VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 2 PAVEMENT DESIGN AND CONSTRUCTION

PART 1

HD 24/06

TRAFFIC ASSESSMENT

SUMMARY

This Standard sets out the method for the estimation and calculation of traffic loading for the design of road pavements. Design aids are provided for easy determination of the number of standard axles for use in the pavement design standard HD 26 (DMRB 7.2.3). It supersedes HD 24/96.

INSTRUCTIONS FOR USE

1. Remove Contents pages from Volume 7 and insert new Contents pages for Volume 7 dated February 2006.

2. Remove HD 24/96 from Volume 7, Section 2 which is superseded by this Standard and archive as appropriate.

3. Insert HD 24/06 into Volume 7, Section 2.

4. Please 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.

CORRECTIONS WITHIN DESIGN MANUAL FOR ROADS AND BRIDGES NOVEMBER 2006

SUMMARY OF CORRECTION – HD 24/06 Volume 7, Section 2, Part 1 TRAFFIC ASSESSMENT

Corrections have been made to figures in Tables 2.5 and 2.6 and also to equations. Paragraph 2.16 has also been revised.

We apologise for the inconvenience caused.

Highways Agency
November 2006

London: The Stationery Office

THE HIGHWAYS AGENCY

SCOTTISH EXECUTIVE

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

WELSH ASSEMBLY GOVERNMENT
LLYWODRAETH CYNULLIAD CYMRU

DRD
Department for
Regional Development
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THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Traffic Assessment

Summary: This Standard sets out the method for the estimation and calculation of traffic loading for the design of road pavements. Design aids are provided for easy determination of the number of standard axles for use in the pavement design standard HD 26 (DMRB 7.2.3). It supersedes HD 24/96.

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REGISTRATION OF AMENDMENTS

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Contents

1. INTRODUCTION

Mandatory Sections

1.1 Sections of this document which form part of the Standards of the Overseeing Organisations are highlighted by being contained in boxes. These are the sections with which the Design Organisations must comply, or must have agreed a suitable departure from Standard with the relevant Overseeing Organisation. The remainder of the document contains advice and enlargement which is commended to Design Organisations for their consideration.

General

1.2 This Part covers the estimation of design traffic for new roads, and the estimation of past and future design traffic for the maintenance of existing roads.

1.3 In the UK, road pavement structural wear resulting from traffic (i.e. fatigue cracking within the bound pavement layers and/or excessive subgrade deformation) and pavement designs (for particular materials) are intrinsically related. Pavement designs for flexible and rigid pavements are presented in HD 26 (DMRB 7.2.3).

1.4 Road pavement structural wear in the UK is estimated using wear factors based on vehicle axle loads. Wear factors have been produced using actual loads measured with Weigh-in-motion (WIM) sensors installed on the highway network.

Implementation

1.5 This Part shall be used forthwith on all schemes for the construction, improvement and maintenance of trunk roads, including motorways, currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay. Design organisations must confirm its application to particular schemes with the Overseeing Organisation.

Use in Northern Ireland

1.6 For use in Northern Ireland, this Standard must be applicable to those roads designated by the Overseeing Organisation.

2. CALCULATION OF DESIGN TRAFFIC

2.1 This method shall be used to determine the pavement design traffic for new and existing roads. If it is considered inappropriate for any reason then further advice must be sought from the Overseeing Organisation.

2.2 The design traffic is the commercial vehicle loading over the design period expressed as the number of equivalent standard (80kN) axles; it is calculated using the commercial vehicle flow, traffic growth and wear factors.

2.3 This method for calculating design traffic incorporates the latest research on wear and a traffic growth estimation based on the National Road Traffic Forecast (NRTF, 1997). The background to the method is reported in TRL Report PPR 066 (2006).

2.4 The factors used to calculate the Design Traffic (T) are as follows:

- Commercial Vehicle Flow at opening (F);
- Design Period (Y);
- Growth Factor (G);
- Wear Factor (W); and
- Percentage of vehicles in the heaviest loaded lane (P).

If reliable data for all these factors are not available, a chart giving an acceptable design value is described in Paragraph 2.16.

