VOLUME 4 GEOTECHNICS AND DRAINAGE
SECTION 2 DRAINAGE

PART 2

TA 80/99

SURFACE DRAINAGE OF WIDE CARRIAGEWAYS

SUMMARY

This Advice Note gives general principles to be followed to determine whether a drainage problem would occur due to improvements to existing roads or to the geometric design of new roads, and gives advice on the measures to be adopted to remedy such a problem. It should be read in conjunction with HD 33/96 (DMRB 4.2) Surface and Sub-surface Drainage Systems for Highways.

INSTRUCTIONS FOR USE

1. This is a new document to be incorporated into the manual.

2. Insert TA 80/99 into Volume 4, Section 2, Part 2.

3. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
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THE DEPARTMENT OF THE ENVIRONMENT FOR
NORTHERN IRELAND

Surface Drainage of Wide Carriageways

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Contents

Chapter

1. INTRODUCTION

General

1.1 This Advice Note gives guidance for the preparation and assessment of drainage designs for carriageway surfaces to limit depths of water during rain storms. It is based on recent research into water depths on wide carriageways. It also gives guidance on measures that can be utilised when problem areas have been identified.

1.2 This Advice Note should be read in conjunction with HD 33 (DMRB 4.2) Surface and Sub-surface Drainage Systems for Highways.

Scope

1.3 The guidance given is applicable to all trunk road projects, including major maintenance, reconstruction and widening. It is applicable to layouts with dual four lane carriageways and also junction areas and changes of superelevation for 2 and 3 lane carriageways.

Implementation

1.4 This Advice Note should be used forthwith for all schemes currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. Design Organisations should confirm its application to particular schemes with the Overseeing Organisation.

Design Principles

1.5 Any water on a road has a lubricating effect and therefore significantly reduces friction between vehicle tyres and the road compared with dry conditions.

1.6 The risk of skidding at any particular location depends on a number of interrelated factors, these can be broadly divided into four groups, i.e.:

(i) Climatic conditions
(ii) Physical characteristics of the road
(iii) Driver behaviour
(iv) Physical characteristics of vehicles

1.7 Table 1 indicates the various factors, their method of control and potential influence by highway designers and driver behaviour.

1.8 Technical standards related to the road surface, including maintenance requirements, are defined in the existing DMRB documents and the Specification for Highway Works. General requirements for highway drainage systems are contained in Volume 4 of the DMRB while requirements and standards related to geometric design are contained in Volume 6 of the DMRB.

1.9 This Advice Note concentrates on road surface drainage designs to limit the depth of water on areas of carriageway.

1.10 The effect of water on the carriageway surface is described in more detail in Chapter 2.
A methodology to assess designs and methods of dealing with potential problem areas are given in Chapter 3.

Table 1 Influences on Resistance to Skidding on Wet Roads

Factor	Control	Influenced by
Water depth	Weather Conditions Highway Design Standards Highway Design	Other Highway Designer Highway Designer
Road Surface Microtexture	Design Standards	Highway Designer
Road Surface Macrotexture	Design Standards	Highway Designer
Road Surface Condition (in service texture)	Maintenance Standards	Highway Designer
Vehicle Speed	Road layout Legislation	Highway Designer Driver behaviour
Tyre Tread Depth	Legislation	Driver behaviour
Tyre Wear (Extent and Form)	Legislation	Driver behaviour
Tyre Pressures	Manufacturer's recommendations	Driver behaviour
Vehicle Specifications	Manufacturers	Other
Tyre Materials	Manufacturers	Other
Tyre Tread Pattern	Manufacturers	Other

2. EFFECT OF WATER ON CARRIAGEWAY SURFACES

Skidding Resistance

2.1 The presence of water on a road surface has a marked effect on friction between vehicle tyres and the road. Due to the lubricating effect of water, the friction known in this context as skidding resistance, is significantly reduced compared with the dry value.

2.2 For a tyre to grip on a wet road, it is necessary for water to be displaced from the contact patch so that the tread can make intimate contact with the microtexture of the road surface. The macrotexture of the surfacing and the tyre tread pattern provide drainage paths. When vehicle speed increases, skidding resistance decreases as the time available for water to be moved from the contact areas reduces.

2.3 If the combination of water depth on a road surface, vehicle speed and tyre condition exceeds the point where tyre tread and surface texture can disperse it, the thickness of the water film in front of the tyre will build up and begin to penetrate the contact patch, reducing the amount of tyre in contact with the road. In the worst case, with a relatively smooth road and limited tyre tread, the tyre may completely lose contact with the road, a condition known as aquaplaning.

