HIGHWAYS DEPARTMENT

GUIDANCE NOTES

CATALOGUE OF ROAD DEFECTS (CORD)

Research & Development Division

RD/GN/015B
January 2013

FOREWORD

The Research & Development Division of Highways Department works towards uniformity of practice with respect to design, construction and maintenance of road pavements. With this purpose in view, the Division arranges for the preparation and publication of standards and guides.

The principal aims of this catalogue (whose short form shall be CORD) are:

(a) to provide a uniform nomenclature for the description of visible defects in pavements, in particular in the recording of such defects in accordance with the Road Inspection Manual (RIM);

(b) to promote the use of defect recognition as an aid to the diagnosis of pavement conditions; and

(c) to provide a method of quantifying each defect type.

The catalogue is intended to be a practical guide for those engaged in highway maintenance. It is hoped that the advice, recommendations and information contained within the catalogue will enable engineers and maintenance staff to identify defects; to diagnose their cause and to select the appropriate remedial treatment.

CORD and RIM are complementary to each other and therefore they should be read and used together.

Defects shown in this Catalogue do not necessarily cover the full range of defects encountered in the field. However, it should cover the majority.

In 2012, two new sets of guidance notes covering preservation of both concrete and bituminous carriageways have been issued. Local application of hot-in-place recycling by thermal patcher has also been extended to small-scale resurfacing. This revision updates the CORD to include the changes arisen from these guidance notes as well as updated measures in pavement maintenance.

Content

Part 1 Explanatory Notes

Part 2 Description of Defects

1. Concrete Pavements

2. Bituminous Pavements

3. Footways and Paved Areas

4. Covers, Gratings and Frames

Part 1

Explanatory Notes

1. Introduction

1.1 The precise description of pavement surface defects is of primary importance when defining surface conditions, establishing a diagnosis of the problems encountered and selecting the most appropriate maintenance treatment. This description must be understandable to all and it is in particular essential that engineers concerned with road maintenance have a common language for describing what they observe on road surfaces.

1.2 These requirements have led a large number of countries to establish road surface deficiency catalogues. However, it is not enough to draw up a descriptive list; the various types of defects must also be classified, their most likely cause assessed and appropriate remedies listed. In line with the approach taken in other countries it is deemed necessary to establish a similar inventory of road surface defects encountered in Hong Kong as an aid to better maintenance practice.

1.3 The different types of defects that may occur are considered under the following categories:

(a) Names;

(b) Description of the essential features together with notes that will aid identification, common synonyms are also given for reference;

(c) A listing of attributes;

(d) Photographs of typical examples;

(e) A listing of possible, or most likely causes; and

(f) Remedies recommended.

1.4 It should be noted that some defects are not illustrated because they are obvious (e.g. fine cracks); others because it is difficult to illustrate them satisfactorily (e.g. very slight raveling and general poor shape). Furthermore, defects differ in many ways and it has not been possible to illustrate all variations. Some judgment based on training and experience will be called for when assessing defects.

1.5 This catalogue covers defects in carriageways (both flexible and rigid), footways and ironworks.

2. Method of Defect Description

2.1 Observation of Defects

A defect refers to the visible evidence of an undesirable condition in the pavement affecting serviceability, structural condition or appearance. Correct diagnosis of the cause of defects can only be made after careful inspection of the pavement by an observer on foot, as he can view the defects at various angles, heights and distance. Nevertheless, defects such as fine cracks and fine crazing are more difficult to see when road surfaces are wet although they often show up well as the road dries out, and when inspecting with strong sun behind. Special care should therefore be taken when inspecting in unfavourable conditions.

2.2 Recording

The format used for field reporting should be consistent with the intended method of processing (computer or manual). For the purpose of detailed road inspections, the inspection forms and procedures laid down in RIM should be followed. The defect code and the main attributes should be recorded on the inspection form.

2.3 Names

The preferred name will convey the appearance of the defect. Some observed defects may not fall neatly into any particular defect type. This may be due to simplification of defect types on one hand and to the existence of multiple defects (e.g. a combination of cracking, rutting and shoving) on the other. Multiple defects will require multiple names (e.g. a rut with crocodile cracking).

2.4 Description

Descriptions outline the characteristic feature of the particular defect type. These descriptions include photos of typical forms, sometimes at different levels of severity. The photos in general, show defects of more than usual severity as less severe defects might not show clearly on the scale available in photos.

Synonyms or other names commonly used for the same defect are given in bracket.

The synonyms are given for academic interest only and readers are reminded not to use these names to avoid confusion.

2.5 Attributes

The attributes included with each defect description can be arbitrarily divided into two broad groups:

- Those which describe the extent (size) of the defect (typically area, length, proportion of the area affected etc.)

- Those which describe the severity (quality) of a defect (typically depth of deformation, width of cracks etc.)

Length, width and area can usually be estimated by the naked eye or by pacing. The use of a 1.2m straightedge associated with a calibrated wedge is recommended to help in depth and height estimates. Sometimes it may be difficult to determine the extent of certain defects as their limits may not be well defined. In these cases, the engineer/inspector has to make judgments concerning the required detail consistent with the proposed application.

In case of multiple defects, attributes of the component defects should as far as practicable be measured and recorded separately.

2.6 Possible Causes & Recommended Remedies

Some possible causes are included with each defect description. It must be borne in mind that using visual observation as diagnostic tool has its limitations since the internal properties of the pavement are not generally known. It is therefore desirable to verify any visually assessed cause by further road testing/investigation.

The possible causes and recommended remedies described in this manual are not intended to be exhaustive but rather to give an indication of the likely causes and the appropriate repair or maintenance treatments for the particular defect. If factors such as importance of the road, extent of the defect, defect weighting factors and intervention levels are taken into account, the final remedial treatment adopted for the road may turn out to be different from that recommended in this manual.

3. Defects in Concrete Pavements

There are five predominant modes of distress in concrete pavement surfaces namely.

- Cracking
- Deformation
- Joint sealant defects
- Spalling
- Surface texture defects

3.1 Cracking

3.1.1 Structural defects manifest themselves mainly in the form of various types of cracks in the slab but inadequate curing of concrete, settlement, movement or restraint at joints may also lead to the development of cracks and subsequent failure.

3.1.2 Treatment of cracks depend on their severity and on whether the slab is reinforced or unreinforced. The severity is defined by the unspalled width of the crack measured on the surface of the slab.

3.1.3 Narrow cracks are defined as being up to 0.5 mm wide and, because they are narrow, are assumed to have retained full aggregate interlock and load transfer and will not allow significant ingress of water.

3.1.4 Medium cracks are defined as being between 0.5 mm and 1.5 mm wide and are assumed to have retained only partial load transfer because of reduced aggregate interlock. They will permit the ingress of water.

