NA+A1:2020 to BS EN 1991-2:2003

Incorporating Corrigendum No. 1

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UK National Annex to Eurocode 1: Actions on structures —

Part 2: Traffic loads on bridges

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National Annex (informative) to BS EN 1991-2:2003, Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges

Introduction

This document has been prepared by BSI Subcommittees B/525/1, *Actions (loadings) and basis of design*, and B/525/10, *Bridges*. In the UK it is to be used in conjunction with BS EN 1991-2:2003.

NA.1 Scope

This document gives:

a) the UK decisions for the Nationally Determined Parameters described in the following subclauses of BS EN 1991-2:2003:

— **1.1** (3)
— **2.2** (2) Note 2
— **2.3** (1) Note and (4) Note
— **3** (5)
— **4.1** (1) Note 2 and (2) Note 1
— **4.2.1** (1) Note 2 and (2)
— **4.2.3** (1)
— **4.3.1** (2)(b) Note 2
— **4.3.2** (3) Notes 1 and 2 and (6)
— **4.3.3** (2) and (4)
— **4.3.4** (1)
— **4.4.1** (2), (3) and (6)
— **4.4.2** (4)
— **4.5.1** (Table 4.4a Notes a and b)
— **4.5.2** (1) Note 3
— **4.6.1** (2) Note 2c), (3) Note 1 and (6)
— **4.6.4** (3)
— **4.6.5** (1) Note 2
— **4.6.6** (1)
— **4.7.2.1** (1)
— **4.7.2.2** (1) Note 1
— **6.4.6.1.1** (6) Table 6.4 and (7)
— **6.4.6.1.2** (3) Table 6.5
— **6.4.6.3.1** (3) Table 6.6
— **6.4.6.3.2** (3)
— **6.4.6.3.3** (3) Notes 1 and 2
— **6.4.6.4** (4) and (5)
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— **6.5.4.6**
— **6.5.4.6.1** (1) and (4)
— **6.6.1** (3)
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— Annex D (2)

b) the UK decisions on the status of BS EN 1991-2:2003 informative annexes;

c) references to non-contradictory complementary information.

NA.2 Nationally determined parameters

NA.2.1 Complementary conditions [BS EN 1991-2:2003, 1.1 (3)]

The models given in **NA.2.34** and **NA.3.1** should be used for the design of buried structures, retaining walls and tunnels, subject to road traffic loading.

NA.2.2 Infrequent values of loads [BS EN 1991-2:2003, 2.2 (2) Note 2]

Infrequent values of loading should not be used.

NA.2.3 Appropriate protection against collision [BS EN 1991-2:2003, 2.3 (1)]

The requirements for protection against collision from road and rail traffic should be determined for the individual project. See also **NA.4**.

NA.2.4 Impact forces due to boats, ships or aeroplanes [BS EN 1991-2:2003, 2.3 (4)]

For impact forces due to boat and ship impacts, refer to BS EN 1991-1-7 and its National Annex.

NA.2.5 Bridges carrying both road and rail traffic [BS EN 1991-2:2003, 3 (5)]

The rules for bridges intended for both road and rail traffic should be determined for the individual project and should be based on, where appropriate, the load models for road and rail traffic as defined in BS EN 1991-2 and this National Annex.

NA.2.6 Models for loaded lengths greater than 200 m [BS EN 1991-2:2003, 4.1 (1) Note 2]

Load Model 1 may be used for loaded lengths up to 1 500 m.

NA.2.7 Weight restricted bridges [BS EN 1991-2:2003, 4.1 (2)]

For road bridges where effective means are provided to strictly limit the weight of any vehicle, specific load models may be determined for the individual project.

NA.2.8 Complementary load models [BS EN 1991-2:2003, 4.2.1 (1)]

Complementary load models and rules for their application may be determined for the individual project. See also **NA.2.34**.

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NA.2.9 Models for special vehicles [BS EN 1991-2:2003, 4.2.1 (2)]

Complementary load models for special vehicles and rules for their application may be determined for the individual project. See also **NA.3.1**.

NA.2.10 Conventional height of kerbs [BS EN 1991-2:2003, 4.2.3 (1)]

The minimum value of the height of a kerb for defining the carriageway width should be taken as 75 mm.

NA.2.11 Use of Load Model 2 [BS EN 1991-2:2003, 4.3.1 (2) (b)]

No additional information is provided.

NA.2.12 Adjustment factors α for Load Model 1 [BS EN 1991-2:2003, 4.3.2 (3) Notes 1 and 2]

The adjustment factors α for the Tandem System and the UDL should be taken from Table NA.1.

Table NA.1 — *Adjustment factors α_Q and α_q for Load Model 1*

Location	α_Q for tandem axle loads	α_q for UDL loading
Lane 1	$\alpha_{Q1} = 1,0$	$\alpha_{q1} = 0,61$ (See note)
Lane 2	$\alpha_{Q2} = 1,0$	$\alpha_{q2} = 2,2$
Lane 3	$\alpha_{Q3} = 1,0$	$\alpha_{q3} = 2,2$
Other lanes	–	$\alpha_{qn} = 2,2$
Remaining area	–	$\alpha_{qr} = 2,2$

NOTE α_{q1} *should be taken as 1,0 for* ***4.4.1****(2) of BS EN 1991-2*

NA.2.13 Use of simplified alternative Load Models [BS EN 1991-2:2003, 4.3.2 (6)]

The simplified alternative load models given should not be used.

NA.2.14 Adjustment factor β for Load Model 2 [BS EN 1991-2:2003, 4.3.3 (2)]

The recommended value for β_Q should be used.