Commercial Vehicle Flow (F)

2.5 A key element in the design is the flow of commercial vehicles. This is expressed as Annual Average Daily Flow (AADF) and is the flow measured in one direction (1-way flow). If the traffic is measured in both directions (2-way flow) this is converted into AADF assuming a 50:50 directional split, unless traffic counts or studies show a significant directional bias.

2.6 Commercial vehicles are defined as those over 3.5 tonnes gross vehicle weight. The structural wear caused by lighter traffic (i.e. bikes, cars and light goods vehicles) is considered to be negligible.

2.7 Table 2.1 identifies the commercial vehicle (cv) classes and categories to be used, as defined in the COBA manual (DMRB 13.1).

2.8 For **new road schemes**, the commercial vehicle class/category count data shall be determined from traffic studies using the principles described in the Traffic Appraisal Manual (DMRB 12.1.1).

2.9 For **existing road schemes** (i.e. maintenance design or re-alignment), a classified count shall be carried out over a 12, 16 or 24 hour period. This must be converted to an AADF using the principles given in the COBA manual (DMRB 13.1.4). For Scotland, use NESA (DMRB 15.1.5).

2.10 To determine the design traffic, the AADF of commercial vehicles per day (cv/d) in one direction, at scheme opening (or for existing road schemes, the current flow) and the proportion in the OGV2 category shall be used.

Table 2.1 Commercial Vehicle Classes and Categories

Commercial vehicle (cv)	cv class*	cv category
	Buses and Coaches	PSV
	2-axle rigid	OGV1
	3-axle rigid	
	3-axle articulated	OGV2
	4-axle rigid	
	4-axle articulated	
	5-axle articulated	
	6 (or more) -axle articulated	

* Classed by axles in contact with the road
PSV = Public Service Vehicle
OGV = Other Goods Vehicle

Example

Count data converted to AADF using COBA 11 classification.

Buses and Coaches	32	PSV
2 axle Rigid	467	OGV1
3 axle Rigid	67	”
3 and 4 axle Articulated	274	OGV2
4 axle Rigid	49	”
5 axle Articulated	938	”
6 or more axle	530	”

Total Flow	2,357	cv/d
Total OGV2 Flow	1,791	cv/d
Percentage OGV2	76%	

2.11 Typical average commercial vehicle flow compositions are given in Table 2.2 (Department for Transport, 2003). There is a wide variation in the values for the proportion of commercial vehicles on the trunk road network and the values in the table may be exceeded in many cases.

Table 2.2 Typical Commercial Vehicle Flow Compositions

Road Type	Motorway or Trunk	Principal
Percentage of Commercial Vehicles (% cv) within AADF	11	4
% OGV2	65	38

2.12 For new road designs, the percentage of OGV2 vehicles shall be obtained by calculation or modelling but shall not be less than the percentage given in Figure 2.1.