3.1.5 Wide cracks are defined as being those which are greater than 1.5 mm wide. It is assumed that they will no longer have any useful aggregate interlock and will therefore provide no load transfer across the crack. They will permit the ingress of water.

3.1.6 Narrow cracks are a normal feature of all reinforced slabs. They are considered to be structurally insignificant and consequently are not likely to require any remedial treatment. However, medium and wide cracks need appropriate treatments to prevent the ingress of water/detritus which could lead to corrosion of steel, softening of the sub-structure and spalling.

3.1.7 The types of cracks documented in the following include:

3.2 Deformation

3.2.1 Deformation is the change in a road surface from the intended profile. There is a great variety of causes some of which are load associated (e.g. traffic) and others are non-load associated (e.g. environmental).

3.2.2 Deformation affects the safety and riding quality of the pavement as it may lead to water ponding thus increasing the chance of aquaplaning and is a traffic hazard.

3.2.3 Two defect types are documented:

3.2.4 Rocking is a dynamic phenomenon and its area of influence is not readily quantifiable. Rocking may be felt with the passage of a vehicle over the affected slab. Joint stepping is evidenced by permanent displacements and can be measured.

3.3 Joint Sealant Defects

3.3.1 It is essential that joint sealants are maintained in an effective condition to preserve their function of preventing silt, grit, stones and water from entering the joints which are provided to accommodate movement in the slab. The accumulation of detritus in the joint will impair its free movement and this may result in spalling at the joints and compression failures. The penetration of water into the joint may also lead to softening of the sub-base or subgrade and may cause corrosion of steel dowel and tie bars.

3.3.2 The life expectancy of most joint seals is comparatively short and it is likely that they will need to be replaced at regular intervals during the life of most pavements depending upon the type of sealing material that is used. Most sealants tend to harden and become brittle with age.

3.3.3 The main types of joint sealing materials for movement joints in concrete carriageway and concrete footway are two part polysulphide based elastomeric compounds and polyurethane – based joint sealants. Gun grade cold applied materials are probably the most appropriate for joint sealing repairs when small quantities of materials are involved.

3.3.4 Joint seal defect can take three distinct forms. In one from (adhesion failure), the edge bond is lost leaving an open gap between joints. In the other the sealant extrudes from the joint, though the joint sealant remains intact. The final form (cohesion failure) is generally an aging phenomenon and shows up as cracks within the seal either transverse or parallel to the joint groove.

3.4 Spalling

3.4.1 Spalling is a condition where distinct, usually angular pieces of concrete have flaked (cracked), or are showing a tendency to flake from the concrete surfaces. This occurs usually at joints, edges, corners or forms directly over reinforcing steel particularly when the steel has inadequate cover.

3.4.2 Spalling can have a variety of causes and unless rectified is likely to impair the effectiveness of the joint seal. This will allow water and detritus to enter the joint which in turn may lead to further deterioration so that both the functioning the joint and riding comport will be adversely affected.

3.4.3 The main causes of shallow spalling are the presence of weak concrete in the arris, the infiltration of incompressible detritus into the joint groove and mechanical damage to the edge of the slab.

3.4.4 Deep spalling at joints usually extend to mid-depth of the slab or deeper. It is mainly caused either by dowel bar restraint or by the ingress of solids into the joint/crack.

3.4.5 Dowel bar restraint can occur in two forms, i.e. misalignment of the bars and/or excessive bond along what should be the free end of the bars. Both can cause deep spalling at contraction and expansion joints as a result of the stress that develops in the concrete when movement at the joint is restrained. Another possible cause of dowel restraints is the use of bars which are bent or have excessively burred ends.

3.5 Surface Texture Deficiencies

3.5.1 These groups of defects are related to surface quality and are concerned with the properties of the upper 10mm to 20mm of concrete. Two defect types are documented:

3.5.2 Ravelling

3.5.2.1 Ravelling is the progressive breakdown (roughening) of the slab to depths commonly of 6mm to 12mm. Mortar and aggregates are lost independently of each other.

3.5.2.2 The most common cause of ravelling in Hong Kong is either overworking of the surface during concreting, the use of steel finishing tools or the use of an excess of water in the mix which results in reduced strength and durability of the concrete surface.

3.5.3 Loss of Surface Texture

3.5.3.1 The skidding resistance of a concrete road depends upon the type and depth of the surface texture and the resistance of the aggregates in the surface of the slab, to polishing and abrasion. The reduction of skidding resistance results from the loss of surface texture and polishing that is caused by the action of traffic on the surface. The rate at which this occurs is largely proportional to the amount of traffic using the road, but this varies with the seasons.

3.5.3.2 Resistance to wet road skidding at high speeds require a coarse (macro) surface texture that will provide good drainage beneath the tyres of vehicles and is measured in terms of texture depth.

3.5.5.3 Resistance to skidding at low speeds requires a finer (micro) texture of the surface to provide a high level of friction between the tyre and the road surface.

3.5.3.4 All road surfaces wear under the action of traffic, particularly during the very early life of the road. But within a short time the micro texture reaches an equilibrium level and thereafter the low speed skidding resistance remains reasonably constant. However, the action of traffic continues to wear the macro surface texture and thus gradually reduces the high speed skidding resistance.

3.5.3.5 In Hong Kong the low speed skidding resistance of small areas is assessed using the Portable Pendulum Tester described in BS 812. For large areas, it has to be measured by specially designed machines such as Sideways force Coefficient Routine Investigation Machine (SCRIM).

3.5.3.6 The skidding resistance of worn surfaces can be restored either by grooving or mechanically roughening the existing surface or by the application of a surface dressing.

4. Defects in Bituminous Pavements

There are four predominant modes of distress in bituminous pavements namely:

- Cracking
- Deformation
- Surface texture deficiencies
- Potholes

4.1 Cracking

4.1.1 Cracks are fissures resulting from partial or complete fractures of the pavement surface and underlying layers. They can range from isolated single cracks to a series of interconnected cracks spreading over the entire pavement surface.

4.1.2 There are a variety of factors leading to cracking of pavement surface. They include:

- deformation
- fatigue failure of the surfacing or pavement structure
- ageing of the surfacing
- reflection of movement of underlying layers
- shrinkage
- poor construction

4.1.3 The detrimental effects associated with the presence of cracks are manifold and include:

- loss of waterproofing
- loss of load spreading ability
- pumping and loss of fines from the base course
- loss of riding quality
- poor aesthetics

4.1.4 The various types of cracks (and the page number where they are described) are:

4.2 Deformation

4.2.1 Deformation can be conceived as any change of the road structure, which leaves the road surface in a shape different from the one intended. It may be due to load associated (traffic) or non-load associated (environmental) influences.

