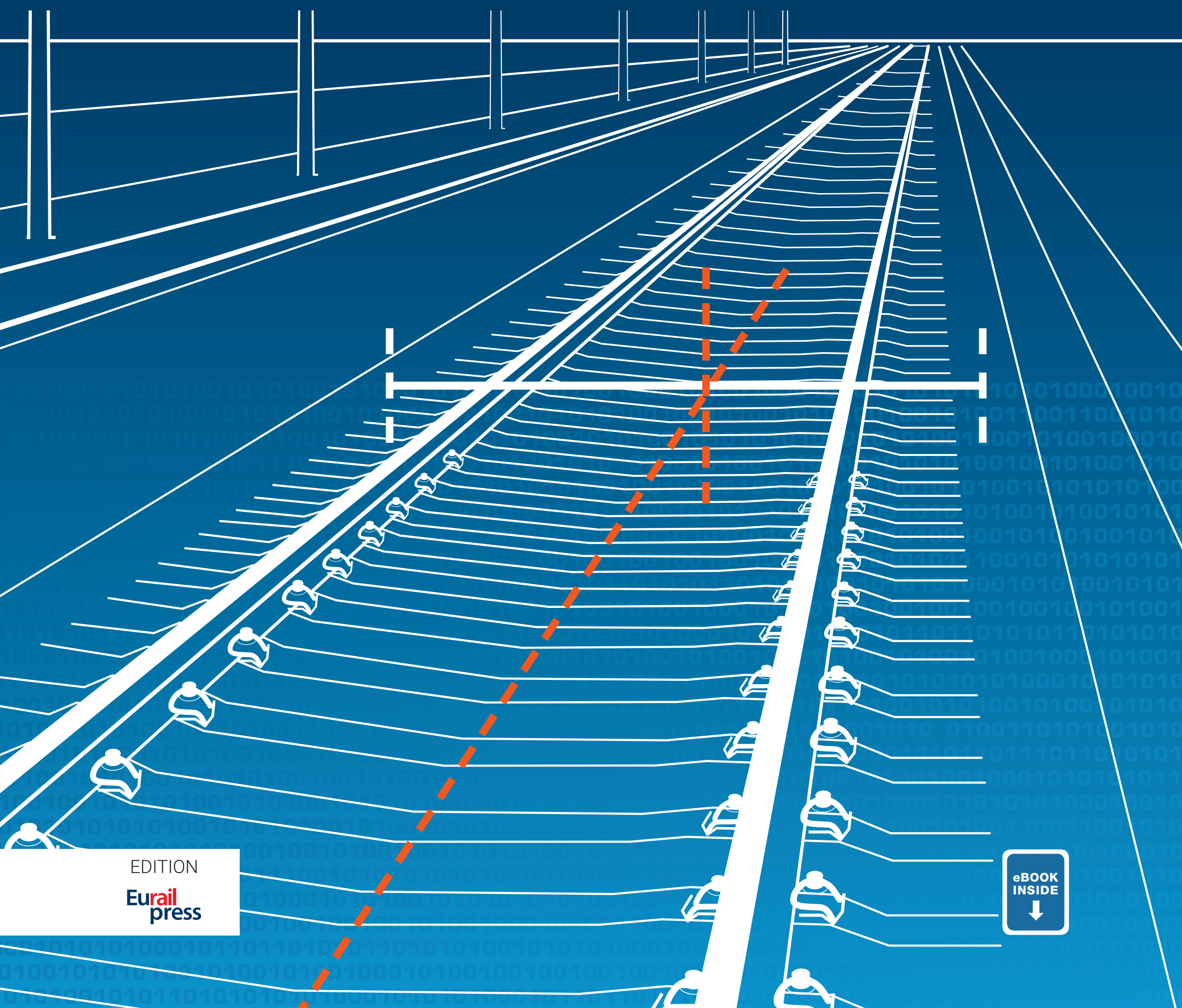
FABIAN HANSMANN | WOLFGANG NEMETZ | RICHARD SPOORS

KEEPING TRACK OF TRACK GEOMETRY

BASICS – ERROR DETECTION – CORRECTION – QUALITY

A comparative overview of the DACH countries and the UK



Bibliographic information published by the Deutsche Nationalbibliothek:
The German National Library catalogues this publication in the German National Bibliography; detailed bibliographic information can be found on http://dnb.de

Publishing House:	PMC Media House GmbH Werkstättenstraße 18 D-51379 Leverkusen
Office Hamburg:	Frankenstraße 29 D-20097 Hamburg Phone: +49 (0) 40 228679 506 Fax: +49 (0) 40 228679 503 Web: www.pmcmedia.com; E-mail: office@pmcmedia.com
Managing Director:	Silvia Goronzy
Publisher/COO:	Detlev K. Suchanek
Editorial Office:	Dr Bettina Guiot
Distribution/Book Service:	Sabine Braun
Cover Design:	Pierpaolo Cuozzo (TZ-Verlag & Print GmbH, Roßdorf)
Typesetting and Printing:	TZ-Verlag & Print GmbH, Roßdorf

1st Edition 2021

ISBN 978-3-96245-225-4

A publication by

PMCMedia
International Publishing

Preface

Dear colleagues!