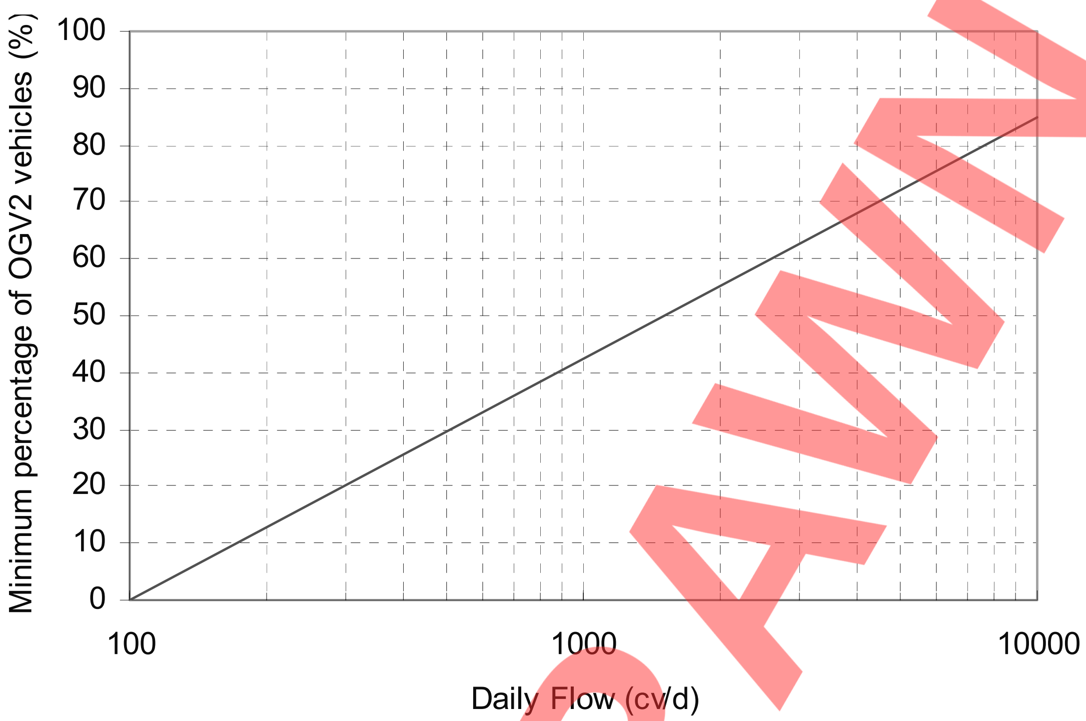


Figure 2.1 Minimum Percentage of OGV2 Class Vehicles for New Construction

Design Period (Y)

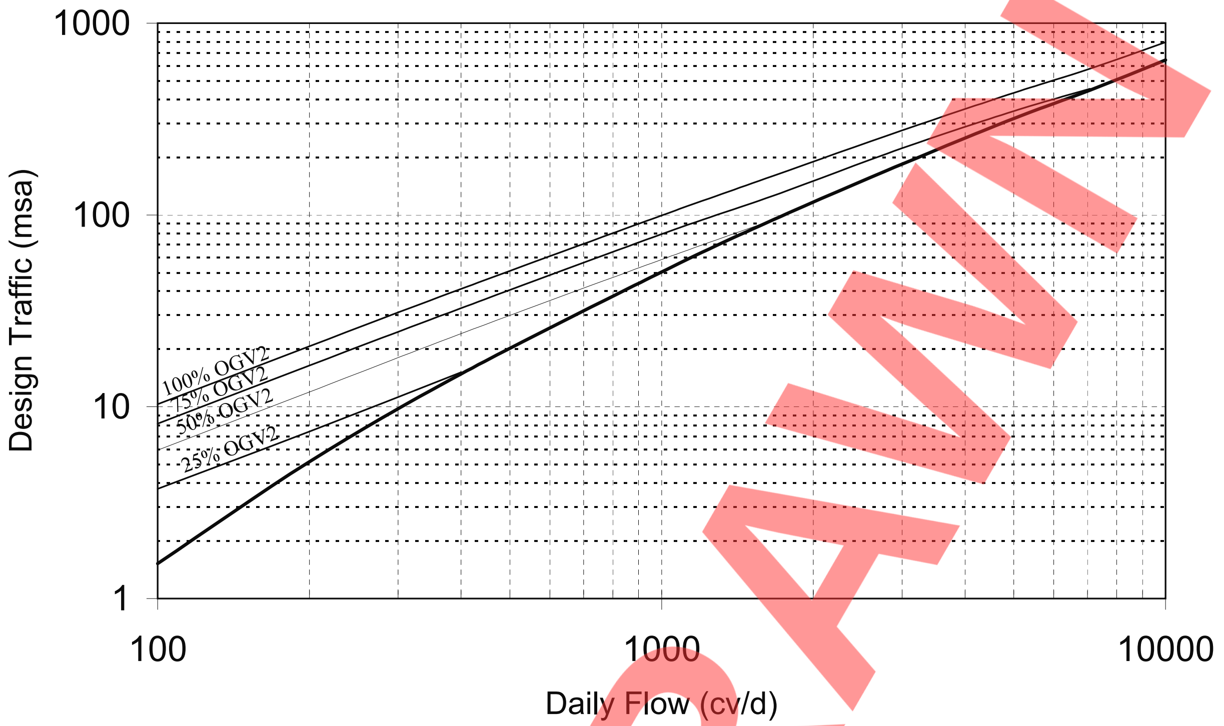
2.13 The number of years over which traffic is to be assessed shall be selected. For past traffic, this will generally be the number of years since opening or last major structural maintenance. For future design traffic this shall generally be 40 years. Other design periods may be used if proven to be economic and agreed with the Overseeing Organisation.

