorway always open to traffic.

KGM should be responsible for the following activities of motorway maintenance and operations:

- Inspections by maintenance patrol unit
- Road cleaning of road surface, tunnel walls, etc.
- Vegetation control
- Snow and ice control
- Repairs of traffic safety and management facilities
- Maintenance and repairs of pavement
- Maintenance and repairs of bridges
- Maintenance and repairs of tunnels and other structures
- Disaster prevention and restoration
- Others

The following matters shall be materialized to implement the above for the objective of motorway maintenance and operations;

- Communications (instruction, response, duty, decision and coordination) system among headquarters, regional division office, main maintenance office and maintenance office
- Extent of activity and responsibility of each office

Maintenance on a contract basis should be gradually increased to cope with an increase of maintenance work volume and to minimize the increase in number of KGM staff and workers, and to promote technical advances of contractors or concession companies. The following should be considered to encourage the use of contractors to carry out motorway maintenance activities:

- Maintenance activities based on a monthly and annual program
- Clarification of working criteria of maintenance and repairs
- Formulation of contracts, supervision and acceptance system for motorway maintenance work
- Establishment of a contract system for private firms to rent KGM's equipment (equipment which is specialized and costly)
- Provide guidance to the contractors on the significance of motorway maintenance.

4.2 Equipment and Workshops

1) Equipment

The number and types of maintenance equipment required at each main maintenance center and maintenance office are closely related to maintaining intended service levels for the motorway section, the weather conditions, the types of major road structures (tunnel, bridge, pavement type, etc.) and the traffic volume. A consideration whether the work will be done by force account or on a contract basis is also necessary for such determination.

The maintenance equipment will be mostly used on a motorway open to public traffic. Therefore the equipment should have the following capabilities:

- high degree of safety and workability
- compact size and substantial maneuverability so as not to affect traffic flow
- high degree of mobility
- Less hazardous to public with respect to noise, vibrations and smell during operations
- capability of performing night work

2) Workshops and Depots

Workshops and depots will be located at each main maintenance center. However, they might be of a small scale since main maintenance centers will be supported by each Regional Division's workshop and depot except the Regional Division 17.

4.3 Data Base and Management System

Data base and management system is indispensable for the motorway maintenance. One of the most important activities is to collect reliable data, in particular, to collect and keep as-built drawings and documents including design reports, construction records, and historical records of maintenance. These records must include inspector's observation of an extraordinary incident, the work carried out, and the interference to traffic, particularly in relation to vehicular accidents and their causes. Various inventories for road structures and facilities shall be developed to maintain the motorway properly.

4.4 Planning of Motorway Maintenance

1) Programming

Motorway maintenance and operations programs shall be made on annual, monthly and weekly basis, considering priority of the work, available resources, past work records, road inventories, road structure inventories, traffic volumes, meteorological data, etc.

2) Annual Program

Annual program will be planned to allocate the scope and scale of monthly work. The following matters shall be included there in based on the annual budget:

- Appropriate monthly activities for inspections, maintenance and repairs shall be allocated in consideration of the characteristics of the work, traffic conditions, and circumstance along the motorway. The volume of work shall be allocated carefully so as not to concentrate in a limited period.
- Personnel, equipment and materials shall be assigned appropriately.
- The programming shall consider local meteorological conditions (temperature, rainfall, snowfall, etc.).
- Maintenance and repairs of pavement shall be undertaken before the damages become serious. Cracks, potholes and corrugation should be repaired before the winter season, since these problems lead to rapidly increasing damages to the pavement due to rainfall and snowfall.
- The scheduling of grass cutting shall be made based on local meteorological conditions.

- The cleaning and repairs of drainage facilities shall be conducted at an appropriate time for the drainage system to function.
- Painting shall be undertaken at an appropriate period considering the seasonal and local conditions.

3) Monthly Program

A monthly program will be planned to allocate daily maintenance and repairs. Changes to the programs can be made flexibly in case a particular repair work is judged to have a higher priority during the actual implementation of the plan.

A monthly program will be established based on the annual program, considering the following:

- Appropriate daily activities for inspections, maintenance and repairs shall be allocated throughout the month.
- Appropriate traffic control shall be arranged for the maintenance and repairs, considering the characteristics of the work, month, date and time-frame.
- Coordination with other works shall be made for a smooth operation.

4) Weekly Program

A weekly program will be planned to allocate daily activities for inspections, maintenance and repairs. A weekly program will be made based on the monthly program, considering the following:

- Breakdown of the monthly activities will be made for weekly and daily activities.
- The work done in the preceding week will be examined and reflected to the following week.
- The accumulated amount of weekly work done in a month will be reviewed for updating the weekly program of the following month.

4.5 Implementation of Motorway Maintenance

1) General

Motorway maintenance shall be conducted, in careful consideration of traffic regulations, traffic safety and circumstances along the motorway, since the motorway is open to public traffic and underground public utilities.

2) Coordination with Police Office

KGM can partially or fully close traffic lanes on the motorway for maintenance and repair works as per the "Highways Traffic Law (approved 13 October, 1983) No. 2918". Therefore, KGM will coordinate with and give a notice in writing to the police office concerned to attain good cooperative result.

3) Coordination with Offices in Charge of Underground Utilities

Serious accidents can occur if underground utilities are damaged during maintenance and repairs. It is necessary for KGM to investigate and identify those utilities in advance, and coordinate with the office in charge of the utilities.

4) Safety during Maintenance and Repairs

(1) Safety standards and signs

Traffic signs and safety devices shall be installed to secure safety for workers and motorway users during maintenance and repairs based on the following standards. Personnel in charge of traffic control for safety purpose shall be assigned to the site during the work.

- Section 3.3, Traffic Management during Motorway Maintenance and Repairs of Operations Manual (this report)
- Traffic Markings and Signs Manual (KGM, Publication No. 218, 1975)
- Marking and Signing Standards on Motorways and Expressways (KGM, publication No. 246, 1983)
- Highway Traffic Law (approved 13 October, 1983), No. 2918, item 13

(2) Important items

Attention should be paid to the following while conducting maintenance and repairs:

- Personnel in charge of traffic control shall be assigned on-site for the safety of workers and motorway users.
- Guide signs and traffic markings shall be installed to remark restricted traveling lanes clearly to motorway users.
- Lighting facilities shall be provided for night maintenance and repairs.
- Equipment, facilities and materials shall be neatly located in the work area for efficient and safe work operations.
- Excavated and excess materials shall be disposed of immediately so that the motorway surface is always free from obstacles during the work activities too.

(3) Personnel for traffic control

Personnel in charge of traffic control shall be assigned during the maintenance and repairs. They shall ensure smooth and safe traffic flow and worker's safety. They shall be familiar with the following items against traffic congestion or accidents:

- To whom contact first
- How to contact
- Countermeasures to be taken first against the congestion or accident

5) Public Announcement

KGM shall perform public announcement activities through the use of variable message signs, radio broadcasts and billboards for motorway users and residents along the motorway. The public announcement shall be done well in advance of actual maintenance and repairs which will last for more than one day with partial closure of travel lanes, or full closure of the motorway. The announcement will include the purpose, type of work, working dates and completion date.

Detours shall be announced and coordinated with the agencies concerned in the case of motorway closures.

6) Meeting with and Instructions to Road Maintenance Units

The Manager of the MMC maintenance section, and Chief of the MO (or his representative) shall meet and coordinate inportant items with the chief technician of the maintenance unit prior to the work so that it may be executed smoothly and safely.

The representative shall discuss the scope and scale of the work with the crew and give sufficient instructions so that the crew of the unit may take appropriate measures against unexpected disasters or accidents.

4.6 Traffic Control Measures and Impact During Motorway Maintenance

1) Traffic Control Measures

It is important for to try to avoid any traffic accidents caused by obstacles during the motorway maintenance activities.

The date, time-frame, construction methods and proposed traffic control measures shall be analyzed for the motorway maintenance activities based on traffic volumes, numbers of traffic lanes and detours.

The following consideration should be made based on the characteristics of motorway maintenance. Reference is made to section 3.3, Traffic Management during Maintenance and Repairs of the "Operations Manual":

(1) Time-frame to carry out the maintenance activities

The time frame to carry out motorway maintenance activities shall be determined based on the following:

(a) Traffic volumes
The time frames with lower traffic volumes shall be selected based on actual hourly traffic volume data.

(b) Construction methods and equipment
Construction methods which minimize traffic disturbances on the motorway and reduce noise and vibrations for residents along the motorway shall be selected.

(c) Detours and traffic control measures

A detour shall be selected in the case where the full width of the motorway is occupied by the construction work. KGM shall coordinate with all agencies concerned with the detour. KGM will notify the traffic the detour to the concerned police office according to the requirements in the "Highway Traffic Law, No. 2918".

(2) Selecting appropriate time-frames

(a) Pavement maintenance

Time-frames with large traffic volumes shall be avoided for pavement maintenance, since the work normally occupies one or two lanes of the carriage way.

Urgent repairs, however, are sometimes required due to road surface damages which may cause disturbances to traffic flow.