NA.2.15 Wheel contact surface for Load Model 2 [BS EN 1991-2:2003, 4.3.3 (4)]

The contact surface of each wheel in Load Model 2 should be taken as a square of sides 0,40 m.

NA.2.16 Load Model 3 (Special Vehicles) [BS EN 1991-2:2003, 4.3.4 (1)]

The following defines Load Model 3 and its conditions of use. They do not describe actual vehicles but have been calibrated so that the effects of the nominal axle weights, multiplied by the Dynamic Amplification Factor, represent the maximum effects that could be induced by actual vehicles in accordance with the Special Types General Order (STGO) and Special Order (SO) Regulations.

The choice of the particular STGO or SO model vehicle for the design of structures on motorways, trunk roads and other minor roads should be determined for the individual project.

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NA.2.16.1 Basic models for STGO vehicles

The following three *SV* model vehicles simulate vertical effects of different types of STGO vehicles with nominal axle weights not exceeding 16,5 tonnes.

NA.2.16.1.1 *SV80*

The *SV80* vehicle is intended to model the effects of STGO Category 2 vehicles with a maximum gross weight of 80 tonnes and a maximum basic axle load of 12,5 tonnes. Figure NA.1(a) gives the basic axle loads, the plan and axle configuration for the *SV80* vehicle.

NA.2.16.1.2 *SV100*

The *SV100* vehicle is intended to model the effects of STGO Category 3 vehicles with a maximum gross weight of 100 tonnes and a maximum basic axle load of 16,5 tonnes.

Figure NA.1(b) gives the basic axle loads, the plan and axle configuration for the *SV100* vehicle.

NA.2.16.1.3 *SV196*

The *SV196* model represents the effects of a single locomotive pulling a STGO Category 3 load with a maximum gross weight of 150 tonnes and a maximum basic axle load of 16,5 tonnes with the gross weight of the vehicle train not exceeding 196 tonnes.

Figure NA.1(c) gives the basic axle loads, the plan and axle configuration for the *SV196* vehicle.

The wheel loads of all the three *SV* model vehicles should be uniformly distributed over a square contact area as shown in Figure NA.1.