2.4 In the UK, major roads are built with a specified minimum texture depth to assist the drainage process and limit the extent to which skidding resistance falls at high speeds. Minimum tyre tread depths are specified by law. For these reasons, aquaplaning is less common than where such controls are not in place.

Drainage Flow Path

2.5 The depth of water on a carriageway surface, for a given intensity of rainfall, depends on the distance and gradient along the flow path. The flow path is the route taken by rainfall runoff from the point at which it falls on the carriageway surface to the carriageway edge. For a carriageway with no longitudinal gradient flow paths will be transverse to the direction of travel. As the longitudinal gradient increases the flow paths will become diagonal. Flow path lengths and gradients will be determined by the combination of carriageway width, carriageway crossfall and longitudinal gradient.

2.6 For evaluation purposes the flow path considered is the maximum distance taken by runoff in reaching the edge of carriageway channel or drainage system. In most cases, except at superelevation roll-overs, this will be represented by rainfall starting at the edge of the carriageway, on the high side of the crossfall.

2.7 The UK standard minimum crossfall is 2.5%. This is one of the higher national standards and is intended to achieve efficient removal of water from carriageways, including undulations caused by rutting. Superelevated sections will generally have crossfalls equal to or greater than 2.5%, however, areas of low crossfall will occur at superelevation rollovers.

2.8 Most roads are designed with minimum longitudinal gradients of 0.5% to allow for adequate water flow along the roadside edge channel and to avoid undue lengths of low gradient at superelevation roll-overs. Designers generally aim to provide sufficient longitudinal gradient along the road centreline in order to provide minimum gradients of 0.5% at carriageway edges at superelevation roll-overs (para 3.7 of TD 9/93 gives advice on avoiding drainage problems at superelevation roll-overs).

2.9 For wide carriageways the most direct drainage flow path, and therefore shortest flow path lengths, occur at zero longitudinal gradient. Therefore low longitudinal gradients can be acceptable, provided that standard crossfalls are maintained and a continuous edge drainage system, or over the edge drainage, utilised. However, it will normally be preferable to provide a longitudinal gradient to assist flow in the drainage system.

2.10 Flow path length increases as longitudinal gradients increase, with a resultant increase in water depths. The rate of increase in water depth is partially offset by the increase in flow path gradient, as it becomes more influenced by the longitudinal gradient and less influenced by the crossfall.

2.11 For lengths of carriageway with consistent geometry, flow path lengths and flow path gradients can be calculated. Figure 2.1 shows flow path lengths for a range of longitudinal gradients and crossfalls on a 4-lane carriageway. Figure 2.2 shows flow path gradients that apply to all carriageway widths. Figure 2.3 indicates the combinations of carriageway width, longitudinal gradient and crossfall that should be avoided if possible.

2.12 For areas of varying width and geometry it will be necessary to consider the carriageway in sections or preferably assess contoured plans of the carriageway surface in order to calculate local flow path lengths and gradients.

2.13 Superelevation roll-overs will require particular attention. The potential problem is indicated by the rapid increases in flow path lengths at low crossfalls. Figure 2.4 indicates the combinations of localised flow path lengths and gradients that should be avoided if possible.

Surface Characteristics

2.14 The dispersal of water from a carriageway surface for particular rainfall intensity also depends on the surfacing material, and in particular, its texture. Rough texture provides depth for water to flow in, but also increases the length of the flow path and introduces many changes in flow direction.

2.15 Under heavy rainfall the least depths of water are likely to occur on relatively smooth surfaces as they become worn, while the greatest depths could occur on new surface dressing with a very deep texture.

2.16 The overall effect on skidding resistance therefore depends upon the combination of the two potentially conflicting factors of amount of texture and depth of water. The most significant characteristic becomes the water depth above the mean level of the texture.

2.17 Porous asphalt has specific characteristics that allow it to contain runoff from low and moderate intensities of rainfall within the surfacing layer. However, when the layer capacity is reached water will emerge and flow over the surface at generally similar depths as on non-porous bituminous surfaces. Advice on the use and drainage of Porous Asphalt is given in HA 79 (DMRB 4.2).