The title “Keeping Track of Track Geometry” is more than a pun chosen deliberately. This book aims to provide a basic understanding of the track system and its maintenance. The track geometry of a railway is the fundamental factor of its quality. Knowledge about track components and their basic interactions is key to the understanding, assessment and management of the role of quality in the system. Only the best possible quality will ensure maximum sustainability and form the cornerstone for the success of the system.

The six chapters of this book not only provide a well-founded introduction to the basic aspects of railway track and track construction, but also give a comparison of the engineering principles adopted in the DACH countries (Germany, Austria and Switzerland) and the United Kingdom. This comparison provides an interesting insight into the practical implementation of those technical principles and illustrates common features as well as differences. From the legal provisions to the basics of the permanent way as well as measurement methods, the book describes the key concepts that are required for the correction of track geometry on plain line track. One of our main objectives was to provide unbiased product and technological information; therefore, we have deliberately left out technology-specific details in some places.

After months of intense, exciting and sometimes also tense work on the manuscript, corrections, rewriting and deleting, it is a special moment to hold the finished book in our hands – a moment we would like to dedicate to those people who have accompanied and supported us through this time. In particular, for the first edition in the German language, we are thinking of Dr Matthias Landgraf and Werner Schachner. Throughout the project, we were able to count on the unquestionable support of our employers Plasser & Theurer and PMC Rail International Academy. Therefore, on behalf of all the assistance we have been given, we would like to express our sincere gratitude to Johannes Max-Theurer, Johann Dumser and Antonio Intini. We hope you enjoy reading our book and look forward to your feedback.

This copy is the second edition, which was initially translated from the first edition into English. The core text and layout of the book remains unchanged. What is new is the introduction of information concerning the principal mainland railway of the United Kingdom, formerly known as British Rail. Today, the former British Rail railway infrastructure is owned and managed by Network Rail, an arm’s length public body of the UK Government. We hope that this second edition will provide the reader with an interesting contrast between track technical matters both in the DACH countries and the UK.

We would like to thank, Deutsche Bahn, Network Rail, OEBB and SBB for access to their track technical standards and permission to use specific data from them. Additional sources of information and more general background references are included in the Bibliography.

Fabian Hansmann | Wolfgang Nemetz | Richard Spoors

Notes on use:

In addition to legal provisions, technical principles are discussed using extracts from standards or internal railway rules and regulations. Any given limit values are examples and have been taken from the rules and standards quoted. These are subject to change. Therefore, the issue date of the source has to be considered. This book helps to depict interactions between individual topics but cannot and should not be a replacement for studying the respective rule or standard.

Unless quoted otherwise, the authors have the property rights of the figures used in the book. We would like to thank MATISA, Plasser & Theurer, PMC Rail International Academy, ROBEL and Trimble for kindly providing their photos and further documents.

Contents

Preface 3

1 Legal and technical rules and standards 9

1.1 Key issues 9

1.2 The railway and its rules and standards 9

1.3 From the technical entity to interoperability 10

1.3.1 Technical unity 11

1.3.2 Legal foundations 12

1.3.3 Interoperability 15

1.4 Cross-border standardisation 18

1.5 Internal railway guidelines 19

1.6 Summary 21

2 Basic principles of the permanent way 23

2.1 Key issues 23

2.2 The railway as a system 23

2.3 Vehicle gauge and structure gauge 23

2.4 Axle loads on the track and their distribution 29

2.4.1 Vertical forces and deflection 30

2.4.2 Lateral forces 32

2.4.3 Longitudinal forces 33

2.5 Classification of lines 36

2.6 The permanent way and its constituent parts 38

2.6.1 The rail 39

2.6.2 Sleepers 50

2.6.3 Track fastenings 59

2.6.4 Track codes 65

2.6.5 Ballast 66

2.6.6 Substructure 73

2.7 Switches and crossings (turnouts)......76
2.7.1 Basic principles 76
2.7.2 Terminology 78
2.7.3 Main components......79

3 Track alignment design 81

3.1 Key issues......81

3.2 Physical principles 81

3.3 Components of a railway route......86

3.4 Limits and standard values 88

3.5 Transition curves and cant ramps......91
3.5.1 Transition curves and linear cant ramps 93
3.5.2 Transition curves and graduated cant ramps......95
3.5.3 Cant deficiency and cant excess......100

