

# Effect of Extreme Climate on Long-term Performance of Railway Prestressed Concrete Sleepers

Li, Dan; Kaewunruen, Sakdirat

DOI:

[10.3390/proceedings2161146](https://doi.org/10.3390/proceedings2161146)

License:

Creative Commons: Attribution (CC BY)

*Document Version*

Publisher's PDF, also known as Version of record

*Citation for published version (Harvard):*

Li, D & Kaewunruen, S 2018, 'Effect of Extreme Climate on Long-term Performance of Railway Prestressed Concrete Sleepers', *Proceedings*, vol. 2, no. 16, 1146. <https://doi.org/10.3390/proceedings2161146>

[Link to publication on Research at Birmingham portal](#)

## General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

## Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact [UBIRA@lists.bham.ac.uk](mailto:UBIRA@lists.bham.ac.uk) providing details and we will remove access to the work immediately and investigate.

# Effect of Extreme Climate on Long-term Performance of Railway Prestressed Concrete Sleepers <sup>†</sup>

Dan Li <sup>1,\*</sup> and Sakdirat Kaewunruen <sup>1,2</sup>

<sup>1</sup> Department of Civil Engineering, School of Engineering, University of Birmingham, Birmingham B15 2TT, UK; S.Kaewunruen@bham.ac.uk

<sup>2</sup> Birmingham Centre for Railway Research and Education, School of Engineering, University of Birmingham, Birmingham B15 2TT, UK

\* Correspondence: DXL561@student.bham.ac.uk; Tel.: +44-794-625-6688

<sup>†</sup> Presented at 2018 International Symposium on Rail Infrastructure Systems Engineering (i-RISE 2018), Brno, Czech Republic, 5 June 2018.

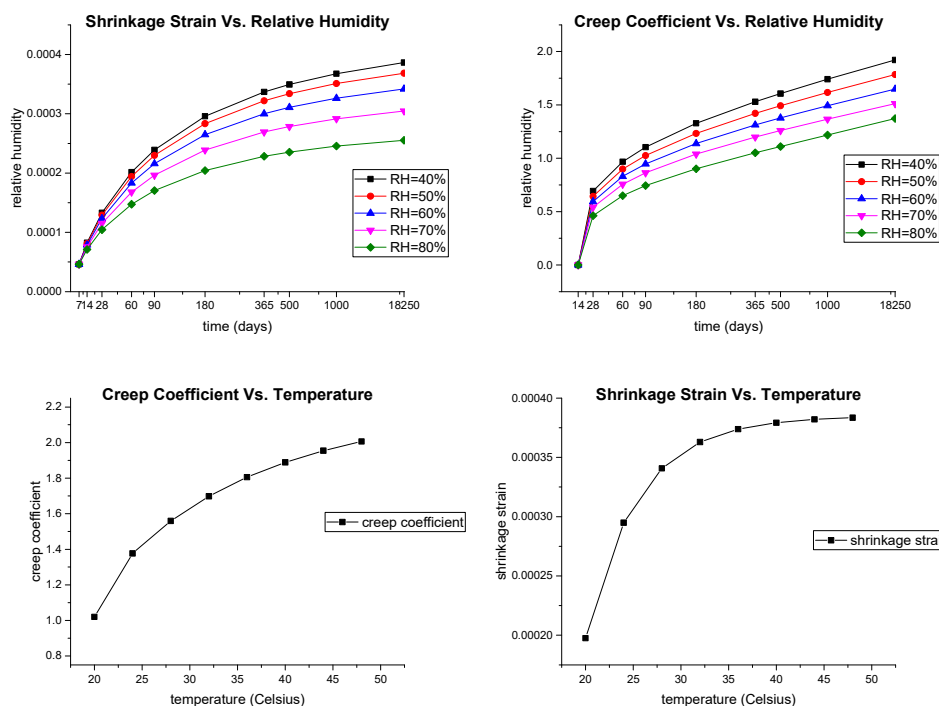
Published: 14 September 2018

---

Prestressed concrete is currently the most used material for railway sleepers because of its superior advantages in structural performance, low maintenance, sustainability, and construction. In practice, many prestressed concrete sleepers are applied in harsh environments subject to various changes of climate uncertainties. Therefore, environmental conditions are a considerably influential factor to the time-dependent behaviour of prestressed concrete sleepers. Climate uncertainty has become a significant issue around the world which has been raised as a global political problem. The reasons resulting in climate change could be human activities, biotic processes, variations in solar radiation received by Earth, and volcanic eruptions. In recent years, the climate change caused the frequency of severe weather patterns increasing (IPCC 2007). Therefore, the railway infrastructure exposed to various extreme climates, the performance can be directly influenced by climate change. ‘Extreme climate’ is defined as unusual, unexpected or unpredicted severe weather based on the historical record in the most unusual ten percent [1–18].

The time-dependent behaviour of concrete has been investigated over a century ago. The gradual development of concrete deformation with time is due to creep and shrinkage. Creep strain is that the strain increases with time under the constant stress. Shrinkage is not relevant to stress and results primarily from the several factors such as loss of water. Creep and shrinkage can cause unduly axial deformation, excessive pre-camber, and loss of prestress. The excessive deflection and excessive shortening are often caused by creep and shrinkage. The unsightly cracking could occur that results in impaired serviceability and durability issues. Environmental factors can largely influence creep and shrinkage. For example, temperature rise increases the deformability of cement paste and accelerates drying [19,20].