2.14 Whole life cost considerations are important to the selection of the design period. A 40-year design period without structural maintenance has generally proven to be the most economic, particularly where traffic flow is high.

Standard Design Traffic Calculation for New Construction

2.15 For new carriageways, all lanes, including the hard shoulder, shall be designed to the same standard as the heaviest loaded lane. The actual traffic in other lanes is not considered.

2.16 Where additional information (see Paragraphs 2.17 onwards) is not available, Figure 2.2 together with Figure 2.5 shall be used to calculate the design traffic for the total traffic flow (i.e. for all lanes in one direction) for a design period of 40-years. In this case, the remainder of Chapter 2 can be omitted.



Daily Flow (one-way) (cv/d)

Figure 2.2 Design Traffic for 40 Year Life

Growth Factor (G)

2.17 The National Road Traffic Forecast (NRTF) is published in eight year intervals and predicts future traffic trends. The 1997 NRTF growth lines shown for OGV1+PSV and for OGV2 (the bold lines on Figure 2.3) shall be used unless specific alternative and more reliable local data are available.

2.18 Past growth, where known from traffic counts, can also be used to give an indication of future trends in a particular situation, but only where data over at least a 10 year period are available, since averaging over a shorter period may give misleading results.

2.19 For each cv class or category, traffic growth can be calculated which is dependent on the selected design period and the growth rate. The growth factor represents the proportional difference between the average vehicle flow over the entire design period and the present flow (or flow at opening). The growth factor for future traffic shall be found by using Figure 2.3.

2.20 If past traffic is being calculated, the applicable growth factor is given in Figure 2.4. Bold lines are shown for OGV1+PSV and OGV2 which represent national trends. These bold lines are to be used unless actual growth rates are known for a specific cv class or category.

2.21 If a series of past traffic counts is available it is preferable to use these to calculate mean vehicle flows for each class between count dates. Under such circumstances a growth factor for past traffic is unnecessary and therefore effectively becomes 1.0.

2.22 The graphs for past traffic do not include adjustments for historic changes in wear factors. As an approximation, the current vehicle wear factors have been used to calculate growth factors.

Wear Factor (W)

2.23 The structural wear to a road associated with each vehicle that passes increases significantly with increasing axle load. Although alternative methods are available, structural wear for pavement design purposes in the UK is taken as being proportional to the 4th power of the axle load, i.e:

$$\text{Wear/axle} \propto L^4$$
(L = axle load)

Thus, a 50% increase in axle load results in a five-fold increase in calculated structural wear.

2.24 A 'standard axle' is defined as an axle exerting or applying a force of 80kN. The fourth power law is used to equate the wear caused by each vehicle type to the number of equivalent standard axles, to give the structural wear factor of that vehicle.

2.25 Sets of wear factors have been produced for maintenance and new design cases; the wear factors for the new design case are higher than for the maintenance case in order to allow for the additional risk that arises from the additional uncertainty with traffic predictions for new designs.