3.6 Minimum lengths 102

3.7 Reverse curves with an abrupt change in curvature ("Track Scissors")......103

3.8 Buffer locking......104

3.9 Track re-alignment – variation of the distance between the centres of two tracks 105

3.10 Gradient change 106

3.11 Summary......108

4 Track geometry defects and the determination of correction values 109

4.1 Key issues......109

4.2 Track geometry defects......109
4.2.1 Definition and their formation......109
4.2.2 Distinction of track geometry defects 110
4.2.3 The Principal Measurement of Track geometry faults in the UK 112
4.2.4 The Phenomenon of Cyclic Top 113
4.2.5 Intervention limits 114
4.2.6 Maintenance methods for correcting track geometry defects 116

4.3 Basic principles of measuring track geometry 117

4.4 Precision method ... 122
4.4.1 Measuring the longitudinal level ... 123
4.4.2 Measuring the alignment ... 136
4.4.3 Systems for measuring longitudinal level and alignment ... 140
4.5 Compensation method ... 150
4.5.1 4-point method: compensation method without known route parameters ... 150
4.5.2 3-point method: compensation method with known route parameters ... 151
4.5.3 Electronic compensation method ... 153
4.6 Correcting isolated defects (Spot Tamping) ... 154
4.7 Overlifting the track position as a maintenance process ... 156
4.8 Summary ... 158

5 The correction of track geometry ... 159

5.1 Key issues ... 159
5.2 Basic principles of track geometry maintenance ... 159
5.3 Correction of track geometry with a tamping machine ... 161
5.3.1 Different types of tamping machines ... 162
5.3.2 Choice of machine type for the UK ... 164
5.3.3 Work units of a tamping machine ... 165
5.3.4 Preparatory work for a sustainable tamping process ... 168
5.3.5 Track geometry data input ... 170
5.3.6 Controlling the tamping process and its parameters ... 174
5.3.7 Spot tamping ... 177
5.3.8 Parallel tamping ... 177
5.4 Dynamic track stabilisers and consolidators ... 178
5.5 Ballast distributing and profiling machines ... 179
5.6 Summary ... 181

6 Acceptance and quality assurance ... 183

6.1 Key issues ... 183
6.2 Acceptance ... 183
6.2.1 Preliminary acceptance ... 183
6.2.2 Final acceptance ... 184
6.2.3 Quality certification for work performed ... 184

6.2.4 Acceptance limit values in EN 13231-1 185
6.2.5 Acceptance limit values in the UK 185

6.3 Sequence of acceptance 186

6.4 Acceptance of track renewals in the UK 186

6.5 Acceptance criteria for tamping work at DB, ÖBB, SBB and NR 186

Bibliography 203

Authors 215

List of abbreviations 217

Index 221

1 Legal and technical rules and standards

Fabian Hansmann and Richard Spoors

1.1 Key issues

This chapter provides an overview of the legal and technical rules and standards in Germany (DB Netz), Austria (ÖBB Infrastruktur) Switzerland (SBB), (also known as the DACH countries) and the United Kingdom (Network Rail). The chapter will provide answers to the following questions:

– Which legal provisions are relevant for the maintenance of the railway infrastructure in these countries?
– What cross-border technical regulations exist and to what extent are they legally binding?
– What content is regulated by TSI Infrastructure?
– What differences are there between the ISO and CEN standards?
– What technical rules and standards apply on the networks of DB, ÖBB, SBB and NR?

1.2 The railway and its rules and standards

When the steam powered railway started operation in the early 19th century, individual countries developed numerous rules and regulations to keep the use of this “dangerous” new means of transport under control. By 1883 in the UK there were around 130 private railway companies with their own Rule Books, primarily focused on the safe operation of trains.

In 1879 the German Imperial Court, as a consequence of a claim for damages, defined a railway company as follows:

“A company, focused on the repeated moving of persons or things over not insignificant spatial distances on a metal foundation, which due to its consistency, construction and smoothness is designed to enable the transport of large amounts of weight and the achievement of a relatively significant speed of the transport movement, and as a result of this characteristic feature combined with the natural forces (steam, electricity, animal or human muscular activity, in the case of an incline of the railway also the own weight of the transport vessel and its load, etc.) used to generate the movement that is capable of generating a relatively powerful effect (depending on circumstances only useful by object, or also causing the destruction of human life or injury to human health) when being operated.” [1]

Such a detailed definition of a railway company may be exaggerated but back then was probably due to the general scepticism towards the new means of transport.

But what does the term “railway” entail?