Effect of Carriageway Edge Markings

2.18 Carriageway surface drainage can be affected by continuous edge markings, particularly where raised rib markings are used. Continuous lines should not exceed a 3mm thickness at the drainage exits to superelevation roll-over areas with flat sections, to permit water to drain over the line during storms.

2.19 Where the longitudinal fall on any section of road is less than 0.67% (1 in 150) gaps should be provided in raised rib markings to prevent the risk of ice formation. Where renewal of markings is being undertaken, existing lines should be removed at the drainage exit to a superelevation roll-over area where the longitudinal fall is less than 0.67%.

FIG 2.1 FLOW PATH LENGTHS
(4 No 3.65 Lanes)

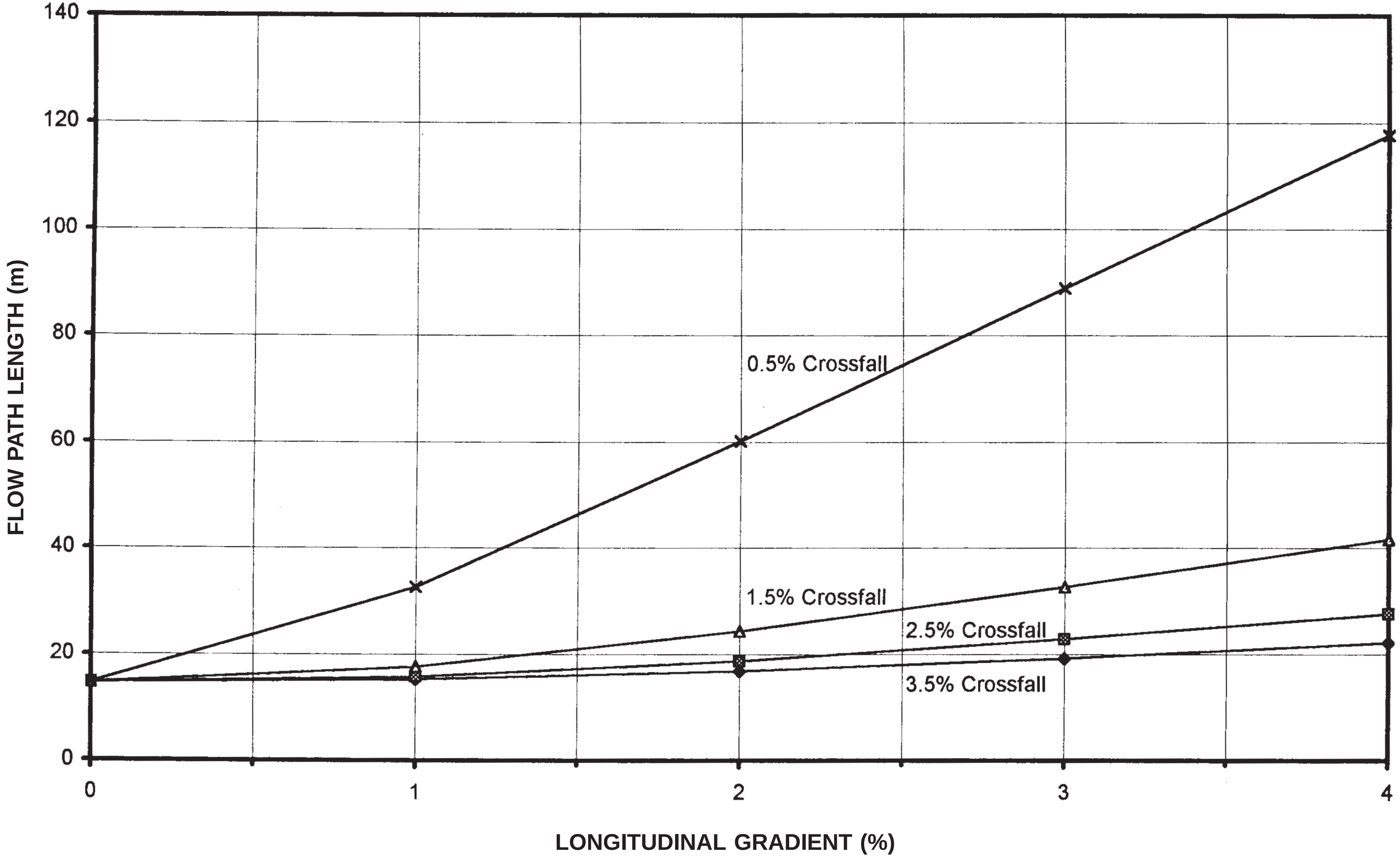


FIG 2.2 FLOW PATH GRADIENTS

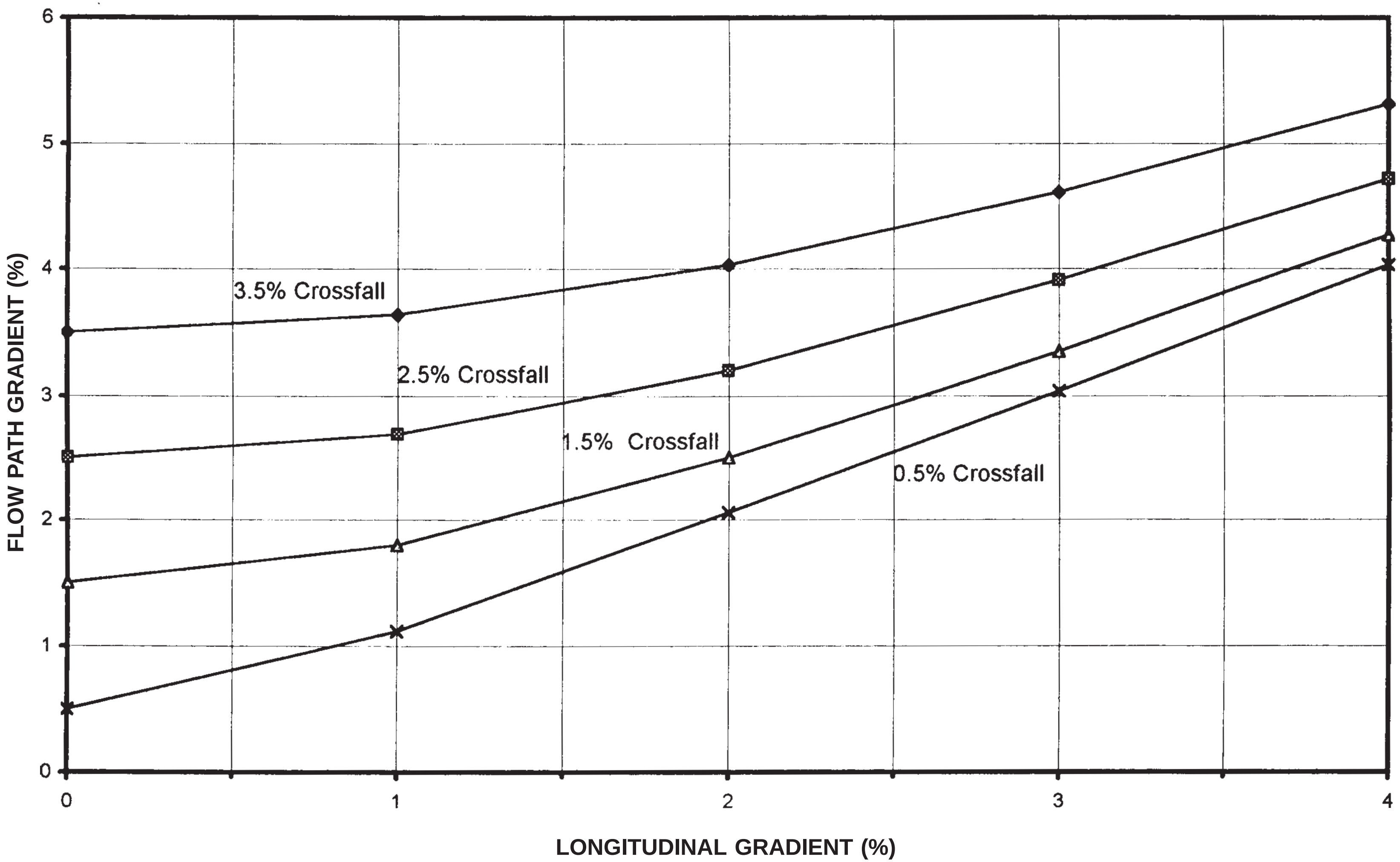
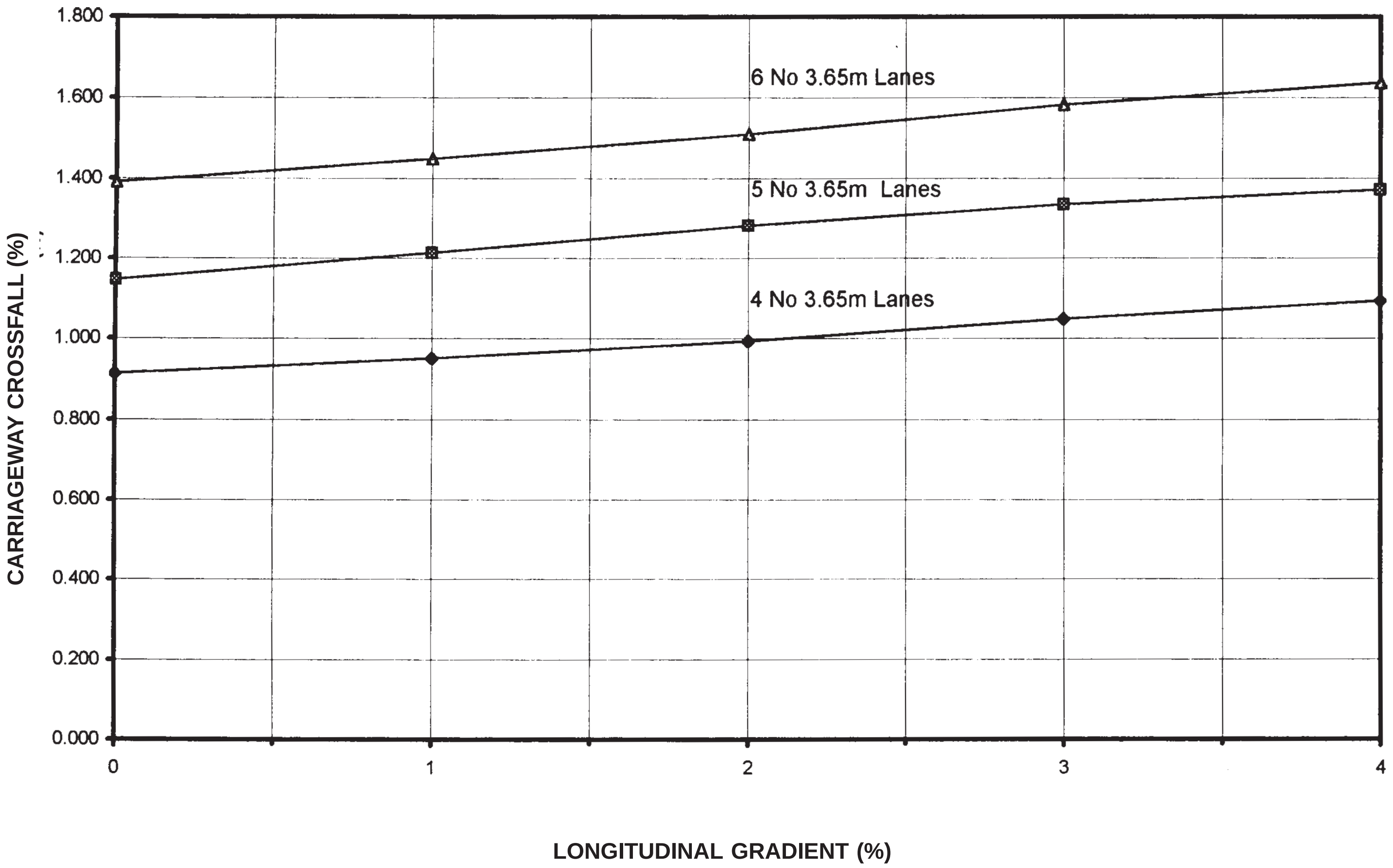
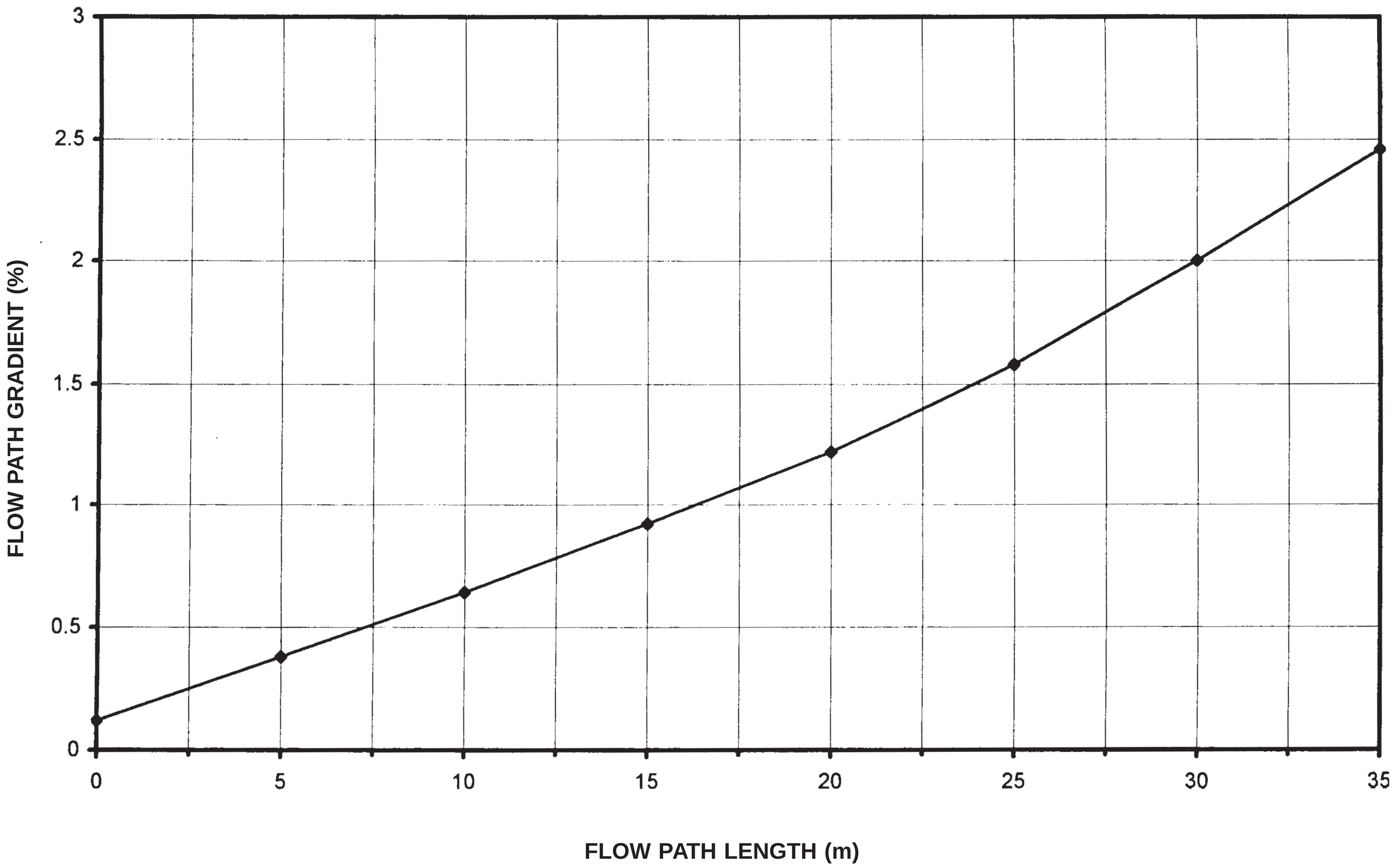


