

(b) Inspection Items

Inspection items are shown in Table 4.7.10.

Table 4.7.10 Inspection Items

Classification	Type	Items
Special Slope Protection	Concrete block Crib Cast-in-place Crib	① Crack, stripping ② Looseness bulging, subsidence ③ Scour ④ Drainage, seepage
	Motor spraying Concrete spraying	① Crack, stripping ② Push-out bulging, misligned joint ③ Scour ④ Drainage and seepage
	Netting and fence	① Damage to net/fence proper ② Damage to the accessories ③ Corrosion ④ Damage to the foundation
	Net hurdling	① Damage to the net hurdling

(5) Masonry

(a) Scope

This section applies to the periodical and special inspections of the Masonry. The subdivisions concerned are shown below:

- ① Concrete block masonry
- ② Concrete block pitching
- ③ Stone Masonry
- ④ Gabion

Masonry is constructed by stacking independent matters, such as concrete block, rubbles, miscellaneous rubbles, and cobble stone.

(i) Concrete block masonry and stone masonry

These types of masonry are used for slopes steeper than 1 : 1 to prevent weathering and erosion of the slope. They are also sufficiently durable against soil pressure when used as a retaining wall.

(ii) Concrete block pitching and stone pitching

Concrete block lining and stone lining are used mainly to prevent weathering and erosion of the slope face for slopes more gentle than 1 : 1 where the soil is non-adhesive sand, mudstone, and clay which is ready to fail.

(iii) Gabion

Gabion is used when sand may run off because of seepage in the slope or when the failure place is to be recovered or when the slope may strip off due to frost heave.

(b) Inspection Items

The inspection items are shown in Table 4.7.11.

Table 4.7.11 Inspection Items

Classification	Type	Items
Masonry	Concrete block masonry	① Crack, looseness bulging ② Settlement, displacement, inclination ③ Abnormality in joint ④ Scour ⑤ Drainage, seepage
	Concrete block pitching	
	Stone masonry	
	Gabion	① Breakage, damage corrosion of steel wires ② Deformation

5) Drainage Facilities

(1) Outline of the Inspection

Damage to the drainage facilities forms both direct and indirect causes to failure of the slope face or water storage over the road surface during unusual weather. Inspection of the drainage facilities should be made carefully for damage and functions of the main body.

This manual deals with this problem by classifying the drainage facilities as follows:

- Road drainage facility
- Slope drainage facility
- Bridge drainage facility
- Drainage of the frontage road and the area adjacent to the road

(a) General requirements of inspection

Inspection of pavement, bridges, and slope faces is the one on a spot or area on one hand. The drainage facilities require the inspection on a spot or line. Therefore, it is

essential to keep in mind the fact that those facilities arranged linearly can function satisfactorily only when all of them are without trouble.

Damage to the drainage facilities is generally minor. In view of a practical situation that failure of the slope is mostly attributable to the faulty condition and defect of the drainage facilities, correct understanding of the field condition, detection of damage while it remains minor, and removal of the cause of disaster are of extreme importance.

(b) Classification of the drainage facilities

Drainage facilities can be classified into a road drainage facilities, slope drainage facilities, bridge drainage facilities, and drainage facilities of the frontage road and the area adjacent to the road.

(i) Road drainage facilities

Road drainage facilities remove rainwater and snow water flowing over the road surface.

(ii) Slope drainage facilities

Slope drainage facilities discharge rainwater and snow water flowing down along the slope as well as seepage in the slope face to the outside of the slope face.

(iii) Bridge drainage facilities

Bridge drainage facilities remove rainwater and snow water flowing over the bridge surface.

(iv) Drainage facilities of the frontage road and the area adjacent to the road

This facilities includes gutters and drainage channels which are provided in the boundary to the right-of-way to remove rainwater and snow water flowing in the through lane and frontage road. Note that the terminal drainage facility below a bridge or viaduct is also included in this section. The slope shoulder drainage facility of the drainage facility of the area adjacent to the road is handled as the slope face drainage facility.

(1) Drainage facility of the earth work

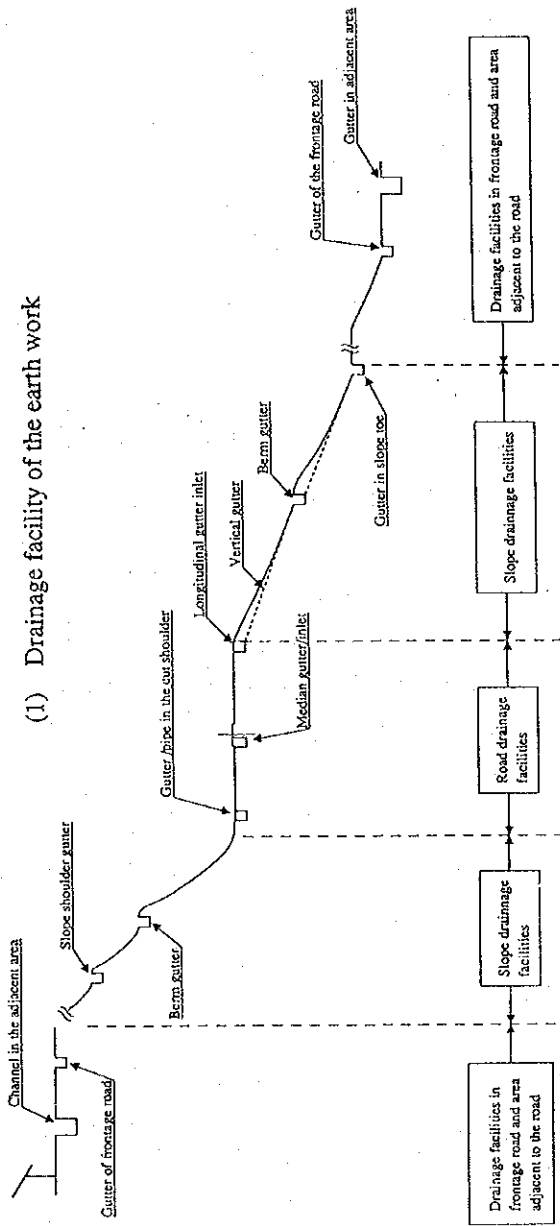


Fig.4.7.4 Graphical view of the drainage facility

(2) Bridge drainage facility

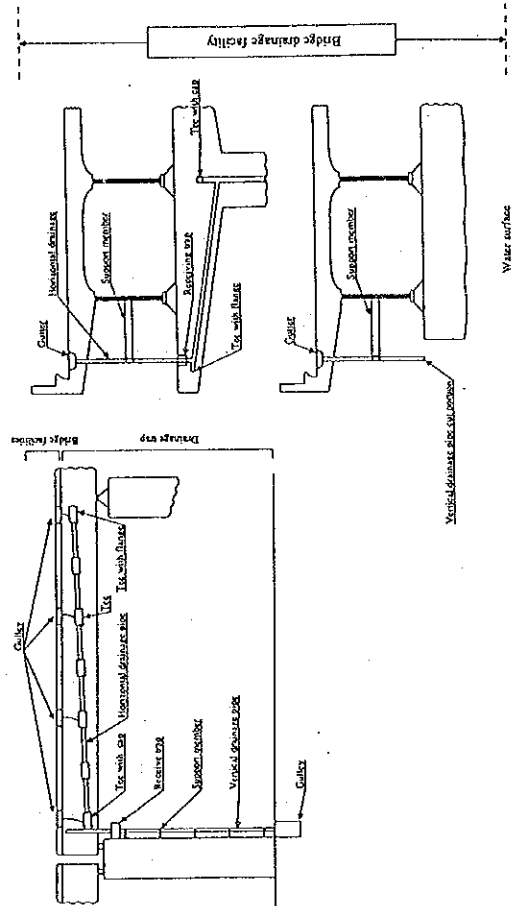


Fig.4.7.4 Graphical view of the drainage facility

(2) Inspection Methods

Inspection is made by approaching from the road shoulder, slope face, bridge, frontage road, and intersection road as near as possible to the object structure. Ocular inspection is made, with a convex, measuring tape, and pole used to determine the position and direction as well as to measure the dimensions. Photos and sketches are used for recording.

It is recommended to carry out inspection of drainage facilities during or immediately after rainfall to check the drainage system, drainage functions, and if there is any damage.

(a) Road drainage facilities

Inspection on these facilities is same as in the case of road inspection. For the median in particular, inspection should be made at the same time with traffic regulation to ensure safety of the on-road operation.

(b) Slope drainage facilities

Inspection on these facilities is the same as the case of slope inspection, but mowing should be made before inspection when planting is excessively thick.

(c) Bridge drainage facilities

Inspection on these facilities is the same as the case of bridge inspection, with a test hammer used to check the drainage pipes.

(d) Drainage facility of frontage road and the area adjacent to the road

Inspection on these facilities is the same as the case of inspection of road and slope drainage facilities.

(3) Road Drainage Facilities

(a) Scope

This section describes periodical and emergency inspection of road drainage facilities. The following types of facilities are covered by this section.

- | | |
|---------------------|-------------------|
| ① Shoulder drainage | ② Medium drainage |
| ③ Inlet/outlet | ④ Drainage pipe |
| ⑤ Manhole | |



Road drainage facilities are classified as follows in terms of the installation place.

Shoulder drainage facilities — { Embankment-side ditch, inlet
Cut - Drainage pipe, side ditch, inlet

Median drainage facilities - Median ditch, inlet, manhole

(Note) The gutter here includes the U-shaped and L-shaped gutter excluding the circular channel and rolled gutter.

(i) *Shoulder drainage facilities of embankments*

In embankments, longitudinal gutter inlets are provided as a rule within an interval of 30 - 100 m to discharge rainwater flowing in the shoulder or shoulder gutter. When only rainwater of the shoulder is to be discharged, the interval may be maximum 200 m.

(ii) *Shoulder drainage facilities of cut sections*

In cut sections, drainage pipes, circular channels, or rolled gutters are provided to discharge rainwater flowing in the shoulder.

Apart from the above, the vertical drainage on slope is installed at points where the longitudinal drainage culvert is connected, at points where the section of the underground grade pipe changes, and in the bottom of the grade.

(iii) *Median drainage facilities*

- In section where the road crossfall is inclined toward the median, a circular channel, rolled gutter, median gutter, median inlet, gully, and manhole are provided to the median to collect and discharge rainwater and snow water on the road surface and within the median.
- The interval of median inlets is basically equal within a range from maximum 30 m to minimum 5 m depending on the linear condition.

- Gullies are provided in consideration of a place where the flow is equal to the allowable water flowing rate of the gutter, the bottom section of the gutter grade, longitudinal gutter of the embankment, cleaning gully in the earth work shoulder, and position of the crossfall structure. Rainwater and snow water collected in the gully are discharged into the longitudinal gutter of the embankment through the drainage pipe crossing under the through lane.

(b) Inspection items

The inspection items are shown in Table 4.7.12.

Table 4.7.12 Inspection Items

Classification	Type	Items
Road surface drainage	Shoulder drainage Median drainage Inlet/outlet Drainage pipe Manhole	① Damage to the facility proper ② Bad connection ③ Accumulation of soil and dust

(4) Slope Drainage

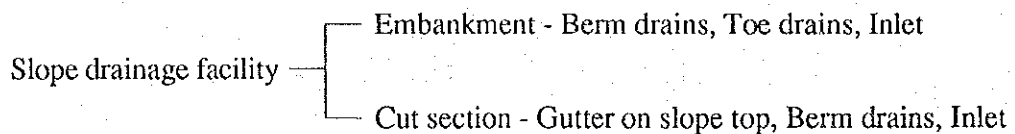
(a) Scope

This section applies to periodical and special inspections of slope drainage.

Slope drainage facilities include:

- ① Gutter on slope top ② Berm Drains
- ③ Toe drains ④ Inlet

Slope drainage facilities applicable to this section may be classified as follows for the embankment and cut section:



(i) Slope drainage facilities of embankments

Embankment slopes are artificial slopes with selected material and tends to become stable as the time passes. Berms are constructed as a rule when the height of embankment exceeds 10 m. Their standard interval is around 10 m when the embankment materials are rocks and cobble stones and around 6 m for other materials. Small steps are provided sequentially from the shoulder, with the standard width. These berms are provided with the gutter to discharge rainwater flowing down along the slope. These gutters include U-shaped gutters made from precast concrete, cast-in-place concrete U-shaped gutters, or plastic soil cement.

(ii) Slope drainage facilities of the cut sections

Slopes of cut sections tends to become gradually unstable due to weathering as the time passes. Failure of cut section slopes occurs frequently in the slope shoulder, middle of the slope face, saddle of the water collection topography, area around the longitudinal gutter and area around the bridge.

Drainage gutters on slope shoulder are provided to prevent rainwater from the adjacent area from entering the slope face. As a rule, berms are provided for high slopes, with the standard width. The slope shoulder gutter is a precast concrete U-shaped one or cast-in-place concrete U-shaped.

(b) Inspection items

The inspection items are shown in Table 4.7.13.

Table 4.7.13 Inspection Items

Classification	Type	Items
Slope drainage	Gutter on slop top Berm drain Toe drain Inlet	① Damage to the facility proper ② Bad connections ③ Accumulation of soil and dust ④ Sectional area reduced by weeds

(5) Bridge Drainage Facilities

(a) Scope

This section applies to periodical and Special inspections of the bridge drainage facilities. The subdivisions concerned are shown below:

① Inlet ② Drainage pipe

- (i) Inlets on bridge deck are arranged as a rule at intervals of certain length along the curbs. They are also provided in the end of the longitudinal curve, in a place with horizontal cross fall near the curving point of the S curve, and on the upstream side of the expansion joint.
- (ii) The bridge drainage pipe receives water from the drainage trough of steel expansion joint and from the gully and includes horizontal and vertical pipes. Also included are the receiving trap at the connection between superstructure and substructure and the expansion joint provided in the middle when the horizontal pipe is directly coupled to two or more gully.

(b) Inspection items

The inspection items are shown in Table 4.7.14.

Table 4.7.14 Inspection Items

Classification	Type	Items
Bridge drainage	Inlet Drainage pipe	① Damage to the facility proper ② Bad connections ③ Accumulation of soil and dust

(6) Drainage facilities in the frontage road and the area adjacent to the road

(a) Scope

This section applies to routine and special inspections to drainage facilities in the frontage road and the area adjacent to the road.

- ① Ditch ② Pipe ③ Inlet ④ Manhole

These facilities are provided to discharge water from the frontage road surface and the adjacent area. Note that the drainage facility under the bridge and viaduct is also covered by this section.

Most of these facilities, excluding the drainage facility under the bridge and viaduct, have been delivered to the administrator for its control. However, they are also to be included in the scope of inspection when vital effect on the traffic of the through line and the road itself is expected due to flash flood or debris flow from the area outside the control area.

Accordingly, it is important to understand the field conditions correctly, to choose hazardous and priority points beforehand, and to report to the respective administrator for countermeasures if any damage is found.

The inspection items are shown in Table 4.7.15.

Table 4.7.15 Inspection Items

Classification	Type	Items
Frontage road and adjacent area drainage	Ditch Pipe Inlet Manhole	① Damage to the facility proper ② Bad connections ③ Accumulation of soil and dust ④ Sectional area reduced by earth

6) Bridges

(1) Outline of the Inspection

By nature of the bridge, delay in detection of the damage may cause increased cost for repair. In this sense, early detection of damage is of extreme importance.

This manual divides bridges into the following types:

① Concrete super-structure ② Concrete sub structure ③ Steel structure ④ Steel plate deck ⑤ Painting ⑥ Bearing ⑦ Railing and curb

(a) General requirements of inspection

If damage is allowed to expand in the bridge, not only presents substantial trouble to the traffic, but also influences greatly the repair cost. Accordingly, periodical inspection for early detection of damage and repair is extremely important to prevent trouble before it actually occurs and to assure smooth traffic.