A clear definition of the term railway in the German language is not irrelevant. Its fuzziness in everyday use has a significant impact on legal and technical framework conditions. Here, two aspects have to be taken into consideration:

1. In contrast to other means of transport, such as the car, the railway in its original form constituted the construction and operation of the asset. Only as late as 2001, the European Union would pave the way for free access to the infrastructure by separating this original concept [2]. Today a clear distinction is made between railway infrastructure managers and railway undertakings.

2. When applying various rules and standards, attention needs to be paid to which parts of the system these apply. Some countries have different guidelines for main line tracks, trams, underground railways etc.

The numerous acts of Parliament, laws, regulations, guidelines and work instructions of all kinds make it difficult to keep an overview. The following section will aim to provide the basic correlations between the legal and technical rules and standards in the four countries (Fig. 1-1). It will concentrate on the issues relating to the rail infrastructure.

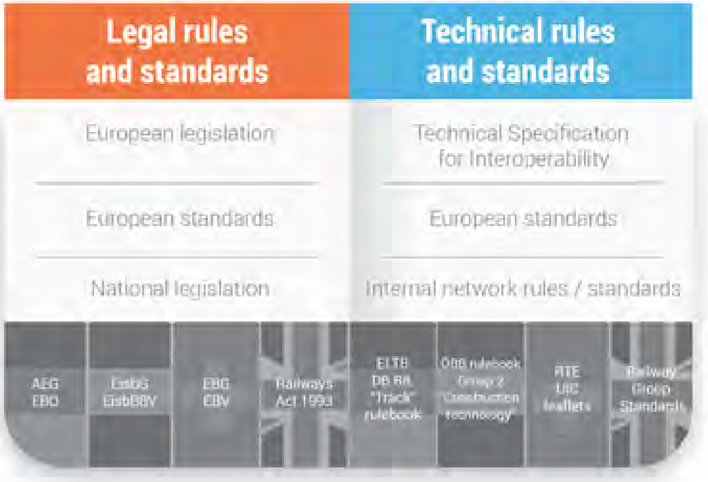


Fig. 1-1: Legal and technical rules and standards

1.3 From the technical entity to interoperability

The first railway networks were formed as self-contained networks, and their rules and standards were heavily dominated by factory standards. [3, p. 20]

> A standard is a "document drafted by consensus and approved by an acknowledged institution. It specifies rules, guidelines or properties for general or recurrent use, pertaining to activities or products thereof. Its ultimate goal is to achieve the highest possible degree of order in a specific context." [4, p. 25]

With the rail connection between Aachen in Germany and Liège in Belgium the first cross-border railway line was opened in 1843. No matter whether the railway companies were under public or private management, it became apparent back then that it would be necessary to harmonise the technical framework conditions. The low flexibility of the gauge-bound system made it more difficult to meet the economical requirement of travelling over cross-border networks, which were very different from each other. In contrast, the military had a strategic interest in restricting and controlling cross-border traffic as much as it could. This can still be seen clearly in the different selection of track gauges throughout Europe (Fig. 1-2).

Fig. 2-15: Overview of the constituent elements of the permanent way

The track panel and the ballast bed underneath are part of the track system. The track panel consists of the rails, the fastening system and the sleepers, with no distinction being made between plain line and turnouts. Additional layers of sand, gravel or asphalt can be used underneath the ballast bed to improve the load bearing properties of the permanent way. In Austria and Germany, these layers are regarded as part of the track bed, while in Switzerland and the UK they are part of the substructure. Engineering structures such as bridges and tunnels as well as cuttings and drainage systems are also part of the substructure.

2.6.1 The rail

There is a lot of argument about the origins of the railways. It is a fact that mine cars were moved on a type of wooden rail in German and English mines as early as the 16th century. [23, p. 8]

In the 17th century, the idea arose in Nottingham, England to use these wooden tracks outside of the mines. In 1603, a coal mine owner by the name of Beaumont joined the two “wooden rails” with crossbars and thus laid the foundations for the modern railway track. This idea made it possible to increase the volume of materials carried up to 5-fold. The wooden rails were fitted with iron fittings at particularly heavily stressed points to increase the life of the track. [24, p. 1]

The contact of steel on steel between the wheel and the rail underneath is the crucial advantage of the railway system. Due to this low frictional value, less energy is required to transport large masses from A to B.

