Self-Healing and Highly-Damped Concrete for Applications as Railway Sleepers and Track Slabs

Huang, Xu; Kaewunruen, Sakdirat

DOI:
10.3390/proceedings2161144

proceedings

Extended Abstract

Self-Healing and Highly-Damped Concrete for Applications as Railway Sleepers and Track Slabs †

Xu Huang [1,*] and Sakdirat Kaewunruen [1,2]

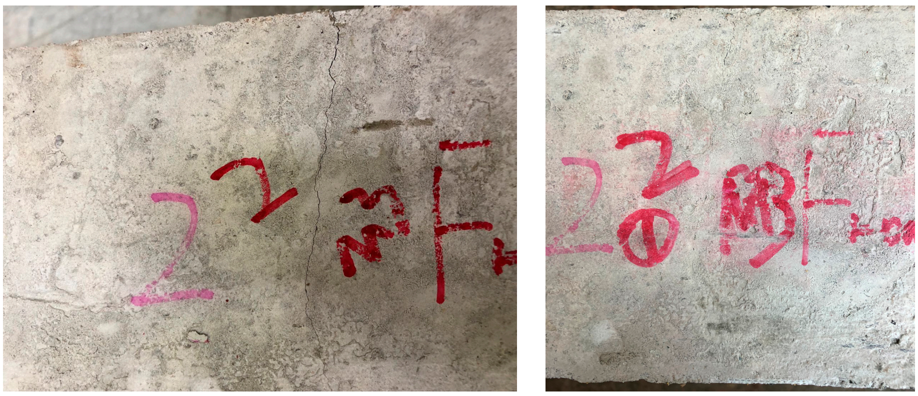
1 Department of Civil Engineering, School of Engineering, The University of Birmingham, B15 2TT Birmingham, UK
2 Laboratory for Track Engineering and Operations for Future Uncertainties (TOFU Lab), School of Engineering, The University of Birmingham, B15 2TT Birmingham, UK; s.kaewunruen@bham.ac.uk
* Correspondence: XXH689@student.bham.ac.uk; Tel.: +44-(0)-1214-142-670

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

Published: 14 September 2018

The demand of concrete material is increasing for applications in railway construction such as railway concrete sleepers, concrete track slabs, viaducts, etc. especially for the expansions of metro, light-rail and urban railway systems, due to their improved multi-functional performance as well as the reduced lifetime cost and carbon footprint compared to the timber or other materials. However, the premature deterioration of concrete sleepers and track slabs (e.g., shear key) under high impact loading and excessive vibration is the major issue that jeopardizes the safety and durability; and then increases the lifecycle cost of concrete sleepers and track slabs [1–12].

This study is the word first to establish and demonstrate a novel self-healing concrete that is practical and useful for urban railway and metro systems. The root cause of crack tends to be due to infrequent but high-intensity impact loading. This implies that the crack would not be frequently repetitive and the self-healing solution to cracks can still be effective in practice. This project builds on the study of crumb rubber to enhance dynamic damping of concrete sleepers [13–17]. Additional use of micro fibres has been adopted to also control the crack width. Eight concrete mixes have been evaluated for autogenous self-healing capability and effectiveness. Artificial and man-made cracks have been developed in the laboratory environment. The depths of crack paths at each location have been investigated in details. The crack healing is monitored using modal impact excitation, ultrasonic pulse velocity, and visual inspection. As shown in Figure 1, the highly-damped concrete shows effective self-healing capability. Based on the study it is found that modal impact excitation shows the lest effective method to monitor cracks, especially when the cracks are rather small (<20% of crack depth over the total depth).



(**a**) (**b**)

Figure 1. Self-healing of crack (**a**) initial crack; (**b**) healed crack after 4 weeks.

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) [18]. The second author wishes to thank the Australian Academy of Science and the Japan Society for the Promotion of Sciences for his Invitation Research Fellowship (Long-term), Grant No. JSPS-L15701 at the Railway Technical Research Institute and The University of Tokyo, Japan.