(b) Classification of bridges

This guideline classifies bridges by material into concrete structures and steel structures, with the former subdivided further into superstructure and a substructure.

From the above structures, the elements of a steel bridge slab, painting, support, and railings and curb are separated according to the damage condition, inspection and repair, and summarized in seven subdivisions.

Fig. 4.7.5 shows the bridge type of concrete structure (superstructure), concrete structure (substructure), steel structure and steel bridge slab. Note that for the rigid-frame bridges (connection box type and portal type), all of top slab, side wall and slab belong to the concrete structure (superstructure). Foot protection, floor protection, and bulkhead belong to the concrete structure (substructure), and the steel-made prevention for bridge fall and inspection passage belong to the steel structure.

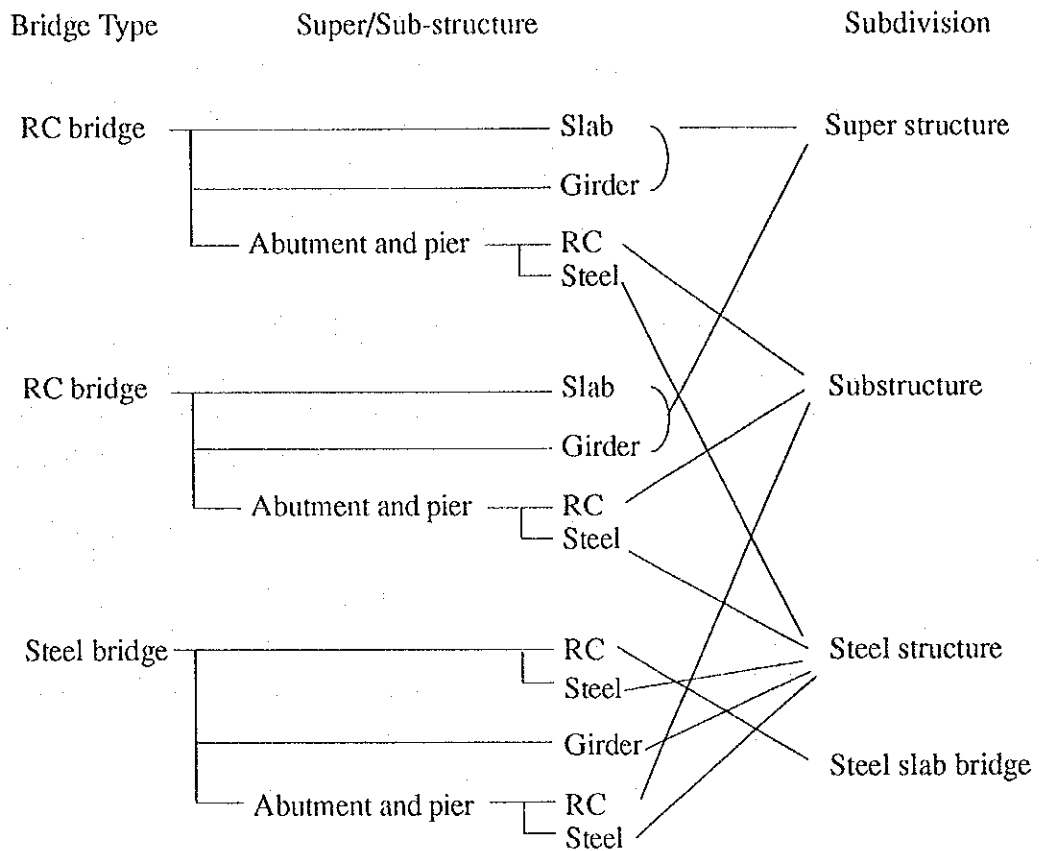


Fig. 4.7.5 Bridge type

(2) Inspection Method

As a rule, inspection is made from the bridge or road surface, from the ground or waterway surface under the bridge, from the inspection passage, abutment and pier. If necessary, a ladder or scaffold may be used to get as near as possible to the object structure.

Ocular inspection is made and binoculars may be used if ocular observation is not sufficient. Convex or measuring tape may be used if necessary to determine the position and direction and to measure the dimensions of the damage. Photos and sketches are taken for recording. For certain structures, damage may be detected by means of unusual sound during passage of a vehicle, feeling or hearing with a test hammer, etc.

Since early detection of damage becomes possible when inspection is made as near as possible to the object structure, the inspection should be made at the same time when a scaffold is assembled for the work and operation.

(a) Concrete structure (superstructure)

Cracks, if any, must be measured with a thickness gauge and the damage point must be provided with a mark and date. Photos or sketches are taken to keep record. The inside of the box girder should be inspected if accessible.

(b) Concrete structure (substructure)

To detect settlement, displacement and inclination, overall judgment in consideration of the condition of other adjacent buildings and the expansion spacing between girder supports is advised in addition to ocular observation of the object structure only. For example, deformation of gutters, cracks or deformation of the masonry and block lining are checked and, if necessary, the degree of inclination is defined by using a leveling cord, plumb, and level, thereby contributing to detection of damage in the whole of the concrete structure (substructure). As regards degradation or scouring, the abutment and pier side should be checked for trace of deformation or damage, with reference made to floor and foot protections in the final drawing. The damages are measured and recorded in a form of sketch.

(c) Steel structure

Abnormal deflection, vibration or sound during passage of large vehicles may help early detection of damage. If dislodgment of high tension (HT) bolts is found, all HT bolts for that bridge are inspected. If this inspection is difficult, it is advisable to conduct sampling inspection for one or more bolts per one connection or 30% or more of all bolts. If checking of bolts for looseness by hammering is difficult, further inspection must be made using a torque wrench.

(d) Steel bridge slab

Inspection is made from a position where the entire slab bottom surface can be observed, mainly if there is any run-off of leaking water and free lime. In particular, a location where free lime has concentrated may suffer vital damage (dislodgment, etc.). Therefore, the crack condition in the deck surface must be checked.

(e) Painting

The deterioration state of painting is checked from a position where the entire members concerned can be observed. Then, the inspector approaches as near as possible to a

portion to check the foulness and rusting condition. If possible, the effectiveness of adhesion of the paint film should be checked by finger touch, and a wire brush should be used to check the influence on the steel material proper for the rusting portion. Photographs for record must be taken for the entire portion and for details. The inside of box girder members is checked also in terms of painting and water storage condition with due care on safety.

(f) Bearing

Apart from ocular observation on the function and condition, it is recommended to perform inspection by means of abnormal sound during passage of vehicles and, if necessary, by feeling and hearing by using a test hammer. In narrow places for which ocular inspection is impossible, a special periscope may be used for observation.

(3) Concrete Structure (super-structure)

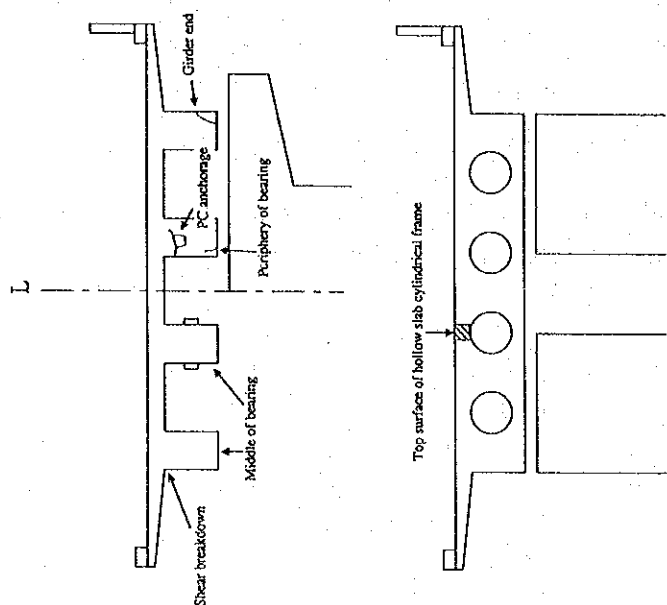
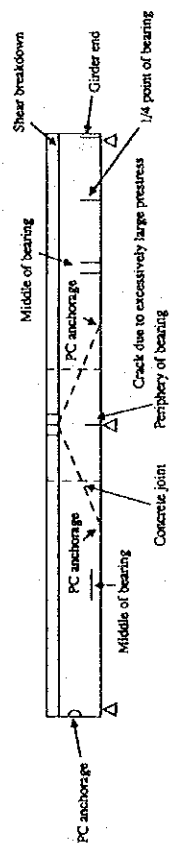
(a) Scope

This section applies to periodical and special inspections to the concrete structure (super-structure). The following parts can be distinguished:

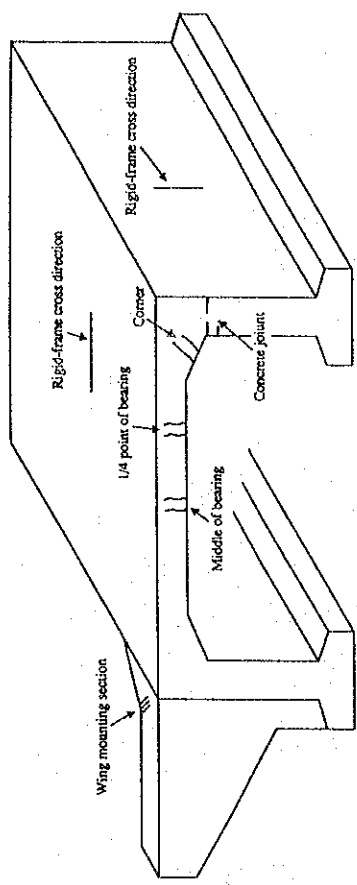
① RC girder ② PC girder ③ RC slab ④ PC slab

The superstructure of a bridge is an important bridge component, which carries the traffic load and transmits the load to the substructure. This section describes the superstructure of concrete bridges while classifying them into reinforced concrete (RC) girders and slabs and prestressed concrete (PC) girders and slabs.

For rigid-frame bridges (continuous box type, portal type), this section applies to the top slab, side wall, and bottom slab.



(1) Girder, slab



(2) Rigid-frame construction

Fig. 4.7.6 Damage Examples for Concrete Structure (Superstructure)

(b) Inspection items

The inspection items are shown in Table 4.7.16.

Table 4.7.16 Inspection items

Classification	Type	Items
Concrete structure (super-structure)	RC girder RC Slab PC girder PC slab	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

(4) Concrete Structure (substructure)

(a) Scope

This section applies to periodical and special inspection for the concrete substructure (substructure). The following parts can be distinguished:

- ① Abutment ② Pier ③ Footing ④ Protection ⑤ Revetment

The substructure carries the load of the superstructure and transmits it via the foundation to the ground. This is the most vital bridge component and it is designed to ensure the most severe load i.e. during earthquakes or floods due to heavy rainfall. In the broad sense of the word, the substructure includes the foundation structures.

(5) Steel Structure

(a) Scope

This section applies to periodical and special inspections for the steel structure. The following parts can be distinguished:

- ① Girder ② Metal slab ③ Pier ④ Steel diaphragm

The steel structure is made principally from steel materials and can be classified into the steel bridge superstructure, steel bridge pier, steel-made prevention work for bridge fall, and inspection passage (and ladder).

Note that this section does not apply to the long bridges (suspension and cable stayed bridges) for which a detailed inspection procedure has been prepared.

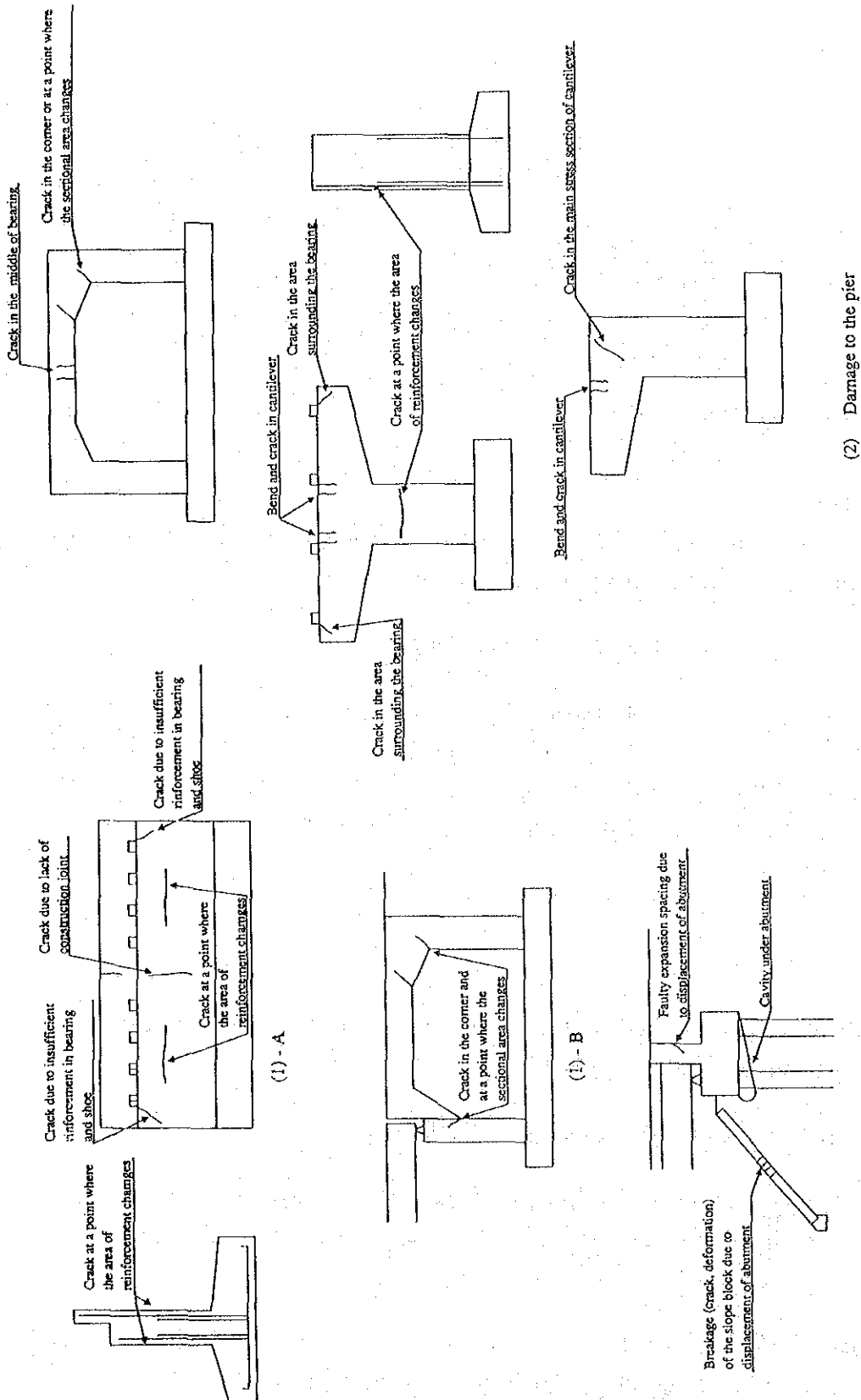


Fig. 4.7.7 Damage Examples for Concrete Structure (Substructure)

(b) Inspection Items

The inspection items are shown in Table 4.7.17.

Table 4.7.17 Inspection Items

Classification	Type	Items
Steel structure	Girder Metal slab Pier Metal diaphragm	① Crack ② Deformation and edge breakage ③ Loose and dislodged bolt ④ Loose and dislodged rivet ⑤ Abnormal sound ⑥ Clearance of bridge

(6) Steel Bridge Slab

(a) Scope

This section applies to periodical and special inspections of steel bridges. Steel bridge slabs are important members to support the wheel load directly and exposed to more severe conditions than other structures. Accordingly, the damage grows rapidly and propagates into damage in the pavement. In extreme cases, the slab may be dislodged and fallen. Early detection of damage through slab inspection, trace monitoring of damage progress and repair before the damage grows too much are essential. In this context, steel bridge slabs are separated in particular from the concrete structure (superstructure).

