

PD 6688-2:2011



BSI Standards Publication

PUBLISHED DOCUMENT

Background to the National Annex to BS EN 1991-2

Traffic loads on bridges

This publication is not to be regarded as a British Standard.

bsi.

...making excellence a habit.
AVA Documents™
Document Sharing Hub

Publishing and copyright information

The BSI copyright notice displayed in this document indicates when the document was last issued.

© BSI 2011

ISBN 978 0 580 58680 4

ICS 91.010.30; 93.040

The following BSI reference relates to the work on this standard:
Committee reference B/525/10

Publication history

First published March 2011

Amendments issued since publication

Date	Text affected
------	---------------

Contents

Foreword *ii*

1 Scope 1

2 Normative references 1

3 BS EN 1991-2:2003, Eurocode 1: Actions on structures – Part 2:
Traffic loads on bridges 1

Annexes

Annex A (informative) Vibration serviceability recommendations for
foot and cycle track bridges 11

Bibliography 19

List of figures

Figure 1 – Comparison of pedestrian load intensity (excluding crowd
loading) variation with loaded length for road (and rail) bridges
supporting footways or cycle tracks and for footbridges 8

Figure 2 – Reduction factor, λ , to allow for the unsynchronized
combination of pedestrian actions within groups and crowds 10

Figure A.1 – Synthetic time history for a random bridge/pedestrian
model 13

Figure A.2 – Reduction of pedestrian speed and flow rates with
density 14

Figure A.3 – Configuration factor K 15

Figure A.4 – Dynamic response factor Ψ 16

List of tables

Table 1 – Loading classes 6

Table A.1 – Typical values of logarithmic decrement of decay of
vibration (δ) between successive peaks 11

Summary of pages

This document comprises a front cover, an inside front cover,
pages i to ii, pages 1 to 20, an inside back cover and a back cover.

Foreword

Publishing information

This Published Document is published by BSI and came into effect on 31 March 2011. It was prepared by Subcommittee B/525/10, *Bridges*, under the authority of Technical Committee B/525, *Building and civil engineering*. A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other publications

This Published Document is a background paper that gives non-contradictory complimentary information for use in the UK with the Eurocode for actions on structures, BS EN 1991-2 and its UK National Annex.

BS 5400-2 has been withdrawn and superseded by BS EN 1990, BS EN 1991-2 and BS EN 1991-1-7. References to BS 5400-2 in this Published Document are informative only and are included to provide readers with a comparison between the withdrawn British Standard and the current Eurocodes.

The following standards BS EN 1991-1-3, BS EN 1991-1-4, BS EN 1991-1-5 and BS EN 1991-1-6 should be consulted when designing bridges.

Presentational conventions

The word “should” is used to express recommendations of this Published Document. The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a Published Document cannot confer immunity from legal obligations.

1 Scope

This Published Document gives non-contradictory, complementary information on traffic loads on bridges for use in the UK in conjunction with BS EN 1991-2 and its UK National Annex.

2 Normative references

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

BS EN 1990:2002, *Eurocode – Basis of structural design*

BS EN 1991-2:2003, *Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges*

NA to BS EN 1990:2002+A1:2005, *UK National Annex for Eurocode – Basis of structural design*

NA to BS EN 1991-2:2003, *UK National Annex to Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges*

3 BS EN 1991-2:2003, Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges

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

A study has been carried out to compare type HA loading that was given in BS 5400-2 (BD 37/01¹⁾ [1]) and Load Model 1 (LM1) in BS EN 1991-2 with the parameters given in the UK National Annex. The LM1 effects are within the acceptable range for spans up to 1 500 m. It is concluded that, assuming type HA loading in BS 5400-2 was suitable for bridges with a span up to 1 500 m, the application of LM1 is appropriate for bridges up to 1 500 m loaded length.