4.2.2 Deformation is an important element of pavement condition as it affects serviceability and may reflect structural inadequacies. It also has significant impact of vehicle operating costs.

4.2.3 In Hong Kong, the common types of deformations often encountered on the road include:

4.3 Surface Texture Deficiencies

4.3.1 Surface texture deficiencies include loss of surfacing materials, loss of surface macrotexture and microtexture. Although they may not reflect pavement structural inadequacy, they have a significant effect on its serviceability (riding quality and safety).

4.3.2 The principal defect types include:

4.4 Potholes

4.4.1 Potholes are bowl-shaped depressions in the pavement surface developing from another defect (cracking, delamination etc.), and resulting in allowing the entry of water and disintegration with removal of material by traffic over weakened spots on the surface.

4.4.2 The principal defect types include:

5. Defects in Footways and Paved Areas

Theoretically the defects for carriageways could also apply to footways and paved areas. However, because of the relatively smaller thickness of footway slabs, defects on footways can be identified by the predominant mode of distress but often not the sub-defect types. For simplicity, some defects are grouped together to form three headings as follows:

5.1 Kerb Defects

Kerb defects are related to misalignment, dislocation, subsidence or other damage of kerbs and are not sub-divided into defect types.

5.2 Blockwork Defects

Blockwork defects are related to stepping, dislocation, tilting, missing, cracking, depression, uneven surface, surface texture deficiency or reduction in skid resistance of paving blocks or vegetation on paving blocks.

5.3 Surface Defects

Surface defects can be classified under the following defect types. Similar defects, if occurred on blocked paving, are collectively grouped under the heading of blockwork defects in Section 5.2.

- cracking
- depressions
- ravelling
- uneven surface

6. Defects in Covers, Gratings and Frames

Defects in drainage/utility covers, gratings and frames may have a significant effect on the riding quality and safety of the pavement. For simplicity, they are grouped as ironwork defects (page 48).

6.1 Ironwork Defects

Ironwork defects are related to damage, misplacing, loosening, sinking or missing of drainage/utility covers, gratings and frames and are not sub-divided into defect types.

This page is intentionally left blank.

Part 2

Description of Defects

1. Concrete Pavements

2. Bituminous Pavements

3. Footways and Paved Areas

4. Covers, Gratings and Frames

Block Cracks (Concrete)

Description

Interconnected cracks forming a series of blocks approximately rectangular in shape, commonly distributed over the full pavement – Plates 1 & 2

Attributes

- Predominant crack width (mm)
- Predominant cell width (mm)
- Area affected (m^2)

Possible causes

- Insufficient slab thickness
- Settlement of sub-base or subgrade
- Advanced stage in pavement life cycle

Recommended remedies

- Narrow cracks in unreinforced slabs and medium cracks in all slabs will need to be sealed; or
- Stitched crack repair
- Wide cracks will necessitate either a bay replacement repair or a full depth repair

Corner Cracks (Concrete)

Description

Crack linking a transverse joint to the slab edge or a longitudinal joint – Plates 3 & 4

Attributes

- Crack width (mm)
- Crack length (m)
- Number of slabs affected

Possible causes

- Lack of load transfer joints
- Dowel bar restraint near edge of slab
- Ingress of solids into joint at edge of slab
- Acute angles in non-rectangular slabs
- Loss of sub-base support

Recommended remedies

- Corner or transverse full depth repair

Plate 1

Plate 2

Plate 3

Plate 4

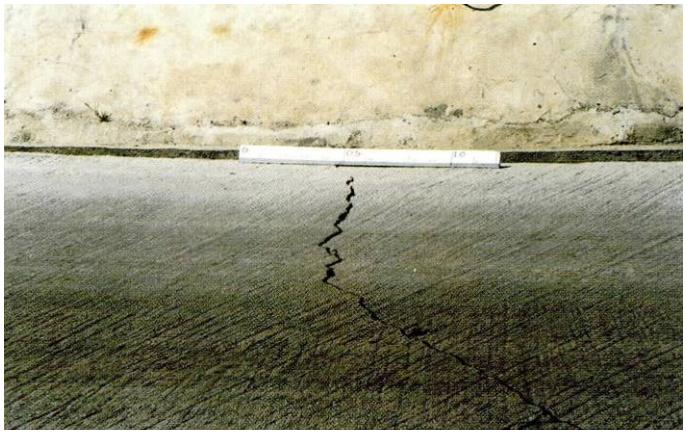
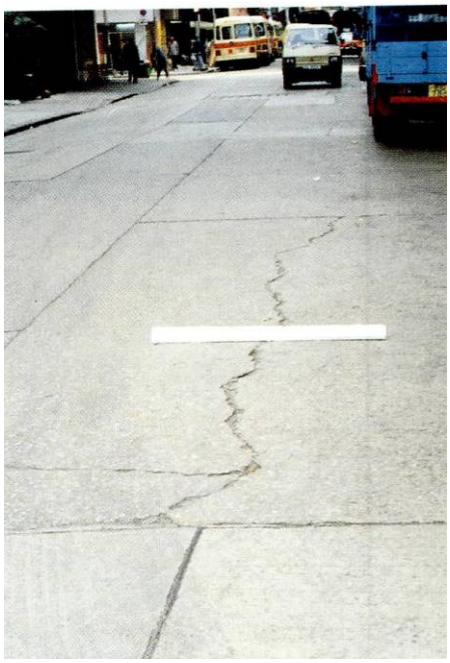


Plate 5

Plate 6

Plate 7

Plate 8



Diagonal Cracks (Concrete)

Description

Multi-directional cracks in the slab which are neither generally transverse, nor longitudinal, nor across the corners of bays – Plates 5 & 6

Attributes

- Crack width (mm)
- Crack length (m)
- Number of slabs affected

Possible causes

- Shrinkage of slab during curing, associated with excess slab lengths or joints sawn too late
- Settlement of the sub-base or subgrade
- Rocking of slab
- Insufficient slab thickness

Recommended remedies

- Narrow cracks in unreinforced slabs and medium cracks in all slabs will need to be sealed; or
- Stitched crack repair
- Wide cracks will necessitate either a bay replacement repair or a full depth repair

Longitudinal Cracks (Concrete)

Description

Unconnected crack running longitudinally along the pavement – Plates 7 & 8

Attributes

- Crack width (mm)
- Crack length (m)
- Crack spacing (mm)
- Area affected (m^2)

Possible causes

- Differential settlement
- Lateral shrinkage associated with excessive slab width

Recommended remedies

- Narrow cracks in reinforced slabs require no immediate action
- Narrow cracks in unreinforced slabs and medium cracks in slabs of all types should be remedied by means of a stitched crack repair
- Wide cracks in all slabs should be remedied either by a longitudinal full depth repair or by means of a bay replacement repair