The original iron fittings on wooden rails were, however, not able to withstand the increasing loads. In 1767, the English ironworks owner Richard Reynolds was, after a few unsuccessful attempts, the first to introduce the flat rail made of cast iron (see Fig. 2-16). [25, p. 7] Cast iron, however, is particularly brittle and not ductile like modern rail steel. Therefore, his flat rails were continuously supported by means of longitudinal timbers. The development of railways in England owed much to George Stephenson, a colliery worker from Northumberland, who studied and learned to repair stationary steam engines as a young man. By 1824 he had opened a factory to build steam locomotives for new colliery railways. This expansion of the early railways also saw the development of foundries and techniques to roll early wrought iron rails. The low level of friction in the contact of metal wheel on metal rail is the crucial advantage of the railway system, as less energy is required to transport large masses from A to B. [26]

Fig. 2-16: Reynolds rail as a representative of the first flat rails, based on [27, p. 16]

Fig. 2-17: Use of L shaped cast iron rails and stone blocks on the Denby Tramway-wagonway (Outram's Railroad) near Little Eaton, Derbyshire, England [28]

The development of new iron rolling mill methods in the UK created stronger wrought iron rails and sleepers reverted to lying crossways. The American R. L. Stevens sailed to England in 1830, bringing with him his ideas for a flat bottom rail section which he had produced in the Dowlais Ironworks in Wales and shipped back to the USA. At the same time Charles Vignole, an Irish engineer, also designed a flat bottomed rail which laid the foundation for the development of today‘s common rail profile, which was first used in its current shape in 1890. In England the preferred profile was not flat bottom but bull head, a design that was developed from the double headed wrought iron rails and it prevailed until 1948.

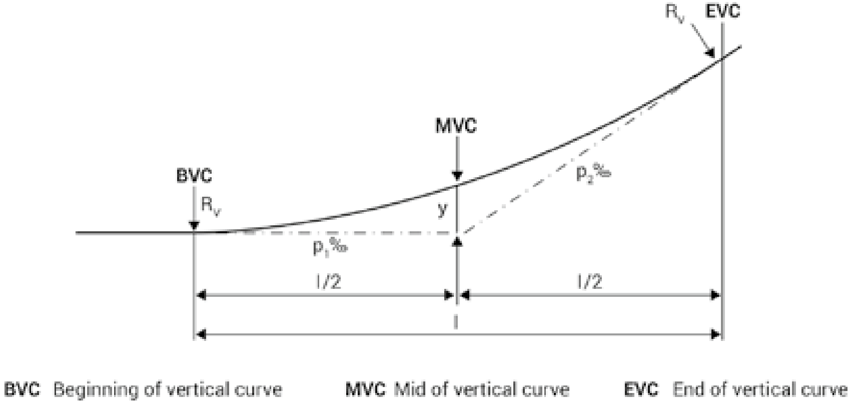


Fig. 3-31: Diagram of a change in vertical gradient and its main geometric points

EN 13803 provides for either a conventional circular curve or a 2nd degree parabola for this smoothing. [7, section 5.2] The standard is slightly more precise than the railway companies' rules and standards when stating those limits. It also distinguishes between speed ranges for the mandatory vertical curve:

$0 < v \leq 230$ km/h   1 ‰

$230 < v \leq 360$ km/h   0.5 ‰

In principle, gradient changes are to be avoided on bridges and in switches and crossings as construction and maintenance are particularly difficult here. Ideally, changes in gradient are provided for on the straight since complicated geometries can arise in a curve due to the combination with the cant.

Depending on the type of vertical curve, a distinction is made between valleys ($p_1 < p_2$) and humps ($p_1 > p_2$). The radii, as calculated in Fig. 3-32, are used for the vertical curve itself. The values for horizontal curves are, however, much greater in comparison. The reason for this is that vertical acceleration up to 0.31 m/s² is regarded as acceptable. This value is only one third of the permissible horizontal lateral acceleration of 0.98 m/s²; this is why the values for horizontal curves are much greater. In the UK, Network Rail's normal design value for vertical acceleration is 2.25 % g. [31]

DB	OEBB	SBB	NR	EN 13803
$v \leq 230$ km/h $R_v = 0.4 \cdot v^2$ $v > 230$ km/h $R_v = 22{,}500$ m	New construction: $R_v = 0.5 \cdot v^2$ Maintenance $R_v = 0.4 \cdot v^2$ but > 2,000 m	$R_v = 0.35 \cdot v^2$ Valleys: $R_v > 2{,}000$ m Humps: $R_v > 2{,}000$ m	$R_v = 0.35 \cdot v^2$	$R_v = 0.35 \cdot v^2$ but > 2,000 m

Fig. 3-32: Examples of the limits of vertical curve radius Rv [7] – [10] [32]

Based on the curve radius determined, the following equations result for the length l or $\frac{l}{2}$

$$\frac{l}{2} = \frac{|p_1| - |p_2|}{2000} \cdot R_v \tag{3-32}$$

and the distance between peaks

$$y = \frac{1000 \cdot l^2}{8 \cdot R_v} \tag{3-33}$$

p_1 and p_2 in [‰]:	gradients
R_v in [m]:	vertical curve radius
l in [m]:	horizontal length of curve
y in [m]:	distance between peaks

Referring to Fig. 3-31 above and using these values, the vertical curves can be uniquely described, and the main points start of vertical curve (BVC), centre of vertical curve (MVC) and end of vertical curve (EVC) can be determined. Unlike for horizontal curves, transition curves are not necessary in vertical curves.

