

Contents

Preface	ix
Acknowledgements	xi
Copyright Acknowledgements.....	xiii
1 Introduction.....	1
1.1 The need for noise and vibration control in railways	1
1.2 The need for a systematic approach to noise control	3
1.3 Sources of railway noise and vibration.....	6
1.4 Structure of the book	9
References	10
2 Introduction to Rolling Noise.....	11
2.1 The source of rolling noise	11
2.2 Speed and roughness dependence	13
2.3 Frequency content.....	17
2.4 Is it the wheel or is it the rail?.....	20
2.5 Overview of the generation mechanism	24
References	26
3 Track Vibration	29
3.1 Introduction	29
3.2 Simple beam models.....	37
3.3 Beam on two-layer support	51
3.4 Timoshenko beam model.....	58
3.5 Discretely supported track models.....	65
3.6 Rail cross-section deformation	76
3.7 Sleeper vibration	82
3.8 Rail pad stiffness	91
References	94
4 Wheel Vibration	97
4.1 Introduction	97
4.2 Wheel modes of vibration.....	97
4.3 Frequency response.....	104
4.4 Simple models for wheel mobility.....	110
4.5 Effects of wheel rotation.....	115
4.6 Experimental results.....	121
4.7 Noise from bogie and vehicle superstructure.....	123
References	126
5 Wheel/Rail Interaction and Excitation by Roughness.....	127
5.1 Introduction	127
5.2 Wheel/rail interaction model.....	128
5.3 Contact zone mobilities.....	141
5.4 Contact filter effect	148
5.5 Measurement of roughness	152
5.6 Processing of roughness data.....	158
5.7 Other excitation mechanisms	164
References	171

6 Sound Radiation from Wheels and Track	175
6.1 Introduction	175
6.2 Simple models for sound radiation.....	177
6.3 Wheel radiation.....	182
6.4 Rail radiation.....	189
6.5 Sleeper radiation	204
6.6 Sound pressure levels during train passage	208
6.7 Validation measurements.....	217
References	221
7 Mitigation Measures for Rolling Noise	223
7.1 Introduction	223
7.2 Reduction of roughness.....	227
7.3 Wheel shape and damping.....	240
7.4 Track response and radiation	254
7.5 Shielding measures.....	266
7.6 Combinations of measures.....	270
References	275
8 Aerodynamic Noise	281
8.1 Introduction	281
8.2 Basic principles.....	283
8.3 Experimental techniques	290
8.4 Numerical techniques.....	299
8.5 Reduction of aerodynamic noise.....	300
8.6 Concluding remarks.....	312
References	312
9 Curve Squeal Noise	315
9.1 Introduction	315
9.2 Curving behaviour	316
9.3 Creep forces.....	319
9.4 Models for frictional excitation	322
9.5 Models for squeal.....	328
9.6 Mitigation measures for curve squeal noise.....	335
9.7 Case study: UK Sprinter fleet.....	338
References	340
10 Impact Noise.....	343
10.1 Introduction	343
10.2 The effect of non-linearities on rolling noise.....	344
10.3 Impact noise due to wheel flats.....	350
10.4 Impact noise due to rail joints	354
10.5 Discussion.....	357
References	358
11 Bridge Noise.....	359
11.1 Introduction	359
11.2 The excitation of bridge noise	363
11.3 Power input to the bridge.....	366
11.4 Vibration transmission and radiation of sound.....	378
11.5 Reducing bridge noise	386
11.6 Case studies	391
References	395

12 Low Frequency Ground Vibration.....	399
12.1 Different types of railway-induced vibration	399
12.2 Assessment of vibration.....	400
12.3 Surface vibration propagation	406
12.4 Excitation of vibration by a train	416
12.5 Examples of calculated vibration from trains	421
12.6 Mitigation measures	429
References	433
13 Ground-Borne Noise	437
13.1 Introduction	437
13.2 Assessment criteria	438
13.3 Vibration propagation from a tunnel	439
13.4 Models for ground-borne noise.....	442
13.5 Predicting ground-borne noise for environmental assessments.....	451
13.6 Mitigation measures: track designs for vibration isolation.....	457
References	464
14 Vehicle Interior Noise.....	465
14.1 Introduction	465
14.2 Characterizing interior noise	467
14.3 Sources of interior noise	470
14.4 Transmission paths	477
14.5 Prediction of interior noise.....	479
14.6 Model assessment and results	479
14.7 Concluding remarks.....	481
References	482
Appendix A: Measurement of Train Pass-by Noise.....	485
Appendix B: Short Glossary of Railway Terminology	489
List of Symbols	493
Index.....	501