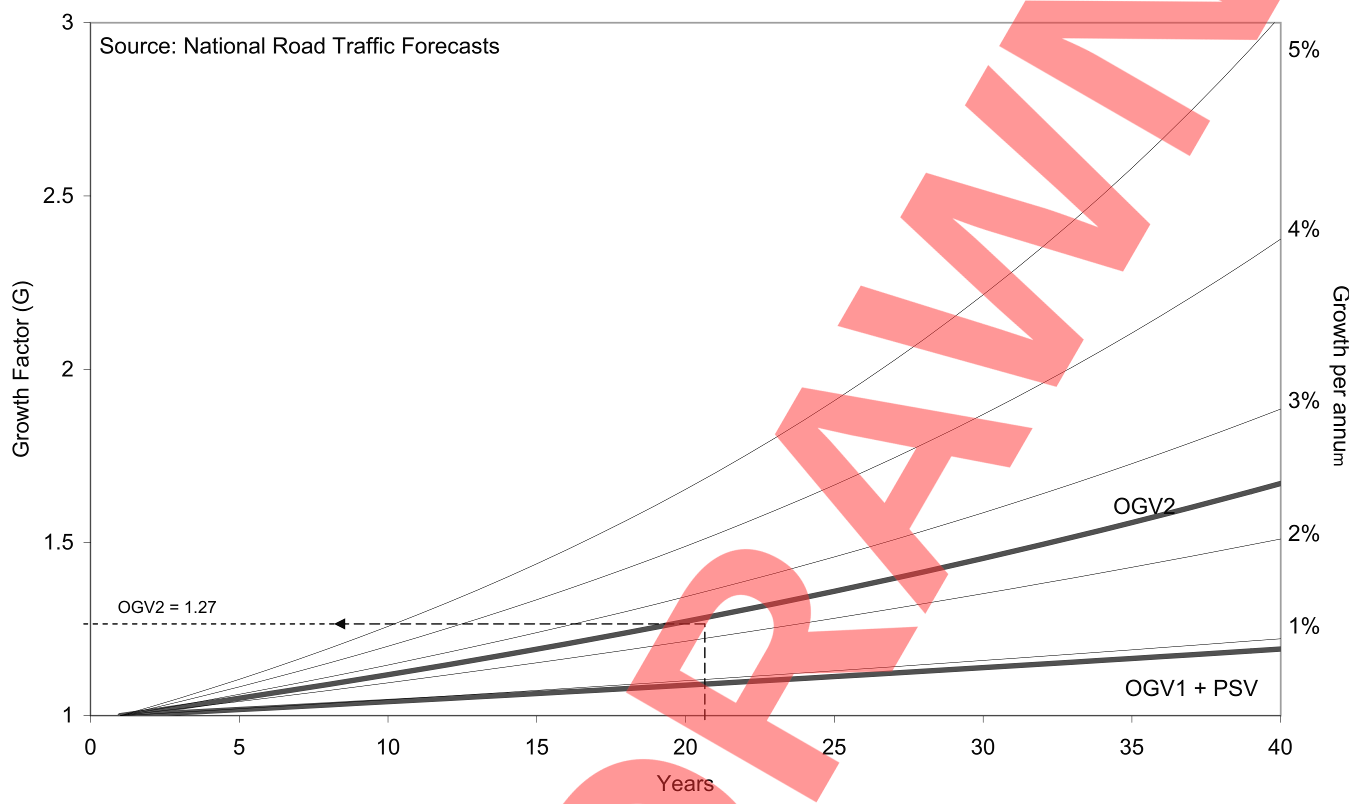
2.26 The wear factors to be used for the Maintenance (W_M), and New design (W_N) cases, are shown in Table 2.3. The derivation of these wear factors is given in TRL Report PPR 066 (2006).

Table 2.3 Wear Factors for cv Classes and Categories

Wear Factors	Maintenance W_M	New W_N
Buses and Coaches	2.6	3.9
2-axle rigid	0.4	0.6
3-axle rigid	2.3	3.4
4-axle rigid	3.0	4.6
3 and 4-axle articulated	1.7	2.5
5-axle articulated	2.9	4.4
6-axle articulated	3.7	5.6
OGV1 + PSV	0.6	1.0
OGV2	3.0	4.4

2.27 In Table 2.3, the data used to calculate the wear factors were obtained from twelve core census sites located throughout the Highways Agency's trunk road network and from traffic data collected in 2003.

2.28 The wear factors for the new road design case, W_N, shall be used to calculate design traffic for all new road and pavement construction projects including road widening.



