# 7 DRAINAGE SYSTEM

## 7.1 GENERAL

Ineffective drainage of runoff may affect a bridge in several ways:

- If flooding of the deck occurs due to blockage of the drainage system, it may create a serious traffic hazard;
- If water flows uncontrolled over concrete or steel surfaces below deck level, corrosion problems will result;
- If debris collects, it will retain moisture and promote corrosion;
- If water is discharged off the bridge other than into a proper drainage channel, it may cause erosion of approaches and possibly undermining of foundations;
- If water is trapped in blocked pipes and freezes, the pipes or their enclosing concrete may be ruptured.

It is therefore most important that bridge drainage systems are regularly inspected and maintained to ensure that water is quickly drained clear of the structure.

Most potential drainage problems can be eliminated by good design and correct installation. Features which affect bridge drainage are described in the following section. These descriptions can be used as a checklist during inspection to determine if any corrective action needs to be taken.

***Figure 7.1: Small grates require frequent maintenance.***

## 7.2 DRAINAGE FEATURES

### 7.2.1 Deck Slopes

To ensure effective drainage of the bridge deck a minimum cross-slope of 2% and a minimum longitudinal grade of 0.5% are recommended, with gutters graded at least at 1%. Care should be taken to maintain these grades during any re-surfacing operations.

### 7.2.2 Kerb Channels

Channels may become blocked with silt and sealing chip, particularly if the slopes and grades are insufficient. If the channels are not cleared regularly, plants will grow in the accumulated debris. This will exacerbate the problems of deck flooding and moisture retention in the concrete.

### 7.2.3 Drainage Inlets

Blockage of inlets with storm debris and/or rubbish is a common cause of drainage problems. Grates need to be hydraulically efficient, strong enough to support traffic, securely fixed, corrosion resistant and not present a hazard to bicycle traffic. To cope with partial blockages their inlet area should be twice the calculated area required. Regular removal of collected debris can help minimise the effects of inadequate design.

### 7.2.4 Drainage Pipes

To avoid clogging with mud and debris it is important that pipe systems have a minimum diameter of 150 mm (200 mm preferred), a minimum radius of 450 mm and are laid at an absolute minimum slope of 2% (but preferably 8%). In addition, clean-out plugs and elbows should be provided at appropriate places and be easily accessible. Open channels or troughs under expansion joints can fill rapidly if they are not regularly maintained.

Care is required when maintaining asbestos-cement pipes or channels and PVC pipes exposed to direct sunlight, as these become brittle with age.

***Figure 7.2: Typical debris collecting on grate.***

### 7.2.5 Drainage Outlets

A common deficiency of drainage systems is their failure to discharge clear of the structure. This may cause staining and corrosion of steel and concrete beams or substructure. If it allows debris to build up, the situation will be aggravated by moisture retention and plant growth. If the discharge is incorrectly positioned, it may also cause the potentially serious problems of erosion of embankments or undermining of foundations.

***Figure 7.3: Drainage outlet discharging water onto concrete deck soffit.***

***Figure 7.4: Drainage outlet below adjacent steel beam soffit.***

### 7.2.6 Drip Grooves

Run-off should be prevented from running across concrete deck soffits or down the faces of girders and piers by casting grooves into the underside of edge beams or the edge of deck soffits. A drip groove can be rendered ineffective if it is too shallow, or if it is straddled by incorrectly installed baseplates for traffic barriers posts, or if it is filled up with material by insects. These problems may be aggravated on bridges with super-elevated decks, because the increased slope will require a deeper drip groove if it is to be effective.

### 7.2.7 Drainage of Voids

Box girders and other voided members should have drain holes as a precaution against build up of condensation or leakage. Such holes may get blocked by birds or insects.

### 7.2.8 Leaking Joints

Most bridges have expansion joints to accommodate thermal or seismic movement (see Section 8.3). These elements usually include provision to prevent leakage from the deck onto bearings, hinges or other substructure components. Leakage may occur from faulty installation, inadequate crossfall of collector channels, ruptured membranes, misplaced compression seals, and adhesive or sealant failure. Allowance for such failures should be made at the design stage to avoid subsequent problems with moisture retention and accumulation of debris.

*Figure 7.5: Leaking deck joint.*

### 7.2.9 Leaking Decks

Leakage may occur in the vicinity of construction joints or shrinkage cracks especially if reflective cracking through overlying bitumen or asphaltic concrete is present.