References

1. Kaewunruen, S.; Remennikov, A.M. Current state of practice in railway track vibration isolation: An Australian overview. *Aust. J. Civ. Eng.* **2016**, *14*, 63–71.
2. Kaewunruen, S.; Remennikov, A.M. Progressive failure of prestressed concrete sleepers under multiple high-intensity impact loads. *Eng. Struct.* **2009**, *31*, 2460–2473.
3. Kaewunruen, S.; Chiengson, C. Railway track inspection and maintenance priorities due to dynamic coupling effects of dipped rails and differential track settlements. *Eng. Fail. Anal.* **2018**, *93*, 157–171.
4. 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.
5. Gamage, E.K.; Kaewunruen, S.; Remennikov, A.M.; Ishida, T. Toughness of Railroad Concrete Crossties with Holes and Web Openings. *Infrastructures* **2017**, *2*, 3, doi:10.20944/preprints201608.0047.v1.
6. Gamage, E.K.; Kaewunruen, S.; Remennikov, A.M.; Ishida, T. Reply to Giannakos, K. Comment on: Toughness of Railroad Concrete Crossties with Holes and Web Openings. *Infrastructures* **2017**, *2*, 3. *Infrastructures* **2017**, *2*, 5, doi:10.3390/infrastructures2020005.
7. Kaewunruen, S.; Wu, L.; Goto, K.; Najih, Y.M. Vulnerability of Structural Concrete to Extreme Climate Variances. *Climate* **2018**, *6*, 40, doi:10.3390/cli6020040.
8. You, R.; Li, D.; Ngamkhanong, C.; Janeliukstis, R.; Kaewunruen, S. Fatigue Life Assessment Method for Prestressed Concrete Sleepers. *Front. Built Environ.* **2017**, *3*, 68, doi:10.3389/fbuil.2017.00068.
9. Paine, K.A.; Dhir, R.K.; Moroney, R.; Kopasakis, K. Use of Crumb Rubber to Achieve Freeze/Thaw Resisting Concrete. In Proceedings of the International Conference on Concrete for Extreme Conditions, Dundee, UK, 9–11 September 2002; pp. 485–498.
10. Kaewunruen, S.; Ngamkhanong, C.; Papaelias, M.P.; Roberts, C. Wet/dry influence on behaviors of closed-cell polymeric cross-linked foams under static, dynamic and impact loads. *Constr. Build. Mater.* **2018**, *187*, 1092–1102.
11. Kaewunruen, S.; Remennikov, A.M. Dynamic crack propagations in prestressed concrete sleepers in railway track systems subjected to severe impact loads. *J. Struct. Eng.* **2009**, *136*, 749–754.
12. Setsobhonkul, S.; Kaewunruen, S.; Sussman, J.M. Lifecycle assessments of railway bridge transitions exposed to extreme climate events. *Front. Built Environ.* **2017**, *3*, 35, doi:10.3389/fbuil.2017.00035.
13. 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.
14. Akono, A.-T.; Chen, J.; Kaewunruen, S. Friction and fracture characteristics of engineered crumb-rubber concrete at microscopic lengthscale. *Constr. Build. Mater.* **2018**, *175*, 735–745.
15. Meesit, R.; Kaewunruen, S. Vibration characteristics of micro-engineered crumb rubber concrete for railway sleeper applications. *J. Adv. Concr. Technol.* **2017**, *15*, 55–66.
16. SARCOS. Memorandum of understanding for the implementation of the COST Action Self healing as preventive repair of concrete structures (SARCOS), 2016. Available online: https://www.sarcos.eng.cam.ac.uk/documents/MemorandumOfUnderstanding (accessed on 1 August 2018).
17. Sa'adin, S.L.B.; Kaewunruen, S.; Jaroszweski, D. Operational readiness for climate change of Malaysia high-speed rail. *Proc. Inst. Civ. Eng. Transp.* **2016**, *169*, 308–320.
18. Kaewunruen, S.; Sussman, J.M.; Matsumoto, A. Grand Challenges in Transportation and Transit Systems. *Front. Built Environ.* **2016**, *2*, 4, doi:10.3389/fbuil.2016.00004.