(b) Road surface cleaning

Sweeping machines for road surface cleaning do not normally affect the traffic flow since they travel on the right shoulder at relatively high speeds while working.

When cleaning the inner shoulder, however, the work shall be done during off-peak hours.

(c) Grass cutting

The right shoulder will be utilized for grass cutting on slopes, and the inner travel lane will be occupied for grass cutting in the median.

Therefore, grass cutting in the median will be done during off-peak hours.

(d) Traffic markings

The painting of traffic markings can be done during the day time since the work can be done in a short time and confined to a certain length.

(e) Repairs to bridges and box culverts

Repairs to bridges and box culverts shall be done during off-peak hours since they occupy one or two lanes and may require pavement works.

2) Environmental Impacts

Smooth construction activities will be considered in an effort to minimize noise and vibrations during the maintenance and repairs.

4.7 Motorway Maintenance Manual for Inspections

4.7.1 General

1) Definition and Purpose of Inspections

The inspections are defined as collecting information on physical conditions of road structures and on traffic usage to the road structures, and as judging the level of deficit or damage in order to keep the motorway in good conditions and to assure traffic safety by the motorway maintenance and operations.

In addition to the above, it is important to reiterate the inspections and record the result to know the development and progress of the defect and damage of the road structures.

The inspection is different from a study consisting of investigation, analysis and appraisal. The study will be required prior to some specific repairs to judge the depth and nature of the defect or damage based on the investigation of detailed measurement using measuring devices or equipment.

2) Types and Frequency of Inspections

There are three 3 types of inspections as follows:

- Routine Inspection
- Periodic Inspection
- Special Inspection

(1) Routine Inspection

Routine inspections cover inspections of damages and unusual conditions on the motorway.

It also covers the traffic usage to the road structures that are tied to traffic safety and smooth flow.

This inspection is normally done visually from a moving patrol car, is augmented occasionally by observations on foot and normally utilizes two or more trained inspectors. One is engineer and the other are non-engineers.

(2) Periodic Inspection

Periodic Inspection is the detailed inspection of road structures such as asphalt pavement, drainage, bridges and slopes, and is normally done on foot. Periodic inspections are conducted by specially trained inspectors, made up of both engineers and non-engineers.

Periodic inspections are split into two types, periodic inspections A and B.

- Periodic inspection - A

  This inspection is generally conducted for road structures and related facilities from many different points of view. This type of inspection is basically done by maintenance crew on site.

- Periodic inspection - B

  Periodic inspection B is conducted to investigate and evaluate in detail the road structures and related facilities such as pavement, drainage, bridges, slopes and traffic safety facilities, and is normally done on foot. Therefore, this requires an inspection plan, survey plan and repair plan.

  An annual inspection program for each road structure should be made prior to the site inspection activity, considering the shape, dimensions and repair history of each road structure from existing data.

(3) Special Inspection

Special inspection is the supplementary inspection conducted in addition to the routine and periodic inspections as required by possible damages due to storms, heavy rain or other unusual conditions.

The content, frequency and coverage differ among these different types of inspections. Table 4.7.1 shows the contents and frequency of routine and periodic inspection.

Each maintenance office conduct the activities of routine, periodic and special inspections by maintenance patrol unit that cover the motorway of 50 to 70 km long.

Inspections shall be done normally by the maintenance patrol unit, such as inspections for vegetation on slopes, pavement, drainage, slopes, bridges, etc.

3) Standard Work Flow for Inspections

Standard flow of inspection is shown in Figure 4.7.1.

The flow specifies the following:

- The extent and depth of inspections depends on the necessity of further investigation, maintenance and repairs.
- The inspection includes recording of maintenance and repairs.

Definition of inspection and investigation is as follows:

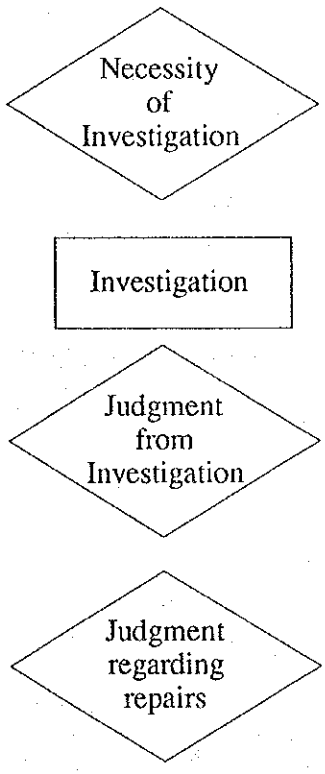
(i) Inspections

Inspection involves apprehending the road and traffic conditions to maintain the road in satisfactory condition and to ensure traffic safety. This also includes judgment on the degree of damage which will be made by the chief of the maintenance office (MO).

(ii) Investigation

Investigation involves measurement, analysis and evaluation in order to define specific problems in case where the inspection can not afford a judgment and evaluation of degree and nature of damages.

Further clarification for Figure 4.7.1 is given as follows:



- Necessity of investigation will be studied on whether the damage detected during inspection requires to check soundness of whole structures.
- Investigation will be conducted when inspection results can not afford to judge and evaluate the degree of damages.
- The damaged structures or facilities are evaluated and judged comprehensively from technological viewpoint on the basis of the result of investigation.
- In addition to judgment of the degree of damages detected by inspections from technical viewpoint, the budget, operating system and repair method are also to be considered to reach comprehensive judgment.

4) Inspection and its Associated Items

It is better to conduct inspections efficiently by combining inspections of several items and structures together when it is possible.

(1) Road structures to be inspected are shown in Table 4.7.2. Before execution of the inspection, the structures that can be inspected together should better be grouped to enhance the efficiency.

(2) The periodic inspection B may be incorporated into the routine inspection process.

(3) The way to associate inspections before actual execution varies depending on the inspection system, road traffic conditions, and local and structural conditions. In this context, the specific combination may be determined in each main maintenance center. Table 4.7.3 is presented for examination of the appropriate combination, showing the "Type of road structures to be inspected" and "Structures that can be inspected together with the road Structures".

5) Preparation of Inspection Plan

The inspection plan must be prepared before implementation of the inspections. The plan must contain the following matters:

- Type, scope, and location of inspection
- Inspection process
- Qualified inspectors and a communication system
- Inspection method
- Report preparation method
- Other particular pertinent matters

Inspections shall be done under the control of chief of MO with assistance of Maintenance Engineer. Head of MMC will decide the selection of prioritized works (maintenance and repairs) considering construction method and available budget.

Table 4.7.1 Routine and Periodic Inspections and Frequency

Functional Category	Classification of Category	Routine Inspection	Periodic Inspection	Special Inspection
Road Surface	Pavement	F	A	
	Curb	F	A	
	Expansion Joint	P	F	
Slope	Vegetation Slope	P	F	If necessary
	Slope Protection Works	P	F	
	Masonry	P	F	
	Retaining Wall	P	F	
Drainage Facilities	Road Surface Drainage	P	F	
	Slope Drainage	P	F	
	Bridge Drainage	P	F	
Bridge	Concrete Super-structure		F	
	Concrete Sub-structure		F	
	Steel Structure		F	
	Painting		F	
	Bearing		F	
	Railing and Curb	P	F	
Tunnel	Lining		F	
	Portal		F	
	Interior Wall	P	F	
	Ceiling Slab		F	
	Drainage	P	F	
Culvert	Reinforced Concrete Box		F	
	Reinforced Concrete Pipe		F	If necessary
	Other		F	
Traffic Safety Facilities	Guard Fence	P	F	
	Anti-dazzle facility	P	F	
Traffic Management Facilities	Traffic Signs	P	F	
	Traffic Markings	F		
	Delineator	F		
	Kilometer Post	F		
Other Facility	Snow Protection Facilities	P	F	
	Meteorological Devices	F		
Vegetation		P	F	
Traffic Conditions		F		
Frequency		see note-1	see note-2	If necessary

F : Inspect the facility fully
P : Inspect the facility Partially
A : Additional Inspection to "F" if necessary
Blank : No Inspection required

Note 1

Routine inspections will be done two (2) to four (4) times a week depending on the traffic volume.