FIG 2.3 EFFECT OF GEOMETRIC DESIGN ON DRAINAGE



Note: The combinations of Longitudinal Gradient and Crossfall below the curves are likely to allow greater depths of water than are normally acceptable on road layouts and should be avoided.

FIG 2.4 EFFECT OF FLOW PATH LENGTH AND FLOW PATH GRADIENT ON DRAINAGE



Note: The combinations of Flow Path Length and Flow Path Gradient below the curve are likely to allow greater depths of water than are normally acceptable on road layouts and should be avoided.

3. ASSESSMENT & DESIGN METHODOLOGY

Introduction

3.1. The importance of considering drainage as a fundamental part of highway design is noted in various current Standards, including TD9, TD16 and HD33 (DMRB 4.2.3).

3.2 It is important that potential constraints to horizontal and vertical alignment are identified early in the design process, preferably before Orders are published. Figures 3.1 and 3.2 show the required assessment process to be followed for carriageways between junctions and Junction/Interchange areas respectively.

Assessment

Assess Drainage Paths and Drainage

3.3 Drainage paths and gradients should be established by consideration of the proposed geometry. Contoured plans will often be the best method for this especially for complicated layouts and superelevation roll-overs. The results should be assessed by comparison with the graphs in Chapter 2.

3.4 For the purpose of this Advice Note, the term Drainage problems is used to refer to water when it is not adequately drained or if water depth on the road surface reduces skidding resistance.