Shrinkage Cracks (Concrete)

Description

Short and oblique in direction and characteristically do not normally extend to the edges of the slab. Initially they are comparatively shallow in depth but as a result of subsequent heating and cooling, wetting and drying, it is likely that some at least will eventually extend across the full width and through the full depth of the slab – Plates 9 & 10

Attributes

- Predominant width of crack (mm)
- Crack length (m)
- Number of slabs affected

Possible causes

- Inadequate curing

Recommended remedies

- Very minor, narrow plastic shrinkage cracks may be self-annealing and consequently require no remedial treatment
- Sealing of the cracks
- Full depth repair
- Demolition and reconstruction of the slab by means of bay replacement repair

Transverse Cracks (Concrete)

Description

Crack or break running transversely across the pavement/slab – Plates 11 & 12

Attributes

- Crack width (mm)
- Crack spacing (mm)
- Crack length (m)
- Area affected (m^2)

Possible causes

- Shrinkage of slab during curing, associated with contraction joints being sawn too late or excessive slab length
- Dowel bar restraint at joints
- Sub-base restraint (lack of separation layer or excessive irregularity of sub-base)
- Insufficient slab thickness
- Rocking
- Developing from joints (case of unmatched joints in two parallel slabs)

Recommended remedies

- Medium width cracks – form a groove and seal
- Wide cracks – transverse full depth repair
- Full bay reconstruction

Plate 9

Plate 10

Plate 11

Plate 12

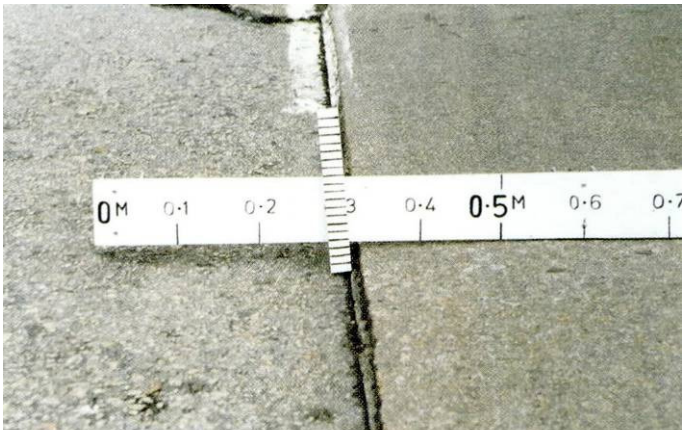


Plate 13

Plate 14

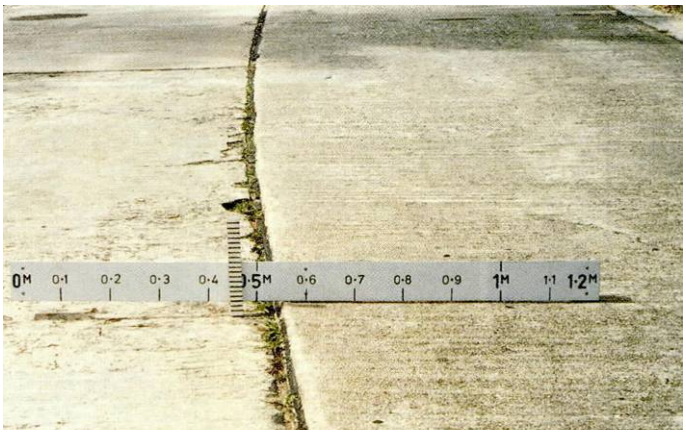
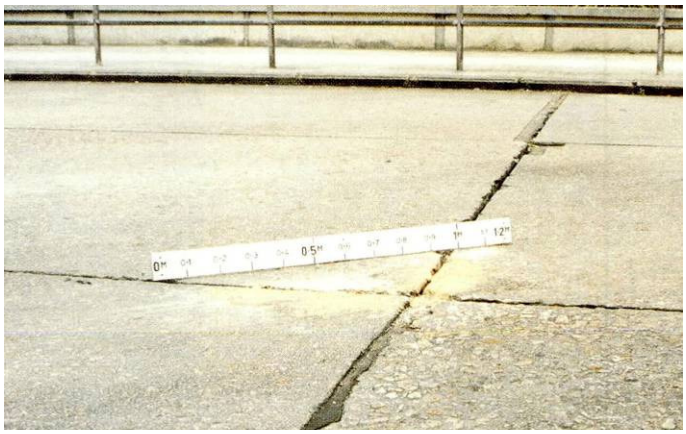


Plate 15

Plate 16



Joint Stepping (Concrete)

Description

Differential vertical displacement of abutting slabs at joints or cracks – Plates 13 & 14 (synonym – faulting)

Attributes

- Difference in elevation (mm) across the joint crack
- Number of slabs affected

Possible causes

- Lack of effective load transfer dowel and tie bars at joints/cracks
- Poor sub-base/subgrade support
- Loss of sub-base material owing to pumping

Recommended remedies

- Total reconstruction of the slab and its subgrade
- Slab lifting in conjunction with either pressure or vacuum grouting undertaken in accordance with specialist sub-contractor's recommendation

Rocking (Concrete)

Description

Vertical movement at joint (or crack) when vehicles pass over – Plate 15, sometimes the vertical movement cause water of slurry to be ejected up through the joints or cracks leading to loss of support which may be referred to as pumping – Plate 16

Attributes

- Cannot usually be quantified

Possible causes

- Lack of support from sub-base
- Lack of or ineffective load transfer dowel or tie bars at joints

Recommended remedies

- Full depth reconstruction
- Pressure or vacuum grouting undertaken in accordance with specialist sub-contractor's recommendation

Joint Sealant Defects (Concrete)

Description

Loss and/or cracking of the seal resulting in foreign material in the joints. Extrusion of sealant leaving mould at joint – Plates 17 to 19

Attributes

- Percentage (by length) of joint affected

Possible causes

(a) Adhesive failure
- Inadequate preparation of the sealing groove
- Faulty or inappropriate sealing material
- Incorrect sealing groove dimensions
- Chilling effect of cold concrete
- Moisture in sealing groove

(b) Cohesion failure
- Age
- Faulty or inappropriate sealing material
- Incorrect sealing groove dimensions
- Lack of bond breaking strip beneath seal

(c) Extrusion
- Overfilled sealing groove
- Incorrect sealing groove dimensions
- Lack of compressible caulking strip at bottom of sealing groove

Recommended remedies

- Remove old seal, thoroughly clean out and prepare groove and re-seal

Surface Spalling (Concrete)

Description

Break down or disintegration of slab surface at edges, joints, corners or cracks – Plates 20 & 21