Note 2

Items	Frequency
Pavement	1 to 2 years intervals
Bridges	2 to 7 years intervals
Others	every years

Table 4.7.2 Road Structures to be Inspected

Functional Category	Classification Category	Road Structures	Items
1. Road Surface	(1) Pavement	(1) Asphalt pavement	① Obstacles on the road (fallen materials, fallen stone, collapsed earth), oil stain, foul road surface ② Pot hole, peeling, subsidence ③ Faulting ④ Rutting ⑤ Crack ⑥ Cross-sectional roughness and corrugation ⑦ Stripping of thin surfacing ⑧ Water storage
		(2) Concrete pavement	① Obstacle on the road (fallen materials, fallen stones, collapsed earth), oil stain, foul road surface) ② Pot hole subsidence ③ Faulting ④ Friction (rutting) ⑤ Crack, edge breakage ⑥ Deformation (cross-sectional roughness) ⑦ Joint breakage ⑧ Buckled or lift of slabs ⑨ Water storage
	(2) Expansion Joint	(1) Groove	① Damage to joint proper ② Damage around joint ③ Water leakage ④ Abnormal sound
		(2) Rubber joint	① Damage to joint proper ② Damage to secondary material ③ Faulting ④ Abnormality in spacing ⑤ Water leakage ⑥ Abnormal sound
		(3) Metal joint	
	(3) Curb	(1) Asphalt Curb	① Damage to the curb proper
		(2) Concrete Curb	
2. Slope	(1) Vegetation	-	① Collapse ② Crack, bulging, falling ③ Spalling, galley ④ Piled soil on berm ⑤ Seepage water ⑥ Fallen tracks abnormally thick weeds, ⑦ Dead planting ⑧ Accumulation of dust ⑨ Spall and rolling stones
	(2) Slope Protection Work	(1) Concrete Block Crib	① Crack, scaling ② Looseness, bulging, subsidence ③ Scour ④ Drainage, seepage
		(2) Cast-in-place Crib	
		(3) Concrete/Mortar spraying	① Crack, scaling ② Push-out, bulging, misligned joint ③ Honey comb ④ Scour ⑤ Drainage and seepage
		(4) Concrete Block Pitching	① Crack, scaling ② Push-out, bulging, misligned joint ③ Scour ④ Drainage and seepage
		(5) Netting & Fence	① Damage to net/fence proper, ② Damage to the accessories ③ Corrosion ④ Damage to the foundation ⑤ Earth accumulated in the back of net
	(3) Masonry	(1) Concrete Block Masonry	① Crack, looseness, bulging ② Settlement, displacement, inclination ③ Abnormality in joint ④ Scour ⑤ Drainage, seepage
		(2) Concrete Block Pitching	
		(3) Stone Masonry	
		(4) Gabion	① Breakage, damage, corrosion of steel wires ② Deformation

Table 4.7.2 Road Structures to be Inspected

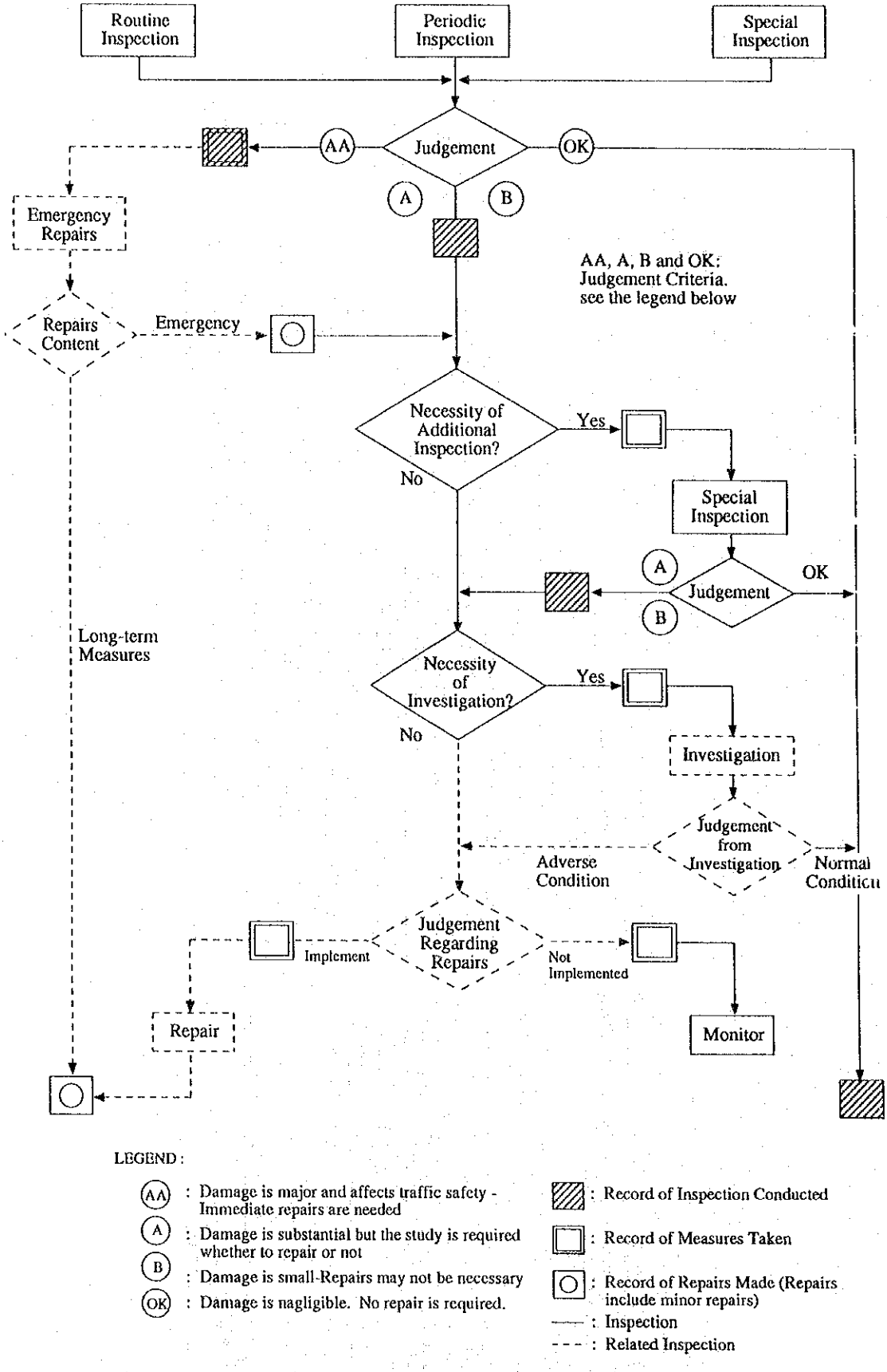
Functional Category		Classification Category		Road Structures		Items
		(4)	Concrete Retaining Wall	(1)	Reinforced Concrete	① Crack, corner failure ② Scaling ③ Exposure and corrosion of reinforcement ④ Settlement, displacement, inclination ⑤ Abnormality in joint ⑥ Scour ⑦ Drainage, seepage
				(2)	Non Reinforced Concrete	① Crack, scaling ② Bad connections Settlement displacement, inclination ③ Abnormality in joint ④ Scour ⑤ Drainage, seepage
3.	Drainage	(1)	Road Surface Drainage	(1)	Shoulder Drainage	① Damage to the facility proper ② Bad connections ③ Accumulation of soil and dust
				(2)	Median Drainage	
				(3)	Inlet/Outlet	
				(4)	Drainage Pipe	
				(5)	Manhole	
		(2)	Slope Drainage	(1)	Gutter on Slope Top	① Damage to the facility proper ② Bad connections ③ Accumulation of dust and earth ④ Sectional area reduced by weeds
				(2)	Berm Drains	
				(3)	Toe Drains	
				(4)	Inlet	
		(3)	Bridge Drainage	(1)	Inlet	① Damage to the facility proper ② Bad connections ③ Accumulation of dust and earth
				(2)	Drainage pipe	
		(4)	Frontage Road and Adjacent area Drainage	(1)	Ditch	① Damage to the facility proper ② Bad connections ③ Accumulation of dust and earth ④ Sectional area reduced by weeds
				(2)	Pipe	
				(3)	Inlet	
				(4)	Manhole	
4.	Bridge	(1)	Concrete Super-structure	(1)	RC Girder	① Water leakage, Free lime ② Crack, corner failure ③ Scaling, spalling ④ Exposure and corrosion of reinforcement ⑤ Honey comb ⑥ Deflection, abnormal sound ⑦ Clearance of bridge
				(2)	PC Girder	
				(3)	RC Slab/PC Slab	
		(2)	Concrete Sub-Structure	(1)	Abutment	① Crack, corner failure ② Scaling ③ Exposure and corrosion of reinforcement ④ Honey comb ⑤ Water leakage ⑥ Settlement, displacement, inclination ⑦ Scour
				(2)	Pier	
				(3)	Footing	① Settlement, displacement, inclination
				(4)	Protection	
				(5)	Revetment	
		(3)	Steel Structure	(1)	Steel Girder	① Crack of steel structure ② Deformation and edge breakdage ③ Loose and dislodged bolt ④ Loose and dislodged rivet
				(2)	Steel Slab	