3.11 Summary

In this chapter we have looked at the basics of plain line track design. Today, the majority of track design is undertaken using computers and specially designed software. Even so, as this method of track design does not rely on the user using empirical formulae, the resulting trace has to demonstrate compliance with national and railway standards for passenger comfort, the transport of goods and above all safety of the railway. It is also important that the available means to install and maintain the permanent way has the ability to maintain the geometric calculations used in the design. We shall start to look at this in the next chapter.

DTSs and consolidators have the aim of keeping the influences of voiding and high initial settlements on tamping quality as low as possible and to pre-empt them in a controlled manner. While the dynamic track stabiliser achieves this effect through horizontal excitations applied to the track panel, consolidators consolidate the ballast crib and try to achieve the same effect in this way. This makes it possible to influence the consolidation process in a targeted manner and to increase the lateral displacement resistance to a level where most reduced line speeds will no longer be necessary after the disturbance of ballasted track.

If neither a DTS nor a consolidator is deployed after tamping, it may be necessary to travel on this section of track at reduced speeds, depending on the type of track and the work undertaken. This reduced speed running will consolidate the ballast and gradually allow the desired loads to be absorbed. After some time, the ballasted track will meet the criteria with regard to the lateral displacement resistance. This process can last to between 0.5 and 1.5 million tonnes of traffic, but also poses the risk of irregular load application. The irregular loads arising from train traffic, e.g. due to flat spots on wheels, may result in inhomogeneous settlements.

Any necessary speed restrictions will have an impact on the capacity of the railway system and the whole network. The lower speeds will not only result in fewer trains being able to pass the section of track but may also have an impact on the timetable.

DTSs and consolidators do not necessarily have to be operated as separate machines. They are increasingly integrated into the designs of existing machines. For example, DTS and consolidators can be integrated into tamping machines or ballast distributing and profiling machines.

Network Rail has had considerable success in recent years with the use of the DTS on switch and crossing unit renewals. The particular machines used are the Unimat 09-4x4/4S Dynamic.

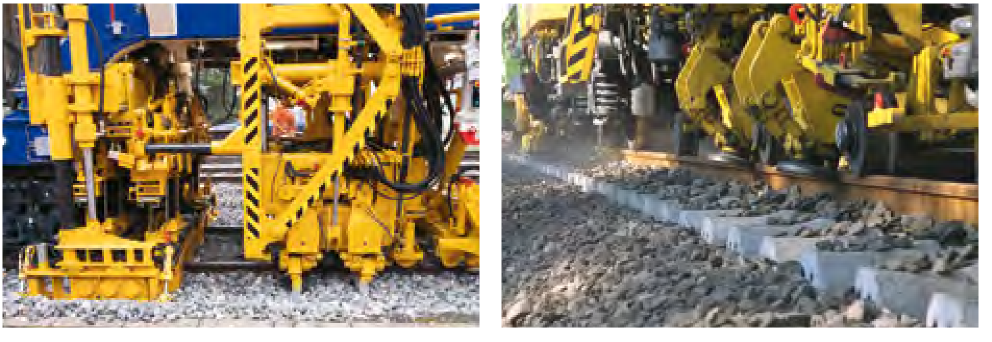


Fig. 5-26: Integrated consolidation unit (MATISA, left) and integrated DTS unit (Plasser & Theurer, right)

5.5 Ballast distributing and profiling machines

Before tamping, in order to have sufficient ballast available in the cribs for the formation of the bearing surface beneath each sleeper, the required quantity of ballast is deposited in the tamping area. This additional ballast will be required as a result of the correction of the track geometry and should ideally be calculated beforehand, depending on the determined correction values. Before tamping a section of track, the ballast is also deposited to the left and right of the two rails in the tamping area in order to strengthen the ballast shoulder.

Fig. 5-27: Unloading new ballast in the UK [27]

On sections of line with high speeds, it may not be permitted to pre-deposit new ballast. Due to aerodynamic effects, high train speeds may cause a suction effect under the trains [28, p. 624] that can result in ballast being whirled up. This is known as flying ballast and can severely damage technical equipment of trains and endanger lives in station areas.