*Figure 7.6: Staining of pier caused by leaking deck joint.*

## 7.3 MAINTENANCE

The key to the success or failure of any existing drainage system is regular maintenance. The frequency of attention will depend largely on the particular environment.

### 7.3.1 Drainage Systems

Many problems can be avoided by collecting and removing debris from the kerb channel, before it enters the system to cause a blockage. For example, spillages of wet concrete, grain or other granular material should be promptly removed, as should objects with potential to block pipes like cans, milkshake containers, dead birds etc.

Where pipes are blocked through build-up of silt, high-pressure water is a commonly used cleaning aid. Where water is unable to break through, a back-flushing technique to reverse the normal direction of flow can be effective. Back-flushing with compressed air can also be used to clear badly plugged pipes but if non-encased PVC pipes are included in the system caution is required to avoid bursting them.

Gully traps are normally cleaned by shovel or suction pumping where available. Gullies will require special attention after gritting for icy conditions.

### 7.3.2 Substructure

The area beneath an open expansion joint should be cleared of debris at the same time as the rest of the system. The same applies where a joint seal has failed, and allows debris to pass through. See also Sections 8.3 and 8.4.

## 7.4 RECTIFICATION OF DEFECTS

### 7.4.1 Drainage Systems

Severe ponding problems on concrete decks caused by lack of fall may be reduced by the judicious drilling of 100 mm diameter drain holes at 2 m centres near the kerb and fitting them with droppers or a collection system where appropriate and as permitted or required by the Resource Consent. Inlets that are prone to blockage by floating debris (e.g. pine needles) can be improved by fitting a domed screen. This will allow water to continue to enter the drains under the floating material until it can be removed.

*Figure 7.7: Inaccessible drainage channel.*

Where new drains are necessary, they should be fitted with sufficient inspection points to allow for both the introduction of high-pressure cleaning water and the ejection of any debris. When retrofitting a drainage system, it is vital that any potential choke points are easily accessible so that build-up of debris can be managed.

### 7.4.2 Substructure

Where substructure concrete is water-stained run-off should be intercepted by grooving, or by insertion of dropper pipes which should extend below any adjacent beam. Free fall of water from a deck drain through the air should not cause an erosion problem where the fall exceeds 7.5m, otherwise erosion protection such as riprap or paving will be necessary.

Leaking deck joints should be repaired (see Section 8.3) and deck cracks sealed with rubberised bitumen.

Where a drip former is not working properly a possible solution is to attach a small galvanised steel or aluminium angle to the underside of the concrete to create an equivalent effect. The angle would need to be sealed against the surface.

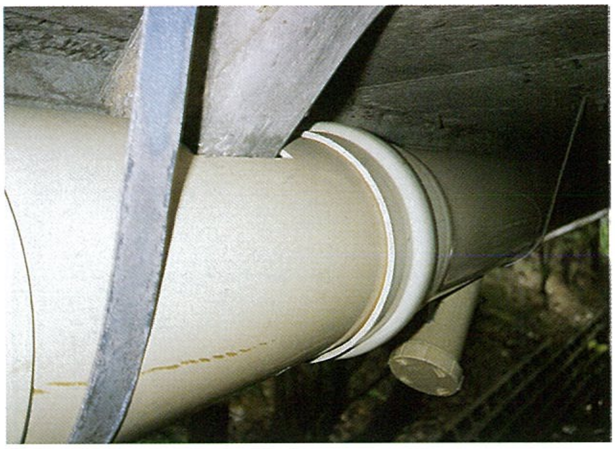

*Figure 7.8: Replacement system with inspection and jetting point.*

## 7.5 BIBLIOGRAPHY

AASHTO (1999): "AASHTO Maintenance Manual: The Maintenance and Management of Roadways and Bridges". American Association of State Highway and Transportation Officials.

NCHRP (1979): "Bridge Drainage Systems". National Co-operative Highway Research Program (USA), Synthesis of Highway Practices 67.

NRB (1977): "Highway Surface Drainage – Design Guide for Highways with a Positive Collection System". National Roads Board.

Woo, D.C. (1988): "Bridge Drainage System Needs Criteria", Public Roads 52 (2).

Young, G.K., Phillippe, J., Bellome, S.J., Norman, J., Hughes, W.E. (1986): "Bridge-deck Drainage Guidelines". Report No FHWA/RD-87/014, Federal Highway Administration, USA.