Table 4.7.2 Road Structures to be Inspected

Functional Category	Classification Category		Road Structures		Items
			(3)	Steel Piers	⑤ Unusual sound ⑥ Clearance of bridge
			(4)	Steel Diaphragm	
	(4)	Steel Slab	-		① Water leakage ② Crack, corner failure, abrasion ③ Scaling ④ Exposure and corrosion of reinforcement ⑤ Honey comb ⑥ Segregation of additional girder
	(5)	Painting	-		① Crack, swelling, scaling, rust ② Water leakage
	(6)	Bearing	(1)	Metal Bearing	① Damage of metal bearing ② Damage of the accessories ③ Corrosion ④ Damage of the bearing concrete, bearing mortor and protection mortor ⑤ Abnormal sound ⑥ Abnormality in inspacing ⑦ Accumulation of soil and dust
			(2)	Rubber Bearing	① Crack, push-out, displacement ② Damage of the bearing concrete and bearing mortar ③ Accumulation of dust
	(7)	Railing & Curb	(1)	Steel Railing	① Damage ② Corrosion
			(2)	Concrete Railing	① Crack, corner failure ② Scaling, damage ③ Exposure and corrosion of reinforcement
			(3)	Curb	① Crack, corner failure ② Scaling ③ Exposure and corrosion of reinforcement ④ Water leakage
5. Tunnel	(1)	Lining			① Crack, corner failure ② Scaling, spalling ③ Water leakage, free lime ④ Abnormality in joint
	(2)	Portal			① Crack, corner failure ② Scaling ③ Exposure and corrosion of reinforcement ④ Abnormality in joint ⑤ Scour ⑥ Settlement, displacement and inclination ⑦ Drainage and seepage
	(3)	Interior wall			① Damage to the slab proper ② Damage to the accessories
	(4)	Ceiling slab			① Damage to the slab proper ② Damage to the accessories
	(5)	Drainage			① Damage to the drainage facility ② Accumulation of soil and dust
6. Culvert	(1)	Reinforced Concrete Box			① Crack, corner failure ② Scaling ③ Exposure and corrosion of reinforcement ④ Honey comb ⑤ Water leakage ⑥ Settlement ⑦ Abnormality in joint
	(2)	Reinforced Concrete Pipe			① Crack ② Scaling ③ Exposure and corrosion of reinforcement ④ Settlement ⑤ Damage of joint ⑥ Accumulation of soil and dust
	(3)	Other Type Culvert			① Damage of culvert ② Corrosion ③ Settlement ④ Damage of joint ⑤ Accumulation of soil and dust

Table 4.7.2 Road Structures to be Inspected

Functional Category		Classification Category		Road Structures		Items
7.	Traffic Safety Facilities	(1)	Guard Fence	(1) Guard Rail (2) Guard Pipe	① Damage of fence ② Damage of accessories ③ Corrosion ④ Damage of foundation
		(2)	Anti-dazzle Facility	(1) Anti-dazzle Net (2) Anti-dazzle Plate	① Damage anti-dazzle facility ② Damage of accessories ③ Corrosion
8.	Traffic Management Facility	(1)	Traffic Signs		① Damage to the sign proper ② Damage to the accessories ③ Corrosion, ④ Damage to the foundation
		(2)	Traffic Markings		① Damage of traffic paint
		(3)	Delineator		① Damage to delineator proper
		(4)	Kilometer Post		① Damage to the marker proper
9.	Other Facility	(1)	Snow Protection Facilities	(1) Snow Fence	① Damage to the fence proper ② Damage to the accessories ③ Corrosion ④ Damage to the foundation
		(2)	Meteorological Device	(2) Avalanche Protecting -	① Damage to the fence proper ② Damage to the accessories ③ Corrosion ④ Damage to the foundation
10.	Vegetation	-		-	① Tree and lawn growth state ② Damage by blight and noxious insects
11.	Traffic Conditions	-		-	



LEGEND :

- AA : Damage is major and affects traffic safety - Immediate repairs are needed
- A : Damage is substantial but the study is required whether to repair or not
- B : Damage is small-Repairs may not be necessary
- OK : Damage is nagligible. No repair is required.

- : Record of Inspection Conducted
- : Record of Measures Taken
- : Record of Repairs Made (Repairs include minor repairs)
- —— : Inspection
- - - - : Related Inspection

Figure 4.7.1 Work Flow for Inspection

Table 4.7.3 Inspection and its Associated Items

LEGENT
- ○ ; Inspect the facility fully.
- (△) ; Inspect the facility Partially.
- △ ; Inspect the facility (not major item for in spection) together with the mark ○.
- ↲ ; Inspect the facility together with the mark ○.
- (blank) No Inspection required

Types of Inspections		Road Surface: Pavement	Road Surface: Expansion Joint	Road Surface: Curb	Slope: Vegetation Slope	Slope: Slope Protection Work	Slope: Masonry	Slope: Retaining Wall	Drainage Facilities: Road Surface: Shoulder	Drainage Facilities: Road Surface: Median	Drainage Facilities: Slope	Drainage Facilities: Bridge	Drainage Facilities: Adjacent areas to Road	Bridge: Concrete Superstructure	Bridge: Concrete Substructure	Bridge: Steel Structure	Bridge: Painting	Bridge: Bearing	Bridge: Railing & Curb	Tunnel: Lining	Tunnel: Portal	Tunnel: Interior Wall	Tunnel: Ceiling Slab	Tunnel: Drainage	Culvert: Reinforced Concrete Box	Culvert: Reinforced Concrete Pipe	Culvert: Other Type Culvert	Traffic Safety Facilities: General Fence (Guard Rail Guard Pipe): Shoulder	Traffic Safety Facilities: General Fence (Guard Rail Guard Pipe): Median	Traffic Safety Facilities: Anti-dazzale net: Shoulder	Traffic Safety Facilities: Anti-dazzale net: Median	Traffic Management Facilities: Traffic Signs	Traffic Management Facilities: Traffic Markings	Traffic Management Facilities: Delineator	Traffic Management Facilities: Kilometer Post	Other Facilities: Snow Fence	Other Facilities: Meteorological	Vegetation	Over Bridge	Traffic Conditions
Routine Inspection (3~5 times/ week)		○	(△)	○	(△)	(△)	(△)	(△)	(△)	(△)	(△)	(△)							(△)	(△)	(△)	(△)	(△)	(△)				(△)	(△)	(△)	(△)	(△)	○	○	○	(△)	○	(△)	(△)	○
Periodic Inspection A (once/year)		△	△	△	○	○	○	○	○		○	(△)	○	△	(△)	△	△	△	(△)	(△)	(△)	(△)	(△)	(△)	(△)	(△)	(△)	○		○		△				△	△	△	△	
Periodic Inspection B: Road Surface	Expansion Joint		○									↲		↲				↲																						
Periodic Inspection B: Slope	Vegetation Slope				○	↲	↲	↲			↲																													
	Slope Protection Work				↲	○	↲	↲			↲																													
	Masonry				↲	↲	○	↲			↲																													
	Retaining Wall				↲	↲	↲	○			↲																													
Periodic Inspection B: Drainage Facilities	Road Surface Median									○																			↲		↲									
	Slope				↲	↲	↲	↲			○																													
	Bridge		↲									○	↲					↲																						
	Adjacent Area to Road											↲	○		↲																									
Periodic Inspection B: Bridge	Concrete Superstructure		↲											○					↲																					
	Concrete Substructure												↲		○																									
	Steel Structure															○	↲																							
	Steel Plate Slab		↲													↲	↲																							
	Painting															↲	○																							
	Bearing		↲									↲						○																						
	Railing•Curb													↲					○																					
Periodic Inspection B: Tunnel	Lining																			○																				
	Portal																				○																			
	Interior Wall																					○																		
	Ceiling Slab																						○																	
	Drainage																							○																
Periodic Inspection B: Culvert	Reinforced Concrete Box																								○															
	Reinforced Concrete Pipe																									○														
	Other Type of Culvert																										○													
Periodic Inspection B: Traffic Safety Facilities	Guard Fence Median									↲																			○		↲									
	Anti-Dazzale net Median									↲																			↲		○									
Periodic Inspection B: Traffic Management Facilities	Traffic Sign																															○								
Periodic Inspection B: Other Facilities	Noise Barrier																															↲								
	Snow Fence																																			○				
Special Inspection (If necessary)		If necessary																																						

(1) Precautions

The inspection plan must be prepared to ensure rational and effective execution of the inspections. On its preparation, a method appropriate to the planned inspection is selected according to the accuracy required of the road structures and the execution method and result of this selected method should be well confirmed beforehand to avoid confusion and bewilderment during the inspection on site. To understand thoroughly the characteristics of the structures, the design standard, drawings and the past inspection record of the structures should be referred to as much as possible.

(2) Inspection time schedule

The scheduling of inspections is important to ensure efficient execution of inspections. The scheduling of inspections to be prepared includes the following two types:

(a) Annual inspection schedule
(b) Monthly inspection schedule

The annual schedule (a) is prepared at the beginning of the year, and the monthly schedule (b) before start of the month concerned. It is necessary to include a review of the result of the preceding month in the monthly schedule.

6) Inspection Tools to be carried

The inspectors must carry the appropriate inspection tools according to the type of inspection and details of their duties.

(1) The general tools necessary for the inspection duties are listed below.

(a) Routine inspections

Camera, binoculars, magnifying glass, measuring tape, test hammer, plumb-bob, pole, backboard, chalk, flashlamp

(b) Periodic inspection

Camera, binoculars, magnifying glass, measuring tape, calipers, thickness gauge, loupe, test hammer, plumb-bob, string line, pole, blackboard, chalk, wire brush, crow bar, scoop, slant rule, rope, flashlamp, etc.,

(c) Special inspection

The use of a Polaroid or video camera may also prove useful during special inspection to be carried out in urgent need.