For this reason, countries have adopted the approach to clear the sleeper surface of exposed ballast stones after tamping and to lower the height of the ballast crib in line with the applicable rules and standards and depending on the maximum speed of the specific section of line (see section 2.6.5). This work is usually carried out by ballast distributing and profiling machines (ballast ploughs/brushes), which will also re-establish the desired ballast profile. To do this, the machines are equipped with ballast ploughs of different profiles.

Fig. 5-28: Ballast distributing and profiling machines: R 21 (MATISA, left) and USP 2010 SWS (Plasser & Theurer, right)

Bibliography

Bibliography – Chapter 1

[1] German Imperial Court: Betrieb einer Eisenbahn und Betriebsunternehmen im Sinne des Reichshaftpflichtgesetzes, 17.03.1879. https://opinioiuris.de/entscheidung/1724, accessed on 26.07.2018.

[2] Directive 2001/12/EC of the European Parliament and of the Council of 26 February 2001 amending Council Directive 91/440/EEC on the development of the Community's railways. Official Journal of the European Communities, 15.03.2001. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0012&from=EN, accessed on 10.01.2019.

[3] Endlicher, K.-O. and Rischanek, A.: Normen im Eisenbahnwesen – Der praktische Gesamtüberblick. Austrian Standards plus Publishing, 2017.

[4] EN 45020: Standardisation and related activities – General vocabulary, August 2007. British Standards Institution.

[5] 1846 act of parliament: The Railway – British track since 1804 by Andrew Dow, published by Pen and Sword books, Barnsley, England.

[6] Federal Republic of Germany: Allgemeines Eisenbahngesetz (AEG). Federal Ministry of Justice and Consumer Protection, 27.12.1993, version of 29.11.2018. https://www.gesetze-im-internet.de/aeg_1994/AEG.pdf, accessed on 11.01.2019.

[7] Federal Republic of Germany: Gesetz über die Eisenbahnverkehrsverwaltung des Bundes (Bundeseisenbahnverkehrsverwaltungsgesetz – BEVVG). Federal Ministry of Justice and Consumer Protection, 27.12.1993, version of 29.11.2018. https://www.gesetze-im-internet.de/aeg_1994/AEG.pdf, accessed on 10.01.2019.

[8] Federal Republic of Germany: Eisenbahn-Bau- und Betriebsordnung (EBO). Federal Ministry of Justice and Consumer Protection, 08.05.1967, version of 26.07.2017. https://www.gesetze-im-internet.de/ebo/EBO.pdf, accessed on 11.01.2019.

[9] Federal Railway Office: Eisenbahnspezifische Liste Technischer Baubestimmungen (ELTB), 18.01.2016. https://www.eba.bund.de/SharedDocs/Downloads/DE/ Infrastruktur/AllgemeineVorschriften/ELTB/21-ELTB_01_2016_Aenderungen.pdf?__blob=publicationFile&v=2, accessed on 12.07.2018.

[10] Freystein, H., Muncke, M., Schollmeier, P.: Handbuch Entwerfen von Bahnanlagen – Regelwerke, Planfeststellung, Bau, Betrieb, Instandhaltung. PMC Media House GmbH, Leverkusen, 2015.

[11] Republic of Austria: Bundesgesetz über Eisenbahnen (EisbG). Federal Ministry for Digital and Economic Affairs, 07.03.1957, version of 14.01.2019. https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10011302, accessed on 11.01.2019.

[12] Commission Regulation (EU) No 1299/2014 of 18 November 2014 on the technical specifications for interoperability relating to the 'infrastructure' subsystem of the rail system in the European Union. Official Journal of the European Union, 12.12.2014. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1299&from=EN, accessed on 11.01.2019.

Authors

Dipl.-Ing. Dr Fabian Hansmann

Fabian Hansmann graduated from Graz University of Technology in 2011 with a degree in civil engineering in the specialist field of environment and transportation. Between 2011 and 2016, he worked as a research associate at the Institute of Railway Engineering and Transport Economy at TU Graz, where he wrote his doctoral thesis (PhD) on “Digital asset management of ‘track’”. During his time at the Institute, he worked together with various railway infrastructure managers and industry partners on research projects on the topic of Life Cycle Costs and asset management. In 2015, he joined Plasser & Theurer in the Marketing and Communication department. His work has provided him with insights into the global developments in the field of track maintenance with a focus on the operation of large on-track machines. In 2019 he started working for Plasser American in Chesapeake (USA) as Senior Scientific Advisor for Railroad Engineering.