Figure NA.1 — *Basic longitudinal configuration of* SV *model vehicles*

(a) *SV80* Vehicle

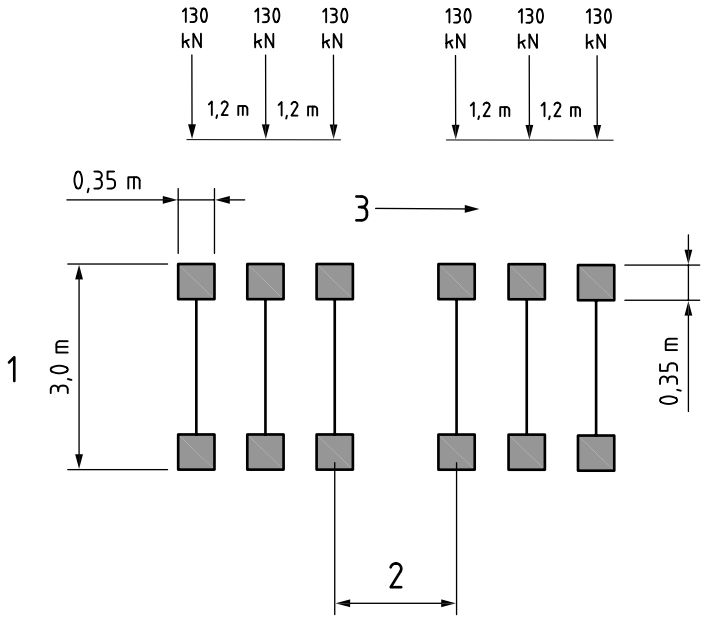

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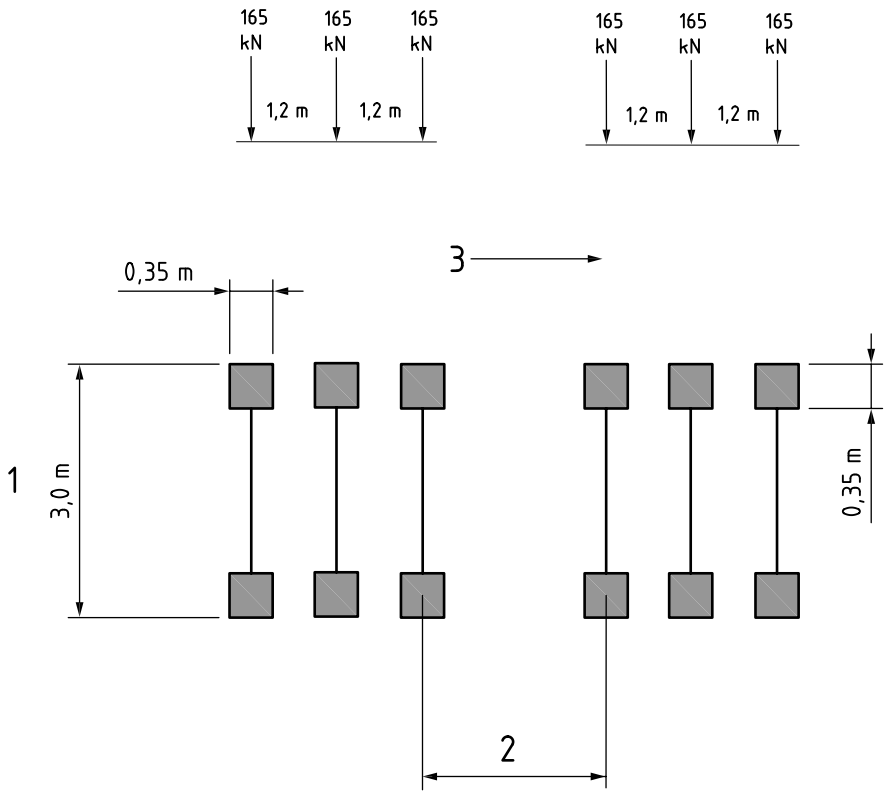
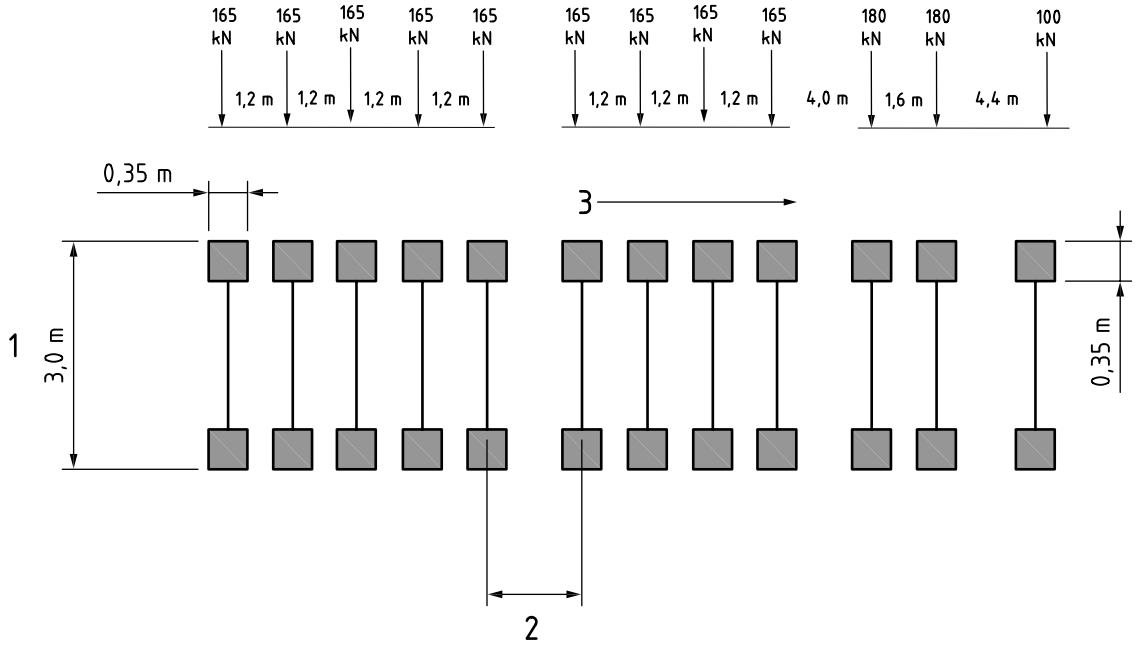
Figure NA.1 — *Basic longitudinal configuration of SV model vehicles (continued)*

(b) *SV100* Vehicle



(c) *SV196* Vehicle



Key

1. Outside track and overall vehicle width
2. Critical of 1,2 m or 5,0 m or 9,0 m
3. Direction of travel

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NA.2.16.2 Basic models for Special Order Vehicles

The following four *SOV* model vehicles simulate vertical effects of Special Order (SO) vehicles with trailer weights limited to:

i) *SOV-250* – Maximum total weight of SO trailer units up to 250 tonnes

ii) *SOV-350* – Maximum total weight of SO trailer units up to 350 tonnes

iii) *SOV-450* – Maximum total weight of SO trailer units up to 450 tonnes

iv) *SOV-600* – Maximum total weight of SO trailer units up to 600 tonnes.

The longitudinal configuration of the four model vehicles is shown in Figure NA.2. The standard configuration has a trailer with two bogies and two tractors; one pulling and one pushing. However, on structures located on a stretch of road with a gradient steeper than 1 in 25, six tractor units in any combination of pulling and pushing that produces the worst effect, should be used for design.