Steel bridge slabs are reinforced concrete slabs or prestressed concrete slabs. This section may be applied to lightweight concrete slabs, RC slabs with steel frame or RC slabs bonded with steel plate.

(b) Inspection items

The inspection item are shown in Table 4.7.18.

Table 4.7.18 Inspection Items

Classification	Type	Items
Steel bridge slab	-	① Water leakage, free lime ② Cracks, corner failure ③ Scaling, spalling ④ Exposure and corrosion of reinforcement ⑤ Honey lomb ⑥ Segregation of additional girder/plate

(7) Painting

(a) Scope

This section applies to periodical and special inspections of the painting.

The purpose of painting is to enhance the durability and to maintain an acceptable appearance of the steel structures. As the time passes, however, painting deteriorates and suffers degradation, discoloration, cracks, blisters, and peeling with rusting appears on the surface. Delay in detection may allow these defects to grow into corrosion, resulting in accelerated wear of the members. Finally, the bridge as a whole is heavily affected. These guidelines describe specifically the inspection of painting in view of necessity of periodical inspection on the effectiveness of painting and to understand correctly the degree of deterioration and rusting condition of the painting.

(b) Inspection Items

The inspection items are shown in the following.

Table 4.7.18 Inspection Items

Classification	Type	Items
Painting	-	① Crack, swelling, stripping rust ② Water leakage

(8) Bearings

(a) Scope

This section applies to periodical and special inspections of the bearings. Bearings are classified as shown below:

(i) Steel bearings

Bearings are provided to connect the superstructure and substructure, transmit dead and live loads as well various loads caused by earthquakes, wind and changes in temperature to both structures. At the same time, the bearings rotate or move in strict response to elongation/ contraction of the superstructure.

Bearings may be classified into steel and rubber bearings, according to the material used. Steel bearings include upper and lower shoes, accessories (stopper, float stop, set bolt, anchor bolt, nut), shoe concrete around the bearings, shoe mortar, and protection mortar.

Rubber bearing include the rubber main plate, shoe concrete around the bearing and shoe mortar.

(b) Inspection items

The inspection items are shown in Table 4.7.19.

Table 4.7.19 Inspection Items

Classification	Type	Items
Bearing	Metal bearing	① Damage of metal bearing ② Damage of the accessories ③ Corrosion ④ Damage of the bearing concrete, bearing motor and protection motor ⑤ Abnormal sound ⑥ Abnormality in spacing ⑦ Accumulation of soil and dust

(9) Railings and Curbs

(a) Scope

This section applies to periodical and special inspections to the railing and curb.

- ① Steel Railing
- ② Concrete Railing
- ③ Curb

(b) Inspection items

The inspection items are shown in Table 4.7.20.

Table 4.7.20 Inspection Items

Classification	Type	Items
Railings and curb	Steel railing	① Damage ② Corrosion
	Concrete railing	① Crack, corner failure ② Scaling, damage ③ Exposure and corrosion of reinforcement
	Curb	① Crack, corner failure ② Scaling, damage ③ Exposure and corrosion of reinforcement ④ Water leakage

7) Tunnel

(1) Outline of the Inspection

A tunnel is a closed space with narrow width. Compared with inspection of general road sections (open sections), inspection in tunnels requires various measures to ensure traffic safety.

This manual subdivides the tunnel into :

- Lining
- Interior wall
- Portal
- Ceiling slab
- Tunnel drainage facilities



(a) General requirements for inspection

Tunnels are extremely sensitive in particular to geological conditions, and the excavation method, kind and material of support used, and lining method employed at a time construction differ from one place to another. Therefore, storage of the complete set of geological data and work record is essential. Above described data plus a repair record after start of the service are necessary for correct understanding of the tunnel condition.

Inspection and maintenance of various equipment installed in the tunnel are executed separately by a specialized engineer. Inspection in compliance with this manual must also be made with due attention paid to the road environment inside the tunnel to see if an environment appropriate to the traffic volume is maintained.

(b) Parts of the tunnel

A tunnel can be divided into lining, portal, interior board, and tunnel drainage facilities.

The main tunnel structure is the lining, and the interconnection and ventilation ducts in a long tunnel are also included in the objects of inspection. The drainage facilities include also road drainage facilities in tunnel and seepage treatment and drainage facilities.

(2) Inspection Method

As a rule, inspection is made from the inspection passage. If necessary, the traffic regulations must be provided to ensure safety. The inspector approaches as near as possible to the object structure from a lift car or from the lane. Inspection is made ocularly, and if necessary tunnel lighting or search lights are to be used to take record with photos or sketches. Inspection in tunnels is extremely hazardous. For the sake of safety, it is recommended to utilize traffic regulations for the purposes (such as inspection of the tunnel traffic safety facilities, etc.).

(3) Scope

This section applies to periodical and special inspections of tunnels and just effective for civil structure.

(4) Inspection Items

The inspection items are shown in Table 4.7.21.

Table 4.7.21 Inspection Items

Classification	Type	Items
Tunnel	Lining	① Crack, corner failure ② Scaling, spalling ③ Water leakage, free lime ④ Abnormality in joint
	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
	Interior wall	① Damage to the slab proper ② Damage to the accessories
	Ceiling slab	① Damage to the slab proper ② Damage to the accessories
	Drainage	① Damage to the drainage facility ② Accumulation of soil and dust

8) Culverts

(1) Outline of the inspection

Culverts are a facilities which cross the road proper and are used as road as it is, as water channel, or as road and water channel. Inspection must be appropriate for the respective functions.

In this manual culverts are subdivided into the following categories:

- Reinforced concrete culvert
- Reinforced concrete pipe culvert
- Corrugated pipe culvert

(a) General requirements for inspection

Culverts are used mostly as a crossing structure and varies types, shapes and dimensions, and application purposes can be distinguished.

Inspection of the culvert is made to determine structural damage to the culvert proper and deterioration of functions (insufficient clearance, insufficient sectional area,

insufficient drainage, disturbance to water passage). In particular or culverts used as a water channel, inspection must be based on a viewpoint similar to that of the drainage facilities.

(b) Classification of culverts

Culverts can be classified into reinforced concrete culverts, reinforced pipe culverts, and corrugated pipe culverts according to the shape and material.

Reinforcement concrete culverts are applicable to various structural types including reinforced concrete portal rigid frame, reinforced concrete box rigid frame, and prestressed concrete rigid frame.

Reinforced concrete pipe culvert include various types, including reinforced concrete pipe, centrifugal reinforced concrete pipe, rolled reinforced concrete pipe, and prestressed concrete pipe.

(2) Inspection Method

Inspection is made from a point as near as possible to the object structure and a lift car or ladder may be used if necessary.

Inspection is made ocularly, and, if ocular inspection is not sufficient, 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.

(3) Scope

This section applies to routine and special inspection of the culvert.

Culvert are used as road or water channel.

(4) Inspection Items

The inspection items are shown in Table 4.7.22.

Table 4.7.22 Inspection Items

Classification	Type	Items
Culvert	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
	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
	Other type culvert	① Damage of culvert ② Corrosion ③ Settlement ④ Damage of joint ⑤ Accumulation of soil and dust

9) Traffic Safety Devices

(1) Outline of the Inspection

Damage to the traffic safety devices is detrimental to the traffic safety and roadside environment. Inspection must therefore be made efficiently with due care not to overlook vital defects.

This manual divides traffic safety devices into:

- ① Guard Fence
- ② Anti-dazzle Facility

(a) General requirements for inspection

Even the same traffic safety device of the same construction varies in degree of damage depending on the weather conditions and other external conditions at the site as well as the frequency of maintenance. One of purposes of inspection is to minimize the maintenance cost (without being satisfied with restoration of the original state) while ensuring the balance of functions on the basis of check result on the relationship of damage with the durability, age and repair cost of each facility.

In the case of traffic safety devices, damage and deterioration of functions adversely affect the traffic safety and roadside environment. It is essential to read the



specifications and reference documents from time to time to be familiar with the characteristics and functions of each structure.

(2) Inspection Method

As a rule, inspection is made from the shoulder side. If necessary, the inspector approaches from the median side as near as possible to the object structure.

Inspection is made ocularly. If necessary, the convex, test hammer, etc. are used to obtain the damage condition and the photos used to take record.

- (a) Inspection of the traffic safety devices remains inefficient if executed independently and thus should be combined with other inspections on a structure to ensure high efficiency.
- (b) For traffic safety devices in the median, an in-depth inspection should be made while the safety is ensured during traffic regulations for maintenance.

(3) Scope of Application

This chapter applies to periodical and emergency inspections of traffic safety devices. The devices are subdivided into the following items:

- Safety fence
 - ① Guard Rail
 - ② Box Beam
 - ③ Guard Cable
 - ④ Guard Pipe
 - ⑤ Concrete Block
- Anti-glare facilities
 - ① Anti-glare Net
 - ② Anti-glare board
 - ③ Beam Shielding Net

10) Traffic Management Devices

(1) Outline of Inspection

Damage to the traffic control devices does not immediately lead to disturbance of the traffic. Except for falling of the posts affecting the traffic on the through lane, damage to a single device does not cause deterioration of the functions.

The following devices can be distinguished:

- | | |
|-----------------|--------------------|
| ① Traffic Signs | ② Traffic Markings |
| ③ Delineator | ④ Kilometer Post |

(a) General requirements for inspection

Inspection of the traffic control devices must be made with due consideration of dislodgment and overturn of the facilities as well as deterioration of functions.

(2) Inspection Methods

As a rule, inspection is made from the shoulder side. If necessary, the inspector approaches from the median side as near as possible to the object structure.

Inspection is made visually and the photos used to take record.

- (a) Though inspection of individual structures (such as delineators) is necessary, inspection of traffic control devices should be made focusing on the effects of the whole continuous system. In this view, inspection is made from a remote place as well as by approaching the object facility as much as possible.
- (b) To visually check the reflection effect, inspection of the signs, markings, and delineators inspections should be made at night.

(3) Scope of Application

This chapter applies to periodical and emergency inspections of the traffic control devices.

(a) Signs

Signs supply various necessary information in a given form on the road to the road users to ensure safe and smooth traffic while maintaining the road construction. In particular, this kind of facility is required on motorways.

Road markings are defined as one of road appurtenances.

Facilities to supply information on the road include variable message signs and signboards. Markings differ from variable message signs in that they generally handle static information and differ also from the signboard in that they are indicated in a given form .

In this manual, traffic signs and signboards equivalent to traffic signs are generally termed as "Traffic Signs".

Traffic signs are divided into the following four types as defined;

- (i) Equivalent to the guide sign
- (ii) Equivalent to the warning sign
- (iii) Equivalent to the regulatory sign
- (iv) Equivalent to the indication sign

- Guide signs: Guide sign in the urban area, exit guide sign, sign to inform the destination and direction, guide sign for rest area
- Warning signs: All warning signs
- Regulatory signs: Signs to indicate road closure for hazardous vehicles, signs for maximum width, signs to indicate the motorway, signs to inhibit entry of vehicles, signs to indicate one-way traffic, signs to indicate height limitation. There are also signs controlled in compliance with agreement with the public safety commission.
- Indication signs: Regulation advance notice and signs.
- Signs equivalent to the guide sign: Signs to indicate the specified place, toll-rate table, place where snow removal is impossible, place where snow removal is possible, target of snow removal, target of chemicals spray, name of route, guide of direction, entry/exit of access for administration of noise barrier.

- Signs equivalent to the warning sign: Warning (advance notice) to drivers concerning traffic, confirmation of vehicular gap, and warnings on sharp curve, downhill grade, weathers (Rain, Speed Down; Frozen; Lateral Wind), caution on speed, frequent congestion, driving asleep, other warnings (frequent accident, overpass, falling stone)
- Signs equivalent to regulatory sign: Noise prevention, no admittance, regulation inside the tunnel, cigarette throw-away inhibition, throw-away inhibition, regulation of speed, and other regulations.
- Signs equivalent to indication sign: Light ON in tunnel, radio, cautions (Put ON seat belt, Check Parking Brake), emergency measures (Caution: "Emergency telephone or Emergency Pushbutton (red lamp) in case of accident or Trouble), and others ("Long-distance drivers to take rest in the parking area", "Danger, Observe the legal speed")

(b) Traffic markings

Road signs are classified as follows:

(i) Road signs

- Roadway center line
- Roadway boundary line
- Roadway edge marking
- Pavement shoulder marking
- Sign to indicate change of the number of lanes
- Channelization
- Nose marking
- Arrow marking
- Toll plaza marking
- Marking to indicate diverging and merging sections among ramps
- Other markings

(ii) Vertical marking

Vertical marking is provided on the road to cause the running vehicles to change direction, on a structure which is outside the road, but causes reduction of lateral clearance for the running vehicles (that is, practical reduction of the carriageway width), or on a structure whose height cannot remain within the clearance.

Specifically, the objects to be marked are as described below:

- Safety fence provided to the abutment, pier, or girder of a viaduct or in their front
- Safety fence provided to the traffic island, safety island, or in their front
- Newel post or railings of a bridge reducing the width
- Curb at a point where the carriageway width becomes narrow or concrete wall at curve

(c) Delineators

A delineator is a facility which is provided along the carriageway to define the road edge and line, thereby induces the sight line of drivers in the daytime and nighttime. The sight line induction effect is particularly high in the case of low visibility due in the nighttime, due to rainfall and snow fall, and during fog.

(d) Kilometer posts

Kilometer posts are provided to indicate the "address" of certain points to enable effective and rapid maintenance.

(4) Inspection Items

The inspection items are shown in Table 4.7.23.

Table 4.7.23 Inspection Items

Classification	Type	Items
Traffic management facility	Traffic signs	① Damage to the sign proper ② Damage to the accessories ③ Corrosion, ④ Damage to the foundation
	Traffic markings	① Damage of traffic paint
	Delineator	① Damage to delineator proper
	Kilometer post	① Damage to the marker proper

The main body referred to herein is a general term including the main body members (sign plate, reflector, kilometer marker) and supports to carry these members. Accessories include brackets and bolts to connect the main body members with the posts.

The foundation is a general term including post mounting anchor bolts, build-in parts, and foundation concrete. For the sign plates, the applicable damages are to include illegible sign characters in addition to damage and deformation of the main body members.

11) Other Facilities

(1) Outline of the Inspection

Other facilities are installed to enhance the safety and to preserve the roadside environment. During inspection, due attention should be paid not only on excessive damage, but also on deterioration of functions. This guidebook subdivides the facilities as follows for description:

- Snow protection facilities
- Meteorological observation equipment

(a) General requirements for inspection

Description of "Traffic Safety Facilities" applies.

(b) Classification of other facilities

For description on subdivision of other facilities, refer to (3) Scope.

(2) Inspection Methods

Inspection is made from a point as near as possible to the object structure. A lift car or ladder may be used if necessary.

Inspection is made visually and, if visual inspection is not sufficient binoculars are used and photos taken for recording.

Concerning inspection on the noise barrier and snow protection facilities, overall viewing of the object structure need to be made from a remote visible point.