3.2 Adjustment factors α for LM1 [BS EN 1991-2:2003, 4.3.2 (3), Notes 1 and 2]

The values given in the NA to BS EN 1991-2:2003, Table NA.1 have been derived based on calibration against HA serviceability limit state (SLS) loading from BS 5400-2 and verified using reliability analysis (see Atkins' *Background to the UK National Annexes to BS EN 1990 and BS EN 1991-2* [2]). This loading should be used together with the partial factors given in the NA to BS EN 1990:2002+A1.

3.3 Adjustment factor β for LM2 [BS EN 1991-2:2003, 4.3.3 (2)]

The NA to BS EN 1991-2, NA.2.14 provides for a wheel load of 200 kN compared with the 100 kN load that was given in BS 5400-2:2006, 6.2.5. However, the wheel contact area has been adjusted as in the

¹⁾ The technical content of BS 5400-2:2006 was extracted from BD 37/01.

NA to BS EN 1991-2, **NA.2.15**, which results in similar contact pressures to those previously given in BS 5400-2.

3.4 Wheel contact surface for LM2 [BS EN 1991-2:2003, 4.3.3 (4)]

The wheel contact area given in the NA to BS EN 1991-2:2003, **NA.2.15** results in a characteristic pressure of $1,25 \text{ N/mm}^2$ compared with $1,1 \text{ N/mm}^2$ that was given in BS 5400-2:2006. The corresponding design pressures are $1,69 \text{ N/mm}^2$ and $1,82 \text{ N/mm}^2$. This also makes the wheel contact areas the same for LM1 and LM2.

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

This value of 900 kN has been retained for harmonization although the value was 750 kN in BS 5400-2, **6.10.1**.

NOTE The value of α_{q1} , used to calculate the braking force is given as 1,0 in the note to the NA to BS EN 1991-2:2003, Table NA.1, which differs from the value used for vertical loading. This is because the α_{q1} values needed to calibrate the braking force and vertical loads are different.

3.6 Horizontal forces associated with LM3 [BS EN 1991-2:2003, 4.4.1 (3)]

3.6.1 Longitudinal braking force [NA to BS EN 1991-2:2003, 2.18.1]

Where the loaded length is less than the length of the SV or SOV vehicle (see Figures NA.1 to NA.3), only the weight of the axles likely to occupy the loaded length when the vehicle is in its most unfavourable position should be considered in calculating ω . Where a structure is designed for SV196, the maximum braking force resulting from either the SV100 or SV196 vehicle should be considered. SV80 and SV100 vehicles produce approximately the same magnitude of braking force because the increase in the basic axle load ω is counteracted by the decrease in the deceleration factor δ .

3.6.2 Centrifugal force [NA to BS EN 1991-2:2003, 2.18.2]

Where the loaded length is less than the length of the SV or SOV vehicle, only the weight of the axles likely to occupy the loaded length when the vehicle is in its most unfavourable position should be considered in calculating W . All three SV vehicle models produce the same level of centrifugal force for loaded lengths over 14 m, and it is therefore sufficient to consider only one vehicle in this case. However, for loaded lengths under 14 m, differences might arise due to the number of axles present and the axle weights. The centrifugal force should therefore be checked for different vehicles.

The horizontal forces should be combined with the vertical loads for SV or SOV vehicles as given in Table NA.3 for Group 6.

NOTE The basis for this can be found in the Background to the UK National Annexes to BS EN 1990 and BS EN 1991-2 [2].

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

The horizontal force transmitted by expansion joints given in BS EN 1991-2:2003 of 180 kN/axle should be used as there was no equivalent value given in BS 5400-2. It is not dissimilar to the value of 180 kN/m run of the joint given in BD 33/94 [3] given that the UDL from each horizontal wheel force of 90 kN applied over a 400 mm width is 225 kN/m.

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

The transverse force due to skew braking or skidding, Q_{trk} , should be considered to act simultaneously with Q_{lk} .

BS EN 1991-2:2003 recommends a value of 25% of Q_{lk} which is approximately 90 kN while BS 5400-2:2006, 6.11.1 gave a constant force for skidding of 300 kN. The latter is considered to be excessive.

