Design Manual for Roads and Bridges

Pavement
Design

CD 224
Traffic assessment

(formerly HD 24/06)

Revision 0

Summary
This document sets out the method for calculating traffic loading for the design of road pavements.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Mar 2020	CD 224 replaces HD 24/06. This full document has been re-written to make it compliant with Highways England drafting rules and has also been updated and simplified.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes HD 24/06, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This document covers the calculation of design traffic (commercial vehicle pavement loading over the design period) for new trunk roads, including motorway schemes and for the maintenance of existing trunk roads, including motorways.

In the UK, pavement designs for particular materials are intrinsically related to the road pavement structural wear resulting from traffic (i.e. fatigue cracking within the bound pavement layers and/or excessive sub-grade deformation). Pavement designs for flexible and rigid pavements are presented in CD 226 [Ref 2.N].

Road pavement structural wear in the UK is calculated using wear factors based on axle loads. Wear factors have been calculated using loads measured using weigh-in-motion (WIM) sensors installed on the road network.

The background to the method is given in TRL Report (TRL PPR 066 [Ref 1.I])

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 4.N] apply to this document.

Abbreviations and symbols

Abbreviations

Abbreviation	Definition
AADF	Annual average daily flow (1-way traffic)
AADT	Annual average daily traffic (2-way traffic)
COBA	COst benefit analysis [program]
cv	Commercial vehicles (over 3.5 tonnes maximum gross vehicle weight)
msa	Million standard axles
OGV	Other goods vehicle (over 3.5 tonnes maximum gross vehicle weight). Where no other data are available, it can be assumed that vehicles over 6.6m long are OGVs.
OGV1	Other goods vehicle 1 (2 and 3-axle rigid vehicles)
OGV2	Other goods vehicle 2 (4-axle rigid vehicles and articulated vehicles with any number of axles)
PSV	Public service vehicle
WebTAG	Web-based transport analysis guidance

Symbols

Symbol	Definition
F	Commercial vehicle flow
F_i	Traffic flow after i years
G	Growth factor
P	Percentage of vehicles in the heaviest loaded lane
R	Annual growth rate
T	Design traffic
Tc	Weighted annual traffic for vehicle category c
W	Wear factor
W_M	Wear factor for maintenance
W_N	Wear factors for new road schemes
Y	Design period

Terms and definitions

Terms

Term	Definition
Design traffic	The commercial vehicle loading over the design period of a pavement. It is expressed as the number of equivalent 80kN standard axles.
New road schemes	Road construction schemes, including road widening, where there is greater uncertainty about traffic flows.
Standard axle	An axle exerting or applying a force of 80kN. The structural wear associated with each vehicle increases with increasing axle load. Although alternative methods are available, structural wear for pavement design in the UK is taken as being proportional to the 4th power of the axle load. The number of standard axles is the estimated structural wear factor for the vehicle class.

1. Scope

Aspects covered

1.1 This document defines the method that shall be used to calculate traffic loading for the design of road pavements.

Implementation

1.2 This document shall be implemented forthwith on all schemes involving the construction, improvement and maintenance of pavements on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 4.N].

Use of GG 101

1.3 The requirements contained in GG 101 [Ref 4.N] shall be followed in respect of activities covered by this document.

2. Calculation of design traffic

2.1 The following factors shall be used to calculate the design traffic (T):

1) commercial vehicle flow (F);
2) design period (Y);
3) growth factor (G);
4) wear factor (W); and
5) percentage of vehicles in the heaviest loaded lane (P).

Commercial vehicle flow

2.2 The annual average daily flow (AADF) of commercial vehicles, at scheme opening (or for existing road schemes, the current flow) shall be used to calculate the commercial vehicle flow (F), for the different vehicle classes.

NOTE *The AADF is the flow measured in one direction (1-way flow).*

2.3 Annual average daily traffic (AADT) shall be converted into AADF assuming a 50:50 directional split, unless traffic counts or studies show a directional bias.

NOTE *The AADT is the traffic measured in both directions.*

2.4 Table 2.4 shows the commercial vehicle classes and categories that shall be used in the calculation of design traffic DVSA Simplified Guide [Ref 1.N].

Table 2.4 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		

New road schemes

2.5 For new road schemes, the commercial vehicle flows by class / category shall be determined from traffic transport analysis using the principles described in the Department for Transport's WebTAG Unit M3.1 [Ref 3.N].

2.6 The flow of other goods vehicle 2 (OGV2) vehicles as a percentage of all commercial vehicles shall be obtained by calculation or modelling.