(3) Scope

This section applies to the periodical and special inspections to the other facilities, including:

- ① Snow Protection Facilities
- ② Meteorological Devices

Table 4.7.24 Inspection Items

Classification	Subdivision	Type	Items
Other Facility	Snow protection facilities	Snow fence	① Damage to the fence proper ② Damage to the accessories ③ Corrosion ④ Damage to the foundation
		Avalanche protecting	① Damage to the fence proper ② Damage to the accessories ③ Corrosion ④ Damage to the foundation
	Meteorological device		① Damage to the device ② Out of order

Table 4.7.25 Ratings for Asphalt Pavement

The numerical values give rough standards

Item	Rating	AA	A	B
1. Obstacle on road (dropped article, fallen stone, collapsed soil), leaked oil, dirt		Hindrance to traffic, obstacles to traffic		
2. Pothole, pitting, scaling		Hindrance to traffic	Over 20 mm in depth and over 20 cm in diameter	10 mm to 20 mm in depth
3. Faulting		Hindrance to traffic	Over 20 mm	10 mm to 20 mm
4. Rutting			Ordinary section: over 25 mm Climbing lane: over 40 mm	Ordinary 15 mm to 25 mm Climbing lane: 20 mm to 40 mm
5. Cracking			Longitudinal cracking or transverse cracking with 5 mm or more in width Alligator cracking losing the bearing capacity in case of rain	Longitudinal cracking or transverse cracking with less than 5 mm width Alligator cracking
6. Skid Resistance			less than 0.25	less than 0.30
7. Longitudinal surface roughness, corrugation			Uncomfortable driving Corrugation: over 30 mm	Vertical displacement Corrugation 10 mm to 30 mm
8. Stripping of carpet-coat (thin surfacing)			Stripping	
9. Stagnant water			Partial stagnant water observed whenever raining	

Notes:

- The above ratings are clarified as follows.

Rating	
AA	Emergency repairs is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardized.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.

- The numerical values shown in the above are reference only and the same values with the Japan Highway Public Corporation.



Table 4.7.26 Ratings for Cut / Fill Slopes

The numerical values are rough standards

Item	Rating	AA	A	B
1. Fall (rock & Debris)		Hindrance to traffic or a third party	Less possibility of growing	Very minor falls
2. Crack, swelling, depression		Hindrance to traffic or a third party	Cracks, swelling or depression perceived from a long distance Less possibility of growing	Small cracks, swelling or depression Less possibility of growing
3. Spalling gully erosion			Wide range spalling or gully erosion Possibility of growing	Partial spalling or gully erosion Less possibility of growing
4. Seepage water		Seepage water with mud or drastic change of seepage water volume, Hindrance to traffic of third party	Drastic change of seepage water volume Less possibility of collapse	Seepage water No possibility of collapse
5. Fallen tree, unusual growth of weeds		Hindrance to traffic or a third party	Fallen or inclined trees, or unusual growth of weeds	
6. Withering damage			Covering rate of vegetation: less than 30 %	Covering rate of vegetation: 30 % - 70 %
7. Accumulation of dirt			A lot of waste on the slope	
8. Flaking stones, boulders		Hindrance to traffic or a third party	Unstable flaking stones or boulders on slope	

Notes:

- The above ratings are clarified as follows.

Rating	
AA	Emergency repairs is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardized.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.

- The numerical values shown in the above are reference only and the same values with the Japan Highway Public Corporation.



Table 4.7.27 Ratings for Concrete Superstructures

The numerical values are rough standards

Item	Rating	AA	A	B
1. Cracks, corner failures		Substantial cracks resulting in falls	Spalling: 50 cm or more in diameter	Spalling: less than 50 cm in diameter
		Hindrance to traffic or a third party		
2. Scaling, spalling		Possibility of growing	Spalling: 50 cm or more in diameter	Spalling: less than 50 cm in diameter
		Hindrance to traffic or a third party		
3. Exposure and rust of reinforcing bars			Main steel bars: exposed 50 cm or more in length rusted PC steel or sheath: extensive exposure, more than 50 cm in length	Main steel bars: partially exposed or rusted PC steel or sheath: partially exposed
4. Air void, honeycomb			Substantial air voids or honeycombs observed	Air voids or honeycombs: smaller scale damage observed
5. Deflection, unusual vibration			Unusual water stagnation on bridge deck, recurring Excessive deflection observed Unusual vibrations on bridge deck	
6. Water leakage, free lime		Hindrance to a third party	Two directional free lime leaks observed. Space less than 50 cm apart.	One directional free lime leak observed
7. Inadequate clearance under deck			Clearance under bridge deck: insufficient	

Notes:

1. The above ratings are clarified as follows.

Rating	
AA	Emergency repairs is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardized.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.

2. The numerical values shown in the above are reference only and the same values with the Japan Highway Public Corporation.



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Table 4.7.28 Ratings of Abutments and Piers

The numerical values are rough standards

Item	Rating	AA	A	B
1. Crack, corner failure		Substantial cracks resulting in falls Hindrance to a third party	Cracks: more than 0.3 mm in width Corner failures, minimum crack space: 50 cm or more	Cracks: more than 0.3 mm in width Minimum crack space: 50 cm to 1 m
2. Spalling		Hindrance to a third party	50 cm or more in diameter	Less than 50 cm in diameter
3. Exposure and main steel bar			50 cm or more in length	Partially exposed or rusted
4. Air void, honeycomb			Large air voids or honeycombs observed in main structure part	Large air void or honeycombs observed
5. Water leakage, free lime		Hindrance to a third party	Steel components: rusted	Leakage of water or free lime: partially observed steel components: rusted
6. Settlement, movement, tilting			Settlement: more than 25 mm in depth The superstructure shoes or the surrounding structures affected Possibility of adding larger stress to the girder due to changes of temperature	15 mm to 25 mm Possibility of affecting the superstructure shoes or the surrounding structures
7. Scour, lowering of stream bed			Exposed up to under the designated line Surroundings of abutment wing: remarkably scoured	Upper part of footing or caisson: exposed due to scour or lowering of stream bed Surroundings of abutment wing: scoured

Notes:

1. The above ratings are clarified as follows.

Rating	
AA	Emergency repairs is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardized.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.

2. The numerical values shown in the above are reference only and the same values with the Japan Highway Public Corporation.



Annual General Report

Form - JS-1
 Year

Legend (Mark the figure of file numbers)

- No mark : Routine inspection
- : Periodical inspection
- : Special inspection

File No.	Name of MMC		Name of MO		Name of road		Section			Functional Category		
	Classification Category	Road Structures	Location	KP	Outline of damage		Inspection items	Judgment	Counter-measure policy	Repair condition		Remarks
									Content	Date of completion		



Monthly Report of Routine Inspections

Form - IS-2
 Year

Legend (Mark the figure of file numbers)
 No mark : Daily inspection
 : Special inspection

Name of MMC	Section	Bound for route	Name of MO	Name of road			Inspection items	Judgment			Counter-measure	Time and method	Date of completion	Remarks
				Functional Category	Classification Category	Road Structures		AA	A	B				



Routine Inspection Report (1)

Form - IS-3

Name of MMC		Legend File number provided in the order of detection KP (/ - -) Function Classification Item of damage Structures Judgment Countermeasure Date (Year/month/day) of inspection Weather		Chief of office	Person in charge
Name of MO				Engineer in charge of technology	Inspector
Name of road				Confirmation Stamp	
Countermeasure policy	(1) First-aid measure (2) Emergency repair (3) Special inspection (4) Investigation (5) Monitoring (6) Repair	Priority inspection object structure 1. Road surface 2. Drainage facilities 3. Tunnel 4. Traffic control devices 5. Other facilities 6. Planning 7. Face of slope 8. Bridge 9. Traffic safety devices 10. Overbridge			

No.	Name of case	Location	Remarks



Routine Inspection Report (2)

Form - IS-4

Year	File number	1. First-aid measure 2. Emergency repair 3. Special inspection 4. Investigation 5. Observation 6. Repair	Section	Bounds	Location				
		Countermeasure policy	I.C ~ I.C			Classification Category	Road Structures	Inspection Items	
								Judgment	
								Countermeasure Policy	
Location Map			Sketch and Photo of Condition						
Cross Section or Vertical View			Outline of Condition						



Periodical and Special Inspection Report

Form - IS-5

Legend (Marked to the figure of file numbers)

- : Periodical A
- △ : Periodical B
- : Special inspection

Name of bureau	
Name of office	
Name of road	

Year		File number		Section	Bounds	Location	Inspector		
		1. First-aid measure 2. Emergency repair 3. Special inspection 4. Investigation 5. Observation 6. Repair		I.C ~ I.C	Road Structures	Inspection	Items	Judgment	
		Countermeasure Policy		Classification Category	Functional Category	Sketch and Photo of Condition		Countermeasure Policy	
Location Map				Cross Section or Vertical View					Outline of Condition



Form - IS - 6

Name of MMC
Name of MO
Name of Road

Annual Inspection Plan (Year)

Inspection Items	Functional Category	Classification Category	1st-Quarter				2nd-Quarter				3rd-Quarter				4th-Quarter			Next Year	Remarks	
			April	May	June	July	August	September	October	November	December	January	February	March	April					
Routine Inspection																				
Periodic Inspection A	Road Surface	Expansion Joints																		
		Vegetation																		
		Special Slope																		
		Masonry																		
Drainage		Concrete Retaining Wall																		
		Road Surface Drainage																		
		Slope Drainage																		
		Bridge Drainage																		
Periodic Inspection B		Frourge Road and Adjacent Area Drainage																		
		Concrete Super-structure																		
		Concrete Sub-structure																		
		Steel structure																		
		Steel slab bridge																		
		Painting																		
		Bearing																		
		Railing & Curb																		
	Tunnel																			
	Culvert																			
Traffic Safety Facilities		Guard Fence																		
		Anti-dazzle Facility																		
		Median																		
Traffic Management Facilities		Median																		
		Traffic Signs																		
Other Facilities		Noise Barrier																		
		Snow Protection Facilities																		
Special Inspection																				



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4.8 Motorway Maintenance Manual for Road Cleaning

4.8.1 General

This section describes the essential maintenance of road cleaning.

There are four groups of activities.

- Road Surface Cleaning: The traveled way and hard shoulder
- Incidental Facility Cleaning: The insides of interchanges, parking lots; rest areas; etc.
- Auxiliary Roadside Facility Cleaning: Toilets
- Roadside Facility Cleaning: Fences; drains; gutters; tunnels; signs; luminaires; etc.

4.8.2 Traffic Safety

Road cleaning operations requires road maintenance staff and vehicles to occupy road space.

This puts the other road users and maintenance staff and vehicles at risk to accident. Special precautions have to be taken.

Traffic regulations are to be put into effect on the basis of "On-road Working". Planning must ensure safe and efficient operation.

Traffic regulation is applied in order to secure the safety of the road users and workers and to improve the work efficiency and must be appropriate to the kind of cleaning operation to be made.

Planning of traffic regulation must ensure safe and positive operations by paying due attention to following matters:

- 1) Safety measures must be taken by arranging guards (traffic controller, field watcher), traffic signs, sign car, etc.
- 2) The plan must enable application of the adequate traffic regulation within the minimum required work days, with due consideration made on the operation period and frequency. The plan includes, for example, an attempt of multiple operations running in parallel within the same regulation area, consideration of the road utilization condition (traffic volume by month, day of the week, time, and direction), etc.

- 3) As a rule, operations must take place in daytime to ensure safety. In any case, the work plan must be established with sufficient allowance for the safety measures, for example, by scheduling night working when the cleaning operation may seriously affect traffic flows.

4.8.3 Road Surface Cleaning

1) Objective

The objective of road surface cleaning is to remove dust debris from the road surface & road verges. Any obstruction may cause a motorist to swerve into the path of a following vehicle or cause damage from a collision of the vehicle with the debris.

Small stones and grit can be thrown up by the wheels of a vehicle and can shatter windscreens or cause other impact damage.

Dirt retains salts moisture, sulphur and other harmful compounds and can cause corrosion to vehicles and concrete.

The purpose of removing dust from the road surface and various facilities is therefore to ensure safe and smooth traffic for the road users by maintaining the road functions, keeping the road and roadside environment satisfactory, and preventing obstructions to traffic flows, and traffic accidents attributable to dust and dirt.

2) Cleaning Plan

The method and efficiency of cleaning depends on the condition of the road and roadside. Efficient and safe cleaning operations requires thorough understanding of these conditions and investigation concerning the cleaning distance and frequency. Since the operational method, machines, and efficiency differs on the condition of road and roadside as well as the location, these conditions must first be known fully before establishing the plan. In-depth investigation must also be made on the work base, machine capacity, dirt dump site, and transportation distance.

In particular, attention must be paid on the following points to ensure that safe and efficient work is carried out.

(1) Understanding of Local Conditions

Condition of the road surface and facilities changes hourly, and inspection by patrols must be made periodically to appreciate the conditions. Inspection by patrols is particularly essential for the roadside drain facilities.

Dirt and debris accumulation in gutters and adjacent to open ditches is to be checked in detail before a flooding season (rainy season, typhoon, thaw) comes in order to prevent submergence of the road surface or disaster on the slope during and after rainfall.

(2) Operation Time and Method

Dirt & debris on the road surface and facilities varies depending on the traffic volume, proportion of large vehicles, geometric construction of the road, topographic conditions, meteorological conditions, and roadside condition. A thorough understanding of these conditions is essential.

- (a) When there are buildings in the neighborhood of the roadside, the operation method must be determined with due attention paid to prevent scattering of dust and dirt.
- (b) It should be noted that high wind may not only scatter dust and dirt, but also cause deterioration of the operation efficiency of the motorway.
- (c) In autumn, fallen leaves may cause blocking of the drainage facilities as well as skidding by vehicles.
- (d) In winter, it should be noted that water sprinkling may result in a frozen road surface.
- (e) In a snowy and cold district, large quantities of salt contaminated dust and dirt may be generated on the road in the thaw season.
- (f) For the road used principally for sight-seeing, the cleaning operations must be planned so that it concentrates during the sight-seeing season.

3) Type and Frequency of Cleaning

These types of road cleaning methods are employed:

- (a) Mechanical cleaning
- (b) Manual cleaning
- (c) Mechanical and manual combined cleaning
 - (i) Road Surface Cleaning Type A is cleaning by a brush type cleaning vehicle or a suction type cleaning vehicle. The areas of cleaning are as follows:
 - a. Right-side shoulders of main lanes and ramps
 - b. Main lanes and ramps where the operation of a sprinkler type vehicle is difficult
 - c. Other areas where the Manager recognizes that cleaning by sweepers is necessary
 - (ii) Road Surface Cleaning Type B is cleaning by sprinkler-type vehicles.

The areas of cleaning are as follows:

- a. Left-side shoulder of main lanes and ramps
 - b. Other areas where the Manager recognizes that cleaning by sprinkler-type cleaning vehicles is necessary
- (iii) Road Surface Cleaning Type C is auxiliary cleaning done manually.

The main activity is to collect loads dropped from trucks and debris on road surface.

- (iv) Road Surface Cleaning Type D is manual cleaning of motorways where Road Surface Cleaning Types A and B are not conducted.

This work is the removal of dust, debris, objects fallen from trucks, and other objects which may be hazardous to traffic.

In types C and D the collected waste is transported away in trucks. As a rule, cleaning of the road surface is to be mechanical in view of safety and efficiency. Manual cleaning by type C is made as a complement to mechanical cleaning. The cleaning of road surface D, on the other hand, is made for the road where mechanical cleaning is not made.

The frequency of cleaning operations must be determined on the basis of the condition of road and roadside, and quantity and content of dust. The practical cleaning plan must be appropriate to the actual state with due consideration on the patrol inspection result and traffic volume, proportion of large vehicles, characteristics of the road (industrial road, sight-seeing road, dust quantity), and local conditions.

4) Cleaning Operations

This operation is made to remove accumulated sand and scattered fallen materials on the road surface either manually or by a road sweeper, thereby eliminating obstacles to the traffic and ensuring safe and smooth traffic of the road users.

(1) Cleaning of Road Surface Type A:

This operation consists of removal of dirt and small debris from the road surface by the road sweeper. The type of sweeper should be an appropriate type and be selected according to the road condition.

