

NOTES ON NUMERICAL FLUID
MECHANICS AND MULTIDISCIPLINARY
DESIGN • VOLUME 99

Noise and Vibration Mitigation for Rail Transportation Systems

Proceedings of the 9th International Workshop
on Railway Noise, Munich, Germany,
4–8 September 2007

Burkhard Schulte-Werning • David Thompson
Pierre-Etienne Gautier • Carl Hanson
Brian Hemsworth • James Nelson
Tatsuo Maeda • Paul de Vos (Eds.)



Springer

NOTES ON NUMERICAL FLUID
MECHANICS AND MULTIDISCIPLINARY
DESIGN · VOLUME 99

Noise and Vibration Mitigation for Rail Transportation Systems

Proceedings of the 9th International Workshop
on Railway Noise, Munich, Germany,
4–8 September 2007

Burkhard Schulte-Werning · David Thompson
Pierre-Etienne Gautier · Carl Hanson
Brian Hemsworth · James Nelson
Tatsuo Maeda · Paul de Vos (Eds.)



Springer

Editors

E.H. Hirschel/München
W. Schröder/Aachen
K. Fujii/Kanagawa
W. Haase/München
B. van Leer/Ann Arbor
M.A. Leschziner/London
M. Pandolfi/Torino
J. Periaux/Paris
A. Rizzi/Stockholm
B. Roux/Marseille
Y. Shokin/Novosibirsk

Noise and Vibration Mitigation for Rail Transportation Systems

Proceedings of the 9th International Workshop
on Railway Noise, Munich, Germany,
4–8 September 2007

Burkhard Schulte-Werning
David Thompson
Pierre-Etienne Gautier
Carl Hanson
Brian Hemsworth
James Nelson
Tatsuo Maeda
Paul de Vos
(Editors)



Springer

Dr. Burkhard Schulte-Werning
Deutsche Bahn AG
Systemverbund Bahn
DB Systemtechnik
Völckerstr. 5
80939 München
Germany
E-mail:
burkhard.schulte-werning@bahn.de

Prof. Dr. David Thompson
ISVR, University of Southampton
Highfield
Southampton SO17 1BJ
United Kingdom
E-mail:
djt@isvr.soton.ac.uk

Dr. Pierre-Etienne Gautier
SNCF Research & Technology
45 rue de Londres
75379 Paris cedex 08
France
E-mail:
pierre-etienne.gautier@sncf.fr

Dr. Carl Hanson
Harris Miller Miller & Hanson Inc.
15 New England Executive Park
Burlington, MA 01803
USA
E-mail:
chanson@hmmh.com

Brian Hemsworth B.Sc., CEng., FIOA
Brian Hemsworth Noise Consultant LLP
16 Whistlestop Close
Mickleover
Derby DE3 9DA
United Kingdom
E-mail:
brian.hemsworth@btinternet.com

Dr. James Nelson
Wilson, Ihrig & Assoc., Inc.
5776 Broadway
Oakland, CA
USA 94618-1531
E-mail:
jnelson@wiai.com

Dr. Tatsuo Maeda
Railway Technical Research Institute
2-8-38 Hikari-cho Kokubunji-shi
Tokyo 185 8540
Japan
E-mail:
maeda@rtri.or.jp

Paul de Vos M.Sc.
DHV BV, Environment and Transportation
P.O. Box 1132,
NL 3800 BC Amersfoort
The Netherlands
E-mail:
paul.devos@dhv.com

ISBN 978-3-540-74892-2

e-ISBN 978-3-540-74893-9

DOI 10.1007/978-3-540-74893-9

Notes on Numerical Fluid Mechanics
and Multidisciplinary Design

ISSN 1612-2909

Library of Congress Control Number: 2008922523

©2008 Springer-Verlag Berlin Heidelberg

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable for prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Typesetting Scientific Publishing Services Pvt. Ltd., Chennai, India.