This study aims at investigating the effects of extreme climatic conditions on the performance and time-dependent behaviour of prestressed concrete sleepers using contemporary design approaches. The study into the effects of climate uncertainties on creep and shrinkage has been investigated on the basis of both environmental temperature and relative humidity. The outcomes indicate that environmental conditions play a vital role in the time-dependent behaviour of prestressed concrete sleepers. The insight of this research can be used to evaluate the serviceability of prestressed concrete sleepers installed in extreme natural climate regions. The effect of extreme climate on long-term performance of prestressed concrete sleepers is shown as Figure 1.



**Figure 1.** The effect of extreme climate on long-term performance of prestressed concrete sleepers.

**Acknowledgments:** The authors are also sincerely grateful to the European Commission for the financial sponsorship of the H2020-RISE Project No. 691135 “RISEN: Rail Infrastructure Systems Engineering Network”, which enables a global research network that tackles the grand challenge of railway infrastructure resilience and advanced sensing in extreme environments ([www.risen2rail.eu](http://www.risen2rail.eu)) [16].

**References**

1. Intergovernmental Panel on Climate Change (IPCC). *Summary for Policymakers*; IPCC: Geneva, Switzerland, 2007.
2. Planton, S.; Deque, M.; Chauvin, F.; Terray, L. Expected impacts of climate change on extreme climate events. *C. R. Geosci.* **2008**, *340*, 564–574.
3. Kaewunruen, S.; Lopes, L.M.C.; Papaalias, M.P. Georisks in railway systems under climate uncertainties by different types of sleeper/crosstie materials. *Lowl. Technol. Int.* **2018**, *20*, 67–76.
4. Lisø, K.R.; Aandahl, G.; Eriksen, S.; Alfsn, K. Preparing for climate change impacts in Norway’s built environment. *Built. Res. Inf.* **2003**, *31*, 200–209.
5. Lin-Ye, J.; Garcia-Leon, M.; Carcia, V.; Ortego, M.I.; Lionello, P.; Sanchez-Arcilla, A. Multivariate statistical modelling of future marine storms. *Appl. Ocean Res.* **2017**, *65*, 192–205.
6. Lin-Ye, J.; Garcia-Leon, M.; Carcia, V.; Ortego, M.I.; Stanica, A.; Sanchez-Arcilla, A. Multivariate hybrid modelling of future wave-storm at the northwestern Black Sea. *Water* **2018**, *10*, 221, doi:10.3390/w10020221.
7. Breda Fontao, P.A.; Zacattini, J.A. Variations of rainfall rhythm in Alto Pardo Watershed, Brazil: Analysis of two specific years, a wet and dry one, and their relation with the river flow. *Climate* **2017**, *5*, 47, doi:10.3390/cli5030047.
8. Meesit, R.; Kaewunruen, S. Vibration characteristics of micro-engineered crumb rubber concrete for railway sleeper applications. *J. Adv. Concr. Technol.* **2017**, *15*, 55–66.
9. Kaewunruen, S.; Meesit, R. Sensitivity of crumb rubber particle sizes on electrical resistance of rubberised concrete. *Cogent Eng.* **2016**, *3*, 1126937, doi:10.1080/23311916.2015.1126937.
10. Kaewunruen, S.; Meesit, R.; Mondal, P. Early-age dynamic moduli of crumbed rubber concrete for compliant railway structures. *J. Sustain. Cement-Based Mater.* **2017**, *6*, 281–292.
11. Kaewunruen, S.; Kimani, S.K. Damped frequencies of precast modular steel-concrete composite railway track slabs. *Steel Compos. Struct.* **2017**, *25*, 427–442.

12. Kaewunruen, S.; Remennikov, A.M. Effect of a large asymmetrical wheel burden on flexural response and failure of railway concrete sleepers in track systems. *Eng. Fail. Anal.* **2008**, *15*, 1065–1075.
13. Kaewunruen, S. Monitoring in-service performance of fibre-reinforced foamed urethane sleepers/bearers in railway urban turnout systems. *Struct. Monit. Maint.* **2015**, *1*, 131–157.
14. Remennikov, A.M.; Kaewunruen, S. Experimental load rating of aged railway concrete sleepers. *Eng. Struct.* **2014**, *76*, 147–162.
15. Hawari, H.M. *Minimising Track Degradation through Managing Vehicle/Track Interaction*; Queensland University of Technology: Brisbane, Australia, 2007.
16. Kaewunruen, S.; Li, D.; Chen, Y.; Xiang, Z. Enhancement of Dynamic Damping in Eco-Friendly Railway Concrete Sleepers Using Waste-Tyre Crumb Rubber. *Materials* **2018**, *11*, 1169, doi:10.3390/ma11071169.
17. Remennikov, A.M.; Kaewunruen, S. A review of loading conditions for railway track structures due to train and track vertical interaction. *Struct. Control Health Monit.* **2008**, *15*, 207–234.
18. Li, D.; Kaewunruen, S.; Robery, P.; Remennikov, A.M. Creep and shrinkage effect on railway prestressed concrete sleepers. In Proceedings of the First International Conference on Rail Transportation, ICRT, Chengdu, China, 10–12 July 2017.
19. Liu, P.; Qiu, X.; Yang, Y.; Ma, Y.; Jin, S. Assessment of the Performance of Three Dynamical Climate Downscaling Methods Using Different Land Surface Information Over China. *Atmosphere* **2018**, *9*, 101, doi:10.3390/atmos9030101.
20. Horton; Radley, M.; Yohe, G.; Easterling, W.; Kates, R.; Ruth, M.; Sussman, E.; Whelchel, A.; Wolfe, D.; Lipschultz, F. Climate Change Impacts in the United States: The Third National Climate Assessment. In *U.S. Global Change Research Program*; U.S. National Climate Assessment: Washington, DC, USA, 2014.



© 2018 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).