Following points require particular attention during operations:

- (a) As a rule, the cleaning operation is made with a road sweeper only. If particularly necessary in the course of operations, safety at the rear must be secured by using a sign car.
- (b) Since cleaning with the sweeper raises dust which is a hazard during sweeping by brush, dust proofing measures must be taken depending on the condition of the road and roadside. Dust proofing is made in principle by a sprinkler equipment of the sweeper. If this sprinkling equipment is not enough because of the extremely large quantity of dust, a separate road sprinkler should be used to sprinkle water before start of cleaning.

- (c) As a rule, the brush application conditions (contact width, locus, contact angle, contact pressure) must comply with the specifications of the machine used.

The brush type vehicle should be a high speed sweeper where the distance to the road surface must be 10 mm or less; the entire surface of the brush must be kept in light contact with the road surface during operation; and the deflector and dirt shoe must be kept parallel to the road surface.

(2) Cleaning of Road Surface Type B:

This operation removes dust on the road surface by using a road sprinkler. During operations, the water pressure from the front left or right sprinkler nozzle of the road sprinkler pushes dust to the outside of the road surface. The standard sprinkling rate is 0.6 ton/km. As a rule, the operation is made with the road sprinkler only. If the condition of the road and roadside does not allow the use of the road sprinkler (bridge, viaduct, section with noise barrier) type A cleaning is applied.

(3) Cleaning of Road Surface Type C:

This operation is made mainly to remove manually any obstacles to the traffic of vehicles, such as fallen cargoes and castaways scattered over the road surface. During removal of these materials, a vehicle (truck, etc.) runs along on the shoulder and collected materials are loaded on the truck for transport to dump later.

Following points require particular attention during this type of operation:

- (a) Workers must be instructed to park the vehicle in a place not obstructive to the traffic of the road users (emergency parking bay).
(b) If necessary, a sign car needs to be used to ensure safety at the back.

(4) Cleaning of Road Surface Type D:

This operation is made to remove manually any obstacles to the traffic within an area about 1.5 m into the roadway from the edge, such as sand, dust, and fallen cargoes and scattered materials over the road surface. During removal of these materials, a vehicle (truck, etc.) runs along on the shoulder and materials thus picked up are loaded on the truck for transport to dump later.

During operations, due attention must be paid to other road users.



4.8.4 Incidental Facility Cleaning

1) Objective

The objective is to clean road surfaces which do not form part of the main traffic roads such as rest areas car parks. This work also includes cleaning of litter from landscaped areas, picnic areas, rest areas etc.

2) Cleaning Plan

The cleaning of these Incidental Facilities is essentially good housekeeping and to prevent the spread of disease due to putrefying food, insects, rodents and wild life.

This work is off-road and therefore requires a lower degree of protection, and can be carried out on a routine basis. Where there is a concession area such as a service area or a restaurant area the cleaning of road surface and the grounds of the facility can be incorporated into the concession agreement.

However where the facilities are operated by the motorway authority the recommendations of this section should be followed.

The cleaning plan must also include consideration of providing additional rubbish receptacles, relocation of receptacles, signing publicity campaigns to ensure that road users use rubbish receptacles correctly and keep them in good conditions.

3) Type and Frequency of Cleaning

There are three types of activity involved:

- 1) Road cleaning
- 2) Collection of litter from landscaped areas
- 3) Emptying of rubbish receptables

Road Cleaning is a combined mechanical and manual operation where the mechanical sweeper cleans the larger open road areas and manual sweeping carried out around parked vehicles.

The collection and emptying of rubbish and litter is manual.

Litter and receptacle emptying in public areas must be carried out on a daily basis.

Litter cleaning in interchange landscaping is twice monthly activity.



4) Cleaning Operations

The operation to remove empty cans and paper scraps scattered in the parking lot and road surface of service and parking areas and in the garden of these areas and interchange. The operation also includes manual cleaning of the wastebaskets and handling of wastes. The purpose is to ensure safe and smooth traffic of the road users and to maintain a satisfactory environment. During operations, the crossing of a parking lot and access ramp should be kept minimum. Where crossing a road is inevitable, due attention must be paid to passing vehicles. It is also essential not to affect the users of the service or parking area.

4.8.5 Auxiliary Roadside Facility Cleaning

1) Objective

This cleaning operation refers only to toilets and water fountains where these are provided.

2) Cleaning Plan

Effective cleaning can only be achieved by ensuring that maintenance personnel have the correct and proper equipment.

This must include clean overalls, rubber boots and rubber gloves to ensure a high standard of visible cleanliness.

The plan must ensure that proper brushes, cloths, mops and scrapers are continuously available to the cleaning staff.

Adequate stocks of detergents and antiseptic cleaning fluids. It is an essential feature that flies and other insects are deliberately kept away from toilet areas and any nests in the building destroyed.

3) Type and Frequency

Manual cleaning is necessary on a daily basis.

4) Cleaning Operations

Public lavatories in the service and parking areas and at bus stops are used by lots of people and, once fouled, become insanitary and unfavorable in appearance. This cleaning operation is made to maintain the satisfactory environment for the road users and the road side area generally by cleaning glass windows, floor, cubicles, water closet bowls, lavatory basins,



taps, mirrors, regular cleaning of ceilings, walls and doors. An essential feature is to record the condition of doors and locks to the cubicles for early repair.

The following points require particular attention during cleaning operations:

- (1) Understanding of the use condition of the public lavatory, so that cleaning is made during a time span when there are less users.
- (2) Guidance must be provided by means of a standing signboards during operation, and due care must be taken not to trouble the users by water or detergent splash.

4.8.6 Roadside Facility Cleaning

1) Objective

The roadside facilities include safety devices signs, drainage facilities, bridge joints and drains luminaires.

The list as described is

Cleaning of fences; surfaces of guard rails (painted type only) and posts of hand rails; surfaces of guide signs; regulatory signs, delineators.

Buried drainage pipe; drainage ditch buried in median strip; circular channel; rolled gutter.

Drainage ditch in the shoulder; vertical drainage; ditch in the slope; drainage ditch in the toe and in benching.

Inlet in the median strip; cleaning of gulley.

Drainage systems and pipe in comb expansion joints of bridges; drainage pipe of bridges.

Cleaning of tunnel; side wall of tunnel.

Cleaning of luminaires.

2) Cleaning Plan

The nature of the work permits several types of work to be carried out at the same time.

The work plan must be built around observed events causing a reduction in the effectiveness of the facility.

After heavy storms accumulated silt, leaves and other materials must be removed from drains so that the facility will be effective in the next station.

After a thaw the accumulated dirt, which will contain corrosive salts must be flushed off the bridge deck and out of method drainage facilities.

After dust storms accumulated sand and dust must be removed.

3) Type and Frequency

The type of cleaning carried out is predominately manual, however these are mechanical appliances available for tunnels, and overhead signs.

Frequency is traffic volume or weather related. For low height posts guard rails, etc. within splash height of passing vehicles cleaning may be weather related but above splash height would be traffic volume related.

Traffic volume is broadly if the vehicular daily count is less than 10,000 vehicles per day cleaning once a year is indicated. 50,000 vehicles or more per day indicates once a month. Inter veining pro-rata vehicle counts would indicate twice yearly or bi-monthly.

Generally once a year for all other facilities is the absolute minimum.

4) Cleaning Operations

(1) Cleaning of fences, barriers, rails, etc.

This operation is to remove, either manually or by using a tunnel washer, the dust adhering to guardrails or handrails, thereby maintaining an acceptable appearance and reflectability.

During operations, due care must be taken not to damage the accessories (fence, delineator, etc.)



(2) Cleaning of Signs

This operation is made to remove manually dust adhering to the surface of guide signs, warning signs, regulatory signs, and delineators, thereby enhancing visibility to ensure safe and smooth traffic flows.

The following points require particular attention during operations:

- (a) A "cherry picker" or other appropriate vehicles may be used when the operation on the elevated place is necessary (cleaning of the overhead guide sign, etc.). The safety measure must be taken with due care.
- (b) During operations, due care must also be taken not to trouble road users by splashing of water or washing water.

(3) Cleaning of the drainage pipe

This operation is to remove, by using a jet cleaner or road sprinkler, the sand and dust accumulated in a buried drainage pipe, drainage ditch in median strip, circular channel, and rolled gutter. The purpose is to maintain the drainage function and to eliminate obstacles to traffic by water pending or streaming across the carriageways. During operations, the water pressure from the nozzle via the high pressure hose of the jet cleaner expels sand and dust in the pipe to the gully for collection. After that, the pipe is flushed with water.

If the sand is solidified so hard as to make the operation with water pressure ineffective, the following methods may be employed:

- Scraping out the sand manually and flushing with water for the large size pipes
- Passing of a screw auger through the pipe and flushing with water for the small size pipes

(4) Cleaning of drainage ditches

This operation is to remove, either manually or by using a road surface and gutter sweeper, the sand and dust that has accumulated in a shoulder ditch, ditch in the median strip, discharge ditch on slope surface, and ditches in benching. The purpose is to maintain the drainage function to eliminate obstructions to the traffic or road disaster attributable to water ponding or flooding over the carriageway or erosion of the slope.



During operations, plants and trees which cover the ditch must also be mowed down because they damage the drainage function, possibly causing future problems. Plants and trees thus mowed down must be stored in such a manner that they do not enter the drainage ditch again, or removed.

(5) Cleaning of the inlet in the median strip

This operation is to remove manually the sand and dust accumulated in the inlets in the median strip, thereby maintaining the drainage function to eliminate obstructions to the traffic due to water ponding or flooding over the carriageway.

During operations, appropriate safety measures must be taken. After completion of cleaning, it is necessary to clean the area around the inlet with care.

(6) Cleaning of the gully

This operation is made to remove, either manually or by using the road surface and gutter sweeper, the sand and dust accumulated in the gully, thereby maintaining the drainage function to eliminate obstructions to the traffic due to water pending or flooding over the carriageways. The following points require particular attention during these operations:

- (a) The work range of the road surface and gutter sweeper is narrow. The sweeper should therefore be stopped with the suction port directly above the gully. This is to limit the hose operation to putting the hose into or out of the gully. If the sand is solidified hard, a shovel or other means is to be used to loosen the sand to facilitate the suction of the sweeper.
- (b) When the removed sand is to be placed temporarily on the road, care must be taken to prevent a scattering of the sand in the surrounding area.

(7) Cleaning of joints

This operation is to remove, either manually or by using a jet cleaner, sand and grit accumulated in a drainage system or pipe of the steel comb expansion joints on a bridge. The purpose is to maintain the drainage function to prevent water collecting on the bridge surface, water falling from the trough, or corrosion or damage to the joint. During operations, sand and grit are pushed out under water pressure applied by the jet cleaner from the high side to the low, then the pipe is flushed with water. In this case, a sheet, etc. needs be used if necessary to prevent spillage of water or sand onto the road or onto property near the bridge.



(8) Cleaning of bridge gulley

This operation is to remove, either manually or by using the jet cleaner, sand and dust accumulated in the gulley and drainage pipe of the bridge. The purpose is to maintain the drainage function and to eliminate obstacles to traffic due to water collection on the bridge surface. As this operation is made on the bridge, utmost care must be taken to prevent a gulley cover, etc. placed temporarily to one side from falling and inflicting damage or injury to vehicles or pedestrians.

(9) Cleaning of tunnel

This operation is to remove, either manually or by using a tunnel side wall washer, the dirt adhering to the tunnel side wall. The purpose is to prevent degradation of sight lines and a decrease in the illuminance.

The operation method includes both manual and mechanical cleaning. Mechanical cleaning is subdivided into a dry type and wet type.

The following points require particular attention during operations:

- (a) Wet type mechanical cleaning produces dirty water from the washing process. Such dirty water must be treated with due consideration of the environmental conditions around the tunnel.
- (b) Dry type mechanical cleaning produces large quantity of dust, deteriorating visibility in the tunnel. Accordingly, appropriate measures must be taken, such as guidance for passing vehicles. A different method may be used if this dry type operation cannot be made because of the roadside condition around a tunnel portal or when oily/greasy impurities are adhering in large quantities.
- (c) Since cleaning becomes more effective with reduced speed, the speed is adjusted according to the degree of dirt accumulation on the side wall whilst taking the capacity of the machine into account.
- (d) To achieve a homogeneous cleaning effect, the distance between the side wall and vehicle must be kept constant. It is also essential to improve cleaning performance to keep the contact pressure as high as possible.
- (e) There are CCTVs, speakers, and other facilities in the tunnel. These facilities must be protected carefully from damage.

- (f) Operations in a tunnel are hazardous, and any accident, once occurring, may grow into a disaster. Safety measures must be taken with utmost care.

(10) Cleaning of luminaires

This operation is to remove, either manually or by using a tunnel washer, the dust adhering to a luminaire. Such luminaires include those for road lighting and tunnel lighting, which are installed along the main lane and ramp and in service and parking areas as well as the luminaires used in internal external illumination sign plates installed along the main lane and interchanges. All require cleaning operations from an elevated platform. Due attention must therefore be paid to operations and safety.

Detergent will cause either insulation failure or corrosion and should be handled with care so as not to adhere to the electrified parts (lamp socket, cable terminal board).

4.8.7 Operational Procedures

As described, most cleaning operations require traffic regulation and are hazardous because the operation is made at low speed and is often in lane conflict with other road users. Besides, the cleaning operation is frequently repeated. In this context, confirmation of the safety, vehicle checkup, and health administration, which are to be made before daily work, require utmost care.

- 1) Confirmation of safety (machine and workers)
 - (1) Daily checkup of the machine
 - (2) Check of attire of workers (helmet, jacket, whistle)
 - (3) Familiarity with the content of the work
- 2) Operations
 - (1) Reconfirmation of the safety arrangements
 - (2) Quick action
- 3) Handling of dust and debris
 - (1) Prevention of dust from being scattered
- 4) Servicing
 - (1) Checkup of the machine at end each day's work
 - (2) Check for any worn parts.



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4.9 Motorway Maintenance Manual for Vegetation Control

4.9.1 General

This section is for the maintenance of trees, shrubs, ground cover, vegetation slopes and other landscaping on motorway rights of way. Plant growth differs according to climate, soil, and other environmental factors. When vegetation control is applied, it shall be implemented efficiently and effectively.

4.9.2 Purposes of Vegetation on the Motorway

The functions of vegetation are listed on Table 4.9.1.

Table 4.9.1 Functions of Vegetation

(1)	Traffic Safety Function	Directional Aspects	a. Directing eyesight			
			b. Helps indicate changes in road direction			
		Accident Reduction Aspects	a. Adaptation to darkness and brightness			
			b. Glare reduction			
			c. Visual Barrier			
			d. Visual buffer			
		Rest Area Aspects	a. Shading			
			b. Peaceful rest areas			
		(2)	Scenery Function	Scenery Adjustment Aspect	a. Controlling vistas	
b. Scenery transitions						
Scenery Aspect	a. Creating new scenery					
	b. Strengthening existing scenery					
	(3)			Environmental Preservation Function	Hazard Prevention Aspect	a. Hazard prevention
						b. Slope protection
Environmental Integration Aspect		a. Visual integration into natural environment				
	b. Vegetation transition into living environment					

4.9.3 Inspection of Vegetation Sites

1) Purpose of Vegetation Site Inspection

The purposes of vegetation site inspections are as follows:

- (1) To collect information for efficient and effective maintenance.
- (2) To find damages by insects and others in the early stages, and take appropriate action.
- (3) To conduct temporary repairs to avoid further deterioration of vegetation areas.
- (4) To evaluate impacts of vegetation on users and the areas close the motorways.

2) Classification of Vegetation Site Inspections

Inspection is classified into three areas as follows: routine, special, and trees and other vegetation inspection. The contents of these inspections is as follows:

(1) Frequency of Inspections

Frequencies of inspection vary according to vegetation conditions or road conditions. The frequency shall consider the capacity to administrate the area.

(2) Inspections Plan

Inspection plans should be prepared in advance of each operations day for efficiency.