2.7 The resulting percentage of OGV2 vehicles shall not be less than 70 per cent.

Existing road schemes (maintenance design or re-alignment)

2.8 Where there are existing AADF data for the scheme, they shall be used to determine the commercial vehicle flow.

2.9 Where there are no existing AADF data, a classified count shall be carried out and converted to AADF using the principles given in the COBA Manual (COBA [Ref 5.N]).

Design period

2.10 For new road schemes, the design period (Y) is the number of years over which traffic is to be assessed, and shall be defined according to the design life given in CD 226 [Ref 2.N].

2.11 For existing road schemes, where past traffic is used, the design period (Y) shall be the number of years since opening or the last major structural maintenance of the carriageway.

Growth factor

Future traffic

2.12 The growth factors for future traffic shown in Table 2.12 shall be used.

Table 2.12 Growth factors (G) for future traffic

Design period (years)	5	10	15	20	25	30	35	40
OGV1 + PSV	1.02	1.05	1.08	1.11	1.14	1.17	1.21	1.24
OGV2	1.04	1.10	1.16	1.23	1.30	1.37	1.46	1.54
All commercial vehicles	n/a							1.45

NOTE 1 The growth factor (G) represents the difference between the average annual vehicle flow over the design period and the present flow (or flow at opening).

NOTE 2 The growth factors (G) are based on scenario 5 of the road traffic forecasts 2015 (RTF 2015 [Ref 2.I]). The equivalent annual growth rates (R) are 1.07% for OGV1, 2.10% for OGV2 and 1.54% for all commercial vehicles.

2.13 Where no information on commercial vehicle classes and categories is available, a 40 year design period (Y) and a growth factor (G) of 1.45 shall be used.

2.14 Where there is a requirement to calculate the traffic flow (F) after i years (for example, when calculating an appropriate polished stone or aggregate abrasion value), the annual growth rate (R) shall be used as in Equation 2.14.

Equation 2.14 Traffic flow

$$F_i = F \times \left((1+R)^i\right)$$

NOTE For example, after 10 years the OGV2 flow (R = 2.10%) becomes 1.021^{10} = 1.23 times the current flow (F). This is larger than the equivalent growth factor (G) for a 10 year design period (1.10 - see Table 2.12) as it is the flow in year 10 rather than the average across the 10 years.

Past traffic

2.15 Where classified local traffic counts are available, they shall be used to calculate traffic flows for each class / category and year.

2.16 Where classified local traffic counts are not available, national traffic statistics shall be used.

2.17 A growth factor of 1.0 shall be used for calculations of past traffic.

Wear factor

2.18 The wear factors given in Table 2.18 shall be used.

Table 2.18 Wear factors for commercial vehicle classes and categories

	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	1.3	1.9
OGV2	3.2	4.9
All commercial vehicles (70% OGV2)	2.7	4.0

2.19 The wear factors for maintenance, W_M, shall be used to calculate design traffic for all maintenance schemes including re-alignment.

2.20 The wear factors for new road schemes, W_N, shall be used to calculate design traffic for all new road construction schemes including road widening.

2.20.1 For motorway schemes requiring widening and re-alignment, the use of W_N and W_M may be applicable.

Percentage of commercial vehicles in the heaviest loaded lane

2.21 For carriageways with 2 or more lanes in one direction, the proportion of vehicles in the most heavily loaded lane (P) shall be calculated using Table 2.21.

Table 2.21 Assumed proportion of commercial vehicles in the heaviest loaded lane

Number of lanes (in one direction)	Flow (F) (cv/day)	P (%)
2 or 3	Up to 5,000	P = 100 - (0.0036 x F)
	Over 5,000 up to 25,000	P = 89 - (0.0014 x F)
	Over 25,000	P = 54
4 or more	Up to 10,500	P = 100 - (0.0036 x F)
	Over 10,500 up to 25,000	P = 75 - (0.0012 x F)
	Over 25,000	P = 45

Percentage of commercial vehicles in other lanes

2.22 Where required for maintenance purposes, the traffic in the other lanes shall be based on the assumptions in Table 2.22.

Table 2.22 Assumed distribution of commercial vehicles in other lanes

2-lanes	All traffic not in the heaviest loaded lane is in the other lane.
3-lanes	All commercial vehicle traffic is in lanes 1 and 2 - traffic not in the heaviest loaded lane is in the other lane.
4 or more lanes	Classified traffic count data are needed to confirm the distribution of traffic across each lane. No commercial vehicle traffic is in the right hand lane.