Attributes

- Maximum depth of spall (mm)
- Length of joint or edge affected (m)
- Area of surface affected (m^2)

Possible causes

- Infiltration of stones, silt or other fine material into the joint groove/crack
- Weak concrete lacking in durability or compaction
- Mechanical damage caused by removal of formwork etc.
- Dowel restraint
- Corrosion of dowels

Recommended remedies

- Thin bonded concrete repair
- Transverse full depth repair
- Full depth corner repair

Plate 17

Plate 18

Plate 19

Plate 20

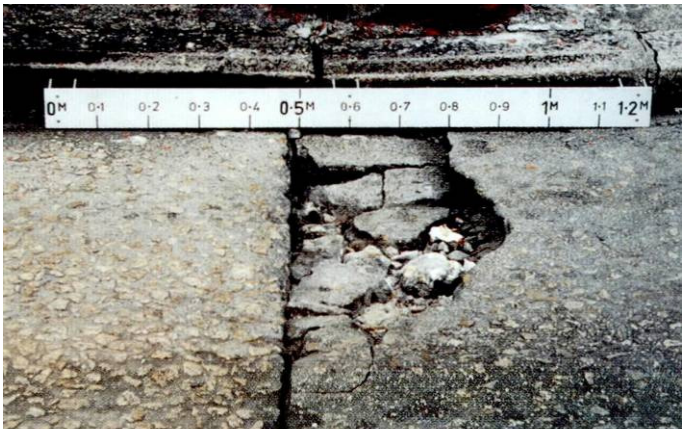


Plate 21

Plate 22

Plate 23

Plate 24

Plate 25

Plate 26

Plate 27

Box-out Spalling (Concrete)

Description

Cracks developed across the slab emanating from manhole and gully recesses – Plates 22 &23

Attributes

- Crack width (mm)
- Area affected (m^2)

Possible causes

- Incorrect positioning of the recess
- Propping of the slab

Recommended remedies

- Narrow cracks in reinforced slabs require no immediate treatment
- Medium cracks in reinforced slabs should be sealed
- Wide cracks in reinforced slabs and all cracks in unreinforced slabs should be remedied by means of bay replacement repair or transverse full depth or corner repair as appropriate

Ravelling (Concrete)

Description

Progressive disintegration of surface; first loss of mortar, then loss of aggregates – Plates 24, 25 & 26 (synonym – scaling)

Attributes

- Depth of ravelling (mm)
- Area affected (m^2)

Possible causes

- Inadequate curing of concrete
- Poor quality concrete
- Overworking of the surface during construction
- Local cement deficiency

Recommended remedies

- Thin bonded surface repair
- Full depth reconstruction for extensive concrete panels

Loss of Surface Texture

Description

Inadequate skid resistance due to surface microtexture or macrotexture, rounded, smooth, polished or glassy appearance – Plate 27 (synonym – slippery surface)

Attributes

- Area of road affected (m^2)

Possible causes

- Abrasion and polished aggregate
- Incorrect selection of aggregates
- Poor construction finishing
- Low-strength mortar worn from surface by traffic

Recommended remedies

- Transverse grooving
- Surface dressing (epoxy based anti-skid surface dressing, textured wearing course, friction course)
- Mechanical roughening

Block Cracks (Bituminous)

Description

Interconnected cracks forming a series of large polygons. Cell sizes are usually greater than 200 mm and can exceed 3000 mm – Plates 28 & 29 (synonym – ladder cracks, map cracks)

Attributes

- Predominant width of crack (mm)
- Predominant cell width (mm)
- Area affected (m^2)

Possible causes

- Hardening and shrinkage of bituminous mixture
- Fatigue cracking in embrittled bituminous wearing course

Recommended remedies

- Cold milling and resurfacing
- Full depth reconstruction
- Hot-in-place recycling

Crocodile Cracks (Bituminous)

Description

Interconnected or interlaced cracks forming a series of small polygons resembling a crocodile hide. Usually associated with wheelpaths and with resilient subgrade. Cell sizes are generally less than 150 mm across but may extend up to 300 mm – Plates 30 & 31 (synonym – alligator cracks, crazing)

Attributes

- Predominant width of crack (mm)
- Predominant cell width (mm)
- Area affected (m^2)

Possible causes

- Saturated base or subgrade
- Rupture of surface course due to traffic load, fatigue, ageing and brittleness of the binder
- Inadequate pavement thickness
- Developing from a surface showing block cracking

Recommended remedies

- Full depth reconstruction – removing the wet material and installing drainage
- Deep inlay
- Hot-in-place recycling
- Skin patches or sealing with emulsion and sand can be used as a temporary repair

Plate 28

Plate 29

Plate 30

Plate 31

Plate 32

Plate 33

Plate 35

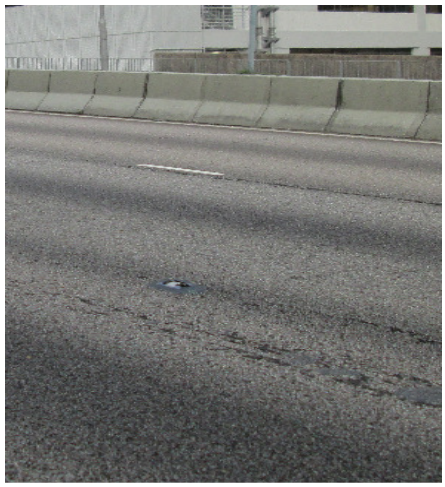


Plate 34

Plate 36

Diagonal Cracks (Bituminous)

Description

An unconnected crack which generally takes a diagonal line across a pavement – Plates 32 & 33

Attributes

- Predominant width of crack (mm)
- Length (m)
- Area affected (m^2)

Possible causes

- Reflection of a shrinkage crack or joint in and underlying cemented material
- Differential settlements between embankments, cuts or structures
- Tree roots
- Service installation

Recommended remedies

- Fill and seal the crack with hot bitumen or other approved crack sealant
- Cold mill and resurface

Longitudinal Cracks (Bituminous)

Description

Crack running longitudinally along the pavement. Can occur singly or as series of almost parallel cracks. Some limited branching may occur – Plates 34, 35 & 36

Attributes

- Width of dominant crack (mm)
- Length of dominant crack (m)
- Spacing (mm)
- Area affected (m^2)

Possible causes

(a) Occurring singly :
- Poor longitudinal joint construction
- Differential movement in the case of pavement widening
- Bitumen hardening
- Incipient slips for roads on slopes or loss of support due to adjacent deep excavation
- Reflection of cracking from joints of underlying concrete pavement