3.5 Where the assessment indicates a potential problem area consideration should be given to reduction of drainage path lengths and/or steepening drainage path gradients. The reduction of drainage path lengths is likely to have a greater effect than improving gradients. Where it is not possible to avoid areas with low gradients, particularly at roll-overs, designers should endeavour to minimise the size of such areas.

Design

Adjustments to Vertical and Horizontal Design

3.6 The first consideration should be given to adjustments to the proposed design while keeping to the normal parameters for gradient and crossfall within current Standards & Advice. While this may be relatively straightforward for new alignments, it is likely to be more difficult for improvements to existing roads, such as widening. In these cases the potential effects of changes to geometry should be compared with the effects of the alternative solutions discussed in this Advice Note.

Increasing Crossfall and Continuation of Superelevation

3.7 Carriageway crossfalls can be increased from the standard 2.5% (1 in 40) to 2.85% (1 in 35) on lengths of carriageway that are straight or have radii well in excess of those requiring elimination of adverse camber. Applying a higher crossfall on only the additional lanes of a widened carriageway does not significantly reduce the depth of water at the edge of the carriageway but can increase the capacity of the road edge channel where kerbs are used.

3.8 Increased crossfalls can also be applied on superelevated sections, and by maintenance of superelevation on straight or nearly straight sections, between superelevated curves of the same hand. This also has the advantage of reducing the number of superelevation roll-over areas and simplifies the drainage design. Superelevation could also be extended to ensure that roll-over areas occur at locations with appropriate longitudinal gradient.

Crown Lines

3.9 Where surface drainage problems exist, rolling crowns (crowns that run diagonally) may be appropriate and they have been used on some motorways and Trunk Roads. Care should be taken in the design, specification and construction of rolling crowns; especially where the option considered is a rigid pavement. Where carriageway crown lines are used, crossfalls should be reduced to 2% for one lane width either side of the crown to limit the change of angle to 4%. Crown lines can be more easily introduced between hardshoulders and superelevated carriageways and at merges and diverges where lane gains and lane drops occur.

3.10 Staggered roll-overs to introduce reversal of superelevation in stages have been carried out successfully where occupation of sites has only been possible on a lane by lane basis in order to minimise disruption to traffic during construction. However, the construction problems associated with implementation of rolling and staggered crowns will normally make their use undesirable unless all other options have been rejected.

Linear Drainage

3.11 Use of longitudinal drainage within nosings at merges and diverges is permitted by current Standards HD 33 (DMRB 4.2). It also notes the importance of safety and structural adequacy, including during maintenance activities when hardshoulders and noses are trafficked.
See specification and construction details MCHW Volume 1-3.

3.12 Where drainage problems at wide merge and diverge areas cannot be solved by additional drainage in nosings, consideration should be given to use of linear drainage within ghost island hatched areas, which are not normally trafficked. Safety and reliability under more regular, although occasional, trafficking should be addressed.
Linear drainage should not be used within hardshoulders or hard strips as these areas are more regularly used by traffic during maintenance operations.

Figure 3.1

**Design and Assessment Methodology
Carriageway between Junctions**

Assessment

(i) Develop preliminary designs following current design standards
(ii) Consider combinations of carriageway widths, horizontal and vertical alignment, crossfall and superelevation
(iii) Calculate flow path lengths and gradients, using contour maps if necessary
(iv) Assess results by comparison with graphs in Chapter 2 to identify if there is a problem (refer to Para 3.2)