Figure NA.2 — *Basic longitudinal configuration of* SOV *model vehicles*

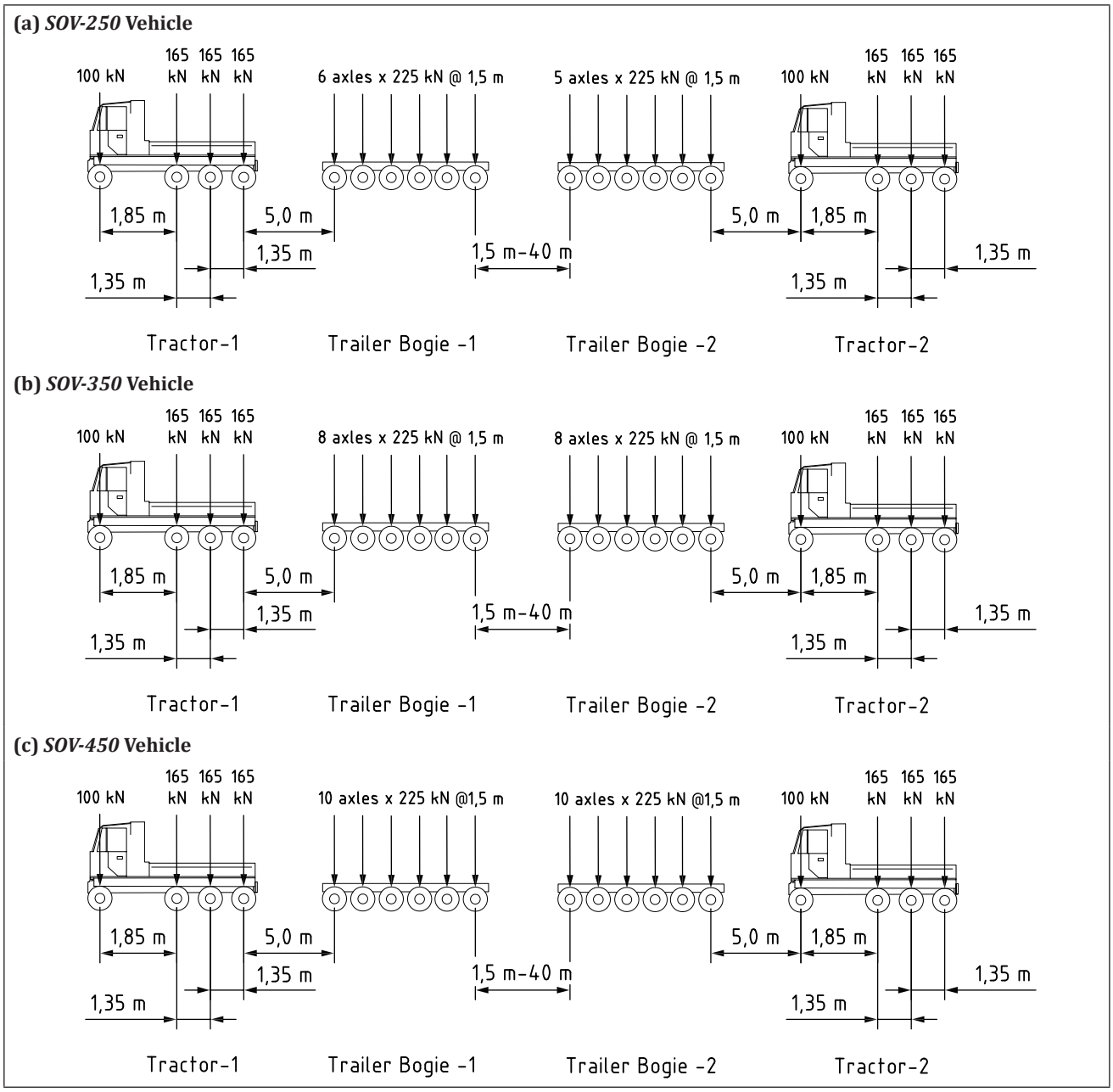

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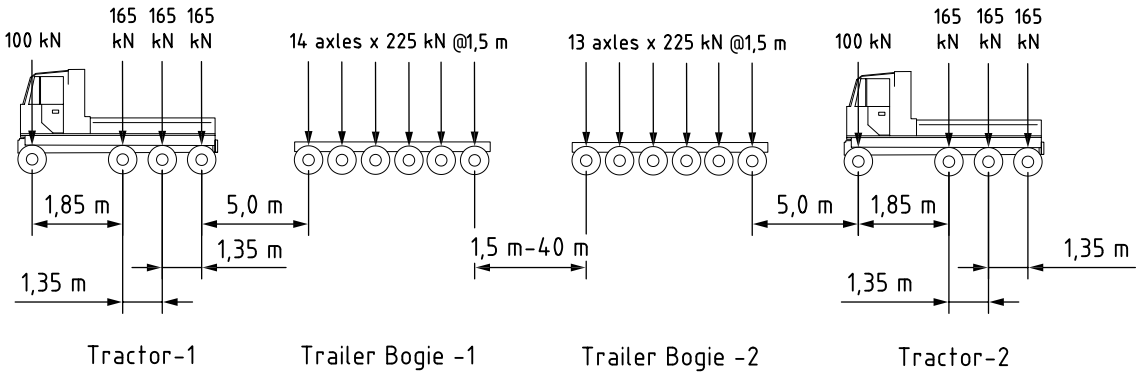
Figure NA.2 — *Basic longitudinal configuration of* SOV *model vehicles (continued)*

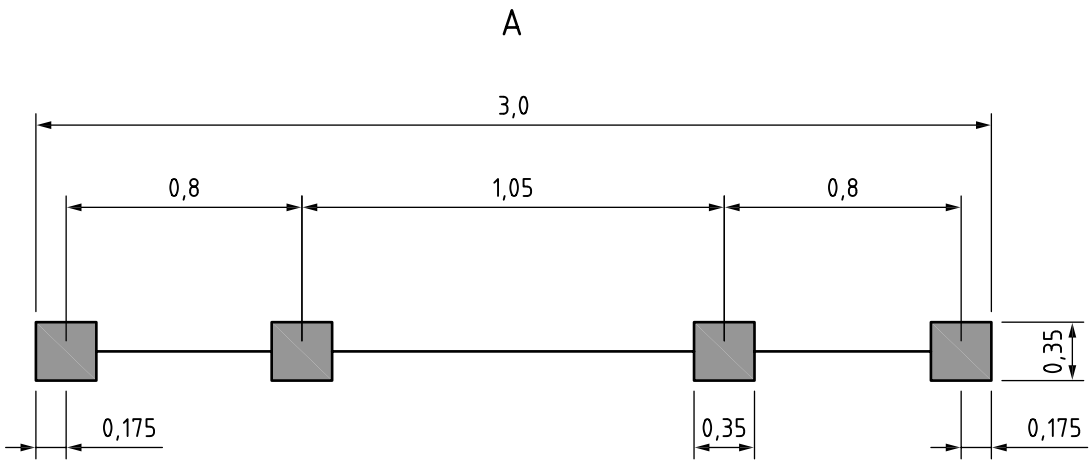
(d) *SOV-600* Vehicle



NOTE For simplicity, 6-axle trailer bogies are shown. The actual number of axles of trailer bogie should be that stated above the figure.