(b) Occurring as a series of almost parallel cracks :
- Volume change of expansive clay subgrade
- Differential settlement of subgrade, e.g. between cut and fill
- Incipient slips for roads on slopes or loss of support due to adjacent deep excavation

Recommended remedies

- Fill and seal the crack with hot bitumen or other approved crack sealant
- Cold mill and resurface
- Improvement of stability of the slopes
- Provision of sufficient lateral support to road excavations

Slippage Cracks (Bituminous)

Description

Half moon or crescent shaped crack in the direction of traffic, commonly associated with shoving – Plates 37 & 38 (synonym – shear crack, crescent crack)

Attributes

- Predominant width of cracks (mm)
- Area affected (m^2)

Possible causes

- Inadequate bond of wearing course with underlying layer or insufficient thickness of wearing course. Inadequate bond may be due to dust, dirt, oil or the absence of a tack coat
- Slippage of wearing course at road locations with high shearing stresses (braking and acceleration zones)
- Low modulus base course

Recommended remedies

- Remove the surface layer from around the crack to the point where there is good bond between the layers. Square up and patch the area with hot-mix bituminous material

Transverse Cracks (Bituminous)

Description

Transverse rupture across the pavement – Plates 39 & 40, for bituminous surfacing over bridge deck or concrete slabs. The crack reflect movement or pattern in the underlying pavement structure and is referred to as reflection crack – Plate 41

Attributes

- Predominant crack width (mm)
- Spacing (mm)
- Length (m)
- Area affected (m^2)

Possible causes

- Construction joint or shrinkage crack (due to low temperature or bitumen hardening) in surfacing course
- Reflection of cracking from lean concrete or concrete bases
- Movement of underlying pavement

Recommended remedies

- Fill and seal the crack with hot bitumen or other approved crack sealant

Plate 37

Plate 38

Plate 39

Plate 40

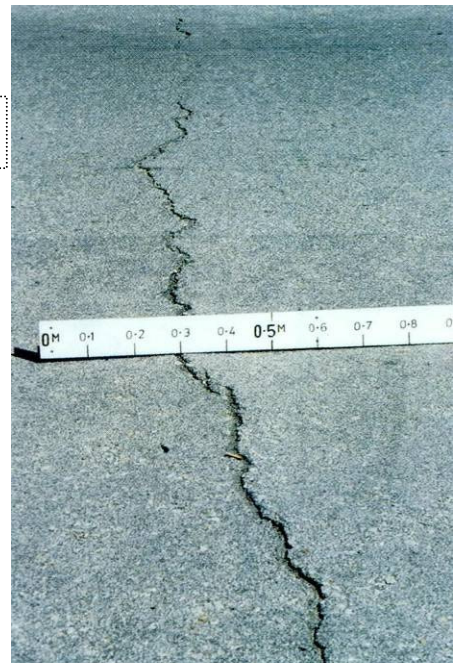


Plate 41

Plate 42

Plate 44

Plate 43

Plate 45

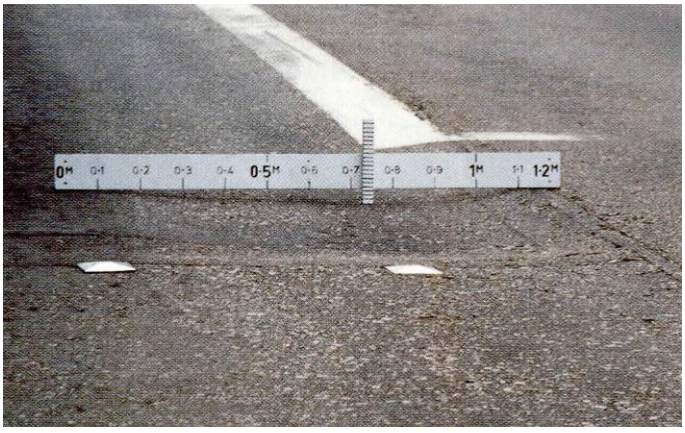


Plate 46

Corrugations (Bituminous)

Description

Transverse undulations, closely and regularly spaced – Plates 42 to 45 (synonym – ripples)

Attributes

- Maximum depth under 1.2m straightedge (mm)
- Crest to crest spacing (mm)
- Length of pavement affected (m)

Possible causes

- Low in service stability of bituminous mix
- Low air voids
- Road locations under high tangential traffic stresses (steep gradients with considerable heavy traffic – braking zones)

Recommended remedies

- Corrugated layers removed by cold milling and resurfacing with polymer modified materials

Depression (Bituminous)

Description

Localised area within a pavement with elevations lower than the surrounding area. May not be confined to wheelpaths and could extend across several wheelpaths – Plate 46

Attributes

- Maximum depth under 1.2m straightedge (mm)
- Area of depression (m^2)

Possible causes

- Settlement of service trenches
- Consolidation of isolated areas of soft or poorly compacted subgrade or embankment materials
- Settlement due to the instability of embankment

Recommended remedies

- Refer the defects to relevant utility undertaking or government department for rectification
- Patching to restore the area to the same grade as the surrounding pavement
- Excavate locally down into fill/poorly compacted subgrade and replace with new compacted fill and pavement

Rutting (Bituminous)

Description

Longitudinal deformation in a wheelpath – Plates 47, 48 & 49 (synonym – channelling)

Attributes

- Maximum depth (under a transverse 1.2 m straight edge)(mm)
- Length (m)

Possible causes

- Inadequate compaction in surfacing or base
- Plastic deformation of bituminous materials (flow) observed longitudinally. It is accelerated by the combined effect of traffic and high temperature.
- Settlement of underlying courses and subgrade under traffic
- Structural failure of subgrade

Recommended remedies

- Levelling the pavement by regulating course and followed by a bituminous overlay
- Dig down to bottom of distress material and replace by stiffer material, e.g. polymer modified stone mastic asphalt
- Localized reconstruction with concrete

Shoving (Bituminous)

Description

Bulging of the road surface generally parallel to the direction of traffic; and/or horizontal displacement of surfacing materials mainly in the direction of traffic where braking or acceleration movement occur – Plates 50 & 51

Attributes

- Maximum depth of bulge under 1.2 m straight edge from high point
- Area affected (m^2)

Possible causes

- Inadequate strength of surfacing or base; aggravated by the combined effect of traffic and high temperature
- Poor bond between pavement layers
- Stop and start of vehicles at intersections
- Pressure exerted by a cement concrete pavement at transition point with bituminous pavement
- Low void content in surfacing or other layers

Recommended remedies

- Square up and remove the shoving for full layer depth followed by patching with stiffer material, e.g. polymer modified stone mastic asphalt
- Localized reconstruction with concrete

