

ICS 91.010.30; 93.040

English Version

Eurocode 1: Actions on Structures - Traffic Loads on Bridges - Track-Bridge Interaction

Eurocode 1 : Actions sur les structures - Actions sur les
ponts, dues au trafic - Interaction voie-pont

Eurocode 1: Einwirkungen auf Tragwerke -
Verkehrslasten auf Brücken - Gleis-Brücken
Interaktion

This Technical Report was approved by CEN on 16 April 2018. It has been drawn up by the Technical Committee CEN/TC 250.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Contents

Page

European foreword.....	5
Introduction	6
1 Scope	7
2 Normative references	7
3 Terms and definitions	7
4 Symbols and abbreviations	9
5 Description of the Technical Issue	10
5.1 General	10
5.2 Axial effects	11
5.2.1 Origin of axial forces and displacements.....	11
5.2.2 Force transfer between track and deck ends.....	11
5.2.3 Rail stresses	11
5.2.4 Forces acting on the fixed point (e.g. Bearing forces)	14
5.2.5 Interaction with sub-structure.....	14
5.3 Vertical effects.....	15
5.3.1 Effect of vertical forces and displacements	15
5.3.2 Bridge deck end rotation.....	15
5.4 Limits to the need for detailed calculations	16
5.5 Calculation of multiple loading conditions.....	17
5.6 Effect of bridge deformations	17
5.6.1 Effect on track geometry	17
5.6.2 Effect on stability of ballasted track.....	18
5.6.3 Effect of ballast degradation over structural joints.....	18
5.7 Effects on track construction and maintenance activities	18
6 History and background	19
6.1 Existing codes and standards	19
6.2 Differences between national rules.....	21
7 Case studies	21
7.1 Scheldt River Bridge (Belgium)	21
7.2 Dedicated high speed lines in France and Spain.....	21
7.3 Olifants River Bridge (South Africa).....	21
7.4 Bridges on Denver RTD (USA)	21
7.5 Historic bridges in central Europe.....	22
7.6 Semi-integral bridges on German high speed lines	22
8 Design considerations for track.....	23
8.1 Representation of axial behaviour of track.....	23
8.2 Understanding of ballast behaviour.....	24
8.2.1 Ballast properties.....	24
8.2.2 Importance of effective ballast retention.....	24
8.3 Description/ limitations of available track devices for mitigation of effects.....	24
8.3.1 Principles	24
8.3.2 Practical solutions	26
8.4 Description/ limitations of bridge design for mitigation of effects	31

8.4.1	General	31
8.4.2	"Steering bars" and virtual fixed points	31
8.4.3	Damper Systems.....	32
8.5	Effects of track curvature and switches and crossings	32
9	Design criteria	33
9.1	General	33
9.1.1	Rail stress	33
9.1.2	Rail break containment.....	33
9.2	Displacement limits	33
9.3	Differentiation between ultimate- and service-loading	35
9.4	Safety factors	35
9.5	Differences between ballasted and ballastless tracks	35
9.6	Calculations for configurations with rail expansion devices.....	36
10	Calculation methods	36
10.1	Methods in EN 1991-2:2003	36
10.1.1	General	36
10.1.2	Software based on UIC 774-3R.....	38
10.1.3	Linear analysis with manual intervention (LAMI)	38
10.2	Load configurations	40
10.3	Sensitivity analysis.....	40
10.4	Numerical comparisons of calculation methods	41
11	Information and process management.....	46
12	GUIDANCE – Current best practice	47
12.1	Bridge design principles	47
12.2	Track design principles.....	47
12.2.1	Ballasted track.....	47
12.2.2	Ballastless track	47
12.2.3	Special rail fastening systems	48
12.2.4	Rail expansion devices.....	48
12.2.5	Derivation of the behaviour.....	48
13	Recommendations for future standards development.....	49
14	Recommendations for future research and development.....	49
14.1	General	49
14.2	Improved input data for existing calculation methods.....	49
14.3	Extension of existing models to include other track configurations	50
14.4	Collecting data for better verification of analytical models.....	50
14.5	Providing a basis for developing new, more rigorous, models.....	50
Annex A (informative)	Calculation of rail break gap	51
A.1	Rail break gap for track with conventional fastenings (not on a bridge)	51
A.2	Rail break gap for track on a bridge, with conventional fastenings.....	52
A.3	Rail break gap for track with sliding (ZLR) fastenings	54
A.4	Limiting values of rail break gap	54
Annex B (informative)	Algebraic studies of longitudinal track characteristics	55
B.1	Algebraic representations of behaviour	55
B.1.1	Sliding action.....	55
B.1.2	The <i>k</i> -function.....	56