The lateral wheel arrangement for the trailer axles of all the *SOV* model vehicles is shown in Figure NA.3. All the wheels are of equal weight. The contact surface of each wheel should be taken as a square of sides 0,35 m.

Figure NA.3 — *Lateral wheel arrangement for trailer axles of all* SOV *models*



Key

A Outside track and overall vehicle width, 3,0 m

The tractor axles of the model vehicles have two wheels, each of equal weight and with square contact areas of side 0,35 m. The outside track and overall width of the vehicle is 3,0 m.

NA.2.16.3 Dynamic amplification factors

In determining the load effects of *SV* and *SOV* vehicles, the basic axle loads given in Figures NA.1 and NA.2 should be multiplied by the appropriate Dynamic Amplification Factor (DAF) for each axle as given in Table NA.2, depending on the value of the basic axle load.

Table NA.2 — *Dynamic Amplification Factors for the* SV *and* SOV *vehicles*

Basic axle load	DAF
100 kN	1,20
130 kN	1,16
165 kN	1,12
180 kN	1,10
225 kN	1,07

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NA.2.16.4 Application of special vehicle models on the carriageway

The *SV* or *SOV* vehicle loading should be combined with Load Model 1, given in **4.3.2** of BS EN 1991-2, together with the load adjustment factors given in **NA.2.12** as follows.

i) Only one *SV* or *SOV* model vehicle should be considered on any one superstructure.

ii) The Load Model 1 should be considered to be at the "frequent" values as defined in **4.5** of BS EN 1991-2 and in BS EN 1990, Annex A.2 and its National Annex. The loading should be applied to each notional lane and the remaining area of the bridge deck.

The *SV* or *SOV* vehicle can be placed at any transverse position on the carriageway, either wholly within one notional lane or straddling two adjacent lanes, with its side parallel to the kerb. The *SV* or *SOV* vehicle should be placed at the most unfavourable position transversely and longitudinally over the loaded length, in order to produce the most severe load effect at the section being considered. The *SV* or *SOV* vehicle should be applied on influence lines in its entirety and should not be truncated.

Where the *SV* or *SOV* vehicle lies fully within a notional lane the associated Load Model 1 loading should not be applied within 5 m from the centre of outermost axles (front and rear) of the *SV* or *SOV* vehicle in that lane as illustrated in Figure NA.4.

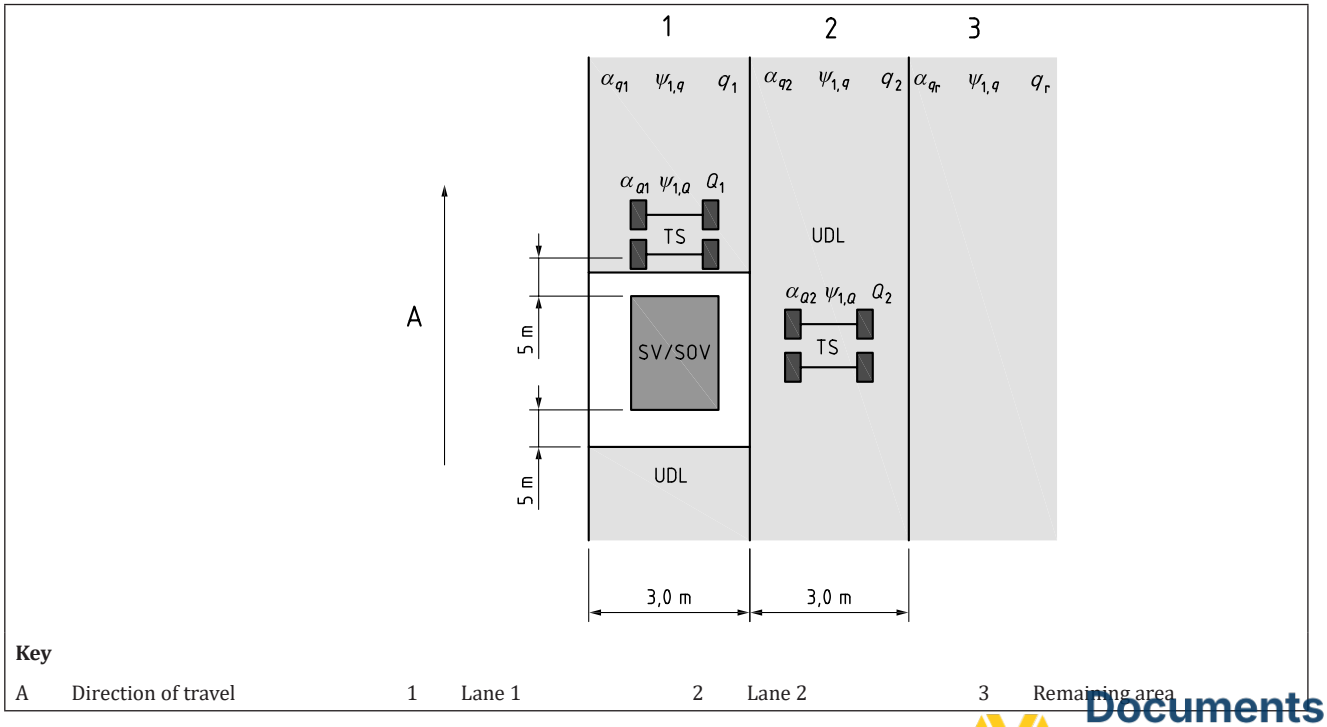
Where the *SV* or *SOV* vehicle lies partially within a notional lane and the remaining width of the lane, measured from the side of the *SV* or *SOV* vehicle to the far edge of the notional lane, is less than 2,5 m [see Figure NA.5(a)], the associated Load Model 1 loading should not be applied within 5 m of the centre of the outermost axles (front and rear) of the *SV* or *SOV* vehicle in that lane.