(2) Other tools and materials to be carried for inspection

When the inspection is to be made by using a vehicle, it is essential to check before departure if all of necessary regulatory tools and materials (rubber cones, arrow mark plates, yellow flags, etc.) are loaded ready for use.

(3) The inspectors must wear a safety helmet, reflective clothing, and non-slip boots. A first aid box and disinfectants should always be kept in the inspector's vehicle.

7) Judgment Criteria

The inspection results are judged by the criteria shown in the table below.

Table 4.7.4 Judgment Criteria

AA	Damage is major and affects traffic safety. Immediate repairs are needed.
A	Damage is substantial, but further examination is required whether to repair or not.
B	Damage is small, but further examination is required whether to repair or not.
OK	Damage is negligible. No repair is required.

(1) Ranking of judgment

The effect of the degree of damage on the road functions varies depending on the individual structures, and the inspection varies in terms of the inspector and the implementation methods used for individual types of inspection. Consequently, it is rather difficult to standardize a judgment on the degree of damage for all structures by resorting to the same standard and accuracy. In any case, however, the use of judgment rank standardized to a certain extent, is necessary for a consistent process for the overall maintenance and repairs of various structures. In this view, the judgment criteria are described above.

This manual describes the judgment criteria on the basis of general condition. Before application of the criteria, the judgment rank need to be determined on the basis of an overall consideration on the features of the structure, the damage condition, the cause of damage, and the degree of the influence on the surrounding area. The numeric figures are used here to facilitate understanding of the specific condition of the damage. However such figures should be considered to be only a rough guideline because of the accuracy demanded for the inspection.

(2) Details of judgment rank

The judgment rank AA requires the repairs to be carried out as soon as possible so that disturbance to general traffic flows and any third parties is soon removed. The term "as soon as possible" here varies naturally in the degree of urgency between the repair of pot holes and repair of settled, or washed-away bridge abutment protection.

Both judgment ranks A and B apply to a case when there exists a damage and a further examination is necessary to determine whether or not a repair is necessary. They have been ranked separately according to the degree of magnitude of damage. Namely, ranks A and B have been set up separately on the basis of two rough guidelines under the assumed ideal conditions free from constraints in terms of a budget implementation system, repair process, and economy; the one requiring early repair and the other allowing observation for the time being, but with the possible necessity of repair in the future.

8) Photographing and Filing

Photographs of the entire appearance of a structure and the damage condition must be taken, if necessary, to confirm and record the inspection results. These must be filed for record purposes.

(1) Precautions for photographing

(a) Photographs become important data for later confirmation of the damage condition and should be taken correctly.

(b) Where a quantitative understanding is possible by referring to the shape and dimensions, the photographs have to be taken with the damage portion in a centre after marking or placing a scale.

(c) If the damage covers a wide area, the required number of photographs must be taken on the entire area and principal portions of damage.

(d) If the point of damage is three dimensional, the required number of photographs must be taken from different angles.

(2) Precautions for filing

(a) The photographs must be given record numbers related to the inspection content of the inspection report.

(b) The photos must be provided with the date of the photograph and, if necessary, a brief description of the content.

(c) The photographs which have not been attached to the inspection report must be arranged in order in an album.

(d) The negatives must be arranged in order in a negatives album, with the strips of the negative film attached. The album size should be standardized to facilitate filing.

9) Report of Inspection Result

The inspection result must be recorded in a specified report form. Any damage whose inspection result has been ranked as "AA" must be reported immediately to a person responsible for inspection duties.

(1) Content of the report

(a) The inspection result report is extremely important as reference data to be used in understanding the condition of a structure, future inspection, planning research, and the planning of maintenance and repairs, progress of damage, and analysis of the cause of damage.

(b) The inspection is carried out for each damage point, i.e. each inspection item, when damage occurs at different points of a structure. If the damage covers multiple inspection items, though it is in fact only one damage, the report handles such damage as one case, but judgment is made for each inspection item.

(c) When any damage or defect of "AA" rank is found, emergency measures are taken and the condition immediately reported to the person responsible for inspection. Such damage or defect report is submitted together with other inspection results in a form of report.

(2) Form of the report

The report of a type described below is prepared.

- Annual General Report ---------- Form IS-1
- Monthly Report of Routine inspections ---------- Form IS-2
- Routine Inspection Report (1) ---------- Form IS-3
- Routine Inspection Report (2) ---------- Form IS-4
- Periodical/Special Inspection Report ---------- Form IS-5
- Annual Inspection Plan ---------- Form IS-6
- Monthly Inspection Plan ---------- Form IS-7

Examples of the above seven (7) forms are attached to the end of this subsection.

(a) Annual General Report (Form IS-1)

The annual general report summarizes the results of all routine, periodic, and special inspections in the year for each object structure.

(b) Monthly Report of Routine Inspections (Form IS-2)

The monthly report of routine inspections summarizes monthly the routine inspection results carried out. This type of report helps to check any failure to report of damage or if the damage requiring on-going observation is well arranged. If the repair has been completed, the date of completion should be entered.

(c) Routine Inspection Report (1) (Form IS-3)

The routine inspection report (1) records the result of routine inspections conducted on a daily basis and is prepared, generally, one sheet a day. It is essential that even the minutest matter is recorded without omission because such matter may prove vital later.

(d) Routine Inspection Report (2) (Form IS-4)

The routine inspection report (2) is used to supplement the routine inspection report (1) and is prepared as required for each damage point. This report describes the condition of each damage point in detail and should be supported with photos or sketches. It is also essential to keep it with care as it is essential material for later confirmation and record keeping.

(e) Periodic and Special Inspection Reports (Form IS-5)

The periodic and special inspection reports record the result of the periodic or special inspection and should, as a rule, be prepared for each damage point. The report recording method and handling are the same as item (d).

4.7.2 Routine Inspections

1) Purpose of Inspections

The major purpose of a routine inspection is to apprehend the conditions of the road structures and traffic, the state of maintenance and repair work, etc., to detect early damage and defects in the road structures, and to determine adequate maintenance and repairs actions.

(1) The purposes of a routine inspection is to apprehend thoroughly the condition of the road structure and traffic as well as the state of implementation of maintenance and repairs. This will determine the appropriate maintenance and repairs necessary to keep the road in a satisfactory condition through early detection of defects and damage to the road. Thus preventing disturbance to road users and inhabitants along the road.

(2) In particular, routine inspections cover not only those portions (road surface, etc.) directly related to the traffic safety but also confirming the road utilization state. It is essential therefore to recognize that routine inspections are the basic activity for motorway maintenance.

(3) If damage is found during routine, periodic, or special inspections and continuous observation is judged necessary for such damage, any change in the subsequent damage condition or the effect on traffic or third party must be traced and understood in the course of routine inspections. Since routine inspections include such operations as one of the purposes of inspection, continuous observation of any change in the damage condition must be made with due care along with efforts to find new damage.

2) Outline of the Inspections

Routine inspections are made to apprehend the conditions of road structures and the traffic use of the structures, within the extent visible from a vehicle, on a daily basis, principally to ensure safe and smooth traffic flows and to remove disturbances to a third party. These inspections are made while inspecting the road from a vehicle to detect early the damage for appraisal.

(1) Routine inspections include detection of structural damage or defects on the road, which obstruct or hinder traffic and third parties, visually or by means of apparatus on-board the car and determination of the appropriate measures for judgment. If necessary, the inspector gets out of the car to conduct visual check or measurement using inspection equipment. This manual considers such activity as a part of routine inspections.

(2) Routine inspections include, apart from the inspection mainly to remove disturbances to traffic flows and third parties, tracing the causes of damage to structures for which continuous observation has been determined on the basis of the past inspection results. In this case, any change in the progress of damage condition must be recorded in the routine inspection report.

3) Inspection Methods

As a rule, routine inspections must be made by two persons who together check the conditions visually from a car.

(1) Routine inspections are made on the road conditions visually from a car. If necessary, the inspector must dismount from the car to make the inspection. It is also necessary to check the pavement and expansion joints by means of feeling in driving and impact sound during driving.

(2) During inspections, the inspectors should change over seats (driver's seat and passenger seat) alternately to avoid biased observations and to improve their inspection techniques.

(3) Since routine inspections are made every day, they tend to become stereotyped compared with the periodic or special inspection. It is therefore necessary to make variations in the inspection content by changing daily or weekly priority items.

(4) The time period required for a routine inspection varies depending on the length to be covered or the circumstances in which damage is detected. The standard period may be around a half day if the routine inspection is not combined with the periodic inspection B.

4) Judgment Criteria

(1) The routine inspections are intended to detect early the damage visually or by feeling in driving on board the vehicle and to make a judgment. In this context, daily training is essential to enable early detection through visual inspection from the car or feeling in driving.

(2) The routine inspections are normally made from a car to detect damage. If necessary, the inspector dismounts from the car to assess the damage and its cause as quantitatively and specifically as possible.

Precise and detailed inspection is difficult to conduct in the course of routine inspection. However the judgment criteria for routine inspections is the same as those for periodic and special inspections. Reference will be made to Tables 4.7.25, 4.7.26, 4.7.27 and 4.7.28.