Plate 47

Plate 48

Plate 50

Plate 49

Plate 51

Plate 52

Plate 54

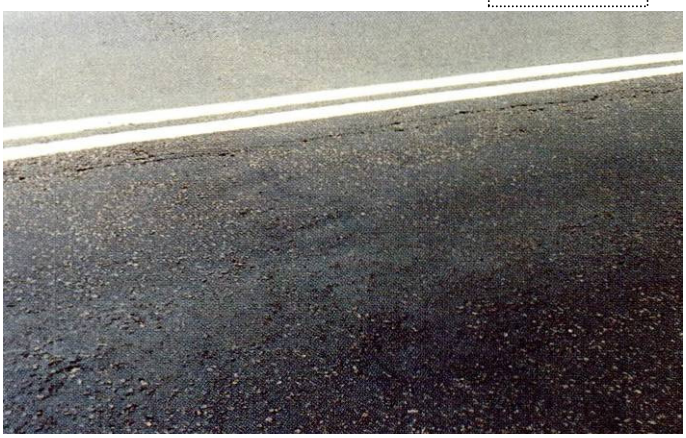
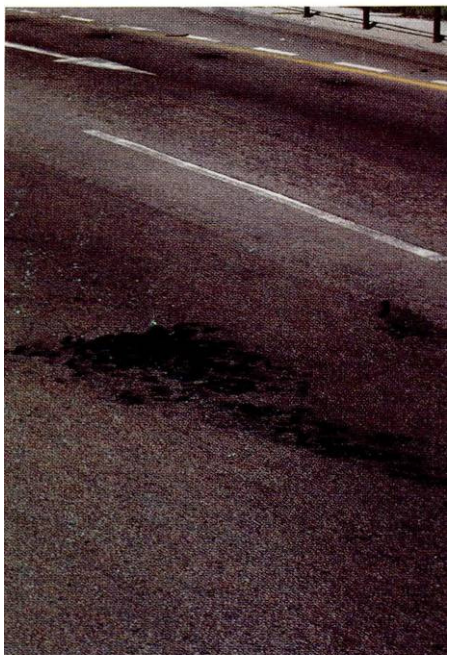


Plate 53



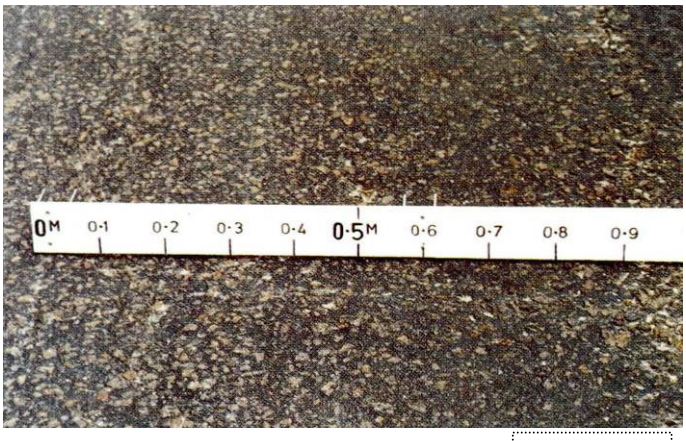


Plate 55

Plate 56

Flushing (Bituminous)

Description

Immersion, partially or completely, of the aggregate into the bituminous binder resulting in a black and brilliant aspect – Plates 52, 53 & 54 (synonym – bleeding, fatting)

Attributes

- Area affected (m^2)
- Percentage (by area) of stone immersed (%)

Possible causes

- Excessive binder content of wearing course and associated low voids
- Penetration of aggregate into base (low strength base)

Recommended remedies

- Cold mill and resurface
- Square patching
- Hot-in-place recycling

Polishing (Bituminous)

Description

Smooth and rounding of the upper surface of the roadstone, usually occurs in the wheeltracks. Identified partly by relative appearance and feel of trafficked and non-trafficked areas. Polished areas will feel relatively smooth and will sometimes be noticeably shiny. The quality of polishing cannot be quantified by observation – Plates 55 & 56

Attributes

- Area affected (m^2)

Possible causes

- Inadequate resistance to polishing of surface aggregates, particularly in areas of heavy traffic movements or where high stresses are developed between surface and tyres
- Normal wear and tear

Recommended remedies

- Cold mill and resurface with standard bituminous wearing course or textured wearing course if high skidding resistance is essential
- Hot-in-place recycling

Ravelling (Bituminous)

Description

Progressive disintegration of the pavement surface by loss of both binder and aggregates – Plates 57, 58 & 59 (synonym – fretting)

Attributes

- Area affected (m^2)

Possible causes

- Separation of bituminous film from aggregates (stripping) due to water action, chemicals (including hydrocarbon oils) or mechanical forces
- Disintegration of aggregates
- Poor construction (segregation, faulty mix design, overheating of mix, bad compaction, inadequate coating of aggregates or aggregates badly embedded)

Recommended remedies

- Cold mill and resurface
- Square patching
- Hot-in-place recycling

Delamination (Bituminous)

Description

Loss of a discrete and large area of the wearing course layer. Usually there is a clear delineation of the wearing course and the layer below – Plate 60 (synonym – peeling)

Attributes

- Thickness of layer(s) removed (mm)
- Area (typical) of individual defects (m^2)
- Number of defects

Possible causes

- Inadequate cleaning or inadequate tack coat before placement of upper layers
- Seepage of water through cracks to break bond between surface and lower layers
- Insufficient thickness or stability of wearing course
- Full damage of surface layer
- Patching over failed pavement

Recommended remedies

- Square patching
- Cold mill and resurface
- Hot-in-place recycling

Plate 57

Plate 58

Plate 59

Plate 60

Plate 61

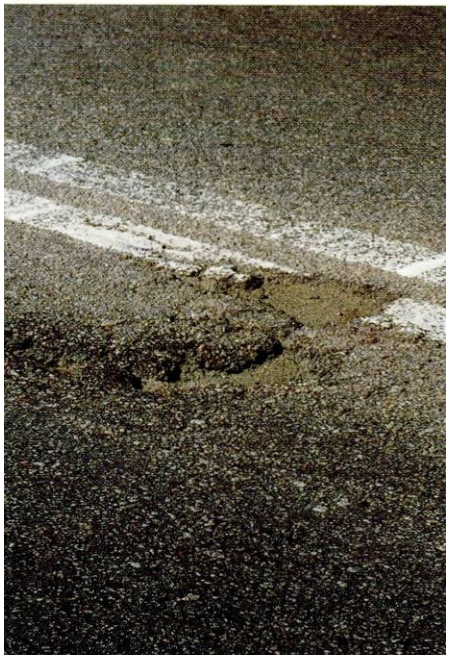


Plate 62

Plate 63

Plate 64

Potholes (Bituminous)