Where the *SV* or *SOV* vehicle lies partially within a notional lane and the remaining width of lane, measured from the side of the *SV* or *SOV* vehicle to the far edge of the notional lane, is greater than or equal to 2,5 m [see Figure NA.5(b)], the "frequent" value of the uniformly distributed load of the Load Model 1 may be applied over the remaining width of the notional lane (in addition to remaining parts of the lane).

The "frequent" value of the tandem system for that notional lane may be applied anywhere along its length.

On the remaining lanes not occupied by the *SV* or *SOV* vehicle, the Load Model 1 at its "frequent" value should be applied in accordance with **4.3.2** of BS EN 1991-2.

Figure NA.4 — *Typical application of* SV *or* SOV *and Load Model 1 loading when the* SV *or* SOV *vehicle lies fully within a* notional lane



Key

A Direction of travel 1 Lane 1 2 Lane 2 3 Remaining area

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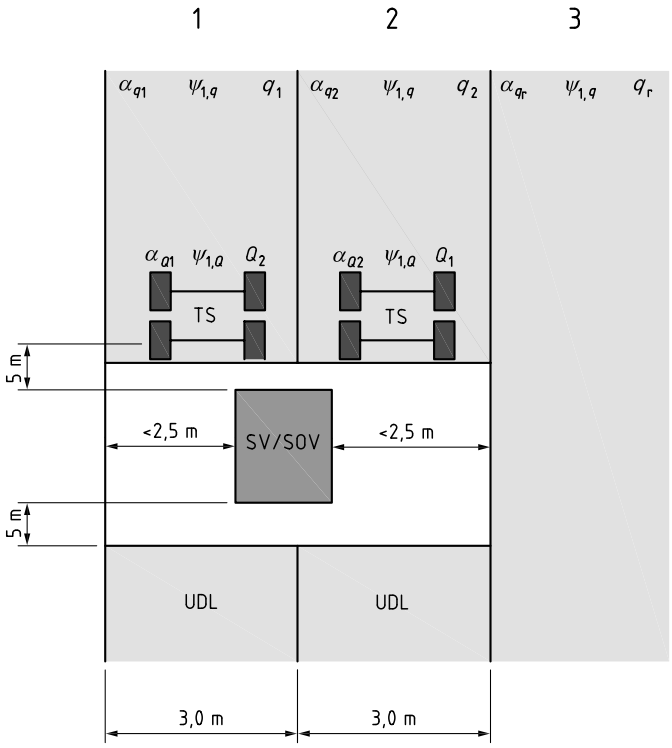
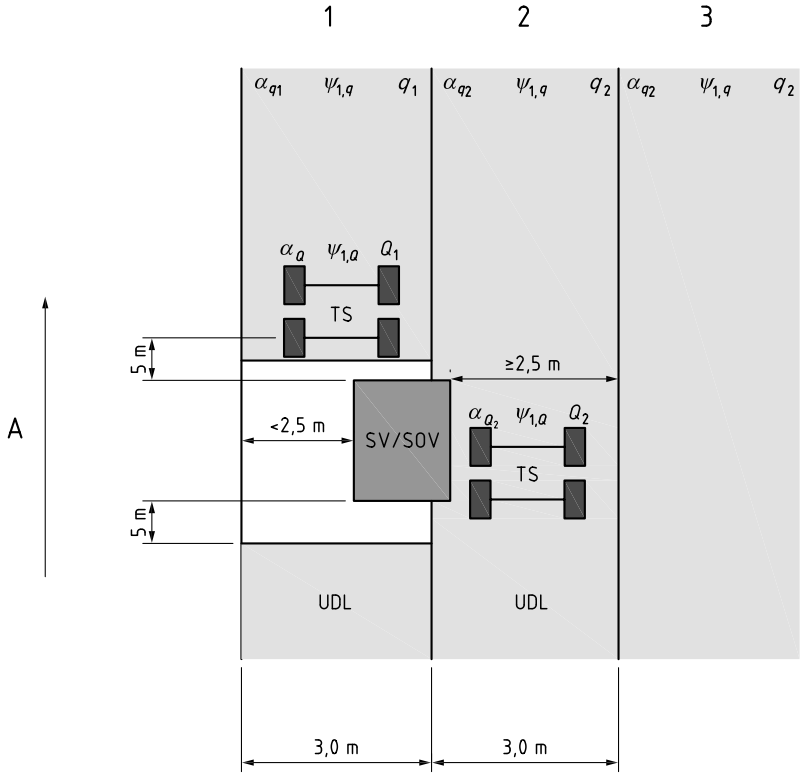
Figure NA.5 — *Typical application of* SV *or* SOV *and Load Model 1 loading when the* SV *or* SOV *vehicle straddles two adjacent lanes*

(a) Distance to the far edge < 2.5 m



(b) Distance to the far edge ≥ 2.5 m



Key

A	Direction of travel	1	Lane 1	2	Lane 2	3	Remaining area

The notional lanes are located so as to produce the maximum load effect at the part of the structure under consideration in accordance with **4.2.4** of BS EN 1991-2.

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NA.2.17 Upper limit of the braking force on road bridges [BS EN 1991-2:2003, 4.4.1 (2)]

The upper limit for the braking force should be taken as 900 kN.

NA.2.18 Horizontal forces associated with Load Model 3 [BS EN 1991-2:2003, 4.4.1 (3)]

NA.2.18.1 Longitudinal braking and acceleration forces

The longitudinal force should be taken as the more severe of either the braking or the acceleration force, determined as below.