(3) Road surface

Concerning road surface damage, such as pot holes, collapse, faulting, longitudinal roughness in the pavement, and damage to the expansion joint, the ride-quality detected by the way of difficulty to maintain directional control, shock, vibration, lurching, or riding comfort are important. These will detect damage and determine the degree of damage and effect on the traffic.

Accordingly, if abnormal shocks or difficulty to maintain the directional control is felt as affecting the traffic, and judgment rank must be "AA" regardless of the measured values.

Pot holes, cracks, and corrugation appearing in the pavement of a bridge may be attributable to a crack in the slabs, which should be taken into account when the inspection is made.

(4) Slope

(a) If a failure is found on an earthwork slope, special slope, masonry, or concrete retaining wall during an inspection from the car and the degree of change is considered to have worsened substantially, the conditions of the surrounding area must also be carefully observed. The judgment rank is set at "AA" when there is any possibility of disturbance to the traffic.

(b) In particular, changes in the condition of the slope can be found by checking the shoulder and soft shoulder in the cut section with care for any deposits after rainfall.

Should any rock debris or concrete pieces (slope protection material) be found therein, there must be a certain change in the slope or cut section and the inspection must be made to judge if such change will cause a disturbance to the traffic.

(5) Drainage facilities

From the car, damage to a road grating can be readily detected. But damage to a facility or accumulation of dust or sand in it is difficult to find in this manner. Therefore, the inspection of drainage facilities must be made as a priority item during rainfall when the defect of these facilities becomes most obvious.

Observations must be made with care because detection of ponding on a road surface or hydraulic jump in discharge of a slope drain are keys to find a drainage problem.

(6) Bridge

Detection of damage to the railing and curb on a bridge is made mainly on the inside of roadway. If any breakage of concrete is found, the inspection must be made with care to see if there is any damage on the outside and if any trouble has occurred or may possibly occur to a third party by this damage.

(7) Tunnel

Damage to the concrete lining of a tunnel must be detected early because it is quite likely to present a future disturbance to the traffic. Such damage is located in a place out of reach of the lighting effect, so the best way to detect such damage is to observe with care the road surface for small concrete pieces or other debris. Due attention must be paid on these points during inspection.

(8) Traffic safety devices

Damage to the traffic safety devices is mostly caused by traffic accidents and the persons responsible for such damage are not known in most cases.

It is therefore necessary to distinguish between old and new damage. Damage to a guard cable may affect not only the point of accident, but often to the adjacent lengths and terminal. Due attention must be paid on this point during inspection.

(9) Traffic control devices

The traffic control devices excluding traffic signs are to be checked by routine inspections only. This fact should be taken into account during judgment in routine inspections.

(10) Other facilities

If a control door of a noise-abatement barrier is open, the barrier effect is reduced, and such door should be closed immediately. This is ranked "AA". Judgment and the necessary correction for such a case should be made in the course of inspection.

(11) Planting

This inspection covers plants and grass within the range visible from the car and is intended to detect the growth state, damage by blight and obnoxious insects, fallen tress, and to check for existing or possible disturbance to traffic.

Accordingly, the judgment rank is set at "AA" if the fallen tree enters into the road to actually disturb or possibly disturb the traffic. The judgment rank is set at "A" if the dead or fallen tree or damage by blight and noxious insects has occurred over a wide area, deteriorating the visual quality (landscape) or disturbing the light shielding function. The judgment rank is set at "B" if the damage is limited to a few trees or occurs only locally.

(12) Overbridge

(a) Object and precautions

The inspection of overbridge covers the girders and abutment, pier surface, bottom surface of slab, the outside of wall, railing, and curb, and guardrails which are visible from the car.

Damage to an overbridge include cracks and spalling occurring frequently in the curb concrete. This damage may possibly affect the traffic in the adjacent lane and require particular attention during inspection.

(b) Damage to the concrete

"Damage to the concrete" included in the inspection items means loss of high strength bolts and rivets of a steel bridge, inlet in the curb, slab, drainage pipes around the abutment and pier foundations, in addition to cracks and spalling of concrete of super-structure and sub-structure.

(c) Damage to the guard rails

"Damage to the guard rails" included in inspection items means loss, inclination, damage, deformation, and corrosion of the protection fence, steel railings, and blind plate, in addition to the guardrail itself.

(d) Measures to be taken according to the judgment result

The judgment rank is set at "AA" when the damage is disturbing or may disturb traffic flows. The necessary emergency measures must be taken and reported immediately to the responsible person. For the judgment ranks "A" and "B", the required items must be informed to the responsible person for the appropriate action.

(13) Traffic condition

It is necessary to check for any conditions which are considered to affect the traffic.

5) Report of Inspection Results

The results of routine inspections must be recorded on the specified forms, reported and filed. The damage of which the judgment result is ranked at "AA" must be reported immediately to the responsible person.

(1) As shown in Fig. 4.7.2, the results of routine inspections must be recorded daily in the routine inspection report and field monthly into the monthly report of routine inspection. At the end of a year, the whole of inspection results of a year is filed and aggregated into an annual general report.

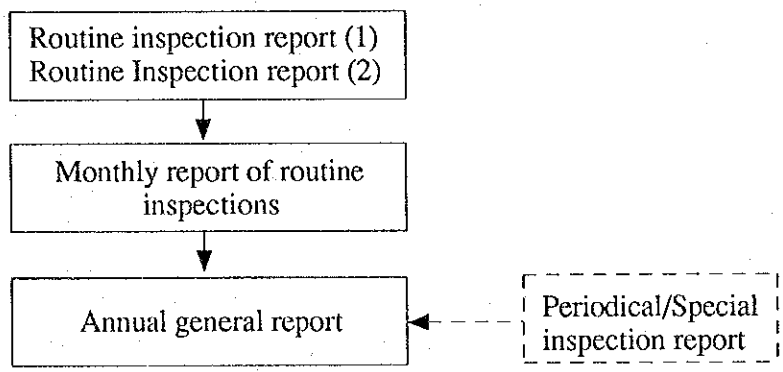


Fig. 4.7.2 Flow of Routine Inspection Result Reports

(2) For the routine inspection report, the damaged point detected is entered with a date (year/month/day) of detection. Once detected and recorded, the damage point need not be re-recorded unless any change is found in the judgment or the condition.

(3) Form IS-1 through Form IS-7 show the examples for each report as shown at pages 4-81 to 4-87.

(4) Precautions for entry

(a) General

(i) If an office covers multiple routes, a report must be prepared for each route.

(ii) If two or more inspection items are found for one damage point, they must all be recorded (the description is therefore made in two or three columns).

(iii) The kilometre posts are indicated at 10 metre intervals.

(iv) The file number is provided in the order of detection or inspection of the day for each inspection date and inspection type.

(b) Routine inspection reports (1 and 2)

(i) The necessary matters related to the condition of damage are entered according to the legend in the routine inspection report (1), Form IS-3. Also entered are the priority object structures of the day, operation and work position and execution conditions, and special remarks.

(ii) For the members whose position can be clearly identified relative to the bridge, such as the bridge expansion joint, etc., the bridge name and the number of abutment and pier are to be added.

<Example> ---------- bridge, A1 or P1

(iii) If pot holes are found in several points in a certain section, representation by a representative position or by an extent of pot-holing, whichever is appropriate, should be selected.

(iv) As special remarks, the special matters which can not be represented by a symbol only or the matters which are not covered by the inspection, but are considered to be reported or recorded, should be briefly described.

(v) The routine inspection report (2), Form IS-4 is a report including mainly the figures and photographs and prepared as required.

(c) Monthly report of routine inspection

(i) The monthly report of routine inspections consists of the summary of the content of the routine inspection reports prepared normally by the daily sheet when the routine inspections are made, so that the subsequent actions taken can be viewed at a glance.

This report is completed every month, but the entry should be made on daily. In this way, the report may be used as a help for daily maintenance duties.

(d) Annual general report

(i) The annual general report is of a form to make entry day by day for each object structure unit. This is further subdivided as required or broken down for each type,

(ii) In the case of transfer from routine inspection to routine inspections (re-registered in line with change in the judgment or condition), routine inspection to special inspection, or periodic inspection to special inspection, the result of inspection is entered for each inspection, resulting in a double entry for the same damage. In this case, correlation between the newest inspection result and previous one must be clarified.

4.7.3 Periodical Inspections

1) Purpose of Inspection

The purpose of periodical and special inspections is to apprehend the condition of the structures, to evaluate possible damage causing degradation of functions and to determinate if repair will be necessary. Periodical and special inspections are made to understand the condition of the structures and to detect and evaluate early any damage causing functional degradation or which may grow into a secondary damage, thereby obtaining data necessary to establish the inspection or survey plan and repair plan.

2) Outline of the Inspection

Periodical inspection involving inspection of structures which cannot be checked in daily inspections. It includes ocular inspection, using inspection equipment if necessary for evaluation and judgement. Special inspection is made as required to supplement daily or periodical inspection, with the inspection content and method as above described. Reference will be made to Tables 4.7.25, 4.7.26, 4.7.27 and 4.7.28 for judgment criteria of periodical Inspections.