B.1.3	Temperature change.....	57
B.1.4	Temperature gradients.....	67
B.1.5	Track springs.....	67
B.1.6	Joint movements.....	71
B.1.7	Track forces resulting from joint movements.....	73
B.2	The Two Spreadsheet Method.....	77
B.2.1	General.....	77
B.2.2	The Temperature Stress Spreadsheet (TSS)	77
B.2.3	The Additional Stress Spreadsheet (ASS).....	80
Annex C (informative)	Examples of Track-Bridge Interaction calculations.....	83
C.1	Introduction to calculation methods	83
C.2	Example 1: Simply supported deck with no rail expansion device.....	83
C.3	Example 2: Series of continuous decks with no rail expansion device.....	85
C.4	Continuous deck with a rail expansion device	88
Annex D (informative)	Alternative method for determining the combined response of a structure and track to variable actions.....	91
Annex E (informative)	Proposed revision of EN 1991-2:2003, 6.5.4.....	92
E.1	General.....	92
E.2	Combined response of structure and track to variable actions	92
E.2.1	General principles.....	92
E.2.2	Parameters affecting the combined response of the structure and track.....	92
E.2.3	Actions to be considered	95
E.2.4	Modelling and calculation of the combined track/structure system.....	95
E.2.5	Design criteria.....	98
E.2.6	Calculation methods.....	100
Bibliography	104

European foreword

This document (CEN/TR 17231:2018) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document is a preview generated by EVS

Introduction

The subject of Track-Bridge Interaction has become particularly important with respect to longer span bridges and viaducts supporting tracks, especially for those carrying high speed trains. However, investigations which have been undertaken in order to address that specific issue have raised points which are relevant to all types of railway bridge. Consequently, the content of this Technical Report is intended to be applicable to all types of railway bridge, for both ballasted and ballastless track, and for all types of railway (e.g. conventional railways, metro and light rail systems, and high speed railways).

It is also clear that the increased availability of computational methods of analysis, since the basis for existing codes was laid down in the 1990s, has made it possible to consider approaches to calculation of Track-Bridge Interaction effects which could not be expected to be used in routine procedures in the past.

There are three principal 'outputs' set out in the final sections of this Technical Report. They are as follows:

- 1) Guidance for designers and maintainers of railway track and structures to assist them in adopting current best practice in taking Track-Bridge Interaction effects into account (Clause 12 of this report).
- 2) Recommendations for future development of standards, especially the revision of the relevant section of the Eurocode EN 1991-2:2003 6.5.4 (Clause 13 and Annex E of this report).
- 3) Identification of areas in which new research and development is needed to make further improvements in approaches to Track-Bridge Interaction (Clause 14 of this report).

1 Scope

This document reviews current practice with regard to designing, constructing and maintaining the parts of bridges and tracks where railway rails are installed across discontinuities in supporting structures. Current Standards and Codes of Practice are examined and some particular case histories are reviewed.

The document gives guidance with respect to current best practice and makes recommendations for future standards development and also identifies areas in which further research and development is needed.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

track-bridge interaction

conditions under which forces and/or displacements in a railway track and its supporting bridge structure are influenced by the fact that rails span discontinuities in a bridge structure e.g. structural movement joints or bridge deck ends

3.2

additional load

load in an element of the track, (e.g. rail and rail fixing) on a bridge compared with what is expected in that element if the same track system were to be installed with the same loading actions away from any bridge

Note 1 to entry The word 'additional' is used in the same sense to describe additional stresses, additional forces and additional deformations.

3.3

thermal fixed point

point in the structure of the bridge, without the track, which is assumed not to be displaced when there is a change in temperature. (Otherwise known as the “centre of thermal displacement” or “thermal centre”)

3.4

deck length

L_D

distance between structural movement joints in the bridge deck

3.5

span length

L_S

distance between vertical supports, e.g. piers and abutments