Printed in acid-free paper

5 4 3 2 1 0

springer.com

NNFM Editor Addresses

Prof. Dr. Ernst Heinrich Hirschel
(General Editor)
Herzog-Heinrich-Weg 6
D-85604 Zorneding
Germany
E-mail: e.h.hirschel@t-online.de

Prof. Dr. Wolfgang Schröder
(Designated General Editor)
RWTH Aachen
Lehrstuhl für Strömungslehre und
Aerodynamisches Institut
Wüllnerstr. zw. 5 u. 7
52062 Aachen
Germany
E-mail: office@aia.rwth-aachen.de

Prof. Dr. Kozo Fujii
Space Transportation Research Division
The Institute of Space
and Astronautical Science
3-1-1, Yoshinodai, Sagamihara
Kanagawa, 229-8510
Japan
E-mail: fujii@flab.eng.isas.jaxa.jp

Dr. Werner Haase
Höhenkirchener Str. 19d
D-85662 Hohenbrunn
Germany
E-mail: office@haa.se

Prof. Dr. Bram van Leer
Department of Aerospace Engineering
The University of Michigan
Ann Arbor, MI 48109-2140
USA
E-mail: bram@engin.umich.edu

Prof. Dr. Michael A. Leschziner
Imperial College of Science
Technology and Medicine
Aeronautics Department
Prince Consort Road
London SW7 2BY
U.K.
E-mail: mike.leschziner@ic.ac.uk

Prof. Dr. Maurizio Pandolfi
Politecnico di Torino
Dipartimento di Ingegneria
Aeronautica e Spaziale
Corso Duca degli Abruzzi, 24
I-10129 Torino
Italy
E-mail: pandolfi@polito.it

Prof. Dr. Jacques Periaux
38, Boulevard de Reuilly
F-75012 Paris
France
E-mail: jperiaux@free.fr

Prof. Dr. Arthur Rizzi
Department of Aeronautics
KTH Royal Institute of Technology
Teknikringen 8
S-10044 Stockholm
Sweden
E-mail: rizzi@aero.kth.se

Dr. Bernard Roux
L3M – IMT La Jetée
Technopole de Chateau-Gombert
F-13451 Marseille Cedex 20
France
E-mail: broux@l3m.univ-mrs.fr

Prof. Dr. Yuri I. Shokin
Siberian Branch of the
Russian Academy of Sciences
Institute of Computational
Technologies
Ac. Lavrentyeva Ave. 6
630090 Novosibirsk
Russia
E-mail: shokin@ict.nsc.ru

Preface

This book contains the presentations given during the 9th International Workshop on Railway Noise (IWRN9) which took place in Munich/Feldafing, Germany, on 4th to 8th September 2007. This workshop was organised by the Acoustics and Vibration Department of DB Systemtechnik, the technical engineering office of Deutsche Bahn AG.

More than 120 participants from 17 countries followed the invitation to the workshop. This great response showed the continuing interest in an important topic of railway technology and offered the opportunity to present the recent results of intense worldwide activities to the international community of railway noise and vibration experts and to share knowledge as well as experience.

Because an efficient transportation network is indispensable to handle the general mobility increase and road networks have reached their socio-ecological limits, the railway network is to be strengthened. For example the European Commission has given distinct political signals to get more passengers onto the railways. This policy represents a clear challenge for the next few decades not only for European railway companies: the considerable increase in mobility will lead to a doubling of the railway traffic volume within the next 10 to 20 years.

To reduce the environmental impact, the Directive on the Assessment and Management of Environmental Noise has been put into force in Europe, aiming at avoiding, preventing or reducing harmful effects of environmental noise on human health. This directive requires member states to produce strategic noise maps by using noise indicators assessing the number of people affected by noise, to inform the public about noise exposure, and to draw up action plans to reduce noise where necessary. These action plans will also tackle railway noise.

Responses to these subjects simultaneously involve the variety of rolling stock vehicles, infrastructure and also operating conditions. Since often efficient and economically satisfying solutions to railway noise problems cannot be found on one single component of the system alone, they need to be studied by considering the railway system with its interdependencies.

The IWRN9 contributions give state-of-the-art answers to such questions and address general rolling noise aspects, new noise reduction technologies, prediction tools and theoretical models, high-speed trains, ground-borne vibrations, cost-benefit considerations of noise abatement as well as rail grinding, corrugation and roughness.

Following the tradition of the previous workshops, IWRN9 was held as a single session event with the aim of providing the optimistic atmosphere for informal and inspired exchange of information on all facets of railway noise and vibration mitigation. Over three and a half days, 64 papers were presented in 13 sessions and in a poster session additional 11 presentations were subject of lively discussion.