(3) Records of Inspections

When inspections are completed, the results should be recorded. In emergencies the results can be recorded after verbal reports.

4.9.4 Classification of Vegetation Control

1) Tree Management

This is the management of planted independent trees, clusters of small trees, tree fences, and linearly planted trees.

2) Grove Management

This is the management of existing woods and saplings when grown as tree groves.

3) Grass Management

This is the management of grass in center dividers, interchanges, service areas and parking areas.

4) Vegetation Slope Management

This is the management of vegetation on cut and fill areas adjacent to the motorways, interchanges, service areas , parking areas and shoulders.

4.9.5 Tree Management

1) Purpose of Tree Management

The functions of trees are maximized by tree management, which is to vitalize and stabilize each tree in the early stages, and to nurture and maintain healthy trees. For this purpose, tree management is subdivided into two categories:

- (1) Management by vegetation location
- (2) Management over a period of time

A management plan should be prepared for each category.

2) Tree Management Tasks

Tree management can be classified into the following tasks:

- (1) Tree Trimming
- (2) Tree Fertilizing
- (3) Chemical Spraying (Pesticide)
- (4) Weed removal
- (5) Vine Cutting
- (6) Tree Watering
- (7) Other Management



4.9.6 Grove Management

1) Purpose of Grove Management

The purpose of grove management is to stabilize groups of trees (if saplings were planted), and to nurture and maintain the group of trees for them to be functional. The management is separated into two categories as follows:

- (1) Management of the grove by its intended function
- (2) Management of changes of the grove over time

A management plan should be prepared for each categories.

2) Grove Management Tasks

Grove management tasks are as follows:

- (1) Grass cutting
- (2) Additional planting
- (3) Root stepping
- (4) Fertilization
- (5) Raising fallen trees
- (6) Felling
- (7) Vine cutting
- (8) Tree chemical spraying (Pesticide)
- (9) High branch cutting
- (10) Branch cutting

4.9.7 Lawn Management

1) Purpose of Lawn Management

The purposes of lawn management are fast and stable growth, improvement of the lawn growth environment, maintenance of visual appearance and fire prevention in the winter. To promote these purposes, a management plan should be prepared for management of changes over time and management by location.

2) Work Standards and Frequencies of Lawn Management Procedures to Help Develop a Management Plan



No.	Subject	Work Standard	Frequency	Work Procedure
(1)	Weed Removal (Herbicide Spraying)	<ul style="list-style-type: none"> Turf growth is disrupted by weeds. Traffic is disrupted by weeds. 	<ul style="list-style-type: none"> Lawn is withering, requires spraying 2-3 times per year to eliminate weeds. 	<ul style="list-style-type: none"> Utilization of spraying machines Spot Treatment by spraying machine on true grasses.
(2)	Manual Weed Removal	<ul style="list-style-type: none"> Turf growth is disrupted by weeds. Visual appearance is disrupted by weeds. Traffic is disrupted by weeds. Herbicide spraying has proved to be not sufficient. 	<ul style="list-style-type: none"> Area near rest facilities - once or twice per year. Turf in through lanes - once per year 	<ul style="list-style-type: none"> Manual pulling.
(3)	Lawn Mowing	<ul style="list-style-type: none"> Turf detachment and insect growth at the ground are anticipated due to the high density of turf and inadequate aeration. Visual appearance is poor and is 50 mm in rest areas or 80 mm elsewhere. Turf is blocking drivers' view. 	<ul style="list-style-type: none"> Interchange, rest areas, center dividers: Lawn mowing, once per year. Edge mowing, once per year. The standard length of turf should be 20 mm. 	Lawn mowers are used for the work. When locations are difficult, sickles are used.
(4)	Lawn Chemical Spraying	<ul style="list-style-type: none"> Damage by insects is expected. Negative impacts to nearby woods, etc., by insects are anticipated. Negative impacts to neighbors are expected. 	<ul style="list-style-type: none"> As necessary 	Spraying machines.
(5)	Lawn Fertilization	Natural organic materials added to maintain the lawn.	Once per year.	<ul style="list-style-type: none"> Manual or fertilizer spreading machine.
(6)	Soil Addition, Aeration	<ul style="list-style-type: none"> Noticeable unevenness is observed. The turf is damaged and normal recovery may not be possible. 	<ul style="list-style-type: none"> The addition of fertilizer, or soil mixed with fertilizer is preferable. 	<ul style="list-style-type: none"> Manual or soil spreading machine. Lawn Spikes shall be used for narrow areas.

3) Lawn Management Tasks

Lawn management tasks are classified as follows:

- (1) Weed Removal (Herbicide Spraying)
- (2) Lawn Mowing
- (3) Lawn Chemical Spraying
- (4) Lawn Fertilization
- (5) Soil Addition, Aeration

4.9.8 Vegetation Slope Management

1) Purpose of Vegetation Slope Management

The purposes of vegetation slope management are for both the short term and long term, as follows:

Short Term Management

- (1) Vegetation planted in the slope surface should be kept in good condition to stabilize the surface of the slope.
- (2) When the slope surface protection function is declining, revitalize the failing vegetation.
- (3) The growth of vegetation shall be managed so as to not disrupt the flow of traffic and to avoid potential impacts to neighboring communities.

Long Term Management

- (4) The vegetation on slopes should be in a natural state in the long run and merged with the surrounding natural vegetation.

To achieve these, the following should be prepared:

- (1) A long term slope vegetation management plan should be prepared.
- (2) The long term plan for vegetation slope management should be used to prepare daily work plans.

4.9.9 Landscaping Structure Management

1) Objectives of Landscaping Structure Management

The objectives of landscaping structure management are as follows:

- (1) Maintain appropriate conditions for functional use
- (2) Maintain good appearance
- (3) Prevention of hazards caused by damaged facilities

To achieve these objectives, deficiencies should be found in the early stages and repaired. When hazardous, the facilities should be repaired immediately. If repairs cannot be made promptly, it may be necessary to prohibit the use of the facilities to prevent accidents.



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4.10 Motorway Maintenance Manual for Traffic Safety and Management Facilities

4.10.1 General

This section describes the procedures and methods for maintaining road safety and management facilities.

Where damaged fences or median barriers, create a safety hazard (such as encroachment upon the carriageway), it should be repaired or removed immediately after the clean-up of the incident which caused the damage. Before permanent repairs are made, consideration should be given to the removal, relocation, or redesign of facilities that are frequently damaged or otherwise identified as ones creating a safety hazard. Full use should be made of *break-away* standards and other design features that improve operational safety.

In all instances, damaged facilities should be corrected as soon as possible. Prompt restoration assures continued protection, information, or visibility, and removes a source of distraction to drivers who tend to decrease speed and look at such situations.

4.10.2 Fences, Barriers and Guardrails

1) Objective

The facilities are provided mainly to prevent a vehicle, whose control has been lost during driving, from running off a road, into an opposing traffic lane. Other functions are;

- (1) Returning a collision vehicle to the normal running direction
- (2) Securing the safety of a driver and passenger(s) of a collision vehicle
- (3) Minimizing physical damage
- (4) Eye guide to drivers

Many different types of these facilities exist along the roads. (1) metal (of several different types and cross-section form); (2) cable; (3) stone; and (4) concrete.

2) Inspection

It is necessary to fully obtain features of each type before start of inspection of the fences. Routine inspection must include checking of the damage state, height, and alignment (or misalignment) of the fences. Should any abnormality be found, correction of a damage must be



made if it is repairable. Particular attention must be paid on the following points during inspection:

- 1) Column and horizontal connection condition
- 2) Settlement, inclination, and warp of columns
- 3) Degree or dirt fouling and condition of paint
- 4) Deformation and damage state of horizontal beams of guardrails and guard pipes
- 5) Damage to beam joint
- 6) Degree of slack in the cable
- 7) Checking of concrete for cracks, and condition of the lower edges

Each facility should be maintained in a nearly "as-built" condition possible, and material must be stockpiled to replace damaged sections as necessary. Most guardrail maintenance is required as the result of vehicle collision rather than damage from corrosion. Corrosion tends to occur under the overlap section of metal plate guardrail and the section can be weakened at this weakest point of the rail. This area is unobservable and inaccessible to paint crews unless they choose to unbolt the sections-something that is not commonly done.

3) Maintenance

When the facility has been deformed or broken due to an accident or disaster or when a certain portion has been found unable to function properly as a result of inspection, the road state, cause of damage, etc. must be recorded for the damaged length or the damaged portion of parts. And, repair must be made immediately to keep the facility in a state allowing it to perform its function. These facilities account for the overwhelming percentage in the road appurtenances damaged by traffic accidents. If restoration of the damage is not to be made promptly and the damaged portion is considered particularly hazardous to the general traffic, it is recommended to undertake tentative restoration by using emergency repair members available. When the difference in height between the road surface and fence has decreased excessively because of repeated overlay, either the height must be adjusted or the new fence must be installed on the outside, so that the fence can restore its functions.

Guardrails should be restored to line and grade as originally constructed. If posts have settled they should be removed and replaced. Posts should be raised, also, in the pavement. Maintaining the correct height differential between the pavement surface and the guardrail is important in order to prevent vehicles from "vaulting" over the rail. Unfortunately, the design of most guardrail posts does not make provision for raising the rail in the event the pavement level is raised.



On a cable guardrail, it is necessary to check tension and springs seasonally, adjusting if necessary to prevent sagging or undue tension.

It is good practice to join short, noncontinuous sections of guardrail. Additionally, any existing obsolete end sections should be modified in accordance with safety design standards which require flared and buried ends.

Damaged guardrails can be replaced with undamaged sections from the yard inventory material. The damage sections are either discarded or, if not too badly damaged, sections can frequently be straightened with special machines developed for that purpose, utilizing rollers shaped to fit common guardrail shapes. Some guardrail incorporates "fixable" performance features, or built-in failure devices to minimize damages to colliding vehicles. For sections designed for progressive deformation, replacement must be achieved in such a way as to retain the design features.

4) Painting

The maintenance unit for sandblasting and priming guardrail consists of one truck, one compressor, a sand pot and three men who can be expected to clean about 43.5 m per hour.

Guardrail should not be painted when the surface is in generally good condition, when nearly as satisfactory results could be obtained by washing. Painting can be accomplished with either spray (standard or electrostatic), brush, or roller. If a brush or roller is used, two men and a truck can be expected to paint 100 lineal feet (30.5 m) of guardrail per hour. Painted rail should be washed, if the paint is sound, a minimum of once every two years, and two men with a truck and washing equipment can clean 75 m per hour.

Under certain circumstances, it is economical to remove old guardrail, replace with stockpiled galvanized material, and have the old guardrail treated at a commercial galvanizing plant for coating and reuse.



4.10.3 Traffic Signs

1) Objective

Maintenance of the visibility and reflectivity of signs is a necessary if a smooth flow of traffic is to be ensured, and if they are to fulfill their purpose of reducing accidents and confusion for motorists. The contrast factor can drop from a 25:1 ratio for clean signs to 6:1 for dirty signs.

2) Inspection

The traffic signs must be checked visually from a patrol car during regular patrolling to see whether or not they are hidden by roadside trees, advertisements, etc., whether the notice board, masts, etc. are damaged. In addition, periodic inspection must be made on the following items:

- (1) Damage, fouling, and corrosion of the notice board and mast
- (2) Peeling of paint and reflecting material
- (3) Notice board installation angle and mounting state
- (4) State of lighting facilities
- (5) State of the foundation
- (6) Reflection performance

Apart from the inspection on the construction as described above, it is necessary to check periodically if the installation place, indication content, and mutual relationship between signs are properly compatible with changing road and traffic conditions (addition of traffic regulation, etc.). Also it is essential to check that the height and size of the signs is adequate, to function properly.

3) Repairs

Damaged notice boards and bent masts, are to be repaired as soon as possible. Loose parts must be retightened immediately to prevent an accident caused by a falling notice board.

The notice board, whose visibility has decreased substantially due to damage or corrosion or whose reflection performance has deteriorated at night must be replaced as early as possible.

When the installation place or information on the board is no longer appropriate in terms of information and visibility, the notice board must be relocated properly by taking the circumstances into account.



4.10.4 Traffic Markings, Delineator and Kilometer Post

1) Objective

These facilities are essential to traffic management after darkness or under conditions of bad visibility.

The maintenance of delineators and kilometer posts is a necessity if a smooth flow of traffic is to be ensured, and if they are to fulfill their purpose of reducing accidents and confusion for motorists.

2) Inspection

Traffic markings must be examined for less of definition due to pilling, abrasion and colour contamination.

Delineators and kilometer posts are observed on routine inspection and any change in condition must be examined. In particular those must be checked to ensure that none has been pulled out of the road surface, and that the delineators are still functioning and correctly placed.

Delineator should have their support undamaged whether mounted on a post or solid obstruction, that the delineator is undamaged and that the direction of the delineator is correct. Delineators should be examined after dark when checking for reflectance.

3) Maintenance of Traffic Markings

The demands for better traffic services have added requirements for public convenience and safety, such as reflectorized paint, faster drying paint, and improved application equipment.

Factors affecting the performance of traffic paint include:

- (1) Paint formulation.
- (2) Substrate.
- (3) Surface preparation.
- (4) Humidity and temperature.
- (5) Application equipment.

The buildup of paint thickness by numerous restripings is a problem. Removal of the old paint and preparation of the pavement for restriping includes the use of air blasts, wire brushing, sand blasting, and pretreatment with mineral spirits, linseed oil, and other primers.



Controlling factors in selecting traffic paints are safety and costs. High-traffic routes normally required faster drying paints than low-traffic routes.

Instant dry - less than 30 sec.

Quick dry - 30 to 120 sec.

Fast dry - 2 to 7 min.

Conventional - over 7 min.

The thickness of paint film in relation to bead size has not been completely resolved. The drying rate of the paint, premix vs. drop-on, equipment wear and bead gradation are factors that must be considered. Frequently unbeaded paint is used and then the beads are dropped on. The wet paint thickness is usually 0.38 mm; however, 0.25 mm has been successfully used. Bead rates vary from 0.5 to 0.7 kg/liter. Modified alkyd resin has gained preference over titanium pigments.

Hot-sprayed and hot-extruded thermoplastic striping materials have several advantages over standard traffic paint. They are both faster drying and longer lasting; however, their first cost is greater and special application equipment is required.

Cold thermoplastics or performed plastic tapes have been limited to special applications and have not been considered as satisfactory as hot thermoplastics. The principal advantage of raised markers is their wet night visibility. The biggest disadvantage is their destruction by snow-plow blades.

Marking equipment ranges in size from small single-line machines to large tandem truck-mounted units capable of placing several lines at a single pass. The larger units have high-capacity air compressors and special heaters for heating paint. Several agencies are using marker equipment that utilizes high fluid pressure of 9,600 - 12,400 kN/m².

Machines are capable of applying traffic striping materials at speeds up to 24 kmph for a 30 cm wide double yellow line with a black separator and even greater speeds may be obtained by increasing the power in the system. Some feature a system of heating the materials, which involves the direct conversion of mechanical energy to heat without going through the heat transfer processes.



4) Maintenance of Delineator and Kilometer Post

Delineator and kilometer post should be replaced using procedures recommended by the manufacturers.

Since delineator are usually within splash height of passing traffic cleaning to restore reflectivity may have to be undertaken after storms or heavy contamination of the motorway surface by dust and mud.

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4.11 Motorway Maintenance Manual for Snow and Ice Control

4.11.1 General

The purpose of snow and ice control is to maintain safe and stable traffic flow during the winter. KGM as the motorway operation agency shall make the following efforts to perform their duties:

- Collection and dissemination of climate and road condition information for motorway users
- Snow removal and de-icing
- Traffic regulations such as speed limits and wearing snow chains on tires or studded tires
- Traffic safety promotion

4.11.2 Administration and Facilities for Snow and Ice Control

1) Plan preparation

Snow and ice control is not a year long activity, but the off-season is important for effective operations during the winter. The following elements of a snow / ice control plan shall be prepared in advance:

(1) Establishment of a Snow/Ice Treatment Administration.