(1) Periodical inspection is made periodically on any structure that cannot be checked in daily inspections. Therefore, the inspection must be made on the structure as planned at the right time to achieve the intended purpose.

Inspection is made by approaching the structure as much as possible on foot using a ladder and beam lifter. Inspection is made ocularly or by using necessary measuring instruments.

(2) Periodical inspection A covers inspection of the condition of the structures over the entire jurisdictional section. The maintenance duty with comprehensive counteraction cannot be executed efficiently unless the inspector is fully familiar with the construction and functions of the road and the conditions of structures within the scope of his/her responsibility. This type of inspection has been established with the intention that the entire office staff attempts to know the condition of the field periodically.

(3) Periodical inspection B is to check the conditions of individual structures in detail. This inspection is mainly to obtain the data for future planning of inspection, survey, and repair through understanding of the soundness of a structure and evaluation and judgment of the conditions. Accordingly, it is essential for the inspector to establish an annual plan and to obtain technical data of structures beforehand by using existing information.

(4) Special inspection is made as required, with similar content and method as periodical inspection, when evaluation and judgment are difficult with the daily or periodical inspection, immediately after abnormal weather, or in response to a report.

3) Road Surface

(1) Outline of the Inspection

The road surface is in direct contact with automotive tires. Inspection of the road surface is therefore extremely vital for safe driving.

In this manual the road surface is categorized in three groups:

① Pavement ② Expansion joints ③ Curbs

(a) General requirements for inspection

Before inspection, an inspection plan must be established by using existing information. The present condition must be obtained on the basis of soil and weather conditions, structure type, traffic volume, and service period while taking the past repair history into account. The pavement register and expansion joint record, which have been kept in order, must also be referred to.

(b) Classification of the road surface

In the narrow sense of the word, road surface includes only the road pavement surface. But in this report, it includes also expansion joints and curbs.

(2) Inspection Method

As a rule, the inspection is made by approaching from the shoulder (from the median if necessary or from the lane after assuring the safety through traffic regulation, etc.) to the object structure as much as possible. The inspection is made ocularly and, if necessary, measurement are made using a convex, measuring tape, post, leveling string, test

hammer, etc. The inspection results are recorded in the form of photos or sketches. For the expansion joints, due attention must be paid additionally to any abnormal sound.

(a) Inspection of the pavement is made from the passage way for inspectors (if existent) tunnel sections and from the island at toll gates.

(b) Inspection of expansion joints is made by viewing from the abutments and piers or from the inspection passage toward the underside of the expansion joint. Abnormal sound is checked particularly when a large vehicle passes. The face plate, face plate back section, and post-placement concrete section are also hammered with a test hammer to check for damage.

(3) Pavement

(a) Scope

This section applies to routine and special inspection for pavement. There are two types of the pavement.

① Asphalt concrete pavement (asphalt pavement)
② Cement concrete pavement (concrete pavement)

(i) Asphalt pavement is normally exposed to external factors (traffic load after pavement, weather conditions) and internal factors (aging of the pavement proper), and the planned maintenance is essential to maintain satisfactory serviceability at all times. Repairs must also be made systematically and rationally on the basis of objective evaluation of the right time and scale.

(ii) Concrete pavement generally consists of a surface course and a base course. The surface course consists of concrete pavement slabs which has rigidity and is resistive against the bending stress caused by wheel load. In this sense, the concrete pavement is called a rigid pavement as compared with the asphalt pavement which is called a flexible pavement.

(iii) This section describes how the pavement inspection should be undertaken basically. For pavement inspection, the method of daily inspection is used in principal, whose basic concept is described in this section.

(b) Inspection items

Inspection items are shown in the Table 4.7.5.

Table 4.7.5 Inspection Items

Type	Items
Asphalt pavement	① Obstacles on the road (fallen materials, fallen stone, collapsed earth) oil stain, foul road surface ② Pot hole, peeling, subsidence ③ Faulting ④ Rutting ⑤ Crack ⑥ Cross-section roughness and corrugation ⑦ Scaling of thin surfacing ⑧ Water Storage
Concrete pavement	① Obstacles on the road (fallen materials, fallen stone, collapsed earth) oil stain, foul road surface ② Pot hole, peeling, subsidence ③ Faulting ④ Friction ⑤ Crack, corner failure ⑥ Determination ⑦ Joint breakage ⑧ Buckled or lift of slabs ⑨ Water storage

(4) Expansion Joint

(a) Scope

This paragraph applies to periodical and special inspections of the expansion joint. The subdivisions concerned are shown below:

① Groove ② Rubber joint ③ Metal joint

Expansion joints vary greatly according to the function, material, and construction method, and can summarized into three types in view of inspection and operation as shown in Table 4.7.6.

Table 4.7.6 Types of Expansion Joint

Type	Remarks
Groove joint	• Cut joint with filler • Angle reinforcement joint • Metal reinforcement joint
Rubber joint	
Metal joint	• Steel finger joint • Steel lap joint • Special joint

(i) Groove joint

The joint is of a structure in which expansion at the bridge end is absorbed by changes of asphalt material, with the cut joint filled with joint filler.

(ii) Rubber joint

The rubber joint includes a press type in which rubber and steel materials of various shapes are combined. In view of the workability and flatness of pavement, the post-installation type is used frequently.

(iii) Steel joint

The metal joint includes a finger joint and a lap joint. Generally, the metal joints are mostly the finger joints.

(b) Inspection Items

Inspection items are shown in the Table 4.7.7.

Table 4.7.7 Inspection Items

Classification	Type	Items
Expansion joint	Groove	① Damage to joint ② Damage around joint ③ Water leakage ④ Abnormal sound
	Rubber joint Metal joint	① Damage to joint ② Damage to secondary material ③ Faulting ④ Abnormality in spacing ⑤ Water leakage ⑥ Abnormal sound

(5) Curb

(a) Scope

This section applies to periodical and special inspections of curbs. Curbs can be subdivided into

① Asphalt curbs ② Cement concrete curbs

In terms of function curbs can be classified into road drainage facilities and protection facilities. Generally, the former type used is 12 cm and the latter about 25 cm in height. In terms of material, curbs may be divided into asphalt curbs and concrete curbs. For bridge curbs, refer to 6-9, "Railings and Curbs."

(i) Asphalt curbs

This type of curb is used most frequently in through lanes, speed changing lanes of various facilities, and ramps, and has a maximum height of 12 cm.

(ii) Precast concrete curbs

There are precast concrete curbs with a height of about 25 cm used for the median of 1.5 m or less in width in the low-standard road, median in the tunnel and interchange ramp, and platform of the bus stops and those with a height of 12 cm used for the bridge and viaduct section.

(b) Inspection Items

Inspection items are shown in Table 4.7.8.

Table 4.7.8 Inspection Items

Classification	Types	Items
Curb	Asphalt curb Precast curb	Damage to the curb proper

4) Slope

(1) Outline of the Inspection

If magnitude slope failures occur, it exerts serious effects on the traffic and the third party. It is therefore essential to inspect slopes based on the carefully-established plan. This manual sub-divides slopes as follows.

(a) General requirements for inspection

(i) Slopes can be divided into natural and artificial slopes. Natural slope are slopes without any artificial treatment, including the area outside the right-of-way. Artificial slopes on the other hand are constructed by the earth work during construction of the road.

(ii) Before inspecting the slope, the inspector must understand the disaster history of the slope concerned to know the state up to now by referring to the slope record. The topographical and geological conditions over a wide area must also be reviewed to know the current situation of the slope concerned. Since weather conditions are an important factor leading to disasters, due attention must be paid to regional characteristics of the rainfall pattern. In this respect, analysis of the rainfall pattern which has led to disasters in the past will prove helpful. Topographical and geological review items are listed below:

- Positioning in terms of geological time classification
- Positional relationship with principal tectonic lines and faultings
- Positioning in the course of topographical development

- Topographical characteristics (landslide topography, presence of kern col, slope aggressive to rivers, and presence of inclination change point) of the original topography before cutting

It is highly likely that slopes where a failure has once occurred become the source of recurrence. Review of the disaster history will therefore lead to determination of the priority inspection points.

Slope protection becomes brittle as time passes. Besides, an external force which could not be expected during construction may act on the slope protection and deform it. In this respect, the slope protection must always be checked with possibility of changes kept in mind.

It should be noted that the remarkable progress of land development and multipurpose land use in these days has greatly affected the stability of slopes in certain cases. In this respect, changes in the surrounding environmental conditions should be considered during inspection.

(i) Slopes of embankments

The conditions of the surface of slopes (that is, if planting is thick enough to cover the face completely or if there is any rain-induced crack) should be known to understand the progress of erosion with rainwater or failure due to frost heave. Accumulation of dust or soil, if any, on the face of slope should be checked with care because such accumulation may block ditches or blight the planting.

Cracks, faulting, and bulging are important warnings indicating possible failure and its progress must be checked. Appropriate countermeasures must be considered if any progress is confirmed.