The braking force on individual axles, $Q_{lk,S}$, expressed in kN, of special vehicles (both *SV* and *SOV*) should be calculated as follows:

$$Q_{lk,S} = \delta w$$

Where δ is the deceleration factor and w is the basic axle load of the relevant *SV* or *SOV* vehicle in kN shown in Figures NA.1, NA.2 and NA.3. The value of δ should be taken as 0,5 for *SV80*, 0,40 for *SV100*, 0,25 for the *SV196* and 0,20 for all of the *SOV* model vehicles.

The acceleration force should be taken as 10% of the gross weight of the *SV* or *SOV* vehicle and distributed between the axles and wheels in the same proportion as the vertical loads.

NA.2.18.2 Centrifugal force and applied in a manner similar

The characteristic value of centrifugal force from *SV* or *SOV* vehicles, $Q_{tk,S}$, should be calculated as follows and applied in a manner similar to Q_{tk} for normal traffic as given in BS EN 1991-2:2003, **4.4.2**.

$$V = \rho \{ \quad \text{whichever is greater: 30 or} \quad \sqrt{\frac{100 \times g \times r}{r + 150}} \} \leq V_{Limit}$$

$$Q_{tk,S} = \frac{W \times V^2}{g \times r}$$

Where:

V = velocity of the *SV* or *SOV* vehicle in m/sec

V_{Limit} = speed limit on the road in m/sec

W = weight of the *SV* or *SOV* vehicle in kN

r = radius of curvature in m

g = acceleration due to gravity = 9.8 m/sec^2

ρ = 0,86 for *SV-80*, 0,77 for *SV-100*, 0,55 for *SV-196*, 0,41 for *SOV-250*, 0,36 for *SOV-350*, 0,33 for *SOV-450* and 0,30 for *SOV-600*.

The centrifugal force should be distributed between axles and wheels in the same proportion as the vertical loads.

NA.2.19 Horizontal force transmitted by expansion joints or applied to structural members [BS EN 1991-2:2003, 4.4.1 (6)]

The recommended value should be used.

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NA.2.20 Lateral forces on road bridge decks [BS EN 1991-2:2003, 4.4.2 (4)]

The minimum transverse force due to skew braking or skidding, Q_{trk}, should be taken as 50% of the longitudinal braking force, Q_{lk}, for loaded lengths up to 120 m. For loaded lengths greater than or equal to 120 m a transverse force of 280 kN should be used.

NA.2.21 Groups of traffic loads [BS EN 1991-2:2003, 4.5.1 Table 4.4a Notes a) and b)]

The groups of traffic loads should be taken as defined in Table NA.3 instead of Table 4.4a of BS EN 1991-2.

Table NA.3 — *Assessment of groups of traffic loads (characteristic values of the multi-component action)*

Load type		**Carriageway**						**Footways and cycletracks**
		Vertical forces				**Horizontal forces**		**Vertical forces only**
Reference		**4.3.2**	**4.3.3**	Annex A	**4.3.5**	**4.4.1**	**4.4.2**	**5.3.2.1** Equation (5.1)
Load system		LM1 (TS and UDL)	LM2 (Single axle)	LM3 (Special vehicles)	LM4 (Crowd loading)	Braking and acceleration forces	Centrifugal and transverse forces	Uniformly distributed load
Groups of loads	**gr1a**	Characteristic						0,6 times Characteristic[2],[3]
	gr1b		Characteristic					
	gr2	Frequent[4]				Characteristic	Characteristic	
	gr3[1]							Characteristic[2]
	gr4				Characteristic			Characteristic[2]
	gr5	Frequent[4]		Characteristic				
	gr6			Characteristic		Characteristic	Characteristic	
		Dominant component action (the group is sometimes designated by this component for convenience).						

[1] This group is irrelevant if gr4 is considered

*[2] Characteristic value obtained from **5.3.2.1***

[3] This is a reduced value accompanying the characteristic value of LM1 and should not be factored by ψ_1. However, when gr1a is combined with leading non-traffic actions this value should be factored by ψ_0

[4] The ψ_1 factors should be taken from the UK National Annex to BS EN 1990

NA.2.22 Conditions for use of Fatigue Load Models [BS EN 1991-2:2003, 4.6.1 (2) Note 2c]

There are no special conditions for the use of Fatigue Load Model 1.

Fatigue Load Model 2 should only be used for cases where the fatigue verification is not influenced by the simultaneous presence of several lorries on the bridge, unless account of their presence is taken using the following approach:

i) Where bridge influence line lengths permit, the maximum and minimum stresses caused by Fatigue Load Model 2 should be obtained by considering the worst load effect of the most onerous vehicle accompanied in the same lane, with a 40 m clearance, by the lightest vehicle in Table 4.6 of BS EN 1991-2, if this causes a worse load effect.

ii) Where two or more notional lanes influence the design detail, the maximum and minimum stresses should be obtained from Fatigue Load Model 2 by placing the most onerous vehicle on the most onerous part of the influence line in the most onerous lane, plus the lightest vehicle on the most onerous part of the influence line in one other lane.

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NA.2.23 Definition of traffic categories and traffic flows [BS EN 1991-2:2003, 4.6.1 (3) Note 1]

Heavy goods vehicle numbers for use in fatigue design should be taken as indicated in Table NA.4 with the additional Notes 4 and 5. Heavy goods vehicle counts may be obtained from site surveys by doubling the observed number of lorries with three or more axles.

