DIN EN 16432-2:2017-10 (E)

Railway applications - Ballastless track systems - Part 2: System design, subsystems and components

Contents

Page

European foreword 6

Introduction 7

1 Scope 8

2 Normative references 8

3 Terms and definitions 9

4 Symbols and abbreviations 10

5 General 15
5.1 Ballastless track system, subsystems and components 15
5.2 Subsystems configuration 16
5.2.1 Ballastless track system with continuous support and embedded rails 16
5.2.2 Ballastless track system with discrete rail seats 17

6 System design 18
6.1 Establishing the system criteria 18
6.2 System assurance plan 19
6.3 System integration 19
6.4 Vertical track stiffness 19
6.5 Track stability 19
6.6 Load distribution and load transfer by subsystems and components 20
6.6.1 Principles 20
6.6.2 Calculation steps 21
6.6.3 Determination of forces (rail seat loads) between subsystems fastening system and supporting structure (prefabricated element or pavement) 22
6.6.4 Prefabricated element loading and load distribution 22
6.6.5 Pavement design 23
6.7 Loading of substructure 25
6.8 Transitions 26

7 Rails 26

8 Rail fastening systems 26
8.1 General 26
8.2 Rail fastening spacing 26
8.3 Adjustment 26

9 Prefabricated elements 26
9.1 General 26
9.2 General design considerations 27
9.2.1 Data to be supplied for the general system design 27
9.2.2 Individual precast element design 27
9.3 Manufacturing process 27
9.3.1 General requirements 27
9.3.2 Curing 28
9.3.3 Surface finish 28
9.3.4 Marking 28

9.4 Quality control ... 28
9.4.1 General ... 28
9.4.2 Quality control during design approval tests ... 28
9.4.3 Quality control during manufacturing ... 29
9.5 Concrete sleepers, bearers and blocks ... 29
9.6 Prefabricated slabs and frames ... 29
9.6.1 Classification ... 29
9.6.2 Design ... 30
9.6.3 Materials ... 31
9.6.4 Geometrical tolerances ... 32
9.6.5 Storage, handling, transport and on-site installation ... 32
9.7 Filling layer ... 33

10 Pavements (layered structure) ... 33
10.1 General ... 33
10.2 Concrete pavements ... 34
10.2.1 Application ... 34
10.2.2 Materials ... 34
10.2.3 Functional requirements ... 34
10.3 Asphalt pavements ... 37
10.3.1 Application ... 37
10.3.2 Design ... 37
10.3.3 Geometrical requirements ... 37
10.3.4 Asphalt materials and mix design ... 38
10.3.5 Materials for surface layer ... 38
10.3.6 Requirements for layers ... 38
10.4 Unbound, hydraulically bound and bituminous bound base-layers ... 38
10.4.1 Application ... 38
10.4.2 Hydraulically bound base layer ... 39
10.4.3 Cement treated base layer (CTB) ... 39
10.4.4 Concrete base layer ... 39
10.4.5 Bituminous base layer ... 40
10.4.6 Unbound base layer ... 40

11 Intermediate layers ... 41
11.1 Functions of intermediate layers ... 41
11.2 Effects of intermediate layers on ballastless track system ... 41

Annex A (informative) Vertical vehicle load ... 43

A.1 Distribution of vertical railway traffic load and calculation of rail seat loads ... 43
A.1.1 General ... 43
A.1.2 Rail seat load P0 [N] ... 43
A.1.3 Rail seat loads Pj [N] due to wheel loads Qi [N] ... 45
A.2 Rail bending moment and bending stress at the rail foot ... 46
A.2.1 Rail bending moment M0 [Nmm] ... 46
A.2.2 Bending stress at the rail foot 0 [N/mm2] ... 46

Annex B (informative) Thickness design calculations for slabs, pavements, frames, beams ... 47

B.1 General ... 47
B.1.1 Introduction ... 47
B.1.2 Effective pavement thickness h1 [mm] ... 48
B.1.3 Bedding modulus k [N/mm3] ... 49
B.1.4 Bearing capacity of beam or slab/pavement supported by cementitious or bituminous base layer ... 52
B.1.5 Slab on Winkler foundation (Westergaard): Longitudinal and lateral bending moments as well as tensile stresses activated by rail seat loads ... 54
B.1.6 Beam on Winkler foundation (Zimmermann): Longitudinal bending moment and tensile stress due to rail seat loads ... 60
B.1.7 Critical longitudinal bending tensile stress ... 64
B.1.8 Critical lateral bending tensile stress ... 64

B.2 Stresses in concrete slab/pavement due to thermal impact 64
B.2.1 General 64
B.2.2 Constant stresses c due to temperature changes T acting in concrete slabs or pavements 65
B.2.3 Linear stresses w due to temperature changes t acting in concrete slabs or pavements ...67
B.3 Determination of maximum allowable flexural fatigue stress due to railway traffic load Q .68
B.3.1 Maximum allowable tensile flexural stress in winter (longitudinal stresses) 68
B.3.2 Maximum allowable tensile flexural stress in summer (lateral and longitudinal stresses) .68

Annex C (informative) Vertical loading 69

Annex D (informative) Examples of calculations 70

D.1 First example (variant II: unbonded multiple layers) and second example (variant III: bonded layers) 70
D.2 Distribution of vertical railway traffic loading and calculation of rail seat loads 70
D.2.1 Rail seat load P0 [N] 70
D.2.2 Rail seat loads Pj [N] due to wheel loads Qi [N] 72
D.2.3 Rail bending moment and bending stress at the rail foot 79
D.3 First example (variant II: unbonded multiple layers) 80
D.3.1 General 80
D.3.2 Bending moment due to rail seat loads 82
D.3.3 Stresses due to thermal impact 91
D.3.4 Determination of maximum allowable flexural fatigue stress due to vehicle load Q 92
D.4 Second example (variant III: bonded multiple layers) 93
D.4.1 General 93
D.4.2 Bending moment due to rail seat loads 95
D.4.3 Stresses due to thermal impact 107
D.4.4 Determination of maximum allowable flexural fatigue stress due to vehicle load Q 108

Annex E (informative) Quality control - Routine tests and frequency of testing 109

E.1 General 109
E.2 Data of the slabs to be checked 109
E.3 Examples for frequency of testing 111

Annex F (informative) Example of ballastless track system design calculation and analysis based on analytical tools 112

Annex ZA (informative) Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC 113

Bibliography 115