There is no formal organisation behind the IWRN but rather an informal, committed International Committee. It supports the chairman during the preparation process with the experience and expertise of its members. Assistance is given to formulate the

scientific programme, to release the Call for Papers, to perform the paper selection process, to act as session chairmen at the IWRN9 workshop and to act as a peer review group for the IWRN9 proceedings.

Special thanks are due to Andrea Sahner, Gisela Rothermel, Melanie Payer, Wolfgang Behr and Alfred Hechenberger of the local committee for all the hard work and care in organising the conference.

The editors are grateful to Prof. E.H. Hirschel as the general editor of the “Notes on Numerical Fluid Mechanics and Multidisciplinary Design” and also to the staff of the Springer Verlag for the opportunity to publish the proceedings of the IWRN9 workshop in this series.

We look forward to this volume being used as a “state-of-the-art” reference by scientists and engineers involved in solving noise and vibration problems related to railway traffic in the years to come.

December 2007

Burkhard Schulte-Werning
David Thompson
Pierre-Etienne Gautier
Carl Hanson
Brian Hemsworth
James Nelson
Tatsuo Maeda
Paul de Vos

Table of Contents

Session 1: High Speed Trains (I)

Environmental Noise Reduction of Tokaido Shinkansen and Future Prospect

H. Kanda, H. Tsuda, K. Ichikawa, S. Yoshida 1

Distortion of Compression Wave Propagating through Shinkansen Tunnel

T. Miyachi, T. Fukuda, M. Iida, T. Maeda, S. Ozawa 9

The Influence of the Train Speed on Vibrations Due to High Speed Trains

G. Lombaert, G. Degrande, J. Bekaert 19

High Speed Train Noise Effects on Wildlife and Domestic Livestock

C.E. Hanson 26

Wind Tunnel Tests on the Control of Aeroacoustic Noise from High Speed Train

N. Yamazaki, T. Takaishi, M. Toyooka, K. Nagakura, A. Sagawa, H. Yano 33

Session 2: High Speed Trains (II)

Measures to Counteract Micro-pressure Waves Radiating from Tunnel Exits of DB's New Nuremberg-Ingolstadt High-Speed Line

Th. Tielkes, H.-J. Kaltenbach, M. Hieke, P. Deeg, M. Eisenlauer 40

Acoustic Assessment of Micro-pressure Waves Radiating from Tunnel Exits of DB High-Speed Lines

K.G. Degen, Ch. Gerbig, H. Onnich 48

High Speed Railway Noise: Assessment of Mitigation Measures

F. Létourneaux, J.F. Cordier, F. Poisson, N. Douarche 56

Noise Measurement Results of Shinkansen High-Speed Test Train (FASTECH360S,Z)

Y. Wakabayashi, T. Kurita, H. Yamada, M. Horiuchi 63

Noise Sources for High Speed Trains: A Review of Results in the TGV Case <i>F. Poisson, P.E. Gautier, F. Letourneaux</i>	71
 Session 3: Ground Borne Vibrations (I)	
Survey of Metro Excitation Frequencies and Coincidence of Different Modes <i>S.J. Cox, A. Wang, A. Adedipe</i>	78
Floating Slab Track above Ground for Turnouts in Tram Lines <i>H.-G. Wagner, A. Herrmann</i>	86
Vehicle/Track Impact Due to Passing the Transition between a Floating Slab and Ballasted Track <i>Z.G. Li, T.X. Wu</i>	94
Recent Developments in Operational Rail Noise and Vibration in NSW, Australia <i>D. Anderson, C. Weber</i>	101
Experimental Validation of a Numerical Model for Subway Induced Vibrations <i>S. Gupta, G. Degrande, G. Lombaert</i>	108
A Numerical Model for Re-radiated Noise in Buildings from Underground Railways <i>P. Fiala, S. Gupta, G. Degrande, F. Augusztinovicz</i>	115
 Session 4: Ground Borne Vibrations (II)	
The Influence of the Soil on Track Dynamics and Ground-Borne Vibration <i>L. Auersch</i>	122
A User-Friendly Prediction Tool for Railway Induced Ground Vibrations: Emission – Transmission – Immission <i>W. Rücker, L. Auersch</i>	129
Using the PiP Model for Fast Calculation of Vibration from a Railway Tunnel in a Multi-layered Half-Space <i>M.F.M. Hussein, H.E.M. Hunt, L. Rikse, S. Gupta, G. Degrande, J.P. Talbot, S. François, M. Schevenels</i>	136
Structure-Borne Noise and Vibration Control for Chatswood Interchange <i>J.T. Nelson, M. Harrison, M. Pettersson</i>	143