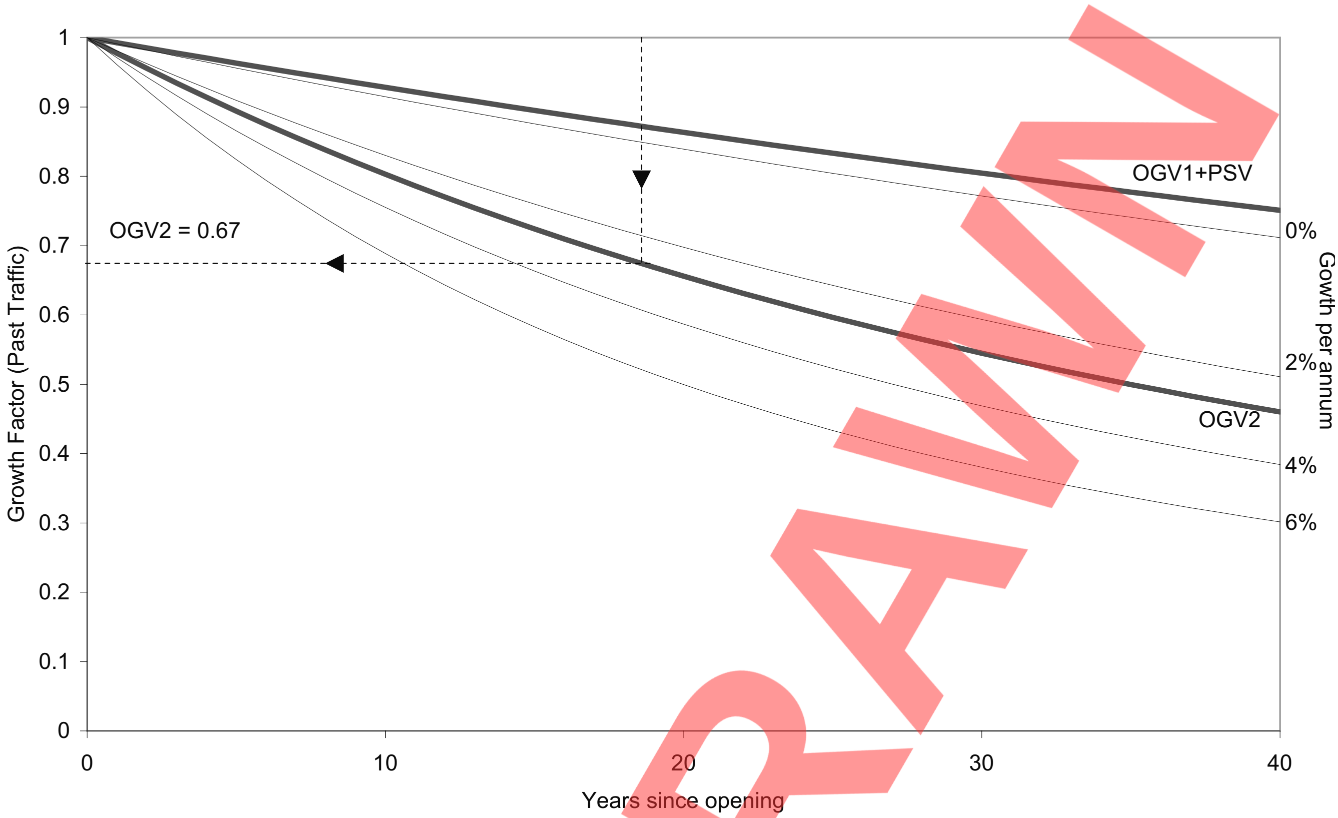
Extracted Growth Factor (G) values assuming 1997 NRTF growth:

Design Period (Years)	5	10	15	20	25	30	35	40
OGV1 + PSV	1.02	1.04	1.06	1.09	1.11	1.14	1.17	1.19
OGV2	1.05	1.12	1.19	1.27	1.36	1.45	1.56	1.67

Figure 2.3 Derivation of Growth Factor (G) for Future Traffic from the NRTF (1997)

Example

Considering OGV2
Design Period 20 years
Growth Factor 1.27



Years since opening	5	10	15	20	25	30	35	40
OGV1 + PSV	0.96	0.93	0.90	0.86	0.83	0.80	0.78	0.75
OGV2	0.89	0.80	0.72	0.66	0.60	0.54	0.50	0.46

Figure 2.4 Derivation of Growth Factor (G) for Past Traffic

Example

Considering OGV2
Time since Opening 19 years
Growth Factor 0.67

Percentage of Commercial Vehicles in Heaviest Loaded Lane (P)

2.29 As stated in Paragraph 2.15, all lanes are designed as for the heaviest loaded lane. For new and existing carriageways with 2 or more lanes in one direction, the proportion of vehicles in the most heavily loaded lane shall be estimated using Figure 2.5.