Description

Irregularly shaped holes of various sizes in the pavement – Plates 61 & 62

Attributes

- Depth of potholes (mm)
- Area of pothole (m^2)
- Number

Possible causes

- Developing from another defect such as too thin a surfacing layer, too many fines etc., resulting in disintegration with removal of material by traffic over weakened spots on the surface
- Moisture entry to base course through a cracked pavement surface

Recommended remedies

- Temporary repair involves cleaning the hole and filling it with either instant hole filling material or bituminous wearing course material
- Permanent repair by square patching or hot-in-place recycling

Kerb Defects (Footway)

Description

Misalignment, dislocation, subsidence or any other types of damage of kerb stones – Plates 63 & 64

Attributes

- Length of kerb affected (m)
- Difference in elevation (mm) between subsided kerb and adjoining footway

Possible causes

- Poor sub-base/subgrade support
- Inadequate side support
- Settlement of service trenches

Recommended remedies

- Relay or replace kerb

Blockwork Defects (Footway)

Description

Stepping/dislocation/tilting (plates 65 to 71), missing (plate 72), cracking (plate 73) and depression/uneven surface (plates 74 to 76), surface texture deficiency (plate 77) or reduction in skid resistance of paving blocks or vegetation on paving blocks (plate 78)

Attributes

- Area affected (m^2)

Possible causes

- Loss of sub-base support
- Settlement of service trenches
- Consolidation of isolated areas of soft or poorly compacted subgrade or embankment materials
- Loss of gap filling material
- Shallow cover of underground utilities
- Heavy usage or abrasion
- Vehicle damage
- Wear and tear
- Bulging/lifting action by tree roots
- High pressure water jetting or regular wetting

Recommended remedies

- Remove blocks adjoining the hole, excavate locally down into fill/poorly compacted subgrade, replace with new compacted fill, and relay blocks
- Seal surface, re-fill gaps or add cement in sand bedding material
- Arrange expertise from LCSD/LU to trim existing tree roots, enlarge tree pits or provide alternatives
- Inform utility undertakers to lower or divert their facilities without sufficient cover
- Erect railing or bollard to prevent illegal parking; if not feasible, reconstruct with additional roadbase and thicker blocks
- Replace defective blocks
- Remove weeds from block gaps

Cracking (Footway)

Description

Interconnected or isolated cracks of any shape – Plate 79

Attributes

- Predominant width of crack (mm)
- Area affected (m^2)

Possible causes

- Insufficient slab thickness
- Settlement of sub-base or subgrade
- Vehicle damage

Recommended remedies

- Narrow cracks and medium cracks in all slabs will need to be sealed
- Wide cracks will necessitate either a bay replacement repair or a full depth repair

Plate 65

Plate 66

Plate 68

Plate 67

Plate 69

Plate 70

Plate 71

Plate 72

Plate 73

Plate 74

Plate 75

Plate 76

Plate 77

Plate 78

Plate 79

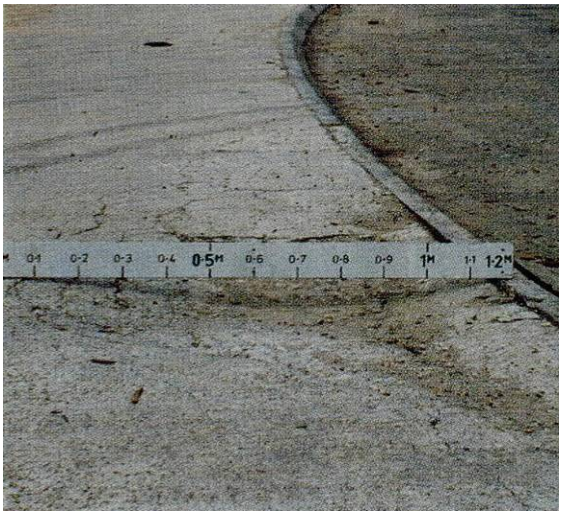


Plate 80

Plate 81

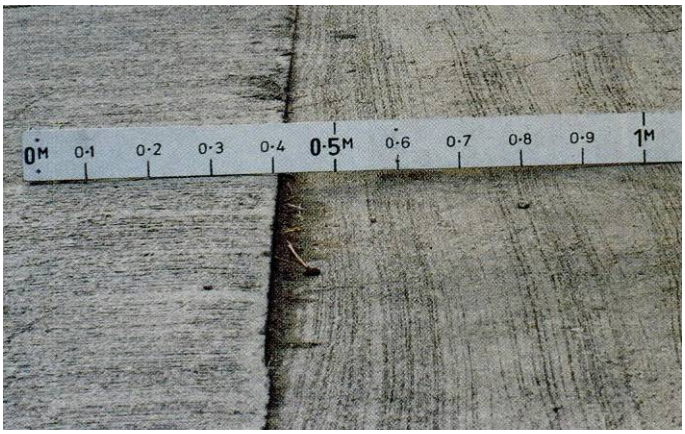


Plate 82

Plate 83

Depression (Footway)

Description

Localised area with elevations lower than the surrounding area – Plate 80

Attributes

- Maximum depth under 1.2 m straightedge (mm)
- Area of depression (m^2)

Possible causes

- Loss of sub-base support
- Settlement of service trenches
- Consolidation of isolated areas of soft or poorly compacted subgrade or embankment materials
- Vehicle damage

Recommended remedies

- Excavate locally down into fill / poorly compacted subgrade and replace with new compacted fill, replace pavement layer or relay blocks
- Patching

Ravelling (Footway)

Description

Progressive disintegration of surface; first loss of mortar (binder), then loss of aggregates – Plate 81

Attributes

- Area affected (m^2)

Possible causes

- Overworking of the surface during construction
- Poor quality concrete
- Inadequate curing of concrete
- Local cement deficiency
- For bituminous paving, refer to Ravelling (Bituminous) on page 38

Recommended remedies

- Reconstruct paving

Uneven Surface (Footway)

Description

Unevenness or ups and downs of the footway surface – Plate 82

Attributes

- Area affected (m^2)

Possible causes

- Poor sub-base/subgrade support
- Poor construction
- Vehicle damage

Recommended remedies

- Reconstruct paving

Ironwork Defects

Description

Cracking (plate 83), damage (plates 84 & 85), misplacing, loosening, sinking (plates 86 & 87) or missing (plates 88 & 89) of drainage / utility covers, gratings and frames

Attributes

- Difference in elevation (mm)
- Number

Possible causes

- Loss of bedding support
- Damaged cover/frame
- Vandalism or theft

Recommended remedies

- Replace the damaged, missing cover/grating/frame
- Adjust the level of the cover/frame

Plate 84

Plate 85

Plate 86

Plate 88

Plate 87

Plate 89