Changes of the slope protection may indicate possible failure of the slope, which can be attributed to settlement of the foundation or erosion of the slope rear side with rainwater. In any case, the progress must be checked and the cause identified.

Blocking of the drainage facilities with earth and sand or its changes causes overflow of the flowing water, resulting in vital disaster. Changes of vertical grooves or the berm ditches in slopes may indicate changes of the slope as a

whole. In other words, the basic cause of these symptoms must be found out and appropriate measures taken.

When slope protection or ditches are constructed on a new embankment, changes occurs to a certain degree until the embankment settles down firmly. In this event, the slope rear side may be eroded or rainwater may flow by the side of the vertical ditch causing erosion. Therefore, inspection intervals must be reduced for new embankments and special inspections must be planned immediately after snow melting.

(ii) Slopes of cut sections

Cracking or bulging of slopes are an important warning to indicate possible failure. Cracks occur first in the slope shoulder and generally develop to cause cracks in the lower slope. During inspection, the inspector must climb to the top of the cut section and check a wide area for any crack. If any crack or bulging is found, its progress must be checked and appropriate measures must be taken if necessary. Changes in the slope protection form also an important warning to indicate possible failure. Such changes occur in advance to cracking in the slope surface. In most of cases, changes are helpful for early detection of failures. However, the cause must be investigated thoroughly because changes may be attributable to insufficient bearing capacity of the structural foundation or loss of earth in the rear of a structure.

Particular attention must be paid to the leachate condition for the slope and the water collection condition in the slope shoulder. For a location where leachate from the slope face is observed at all times, attention must be paid during inspection after rainfall because for such a slope failure is highly possible due to excess pore water pressure. Besides, in the ground condition with a valley between right and left elevated portions, the drainage state of rainwater flowing down the valley must be checked carefully because the slope may suffer water-induced cracks. When change in the surrounding environment has caused substantial change in the water supply state to the slope, its effect must also be checked. Changes in the seepage water state in the slope face (new seepage, excessive increase or decrease in the water quantity, or seepage water beginning to be turbid) will become important judgment data to detect early changes (cracking, etc.) in the future.

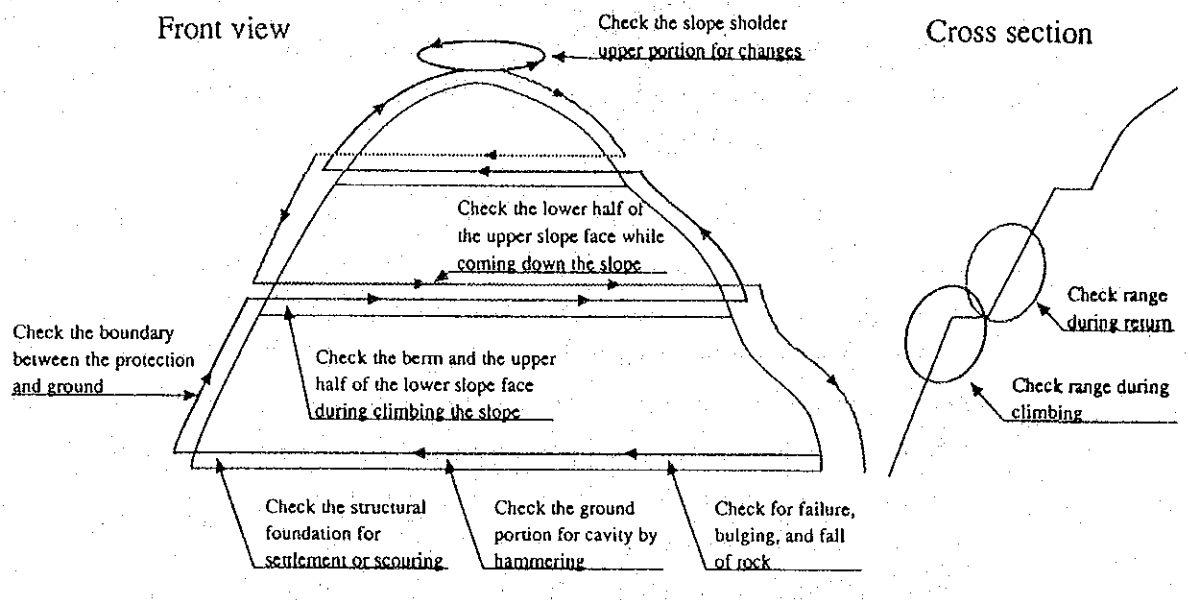
(b) Classification of slope faces

The slope face supports the road surface and earth structure which makes up a principal portion of the road. Its protection roughly divided into the protection by planting and protection by structures. The latter is further sub-divided into a special slope face, masonry, and concrete retaining wall.

(2) Inspection Methods

The inspection is made by approaching from the slope shoulder, toe of slope, or berm as near as possible toward the object structure. Inspection is made ocularly, and, if ocular inspection is not enough, binoculars are used. If necessary, a convex, measuring tape, or post may be used to determine the location and direction and to measure the dimensions. Photos and sketches are to be used for recording.

(a) To check the slope, the route shown in Fig. 4.7.3 can be taken.



Note : The figure shows the cut slope face. The same applies to the embankment slope.

Fig. 4.7.3 Inspection Route for Slopes

(b) During inspection of planted slope faces or slopes, small failures or cracks may be overlooked where the planting is thick. Efforts must be made to prevent overlooking while referring to the route shown in Fig. 4.7.3. When inspection is to be made outside the area under control, due care must be taken to prevent trouble related to admittance.

(c) Special slope faces, masonry, and concrete retaining walls must be checked ocularly while approaching the object structure as much as possible. A scaffold or life line may be used during inspection when a ladder or steps for inspection is not available.

(d) For the portion provided with mortar or spraying, hammering inspection with a test hammer in addition to ocular inspection may help detecting breakage from the ground or formation of cavities.

(3) Slope Vegetation

(a) Scope

This section applies to routine and special inspections.

During inspection, however, planting work need not be handled separated from above because it is practically difficult to know the kind of work at the time of construction.

Slope protection by vegetation is made principally to prevent erosion of the slope, but improvement of the landscape has come to be considered vital as one of purposes of the planting work. Selection of the kind of work depends on the scale and the shape of slope face, soil conditions, weather conditions, and the existing state of surrounding slope faces.

Even after having taking root, the planting alone can not prevent landslides or failure of the slope face or slope. Therefore, sufficient stability of the slope face proper is a prerequisite.

(b) Inspection Items

Inspection items are shown in Table 4.7.9.

Table 4.7.9 Inspection Items

Classification	Type	Items
Vegetation		① Collapse ② Crack, bulging falling ③ Spalling, galley ④ Piled soil on berm ⑤ Seepage water ⑥ Fallen tracks ⑦ Dead Planting ⑧ Accumulation of dust ⑨ Spall and rolling stones

(4) Special Slope Protection

(a) Scope

This chapter applies to periodical and special inspections of the special slope protection. Slope protections can be categorized as follows:

① Concrete blocks
② Cast-in-place concrete block
③ Motor Spraying
④ Concrete Spraying
⑤ Concrete Lining
⑥ Prevention net for falling stone
⑦ Prevention fence for falling stone
⑧ Net hurdling

(i) Concrete block

Concrete blocks are used in places where planting is not suitable or where vegetation cannot prevent failure of the surface, such as a cut slope with seepage, an excessively high slope, and an embankment slope steeper than the standard grade. Concrete blocks are mostly applied to gentle slopes with a grade of 1:0.8 or less.

(ii) Cast-in-place concrete blocks

Cast-in-place frames are provided to weathered rock or long slope faces when the long-time stability of the slope is doubtful or when the use of a concrete block frame can not eliminate the possibility of failure completely.

(iii) Mortar spraying

Mortar grouting is applied to rocks without overall seepage in the slope which is weathered readily, rocks which may probably be weathered and peeled, rocks with many cracks and joints and hazardous falling stones, and to places where planting is not suited (conglomerate, hard pane, etc.).

(iv) Concrete spraying

Concrete spraying is used in a places where mortar spraying to cope with. This method is positioned in-between mortar grouting and concrete lining.

(v) Concrete lining

Concrete lining is used in rock mass with lots of joints or talus layer which is likely to fail and for which the use of concrete frames, mortar spraying, or concrete spraying is considered not enough. High slopes or steep slopes is provided with wire net or reinforcement and the legs or anchor to prevent slide.

(vi) Prevention net for falling stone

Prevention nets for falling stones are used for the cut slope face of soft rock or gravel containing soil in a place where the gravel layer may fall due to scouring with rainwater or for the hard rock slope face in a place where falling stone is expected in the future.

(vii) Prevention fence for falling stone

Prevention fences for falling stones are used for the long cut slope face in a place where falling stone (should it occur because of earthquake or heavy rain) cannot be prevented from exerting substantial effect on the traffic by the prevention net for falling stone only or where falling of rolling stone is expected from the area adjacent to the road (outside the area under control).

(viii) Net hurdling

Net hurdling is used when there is a possibility of sand running off from the slope face until the planting takes root and the slope face is stabilized.