2.30 The heaviest loaded lane for carriageways with 2 or 3 lanes is typically the nearside lane referred to as Lane 1. The heaviest loaded lane for carriageways with 4 or more lanes is not always Lane 1. Junctions with lane drops and lain gains will considerably influence the flow of vehicles in each lane.

Percentage of Commercial Vehicles in Other Lanes

2.31 For maintenance purposes it is sometimes necessary to estimate the traffic in the other lanes separately.

2.32 The distribution of traffic between lanes can, under certain circumstances, vary considerably between different roads. The distribution can be influenced by traffic flow, by the proximity to junctions and on approaches to traffic signals and roundabouts.

2.33 For 2-lane roads, all traffic not in Lane 1 will be in Lane 2. For 3-lane roads, it should be considered that all commercial vehicles not in Lane 1 are in Lane 2 although commercial vehicles up to 7.5 tonnes are permitted to use the right hand lane. For roads with 4 or more lanes, data from a core census site or a traffic count shall be necessary to confirm the distribution of traffic across each lane.

Design Traffic (T)

2.34 The future cumulative flow, in terms of million standard axles (msa) for cv class T_i can be determined according to the following equation:

$T_i = 365 \times F \times Y \times G \times W \times P \times 10^{-6}$ msa

Design Traffic (T) = ΣT_i

Where:

F = Flow of Traffic (AADF) for each traffic class at opening
Y = Design Period (Years)
G = Growth Factor (from Figure 2.3)
P = Percentage of vehicles in the heaviest loaded lane (Figure 2.5)
W = Wear Factor for each traffic class (W_M for Maintenance or W_N for New Design Case) from Table 2.3

For past traffic, Y = years since opening; G = Growth Factor according to Figure 2.4.

If the calculation of traffic in other lanes is for maintenance purposes, P shall be the percentage of the commercial vehicles determined to be in each lane, refer to paragraph 2.33.

2.35 For new design cases, the calculation of design traffic is typically made by category, e.g.: OGV1 and OGV2.

2.36 Design traffic calculations can be made using the form shown in Table 2.4 and Tables 2.5 and 2.6 present two examples using Table 2.4 to calculate the design traffic (for new design and for maintenance).