↓

Possible drainage problems

↓

YES | **NO**

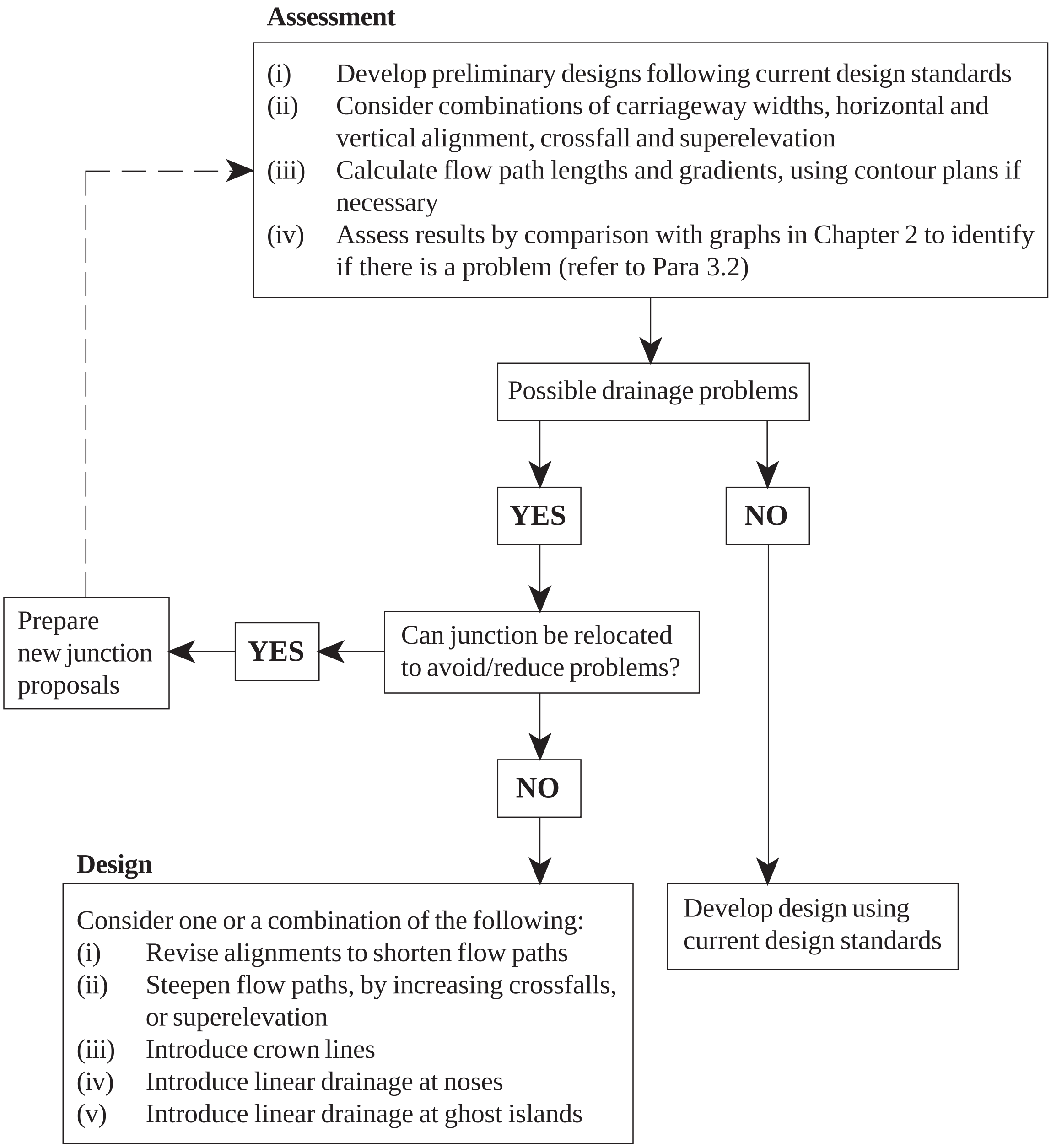
Design

Consider one or a combination of the following:
(i) Revise alignments to shorten flow paths
(ii) Steepen flow paths, by increasing crossfalls, continuing superelevation, increasing rate of rollover, extending superelevation
(iii) Increase crossfall or superelevation
(iv) Introduce crown lines

(NO →) Develop design using current design standards

Figure 3.2

Design and Assessment Methodology
Junction Areas



4. REFERENCES

Design Manual for Roads and Bridges (DMRB)

HD 33 Surface and Sub-surface Drainage Systems for Highways (DMRB 4.2)

HA 37 Hydraulic Design of Road Edge Surface Water Channels (DMRB 4.2)

HA 39 Edge of Pavement Details (DMRB 4.2)

HA 79 Edge of Pavement Details for Porous Asphalt Surface Courses (DMRB 4.2)

HD 26 Pavement Design (DMRB 7.2)

HD 27 Pavement Construction Methods (DMRB 7.2)

TA 57 Roadside Features (DMRB 6.3)

TD 9 Highway Link Design (DMRB 6.1)

TD 16 Geometric Design of Roundabouts (DMRB 6.2)

Manual of Contract Documents for Highway Works (MCHW)

Specification for Highway Works (MCHW 1)

Notes for Guidance on the Specification for Highway Works (MCHW 2)

Highway Construction Details (MCHW 3)

5. ENQUIRIES

All technical enquiries or comments on this document should be sent in writing as appropriate to:

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