Measurements and Investigations at the Floating-Track-Bed System in the North-South Tunnel in Berlin <i>T. Jaquet, R. Garburg</i>	150
Propagation of Vibrations Due to a Tramway Line <i>M. Maldonado, O. Chiello, D. Le Houédec</i>	158
Session 5: General Rolling Noise Aspects (I)	
Railway Noise Statistics by Monitoring Stations – Input for Dutch Prediction Method RMR and Track Access Charging <i>E. Verheijen, M.S. Roovers, J.W. van den Brink</i>	165
Measurement and Modelling of Noise from the Arsta Bridge in Stockholm <i>A. Wang, O.G. Bewes, S.J. Cox, C.J.C. Jones</i>	172
Minimising Noise from Viaducts in the Borough Area of London for the Thameslink Programme <i>C. Cobbing, C.J.C. Jones</i>	179
The New German Prediction Model for Railway Noise “Schall 03 2006” – Potentials of the New Calculation Method for Noise Mitigation of Planned Rail Traffic <i>U. Mochler, M. Liepert, U.J. Kurze, H. Onnich</i>	186
Floating Slab Track Re-engineering: Experience Drawn from a Completely Renovated FST Damaged by Major Flooding in Sao Paulo Metro <i>P. Carels, K. Ophalffens, P. Pinto, R. Kelly</i>	193
Session 6: General Rolling Noise Aspects (II)	
In-Car Noise and Carriage Floor Vibration on Different Track Forms and Curvatures in a Metro System <i>A. Wang, S.J. Cox, H. Huang, L. Liu, J. Jiang, J. Sun</i>	201
Experimental and Theoretical Analysis of Railway Bridge Noise Reduction Using Resilient Rail Fasteners in Burgdorf, Switzerland <i>K.P. Köstli, C.J.C. Jones, D.J. Thompson</i>	208
Comparison of Two Metrics for Assessing Human Response to Vibration <i>R. Carman, C. Reyes, G. Glickman, M. Schaeffler</i>	215

A Study on Source Mechanism in the Interior Noise Problem of High Speed Trains	
<i>H.I. Koh, H.B. Kwon, W.H. You, J.H. Park</i>	222
Reducing the Noise Emission by Increasing the Damping of the Rail: Results of a Field Test	
<i>B. Asmussen, D. Stiebel, P. Kitson, D. Farrington, D. Benton</i>	229
Session 7: Cost Benefit Considerations of Noise Abatement	
Railway Noise Abatement: The Case for Retrofitting Freight Vehicles with Composite Brake Blocks	
<i>J. Oertli</i>	236
A Systematic Approach for Arriving at Reasonable Heights and Locations for Noise Barriers Adjacent to Railway Lines	
<i>C. Weber, K. Atkinson</i>	243
How Can Infrastructure Manager Influence Noise Generation of Rolling Stock	
<i>M.T. Kalivoda</i>	250
Acoustic Effectiveness of Damped Wheels and Impact on Life-Cycle Cost of Different Typologies of Passenger Trains	
<i>A. Bracciali, S. Cervello, P. Gatti</i>	257
Mitigation Measures for Open Lines against Vibration and Ground-Borne Noise: A Swiss Overview	
<i>R. Müller</i>	264
Session 8: Prediction Tools and Theoretical Models (I)	
Preliminary Analysis on Effect of Sleeper Pitch on Rail Corrugation at a Curved Track	
<i>X. Jin, Z. Wen, Q. Liu, Z. Zhou</i>	271
A Hybrid Model for Noise Generation from a Railway Wheel Due to Wheel/Rail Impact	
<i>X. Xiao, X. Jin, X. Sheng</i>	278
A Time Domain Model for Wheel/Rail Interaction Aiming to Include Non-linear Contact Stiffness and Tangential Friction	
<i>A. Pieringer, W. Kropp, J.C.O. Nielsen</i>	285
Optimization of Track Parameters, Considering Their Physical Dispersion, to Minimize Rail Corrugation	
<i>O. Oyarzabal, J. Gómez, J. Santamaría, E.G. Vadillo</i>	292