Design traffic

2.23 The future cumulative design traffic, in terms of million standard axles (msa), for commercial vehicle class or category c shall be calculated according to Equation 2.23a and 2.23b.

Equation 2.23a Weighted annual traffic

$$T_c = 365 \times F \times G \times W \times 10^{-6} msa$$

Equation 2.23b Design traffic (T)

$$T = \sum T_c \times Y \times P$$

where:

T_c	Weighted annual traffic for commercial vehicle category c
F	Commercial vehicle flow (AADF)
G	Growth factor
W	Wear factor (W_M for maintenance or W_N for new design)
Y	Design period (years)
P	Percentage of commercial vehicles in the heaviest loaded lane
T	Design traffic

2.23.1 Design traffic calculations may be made using the proforma given in Table 2.23.1.

Table 2.23.1 Table for the calculation of design traffic

Commercial vehicle class or category	**AADF (F)**	**Growth factor (G)**	**Wear factor (W)**	**Weighted annual traffic (T_c)**
			W_M or W_N	
Either by class buses and coaches (PSV)				
OGV1 2 axle rigid 3 axle rigid				
OGV2 4 axle rigid 3 and 4 axle articulated 5 axle articulated 6 axle articulated				
Or by category OGV1 + PSV OGV2				
Total daily flow (cv/day)		**Total weighted annual traffic** $(\sum T_c)$		
		Percentage of vehicles in heaviest loaded lane (P)		
		Design period (Y)		
		Design traffic (T)		

NOTE 1 An example calculation for maintenance schemes (by class) is given in Table 2.23.1N1.

Table 2.23.1N1 Design traffic calculation example for maintenance schemes

Commercial vehicle class	**AADF (F)**	**Growth factor (G) (20 years)**	**Wear factor (W)**	**Weighted annual traffic (T_c)**
			W_M	
Buses and coaches (PSV)	77	1.11	2.6	0.08
OGV1 2 axle rigid 3 axle rigid	 914 59	 1.11 1.11	 0.4 2.3	 0.15 0.05
OGV2 4 axle rigid 3 and 4 axle articulated 5 axle articulated 6 axle articulated	 53 302 1,021 574	 1.23 1.23 1.23 1.23	 3.0 1.7 2.9 3.7	 0.07 0.23 1.33 0.93
Total daily flow (cv/day)	3,000	**Total weighted annual traffic** $(\sum T_c)$		2.87 msa
		Percentage of vehicles in heaviest loaded lane (P)		89.2%
		Design period (Y)		20 years
		Design traffic (T)		51 msa

NOTE 2 An example calculation for new road schemes where minimum 70% OGV2 applies (by category) is given in Table 2.23.1N2.

Table 2.23.1N2 Traffic calculation example for road schemes (minimum 70% OGV2 applied)

Commercial vehicle category	**AADF (F)**	**Growth factor (G) (40 years)**	**Wear factor (W)**	**Weighted annual traffic (T_c)**
			W_N	
OGV1 + PSV OGV2	360 840	1.24 1.54	1.9 4.9	0.31 2.31
Total daily flow (cv/day)	1,200	**Total weighted annual traffic** $(\sum T_c)$		2.62 msa
		Percentage of vehicles in heaviest loaded lane (P)		95.7%
		Design period (Y)		40 years
		Design traffic (T)		100 msa

NOTE 3 An example calculation for new road schemes where there is no information on commercial vehicle categories is given in Table 2.23.1N3.

Table 2.23.1N3 Traffic calculation example for new road schemes where there is no information on vehicle categories

Commercial vehicle category	**AADF (F)**	**Growth factor (G)**	**Wear factor (W)**	**Weighted annual traffic (T_c)**
			W_N	
Total daily flow (cv/day)	2,000	1.45	4.0	4.23 msa
		Percentage of vehicles in heaviest loaded lane (P)		92.8%
		Design period (Y)		40 years
		Design traffic (T)		157 msa

3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Driver and Vehicle Standards Agency. Department for Transport. DVSA Simplified Guide, 'A Simplified Guide to Lorry Types and Weights'
Ref 2.N	Highways England. CD 226, 'Design for new pavement construction'
Ref 3.N	Department for Transport (UK). WebTAG Unit M3.1, 'Highway Assignment Modelling'
Ref 4.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 5.N	Mott MacDonald. COBA, 'The COBA User Manual'

4. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	Transport Research Laboratory. VM Atkinson, D Merrill and N Thom. TRL PPR 066, 'Pavement wear factors'
Ref 2.I	Department for Transport. RTF 2015, 'Road Traffic Forecasts 2015'