A system shall be established taking into consideration the period of operation, work assignments, cooperation with the traffic management section, establishment of an information network, coordination with the police and road manager, cooperation with the media, and education and training of workers.

(2) Facility and Equipment Preparation

Maintenance and repair shall be conducted on existing equipment, and road facilities such as ditches and signs.

(3) Monitoring Area Conditions

Climate and road characteristics (classification, intensity, and frequency of problem areas caused by the condition of the road), shall be monitored.

(4) Completion of Regular Maintenance

Ordinary road maintenance shall be completed before winter on the motorway sections of each main maintenance center where snow / ice control are major concerns.

2) Period for Snow / Ice Control

The period for Snow/Ice control shall be determined for provide smooth traffic operation during snow and ice conditions. For this purpose, as much maintenance work as possible shall be completed. Facilities for snow/ice treatment shall be maintained and inspected. During the snow/ice treatment period, weather conditions shall be monitored and facilities will be ready for operation at all times. The determining factors for the time periods are past records of the first day of snow, the last day of snow and days of freezing temperatures. Especially during early winter, responses to snow tends to be delayed, therefore, special attention is required to determine the operation period.

3) Administration of Snow / Ice Control

The Snow / Ice Control activity varies depending on the weather, motorway and traffic conditions. The administrative structure shall reflect the conditions to conduct effective Snow / Ice Control. Snow / Ice Control shall be divided into warning, dispatch, and emergencies, as follows:

Snow/Ice Treatment Administration

Warning	Snow or icy roads are expected from the weather forecast, preparation is necessary.
Dispatch	Snow or icy roads are expected from the weather forecast, or snow or icy motorway conditions are present, operations are necessary.
Emergency	Intense and continuous snowfall affecting snow removing operations or a long-term motorway closing is expected or present. Special measures are necessary.

Warning stages for Snow / Ice Control administration occur when snowfall or road icing is anticipated by the weather forecast. While collecting information regarding road surface conditions, necessary personnel shall be called to prepare for dispatch.

The dispatch stage of Snow/Ice Control administration occurs when snowfall or motorway icing is forecaster or has occurred. The task consists of the following:



- Snow removal work
- Spreading de-icing agents
- Enforcement of fire chain requirements
- Initiating the snow removal fleet

The emergency stage of Snow/Ice Control is occurs when traffic congestion due to heavy snowfall lasts long hours despite snow removal efforts. Not only is snow removal at the maximum capacity, but assistance from other agencies has been requested to remove stuck vehicles or help persons in stopped vehicles.

The organization, communications, transportation, and content of work activities shall be determined according to the Snow / Ice Control administration procedures for each department in a region.

4) Equipment

(1) An Example Calculation to Determine the Number of Vehicles Fleet Required for Snow Removal

The following is an example of a typical calculation to determine the number of vehicles required for snow removal:

Conditions

Maximum snowfall rate per hour = 2 ~ 6 cm / hr

Equipment operational velocity = 30 km / hr

Efficiency of operation = 0.8 x normal

Safety factor for distance of operation = 1.1 x normal

Calculation for N, number of snow removal vehicles required:

$$\begin{aligned}
 N &= (\text{Distance of operation} \times 2 \times 1.1) / (30 \times 0.8) \\
 &= (50 \text{ km} \times 2 \times 1.1) / (30 \times 0.8) \\
 &= 4.5 \text{ vehicles, or approximately} = 4 \text{ vehicles}
 \end{aligned}$$

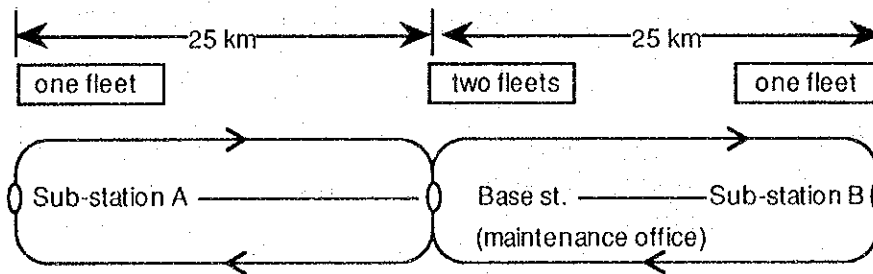
The minimum number of snow removal vehicles for any fleet is two vehicles to be able to maintain four lanes open to traffic to operate in a thorough and efficient manner.



Typically a range of two to four vehicles can keep a segment of roadway open with a cycle of at least once per hour over the same segment.

The following is a standard example of how a maintenance office (base station) and two sub-bases can work effectively to maintain a roadway during a snowfall.

Example



In the above example, newly fallen snow is removed approximately once per hour in each section of roadway if two vehicles are positioned at the base station (maintenance office) and one each at the sub-stations.

(2) Required Equipment Numbers

The equipment requirements for snow and ice removal are dependent upon the following four items:

- The anticipated snowfall along specific sections of motorway.
- The depth to which snow is removed from the road surface.
- The number of lanes to be opened to traffic during a snowfall.
- The frequency of snowplowing or ice removal for each traffic lane per hour.

Typical snow and ice removal equipment for 4 lane sections of road are shown in the following table. In addition to looking at the basic requirements shown in the following table, it is essential that the snow and ice removal fleet and facilities for each specific section of motorway be designed to take into account the length and design of the particular section of road to be maintained, as well as the location of the salt stores or suppliers.

Table 4.11.1 Typical Numbers of Snow Removal Vehicles

	Type of Equipment	Service Levels		
		1 (Ave. Snowfall 1.0 - 0.3 m)	2 (Ave. snowfall 0.3 - 0.05 m)	3 (Ave. snowfall less than 0.05 m)
Fresh Snow Removing	10 ton truck*	2	1	-
	Unimog truck *	4	2	1
	7 ton truck*	2	1	1
Prevent freezing	chemical sprayer	2	2	1
	sprinkler truck	2	1	1

- Notes: (1) The equipment numbers are determined based on an assumption that most vehicles don't use snow chains on tires or studded tires.
 (2) Freezing Prevention will be conducted after removing fresh snow.
 (3)* Indicates with - attachment.

5) Maintenance of Equipment for Snow / Ice Control

The snow removing equipment consists of machines used only for the purpose of snow removal and machines used for both maintenance and snow removal purposes. Inspection and maintenance shall be done during the period of snow removal. Especially, single purpose machines used only for snow removal shall be handled carefully, since the single purpose machines are not used except in winter. The dual purpose machines oil and lubricants shall be inspected since the climate, temperature and other conditions are different from the summer.

The following is a list of vehicle maintenance items to be considered.

- (1) Special equipment attachments for snow removal machinery (plows, strengthened wipers, car heaters, plow edges, tire chains) shall be maintained with the main vehicle body and shall be ready for the winter period.
- (2) Snow removal vehicles that are not used in the summer shall be inspected thoroughly. Lubricants, battery charges, and electric wiring shall be especially inspected and maintained.

- (3) Snow removal machines shall have signs attached to the bodies indicating that the vehicles are at work to help avoid traffic accidents. It is preferred to use a uniform color for snow removal and related vehicles, for easy detection and warning to drivers.
 - (4) To repair the snow removal vehicles as fast as possible, it is important that spare parts (cutting edges, tire chains, and others) be purchased in advance. The use of the parts shall be monitored, and the stock, delivery routes, and times of delivery shall be discussed with dealers and makers to minimize the parts acquisition time.
 - (5) The repair of the vehicles shall be discussed with the work shops in advance for fast repair.
 - (6) The Snow/Ice Control equipment shall be washed after use to prevent rusting from chemicals.
- 6) Facilities and Meteorological Observation Devices

The following facilities and devices are required for snow & ice control activities. During the winter these facilities and devices shall be inspected and maintained.

- Traffic safety facilities such as signs, snow poles
- Meteorological Observation Devices such as thermometers for the road surface and the atmosphere
- Garages, chemical storage areas, maintenance units, etc.

(1) Garages

Snow at garage entrances shall be removed, since during Snow/Ice control periods wind blown snow or snow from garage roofs tends to freeze and block the garage entrances.

After the Snow/Ice control period, the insides of garages shall be cleaned so that rusting can be prevented from the de-icing salt. If necessary, metal parts shall be repainted.

(2) Chemical Storage Areas

Chemical storage areas shall be inspected and maintained, especially the areas on/near cranes and operating machines.

During the Snow/Ice control period, powdery substances from chemicals are stick, and deliquescence causes slippage of cranes attached to the ceiling. Rails and cranes shall be inspected periodically.



After the Snow/Ice Control period, machines shall be wiped and oiled. After maintenance of the hydraulic cranes, the pistons shall be stored in the cylinders.

(3) Maintenance Units

As the maintenance unit offices are not used during the summer, the availability of water, gas, and electricity shall be checked at the end of the Snow & Ice Control period.

4.11.3 Weather Information Collection and Dissemination

1) Information collection

The collection and analysis of weather information, provision of guidance information to road users, and making correct judgments on the types of Snow/Ice control activities are necessary to maintain safe traffic in the winter.

Appropriate weather information collection devices should be installed on the motorway, and information from the Meteorological Agency shall be collected, analyzed, and used to forecast. The information shall be used for Snow/Ice Control.

Figure 4.11.1 shows the flow of data collection to treatment measures

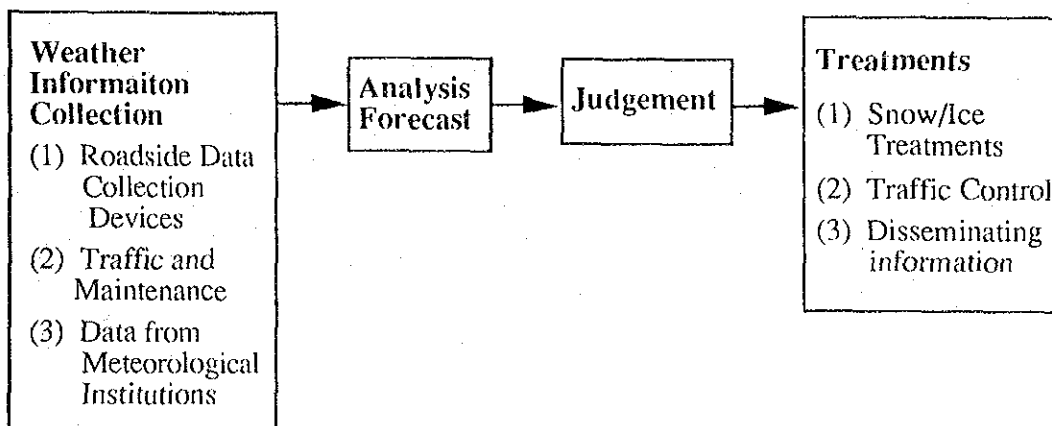


Figure 4.11.1 Flow of Weather Information

2) Information analysis

Meteorological information analysis will be done by a qualified technical staff member of KGM at each main maintenance center or by an expert who works on a contract basis with KGM.

The analysis will produce the following forecast:

Daily

- Weather in 24 hours
- Next morning lowest temperature and road surface temperature
- Snow accumulation depth and rainfall volume
- Frost forecast

Long Term

- Bi-weekly and weekly
- Bi-monthly and monthly
- Three month period

Meteorological experts are the major help for decisions regarding weather warnings. However, when at the stages of de-icing agent spreading or road patrols for snow removal dispatch initiatives, the maintenance office chief judges the time of dispatch based on the meteorological data devices (atmospheric temperatures and road surface temperatures).

4.11.4 Snow and Ice Control Activities

1) Fundamental Concept

There are several snow removal methods: manual removal, machine removal, and melting methods. Among those methods, machine removal is the most popular method for good cost performance, reliability and flexibility.

In this Section, machine snow removal on the motorway is discussed. New snow removal and transport, target of snow removal, dispatch standards, and operation methods are discussed. Also, other snow removal procedures for special locations are discussed in this Section.

For KGM, it is the policy to remove snow to the surface of the motorway, or to a "black" condition since most vehicles don't use snow chains or studded tires.

Therefore, the following concept will be applied for Snow / Ice Control, considering dispatch, traffic regulations and road closures.



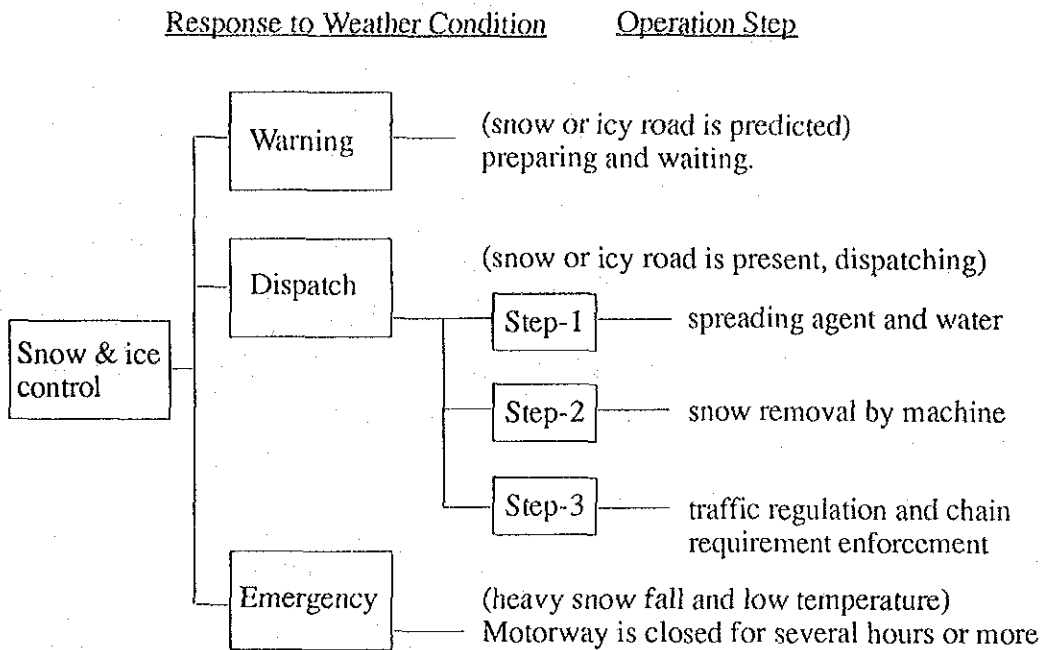


Figure 4.11.2 Operation Step for Snow & Ice Control

2) Snow Removal

(1) Target of snow Removal

When snowing, new snow shall be removed to the motorway surface. The carriageway shall be kept as wide as possible.

- (a) Interruption of traffic flow on curves and traffic accidents tend to occur in the initial stages of snowfall due to slick conditions of the motorway surface, insufficient preparation of most drivers and large volumes of traffic facing snow conditions during a short period of time.

The interruption of traffic flow and traffic accidents during the initial stages of snowfall affect snow removal activities and further deteriorate the traffic conditions. Therefore, snow removal in the initial stages is important, as it affects the later snow removal. New snow shall be removed as quickly as possible.

- (b) During continuous snowfall, when accumulation of snow exceeds 5 cm, traffic flow is severely affected. Even worse, snow removal becomes difficult due to snow compacted by accumulated snowfall and vehicles. Snow shall be removed before its accumulated depth is not to exceed 5 cm.

- (c) When the snowfall continues, the traveled way becomes narrower due to the increasing snow embankment caused by snow removal. The traveled way shall be cleared as wide as possible for expected continuous snowfall.
- (d) Snow removal crews shall be dispatched before the snow accumulation becomes 3 cm, but after a time with a certain accumulation of snow occurs.