Predicting the Effect of Temperature on the Performance of Elastomer-Based Rail Damping Devices <i>N. Ahmad, D.J. Thompson, C.J.C. Jones, A.H. Muhr</i>	299
Estimation of Sound Transmission through Extruded Panels Using a Coupled Waveguide Finite Element-Boundary Element Method <i>C.M. Nilsson, A.N. Thite, C.J.C. Jones, D.J. Thompson</i>	306
Session 9: Prediction Tools and Theoretical Models (II)	
Squeal Prediction for a Bogied Vehicle in a Curve <i>Z.Y. Huang, D.J. Thompson, C.J.C. Jones</i>	313
Synthesis of Noise of Operating Vehicles: Development within SILENCE of a Tool with Listening Features <i>E. Bongini, S. Molla, P.E. Gautier, D. Habault, P.O. Mattéi, F. Poisson</i>	320
IMAGINE Rail Noise Sources – A Practical Methodology <i>M. Beuving, B. Hemsworth, R.R.K. Jones</i>	327
Optimization of a Wheel Damper for Freight Wagons Using FEM Simulation <i>W. Behr, S. Cervello</i>	334
Session 10: Grinding, Corrugation and Roughness (I)	
Types of Rail Roughness and the Selection of Vibration Isolation Measures <i>H.E.M. Hunt</i>	341
Rail Roughness Monitoring in the Netherlands <i>A.H.W.M. Kuijpers</i>	348
Rail Roughness Level Assessment Based on High-Frequency Wheel–Rail Contact Force Measurements <i>Jens C.O. Nielsen</i>	355
Session 11: Grinding, Corrugation and Roughness (II)	
Testing the New Acoustic Rail Roughness Measurement Standard <i>C. Jones, P. Fodiman, F. Létourneaux, B. Croft</i>	363

Practical Implementations and Benefits of Highly Accurate Rail Roughness Measurements <i>S. Lutzenberger, P. Holm</i>	370
Session 12: New Noise Reduction Technologies (I)	
New Rail Dampers at the Railway Link Roosendaal-Vlissingen Tested within the Dutch Innovation Program <i>E. van Haaren, G.A. van Keulen</i>	378
Theoretical Study on Noise Reduction of Rail Component by Use of Rail Absorber <i>T.X. Wu</i>	384
Reducing Wheel-Rail Interaction Forces and Roughness Growth by Application of Rail Dampers <i>B.E. Croft, C.J.C. Jones, D.J. Thompson</i>	392
Session 13: New Noise Reduction Technologies (II)	
Mitigation of Wheel Squeal and Flanging Noise on the Australian Rail Network <i>D. Anderson, N. Wheatley</i>	399
How to Avoid Squeal Noise on Railways State of the Art and Practical Experience <i>S. Bühler, B. Thallemer</i>	406
Noise Reduction Measures at Freight Train Locomotives “Blue Tiger” <i>C. Czolbe, M. Hecht</i>	412
Noise Reduction at Urban Hot-Spots by Vehicle Noise Control <i>U. Orrenius, S. Leth, A. Frid</i>	419
Poster Session	
Directivity of Railway Rolling Noise <i>X. Zhang</i>	426
Complex Eigenvalue Analysis of Railway Curve Squeal <i>G.X. Chen, J.B. Xiao, Q.Y. Liu, Z.R. Zhou</i>	433
Wave Propagation in Railway Tracks at High Frequencies <i>J. Ryue, D.J. Thompson, P.R. White, D.R. Thompson</i>	440

Stability and Transient Analysis in the Modelling of Railway Disc Brake Squeal	
<i>X. Lorang, O. Chiello</i>	447
Large-Scale Fatigue Test of Stone Wool Based Anti-vibration Mats	
<i>K.B. Gatzwiller</i>	454
Author Index	461