

Sustainable and self-sensing concrete: new findings and applications in railway infrastructures

Kaewunruen, Sakdirat; Huang, Xu; Akono, Ange-Therese ; Ishida, Tetsuya

License:

Creative Commons: Attribution (CC BY)

Citation for published version (Harvard):

Kaewunruen, S, Huang, X, Akono, A-T & Ishida, T 2020, Sustainable and self-sensing concrete: new findings and applications in railway infrastructures. in *Concrete Society Technical Presentation*. The Concrete Society.

[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 providing details and we will remove access to the work immediately and investigate.

Technical Presentation
**Sustainable and Self-Sensing Concrete:
New Findings and Applications in Railway
Infrastructures**

Tuesday 11th February 2020
5:30 pm for 6pm start

**at the University of Birmingham, Murray Learning Centre,
Room LC-UG09**

The presentation will look at the following

- Why concrete is currently neither environmentally nor economically sustainable.
- Alternative solutions to solve the sustainability issue of concrete.
- Lack of self-monitoring ability of concrete for failure or changes in the structure.
- Factors influencing the self-monitoring ability
- Performance of rubberized concrete with CNT (Carbon nano tubes).
- Case studies for applications in railway infrastructure systems.

Speakers: Xu Huang and Sakdirat Kaewunruen

Presentation should last 30-40 minutes with questions

This is a free event - to register your attendance please contact:

The Concrete Society - regional-events@concrete.org.uk

Or - 01276 607140

Campus map:

<https://www.birmingham.ac.uk/Documents/university/edgbaston-campus-map.pdf>

Follow us on [LinkedIn](#)  Twitter [@UKConcrete](#) 

SUSTAINABLE AND SELF-SENSING CONCRETE: NEW FINDINGS AND APPLICATIONS IN RAILWAY INFRASTRUCTURES

Sakdirat Kaewunruen¹
Xu Huang¹
Ange-Therese Akono²
Tetsuya Ishida³

¹*Birmingham Centre for Railway Research and Education, Department of Civil Engineering, School of Engineering, the University of Birmingham, Birmingham, B15 2TT UK; Email: s.kaewunruen@bham.ac.uk*

²*Sustainability & Nanomechanics Laboratory, University of Illinois at Urbana-Champaign, 3108 Newmark Civil Engineering Laboratory, 205 N. Mathews Ave., Urbana IL 61801 USA; Email: aakono@illinois.edu*

³*Concrete Engineering Laboratory, Department of Civil Engineering, the University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan; Email: tetsuya.ishida@civil.t.u-tokyo.ac.jp*

ABSTRACT: The majority of civil infrastructure is constructed using concrete materials and currently concrete production is at all time high resulting in significant carbon dioxide emissions. Furthermore, concrete structures have low tensile strength and low ductility increasing the risk of failure. Therefore concrete is currently neither environmentally nor economically sustainable. This experimental investigation has been highly promising in identifying an alternative solution to solve the sustainability issue regarding concrete. Our critical literature showed that there have been successful in identifying the most optimum solution to solve the issue of carbon dioxide emissions related to concrete production but concrete structures still lacks of self-monitoring ability for failure or any changes in the structure. This paper will identify the factors that influence the self-monitoring ability as mainly the conductive filler, fabrication and dispersion, which are the critical parameters. Experimental study has been carried out to identify the most environmentally sustainable solution with a minimum of 50MPa strength. We have investigated the performance of rubberized concrete with CNT (Carbon nano tubes), which enables self-monitoring ability and reduces carbon dioxide emissions by 140kg per meter cube of concrete produced in comparison to a meter cubed of ordinary Portland cement concrete. Case studies for applications in railway infrastructure systems will also be highlighted in this presentation.

KEYWORDS: Concrete, Sustainable material, Self-sensing; Self-monitoring; Innovative material; Carbon nanotubes

Acknowledgement

The first author wishes to gratefully acknowledge Australian Academy of Sciences and the Japan Society for Promotion of Science (JSPS) for his JSPS Invitation Research Fellowship (Long-term), Grant No L15701, at Track Dynamics Laboratory, Railway Technical Research Institute and at Concrete Laboratory, the University of Tokyo, Tokyo, Japan. The JSPS financially supports this work as part of the research project, entitled “Smart and reliable

railway infrastructure”. The authors would also like to gratefully acknowledge the University of Birmingham’s BRIDGE Grant, which financially supports this work as part of the project “Improving damping and dynamic resistance in concrete through micro- and nano-engineering for sustainable and environmental-friendly applications in railway and other civil construction”. This project is part of a collaborative BRIDGE program between the University of Birmingham and the University of Illinois at Urbana Champaign. Special thanks to European Commission for H2020-MSCA-RISE Project No. 691135 “RISEN: Rail Infrastructure Systems Engineering Network”. In addition, the sponsorships and in-kind assistance from CEMEX, Network Rail, Rail Safety and Standard Board UK, J. Allcock & Sons Ltd., Lehigh Technologies Incorporation and Nanocyl are highly appreciated.

References

- [1] D. Chung, Self-monitoring structural materials. *Materials Science and Engineering: R: Reports*, 1998, 22(2), 57-78.
- [2] Huang, X., Kaewunruen, S., 2020, “Self-healing and high-damping concrete”, *Handbook on New Materials in Civil Engineering*, Springer.
- [3] R. Meesit, S. Kaewunruen, P. Mondal, Dynamic properties of early-age micro-and nano-engineered concrete for compliant railway structures, *RILEM International Conference on Strategies for Sustainable Concrete*, Rio de Janeiro, Brazil, December 14-16, 2015.
- [4] Kaewunruen S, Aikawa A, Remennikov AM, 2020, The importance of ‘dynamics’ in the design and performance-based testing criteria for railway track components, *Procedia Structural Integrity* 21, 83-90.
- [5] Li, D., Kaewunruen S, 2019, Mechanical properties of concrete with recycled composite and plastic aggregates, *International Journal of GEOMATE* 17 (60), 231-238.
- [6] Akono AT, Chen J, Kaewunruen S, 2018, Friction and fracture characteristics of engineered crumb-rubber concrete at microscopic lengthscale, *Construction and Building Materials* 175, 735-745.
- [7] Kaewunruen S, Wu L, Goto K, Najih YM, 2018, Vulnerability of Structural Concrete to Extreme Climate Variances, *Climate* 6 (2), 40.
- [8] Meesit, R., Kaewunruen, S., 2017, Vibration Characteristics of Micro-Engineered Crumb Rubber Concrete for Railway Sleeper Applications, *Journal of Advanced Concrete Technology* 15 (2), 55-66.
- [9] Kaewunruen S, Meesit R, Mondal P, 2017, Early-age dynamic moduli of crumbed rubber concrete for compliant railway structures, *Journal of Sustainable Cement-Based Materials*, 6 (5), 281-292.
- [10] Kaewunruen, S., Meesit, R., 2016, Sensitivity of crumb rubber particle sizes on electrical resistance of rubberised concrete, *Cogent Engineering*, 3(1): 1126937. doi: 10.1080/23311916.2015.1126937
- [11] Kaewunruen, S. and Remennikov, A.M., 2009, "Progressive failure of prestressed concrete sleepers under multiple high-intensity impact loads." *Engineering Structures*, 31(10): 2460-2473.
- [12] Remennikov, A.M. and Kaewunruen, S., 2008, "A review on loading conditions for railway track structures due to train and track vertical interaction." *Structural Control and Health Monitoring*, 15: 207-234.