Table NA.4 — *Indicative numbers of heavy goods vehicles expected per year and per lane in the United Kingdom*

Type	Traffic categories		N_{obs} per lane (millions per year)	
	Carriageway layout	No. of lanes per carriageway	Each slow lane	Each fast lane
Motorway	Dual	3	2,0	1,5
Motorway	Dual	2	1,5	1
All purpose	Dual	3		
All purpose	Dual	2		n/a
Slip road	Single	2		
All purpose	Single	3	1,0	0
All purpose	Single	2		0
Slip road	Single	1		n/a
All purpose	Single	2	0,5	0
Local (low lorry flow)	Single	2	0,05	0

NOTE 1 Notes 1 and 2 in BS EN 1991-2 may be disregarded for UK purposes.

*NOTE 2 There is no general relation between traffic categories for fatigue verifications, and the loading classes and associated α factors mentioned in **4.2.2** and **4.3.2**.*

NOTE 3 Intermediate values of N_{obs} are not excluded, but are unlikely to have significant effect on the fatigue life.

NOTE 4 Basing the numbers of heavy goods vehicles on counts of multi-axled lorries ensures a reasonably reliable match between the codified traffic model and the number and types of vehicle that cause the most fatigue damage in the actual traffic.

NOTE 5 The values presented in Table NA.4 are design values that are intended to reflect approximate road capacities, and they may not match observations of current usage. Traffic flows at a small number of sites may exceed these values, but the differences are unlikely to have a very significant influence on designs.

NA.2.24 Dynamic additional amplification factor due to expansion joints [BS EN 19912:2003, 4.6.1 (6)]

The recommended value should be used.

NA.2.25 Fatigue Load Model 3 [BS EN 1991-2:2003, 4.6.4 (3)]

The conditions of application for two vehicles in the same lane should be determined for the individual project.

NA.2.26 Fatigue Load Model 4 [BS EN 1991-2:2003, 4.6.1 (2) Note 2(e), 4.6.5 (1) Note 2]

As allowed in **4.6.5**(1) Note 2 and **4.6.1**(2) Note 2(e), the Fatigue Load Model 4 as defined below, along with the rules for its application, should be used in place of the model given in **4.6.5** of BS EN 1991-2.

Fatigue Load Model 4 may be used where the application of models 1, 2 and 3 all fail to provide sufficient fatigue life. Fatigue Load Model 4 may also be used when the influence line length, for details sensitive to fatigue, is short enough to have reversals of sign within a loaded length that is similar to typical vehicle wheel and axle spacings.

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The standard lorries given in Table NA.5 for Fatigue Load Model 4 should be used for fatigue design on all routes in the UK. Where the length of the influence line permits, and/or where two or more notional lanes influence the design detail, Fatigue Load Model 4 should be applied as follows.

The fatigue damaging stress cycles due to the transit of Fatigue Load Model 4 lorries should be assessed and counted using the rainflow counting procedure described in BS EN 1993-1-9. Fatigue damage should be assessed on the basis of stress cycles calculated from two traffic lanes only. These lanes (described as lanes 1 and 2 for the purpose of this clause) are the two notional lanes that individually cause the most theoretical fatigue damage in the component under consideration. Vehicle numbers in these lanes should be obtained from Table NA.4.

Damage summation D_d is obtained by adding contributions from the following cases.

i) Lane 1 traffic alone, with 80% of lane 1 lorry numbers.

ii) 20% of lane 1 traffic running in convoy with vehicles at 40 m spacing, centre of rearmost axle of front vehicle to centre of foremost axle of vehicle behind.

iii) Lane 2 traffic alone, with 80% of lane 2 lorry numbers.

iv) 20% of lane 2 traffic running in convoy with vehicles at 40 m spacing, centre of rearmost axle of front vehicle to centre of foremost axle of vehicle behind.

The effect of side-by-side running should be allowed for by multiplying the total damage, D_d, by ⟦A1⟩ the factor $(1+K_b.Z)$, ⟨A1⟧ where: K_b = ratio of the maximum stress range caused by single vehicles in lane 2 to the maximum stress range caused by single vehicles in lane 1, and:

i) if loaded length ≤ 3,0 m, Z = ⟦A1⟩ 0,0 ⟨A1⟧;

ii) if 3,0 m < loaded length < 20 m, Z varies linearly in proportion to the logarithm of the loaded length from ⟦A1⟩ 0,0 to 0,5 ⟨A1⟧;

iii) if loaded length ≥ 20 m, Z = ⟦A1⟩ 0,5 ⟨A1⟧.

NA.2.27 Fatigue Load Model 5 (based on recorded traffic data) [BS EN 19912:2003, 4.6.6 (1)]

The derivation of a site-specific model should be considered as follows:

i) where knowledge of local traffic conditions is poor;

ii) where local circumstances are very particular (e.g. sea ports).

The fatigue damaging stress cycles due to transit of recorded lorries should be assessed and counted using the rainflow counting procedure described in BS EN 1993-1-9. Fatigue damage should be assessed on the basis of stress cycles calculated from two traffic lanes only. These lanes (described as lanes 1 and 2) are the two traffic lanes that individually cause the most theoretical fatigue damage in the component under consideration.

The stress cycles obtained from analysis of recorded traffic data should be multiplied by a Dynamic Amplification Factor φ_{fat} which can be taken as φ_{fat} = 1,2 for a pavement surface of "good" roughness and φ_{fat} = 1,4 for a pavement of "medium" roughness. An additional Dynamic Amplification Factor should be applied for locations close to expansion joints as given in **4.6.1**(6) (See also Annex B of BS EN 1991-2).

The procedure for damage summation D_d should be as that given in **NA.2.26** for Fatigue Load Model 4.

NA.2.28 Collision forces on piers and other supporting members [BS EN 1991-2:2003, 4.7.2.1 (1)]

For the application of this clause, refer to BS EN 1991-1-7 and its National Annex.

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