When snow removal crews are dispatched before snow accumulates to 3 cm, the average accumulation becomes less than 5 cm after one-hour of snow removal activities in most sections. Since motorway lengths and snow intensities vary, the dispatch standards shall be determined recognizing those factors.

(2) Methods of snow removal

New snow shall be removed by groups of snow removal trucks, unless otherwise stipulated.

- (a) To avoid compaction and traffic flow interruption, high-speed snow removal vehicles are desirable.

Snow removal trucks are the fastest using current technology. The operational speeds are 30 to 40 km/hour, if snow accumulation is less than 10 cm, and they are applicable in intensive snow fall conditions. The speed of another snow removing vehicle, "a motor grader" is slow (20-25 km/hour). The application of "motor graders" on motorway is disregarded.

- (b) Snow removal by one snow removing truck per lane is not effective, since snow on the other lanes solidifies as time goes by. For effective removal, the removal is usually conducted by a party of 2 or more snow removal vehicles.

The width of removal by one snow removal truck is 3.5 meters (5.5 meters with a side-wing). Therefore, generally two snow removal vehicles form one party. The vehicles are indicated in Figure , however, there are two methods of vehicle usage depending on how public traffic is treated.

- To keep the distance between the front truck and the rear truck short, and to stay ahead of any following public traffic.
- To accept passing. The distance between snow removal vehicles is about 300 meters.



This method is used for low traffic volume sections, and drivers should be accustomed to driving in the snow. For traffic safety, the first method is better.

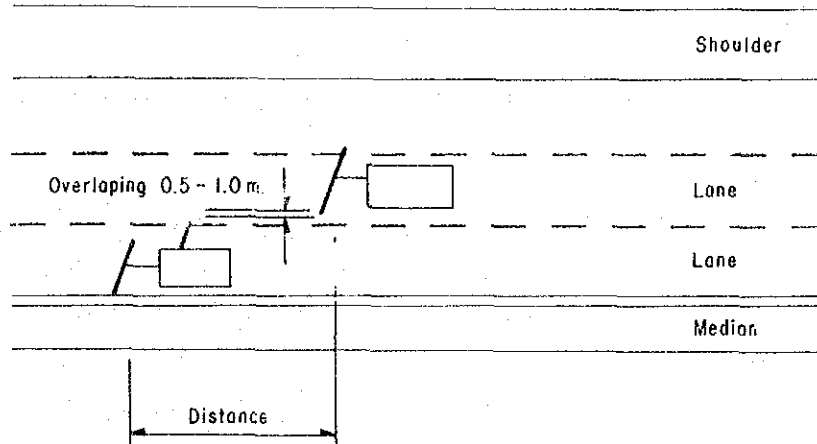


Figure 4.11.2 Positions of Snow Removal Vehicles

A maintenance patrol car or traffic sign truck shall follow the snow removal vehicles to distinguish it from other public vehicles to help provide traffic safety activities.

(3) Snow removal at special locations

Special Locations for Snow/Ice Control are the following:

- Areas near entrances and exits of tunnels
- Interchanges
- Service Areas, Parking Areas
- Bus Stops, Climbing Lanes

Continuous machine operation of Snow/Ice removal at special locations tends to be difficult, unlike that for throughways. Special operations methods are usually employed. The time required to complete the work depends on the quantity of snowfall, traffic volumes, and the availability of workers and machinery. Generally, the work tends to be time consuming.

The special locations are considered as parts of the main roads. The same level of snow removal effort shall be spent as for the main throughways.

(a) Areas near entrances and exits of tunnels

Wind blown snow or snow from snow removal vehicles can end up in tunnels. In extreme cases, wind blown snow can extend up to 50 meter beyond the entrances of tunnels. The traveled way gets narrowed, and traffic gets disrupted if this happens.

Snow shall be removed in the early stages of accumulation before the snow intrudes into the tunnel.

On a separated four lane road, backing up of snow removal vehicles is not preferred, since U-turns are very dangerous. For this type of tunnel, while one lane of traffic is closed, the snow shall be loaded into dump trucks by loader or by other means, and transported by the dump trucks. The work shall be done while the accumulation of snow is still low. Keeping snow storage space near the entrances of tunnels is the effective way to deal with the problem, since the snow removal methods mentioned are time consuming and become possible because of traffic flow disruptions.

Snow removal vehicles with substantial mobility are preferred. A unimong with an angling plow is especially suitable.

(b) Interchanges

(i) Ramps

The shape of ramps makes fast snow removal difficult. One method is to accumulate snow along the shoulders rather than throwing it far.

Since ramps must be closed while working, in heavy traffic areas, the work may be disrupted by the traffic. In merging lane sections, special attention shall be paid to the work and to traffic safety.

(ii) Toll plazas

The fast snow removal work that pushes snow to the sides is not suitable at toll-booths, which have several lanes.

The work requires the clearing of multiple lanes. In intense snow areas, different types of snow removal vehicles, may have to be employed. I-shaped plows with capabilities for small radius turns and angling shall be suitable for work that requires a forward pushing movement to remove snow from the site.

In locations which have irregular shapes, such as around tollbooths, snow removal work shall be conducted manually or by small snow removal devices. Snow melting devices may be considered as an alternative.

(iii) Service Areas, Parking Areas

Parking Areas

I-shaped plows which pushes snow forward with an angling capability are suitable, since the work requires small radius turns.

Sidewalks

Sidewalks are paths which connect restaurants, shops and stores, and restrooms in service areas and parking areas. The work shall be focused on these areas.

Snow removal work of sidewalks is conducted manually.

(iv) Bus Stops, Climbing Lanes

Less attention is paid for snow removal work at bus stops and climbing lanes in the process of through lane snow removal work. This is because the snow removal vehicles leaves the snow at the shoulder for the removal crews at those locations so that the effort of the through lane snow removal does not become disrupted.

For this reason, additional snow removal vehicles specially designed for this work is desirable. Generally, however the work is conducted by the same snow removal vehicles after through lanes are nearly completed.

3) Ice Control Activities

(1) Fundamental Concept

Road icing is a phenomenon which occur when there is water or moisture on the road and the temperature of the road surface drops to lower than 0°C. Measures for icy roads are as follows:

- (a) Remove of water and moisture from the road surface.
- (b) Keep the temperature of the road surface higher than 0°C.



- (c) Make the freezing temperature of the moisture of the road surface lower than the temperature of the road surface.

The example methods for a. are to utilize sunshine, or to drain water from the roadside. As for b., the road surface temperature raising measure is accomplished by laying electric heater cables in the pavement.

De-icing agent spreading is used to increase the freezing point of water on the surface. The application of de-icing agents is in category c..

There are several ways to accomplish Snow/Ice Control, but the use of de-icing agents is the common way of treating snow and ice for its reliability and economical efficiency.

The main purpose for de-icing agents are to prevent roads from becoming icy. It is important to note that the purpose is not to melt an already icy road.

The applicability of uses for de-icing agents shall be determined by the regional climate and tire conditions. The scope of the use of de-icing agents is not limited to ice, it also includes accumulated snow on the surface.

(2) Selection of De-icing Agents

De-icing agents used are the followings:

- Hydrated Calcium Chloride (CaCl₂•2H₂O)
- Hydrated Magnesium Chloride (MgCl₂•6H₂O)
- Sodium Chloride (NaCl)

De-icing agents shall be selected based on the following characteristics of the compound.

- Low freezing temperature, water soluble
- Durability of effectiveness
- Rapid reaction and effectiveness
- Easy storage
- Easy handling (easy transport and spreading)
- Low and stable cost
- Ample supply
- Easy use as a mixture
- Little negative secondary impacts

The three de-icing agents mentioned above were selected with consideration of the above characteristics.

Each de-icing agent's fusion point depression, moisture absorption, and reaction speed are different as indicated in Figure 4.11.3, Table 4.11.2, and Table 4.11.3. Therefore, effective use of the characteristics of each de-icing agent is preferred. There are solid (flake, or granular) and liquid de-icing agents.

Table 4.11.2 Chemical Characteristics of De-icing Agents

Name of De-icing Salt	Chemical Equation (Purity)	Lowest Freezing Temperature	Lowest Temperature of Application	Shape	Dissolution Reaction (Heat of fusion)	note
Magnesium Chloride	$MgCl_2 \cdot 6H_2O$ (45%)	-32°C	-13°C	Flake	Exothermic (14cal/g)	
Sodium Chloride	NaCl (95%)	-22°C	-8°C	Granular	Endothermic (-17.4cal/g)	
Calcium Chloride	$CaCl_2 \cdot 2H_2O$ (75%)	-54°C	-15°C	Flake	Exothermic (80cal/g)	

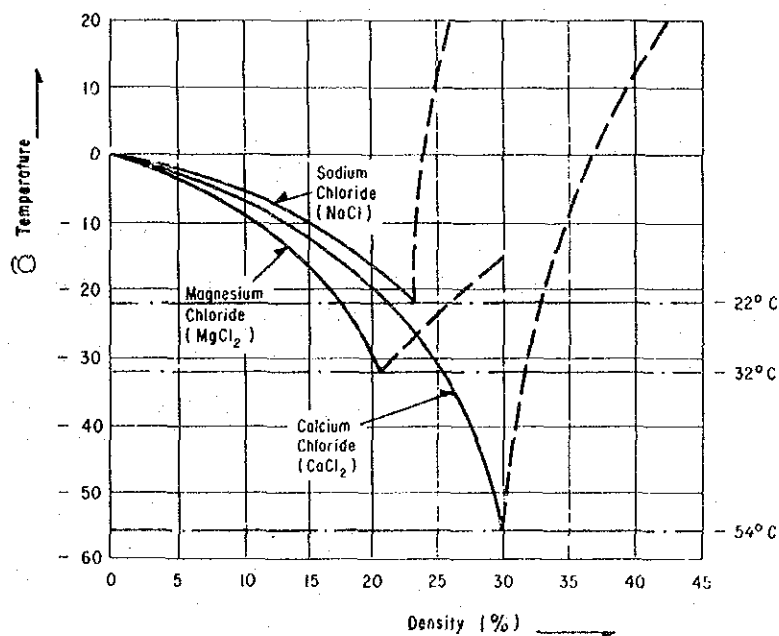


Figure 4.11.3 De-icing Agents and Temperatures

Table 4.11.3 Comparison of De-icing Agents

	Calcium Chloride	Magnesium Chloride	Sodium Chloride	note
Dissolution	○	○	△	
Durability	○	○	△	
Fast Effect	○	○	△	
Storing	△	△	○	
Handling	△	△	○	
Economic Efficiency	△	△	○	
Supply Availability	△	△	○	Regional Difference
Mixing	○	○	○	
Secondary Impact	○	○	○	

Note: ○ good, △ fair

(3) Applicable regions

Applicable regions of de-icing salts by salts' melting temperature are the followings:

- Cold Region
Calcium Chloride, Magnesium Chloride
- Relatively Warmer Region
Sodium Chloride

(4) Hazardous locations of icy roads

Road icing hazards are evaluated by thermometers (atmospheric temperature, road surface temperature) installed along motorway, wind speed and direction gauges, and patrolling.

The following locations are identified as potentially highly hazardous (icing problems) locations:

- (a) Viaducts or bridges
- (b) High fill or half cut and half fill sections
- (c) Shaded cut sections



(5) Timing of spreading

- (a) Generally, spreading de-icing agents just before roads become icy is the most effective preventative measures, when road icing is anticipated due to snowfall, rain, and temperature drop. Identifying the exact time and location of randomly occurring road icing is not possible. However, hazardous locations can be identified from past experience.
- (b) De-icing agents shall be applied at the beginning of snowfall or after snow removal to make the removal of compacted snow from the pavement surface easier.

(6) Method of spreading

Generally, de-icing agents (solid or liquid) shall be spread by machines (Chemical Spreading Machines, Sprinkler Vehicles). Since solid and liquid de-icing agents have differing merits regarding durability and the speed of effect, the characteristics shall be taken into account and applied accordingly.

(7) Quantity of spreading

The standard quantities of de-icing agents to be spread shall be the following:

	Classification	Standard Quantity	note
Solid	calcium chloride magnesium chloride sodium chloride	30 g/m ²	
Liquid	calcium chloride magnesium chloride sodium chloride	0.1 l/m ²	Concentration ranges from 15 - 35 % depending on the road surface temperature.

The quantity of de-icing agent spreading is a function of time of year, and the micro climate of a location, since freezing temperatures are affected by the characteristics of de-icing. The possibility of differentiating the quantities used during spreading according to differing factors is slight, as fluctuating climate conditions and the capability of current spreading machines and facilities make quantity adjustments difficult. Therefore, uniform standard spreading quantities are determined according to the results of tests and data from past operations.

Actual spreading quantities change by the following conditions:



- The velocity of the spreading (sprinkler) vehicles
- The wind and the structure of the road in segments of operation
- The accuracy of spreading machines

To spread de-icing agents evenly, in a strict sense, is not possible. Therefore, standard quantities of spreading shall be considered as values for guidance of the spreading work.

4.11.5 Traffic Regulation

The following traffic control and guidance should be practiced for traffic safety and reliability with considerations for weather conditions, surface conditions, traffic conditions, and work conditions:

- Traffic Safety Promotion
- Speed Limits
- Tire Chain Requirements
- Lane Controls
- Traffic Closures

1) Traffic Safety Promotion Criteria

When visibility is reduced by snowfall, the road surface is slippery because of ice or snow, or when traffic accidents or traffic congestion occurs, then measures like speed limit control, chain requirements, lane closures and other traffic control measures are necessary. Traffic shall be controlled according to the directives of KGM. Criteria for traffic regulations are shown in Table 4.11.4.

2) Traffic Control Methods

Traffic conditions and traffic restrictions information are provided by using Variable Message Signs and temporary information signs.

Each of operation method is as follows:

(1) Safety Driving Instructions

- Indication of the necessary items by using Variable Message Signs and temporary information signs
- Indication of necessary items by temporary cloth signs spanning the roadway

(2) Speed Limits

- Indication of necessary items by using Variable Message Signs



(3) Tire Chain Requirements

- Indication of necessary items by using Variable Message Signs
- Indication of necessary items by temporary cloth signs spanning the roadway
- Selection of locations for tire chain installation and removal, considering toll plazas and IC, PA, SA, BS.
- Location of the crews and required facilities (signs, rubber cones).

(4) Motorway Closures

- Indication of necessary items by using Variable Message Signs
- Dispatching the necessary crews

4.11.6 Record

Snow / Ice Control events shall be recorded on specific forms and stored in a specific manner to reflect Snow / Ice Control experiences for future reference.

Table 4.11.4 Criteria for Traffic Regulations

Condition	W*	SL*	TCR*	LC*	C*
Weather (Snow, Rain, Fog, Storm)	○				
At the beginning snowfall, visibility is getting worse	○				
Relatively low visibility due to rain and fog	○				
Visibility is low due to snowfall driving is hazardous		○			
Low visibility due to rain or fog driving is hazardous		○			
Very low visibility due to intense snowfall, rain or fog					○
Low visibility due to wind driven snow		○			
Very low visibility due to intense wind driven snow					○
Road Surface (Ice, Snow Accumulation, Compacted Snow)	○				
Wet surface because of snowfall	○				
Wet surface because of melting snow	○				
Icy road is anticipated because of wet surface		○			
Beginning of snow accumulation due to snowfall.		○			
			○		
Accumulation of snow due to snow fall			○		
Compacted snow on road surface			○		
Driving difficulty due to intense snowfall, accumulation of snow and blown snow					○
Snow/Ice Work (Snow Removal, De-Icing)	○				
No impact to through traffic of widening snow removal					
Some impacts to through traffic of widening snow removal		○			○
During icing prevention (machine spreading)		○			
During new snow removal		○			
During transport of snow removal		○			

* W: Warning, SL: Speed Limit, TCR: Tire Chain Requirement, LC: Lane Control, MC: Motorway Closure