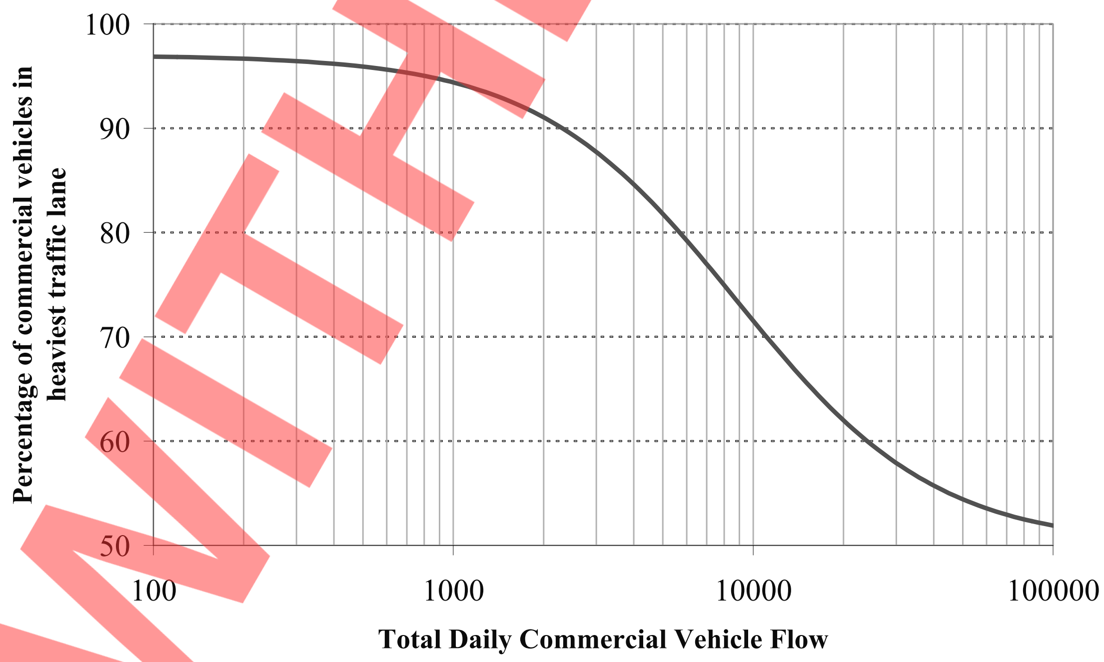


Figure 2.5 Percentage of Commercial Vehicles in Heaviest Loaded Lane (P)

Commercial vehicle class or category	AADF (F)	Growth Factor (G)	Wear Factor (W)	Weighted Annual Traffic (by class or by category)
Either by class Buses and Coaches (PSV) OGV1 2 axle rigid 3 axle rigid OGV2 4 axle rigid 3 and 4 axle artic 5 axle artic 6 axle artic				
Or by category* OGV1 + PSV OGV2				
Total daily flow (cv/d)		Total weighted annual traffic		
T = 365×F×Y×G×W×P×10⁻⁶msa		Percentage of vehicles in heaviest traffic lane (P)		
		Design Period (Y)		
		Design Traffic (T)		

Weighted annual traffic = $365 \times F \times G \times W \times 10^{-6}$msa

Design Traffic (T) = Total weighted annual traffic $\times Y \times P$

* See Paragraph 2.12

Table 2.4 Table for the Calculation of Design Traffic

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Commercial vehicle class or category	AADF (F)	Growth Factor (G)	Wear Factor (W) W_M	Weighted Annual Traffic (by class or by category)
Either by class				
Buses and Coaches (PSV)	77	1.09	2.6	0.08
OGV1				
2 axle rigid	914	1.09	0.4	0.15
3 axle rigid	59	1.09	2.3	0.05
OGV2				
4 axle rigid	53	1.27	3.0	0.07
3 and 4 axle artic	302	1.27	1.7	0.24
5 axle artic	1,021	1.27	2.9	1.37
6 axle artic	574	1.27	3.7	0.98
Or by category*				
OGV1 + PSV				
OGV2				
Total daily flow (cv/d)	3,000	Total weighted annual traffic		2.95 msa

$T = 365 \times F \times Y \times G \times W \times P \times 10^{-6}$ msa	Percentage of vehicles in heaviest traffic lane (P)	86%
	Design Period (Y)	20 years
	Design Traffic (T)	51 msa

Weighted annual traffic = $365 \times F \times G \times W \times 10^{-6}$ msa

Design Traffic (T) = Total weighted annual traffic $\times Y \times P$

* See Paragraph 2.12

- Maintenance calculation made by class
- Commercial vehicle flow of 3,000 vehicles per day
- The design period is 20 years
- NRTF growth has been assumed

Table 2.5 Traffic Calculation Example for Maintenance

Commercial vehicle class or category	AADF (F)	Growth Factor (G)	Wear Factor (W) / W_N	Weighted Annual Traffic (by class or by category)
Either by class Buses and Coaches (PSV) OGV1 2 axle rigid 3 axle rigid OGV2 4 axle rigid 3 and 4 axle artic 5 axle artic 6 axle artic				
Or by category*				
OGV1 + PSV	744	1.19	1.0	0.323
OGV2	456	1.67	4.4	1.223
Total daily flow (cv/d)	1,200	Total weighted annual traffic		1.55 msa

$T = 365 \times F \times Y \times G \times W \times P \times 10^{-6}$ msa

Percentage of vehicles in heaviest traffic lane (P)	94%
Design Period (Y)	40 years
Design Traffic (T)	58 msa

Weighted annual traffic = $365 \times F \times G \times W \times 10^{-6}$ msa

Design Traffic (T) = Total weighted annual traffic $\times Y \times P$

* See Paragraph 2.12

- New design calculation made by category
- Commercial vehicle flow of 1,200 vehicles per day
- The design period is 40 years
- NRTF growth has been assumed

Table 2.6 Traffic Calculation Example for New Design

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3. REFERENCES AND BIBLIOGRAPHY

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

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