Wolfgang Nemetz

Wolfgang Nemetz completed his education at the Höhere Technische Bundes-Lehr- und Versuchsanstalt Wiener Neustadt in the field of electrical engineering. In 1985 he joined ÖBB, where he worked in track and switch surveying until 1991. Subsequently he acted as ÖBB operations manager of track/switch tamping machines and rail grinding trains. From 1998 to 2003 he took over the nationwide control of tamping machines and surveying. From 2003 to 2007, he was responsible for the technical and operational implementation of the entire mechanical track construction operation at ÖBB. After extensive organisational changes in the company, in 2007, he took over the management of the performance management department for the construction and maintenance of the Plant Service division of ÖBB-Infrastruktur BAU AG. From 2010 until his move to the private sector, he was most recently head of the Mechanical Engineering department at ÖBB-Infrastruktur AG. Since 2017, Wolfgang Nemetz has been working at the PMC Rail International Academy in project management, consulting and as Head of Division Development Austria.

Richard Spoors, MICE, FPWI

Richard Spoors (75) joined British Rail in 1964 as a Student Civil Engineer. After graduating from the University of Bradford with a degree in Civil Engineering, he honed his skills as a railway civil engineer on the Regions of British Rail, culminating with his appointment to the position of Regional Civil Engineer, Scotland, in 1989. The privatisation of the UK’s railways took him into Railtrack and then Network Rail, from where he retired in 2005 having led the civil engineering team specifying and approving the upgrade of the West Coast Main Line. During the next period of Richard’s career as a consultant he supported the UK Rail Regulator in their review of Network Rail’s track policy. His particular interest in the management of all aspects of track saw him elected President of the Permanent Way Institution in 2004 and 2009.

Elements of the elevation 87
Elements of the layout 87
Embankment 74, 75
EM-SAT 141, 142
EN 13231-1 183, 184, 186, 194, 195, 196
EN 13848 184
Error dimension (in a transition) 171
European railway area 15

F

Federal Railway Authority (EBA) 12
Federal Railway Transport Administrative Law (BEVVG) 12
Federal Transport Office (BAV) 14
Fishplate 34, 35, 63
Fixed points 145
Forces 29
Centrifugal 82
Diagram of forces 85
Equilibrium of forces 85
Lateral 32, 33, 81, 100
Longitudinal 33, 34, 63
Vertical 30, 32, 81
Formation 32, 38, 74
Front tower operator 168, 170

G

Gauge
Nominal 46
Track 28, 46, 47
Widening 26, 47
Gauging (of structure) 24, 28
General Railway Act (AEG) 12
Geodetic survey 118, 119, 147
Gradient 86, 93, 106
Gradient change 106
Graduated cant ramp 96, 98
Graduated transition curve 95, 96, 97, 100

H

Hallade 149
Her Majesty's Railway Inspectorate (HMRI) 14
Hunting 42, 43

I

Implementing Provisions of the Railway Regulation (AB-EBV) 14
Inertial measurement unit (IMU) 148
International Organisation for Standardisation (ISO) 18
International Railway Union 11
Interoperability 15
Intervention and alert limits 114, 116

J

Jolt 86, 90

L

Lateral acceleration 83, 84, 106
Law of inertia 81, 82
Levelling 134, 135
Lifting clamps 165, 174
Lifting hooks 165
Lifting-lining unit 165, 168, 174
Lifting value
Minimum lifts 173
Permissible lifting values 172
Limits
Design 88
Exceptional 88
Normal 88
Recommended 88
Linear cant ramp 93, 95
Lineside drainage 69
Lining rollers 165
Long chord measurement 139, 140
Longitudinal chord procedure 131
Longitudinal level 111, 123, 185, 190

This technical book provides a comprehensive, practical overview of all aspects of track alignment correction, taking into account the relevant regulations of the DACH countries (Germany, Austria and Switzerland) and the United Kingdom.

First of all, the fundamentals of track alignment and the interrelationships between track components and their stresses are described in a clear and practical manner. Starting from these fundamentals of track alignment, the book then spans the thematic arc from the determination to the methods of measurement and correction of track position defects to quality control. The entire tamping process, including all the necessary accompanying work, is explained clearly and independently of the manufacturer.

Regardless of the existing level of knowledge, this book offers interested parties from all areas of railway engineering an insight into the planning, execution and acceptance of tamping work in the DACH countries and the UK.

The six chapters of this book not only provide a well-founded introduction to the basic aspects of railway track and track construction, but also give a comparison of the engineering principles adopted in these four countries.

This comparison provides an interesting insight into the practical implementation of those technical principles and illustrates common features as well as differences. From the legal provisions to the basics of the permanent way as well as measurement methods, the book describes the key concepts that are required for the design and maintenance of track geometry on plain line track.

Extra: Free e-book included. Users who have a PDF reader installed on their device (PC, tablet, smartphone) can access the content of the book electronically including a search function.

ISBN 978-3-96245-225-4
9 783962 452254