3.9 Fatigue load models [BS EN 1991-2:2003, 4.6]

Background to the fatigue load models can be found in the *Derivation of the UK National Annex to Clause 4.6: Fatigue Load Models* [4].

3.10 Dynamic additional amplification factor due to expansion joints [BS EN 1991-2:2003, 4.6.1 (6)]

No modification is proposed as the recommended values are reasonably close to those that were given in BS 5400-10²⁾.

3.11 Fatigue LM4 [BS EN 1991-2:2003, 4.6.1 (2) Note 2(e) and 4.6.5 (1) Note 2]

Fatigue LM4 consists of sets of standard lorries that together produce effects equivalent to those of real traffic. The NA to BS EN 1991-2:2003, Table NA.5 defines the properties of standard lorries for use in fatigue design on all routes.

The characterization of road traffic for fatigue design purposes depends on the traffic lane configuration, traffic flow rates, proportions of heavy goods vehicles, types of heavy goods vehicles and vehicle usage. Traffic flow rates are route-dependent and the NA to BS EN 1991-2:2003, Table NA.4 should be used to determine the traffic flows. However, road provision is made approximately in relation to demand, and it is recommended that the highway traffic flow rates that are presented in the NA to BS EN 1991-2:2003, Table NA.4 be adopted for design as stated in the National Annex.

²⁾ Now withdrawn and superseded by BS EN 1993-1-3.

3.12 **Fatigue LM5 (based on recorded traffic data)** **[BS EN 1991-2:2003, 4.6.6 (1)]**

Fatigue LM5 consists of the direct application of recorded traffic flows at specific sites. The traffic flow data for the development of such a model can be supplemented, if appropriate, by statistical extrapolation.

The following guidelines should be used in the development of a site-specific fatigue load model.

- Limited data indicates that the nature of use and, therefore, the weight distributions of each type of heavy goods vehicle appear to depend more on the country (and thus the legislative and vehicle control frameworks) than to sites within individual countries.
- Certain sites are particularly subject to asymmetric flows and vehicle populations might contain unusually large fractions of either fully laden or empty vehicles. Such sites might include access routes to mines or quarries, to large industrial locations and to port facilities.
- It is most important to accurately model the numbers of the heavier goods vehicle types. Estimates of the “total goods vehicle flow” can therefore be very misleading, owing to the variable means of monitoring and classifying twin axle lorries. Care should be taken to accurately estimate the number of lorries with three or more axles, and to correctly match the numbers of such vehicles to those in general traffic models where these are used.

3.13 **Effects of collision forces on vehicle restraint systems** **[BS EN 1991-2:2003, 4.7.3.3]**

3.13.1 **Global effects, 4.7.3.3 (1)**

The magnitude of forces transferred to a structure during vehicle collision against a vehicle restraint system depends on a complex interaction between the speed of impact, mass and stiffness of the vehicle, the strength and stiffness of the restraint system, the stiffness of the connection between the vehicle restraint system and the structure and the stiffness of the structure. For design purposes simple rules are required that take account of the key parameters.

In BS 5400-2 the forces were based on the containment level and mass of the structure. In BS EN 1991-2 the forces are based on the stiffness of the connection. However, it was felt that designers could have difficulty in determining whether the stiffness of a connection is weak or strong. The approach recommended in the National Annex takes into account only the containment level and the stiffness of the parapet, which can be more readily determined by the designers. The magnitude of forces given in the NA to BS EN 1991-2:2003, Table NA.6 is broadly in line with those that were specified in BS 5400-2:2006, 6.7.

The transverse forces in the NA to BS EN 1991-2:2003, Table NA.6 correspond to the values given in BS EN 1991-2, Table 4.9 (n) while the longitudinal and vertical forces were based on BS 5400-2:2006, 6.7 with partial factors set to unity. It is possible that BS EN 1991-2 does not take into account the longitudinal and vertical forces as they were assumed not to have a significant influence on the design.