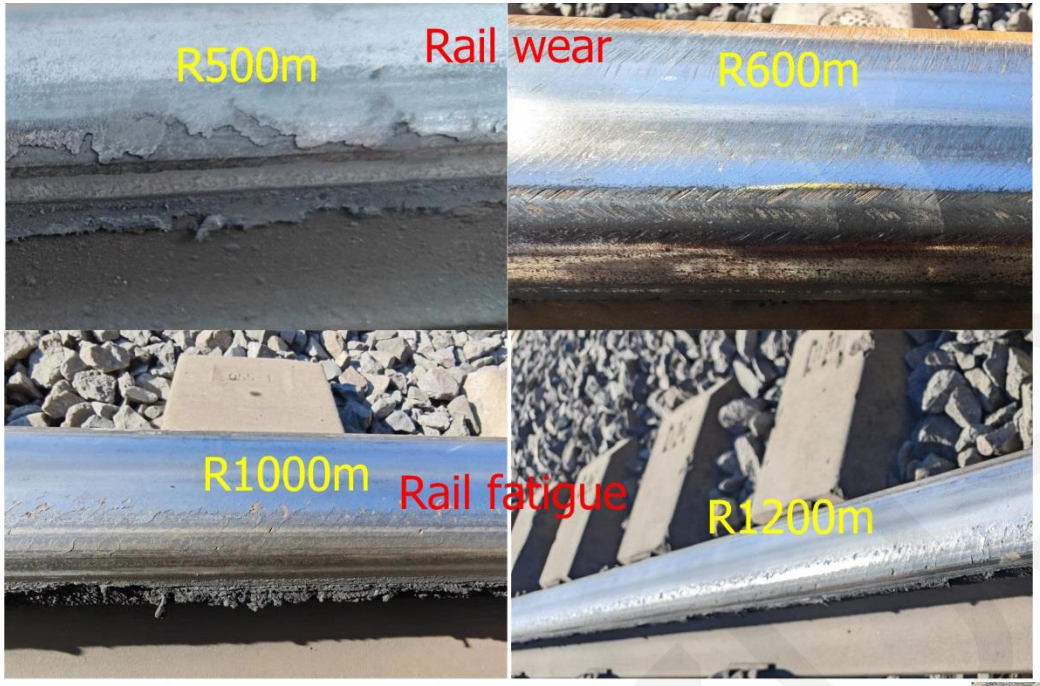
Journal of Zhejiang University-SCIENCE A

Rail profile optimization through balancing of wear and fatigue

Binjie XU, Zhiyong SHI, Yun YANG, Jianxi WANG, Kaiyun WANG

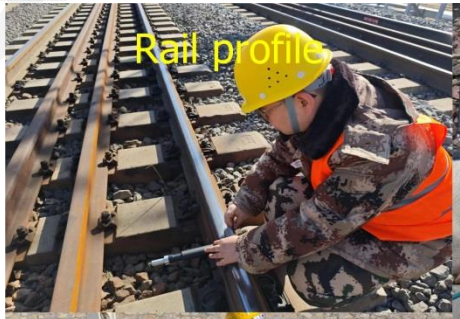
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重载铁路现场情况



重载铁路钢轨损伤特征展示：
半径小于**R800**表现为磨耗损伤；半径大于**R800**表现为疲劳损伤

课题组在现场测试了半径**600m**曲线段上的钢轨磨耗、疲劳裂纹与轮轨相互作用力。







Continuum Mechanics

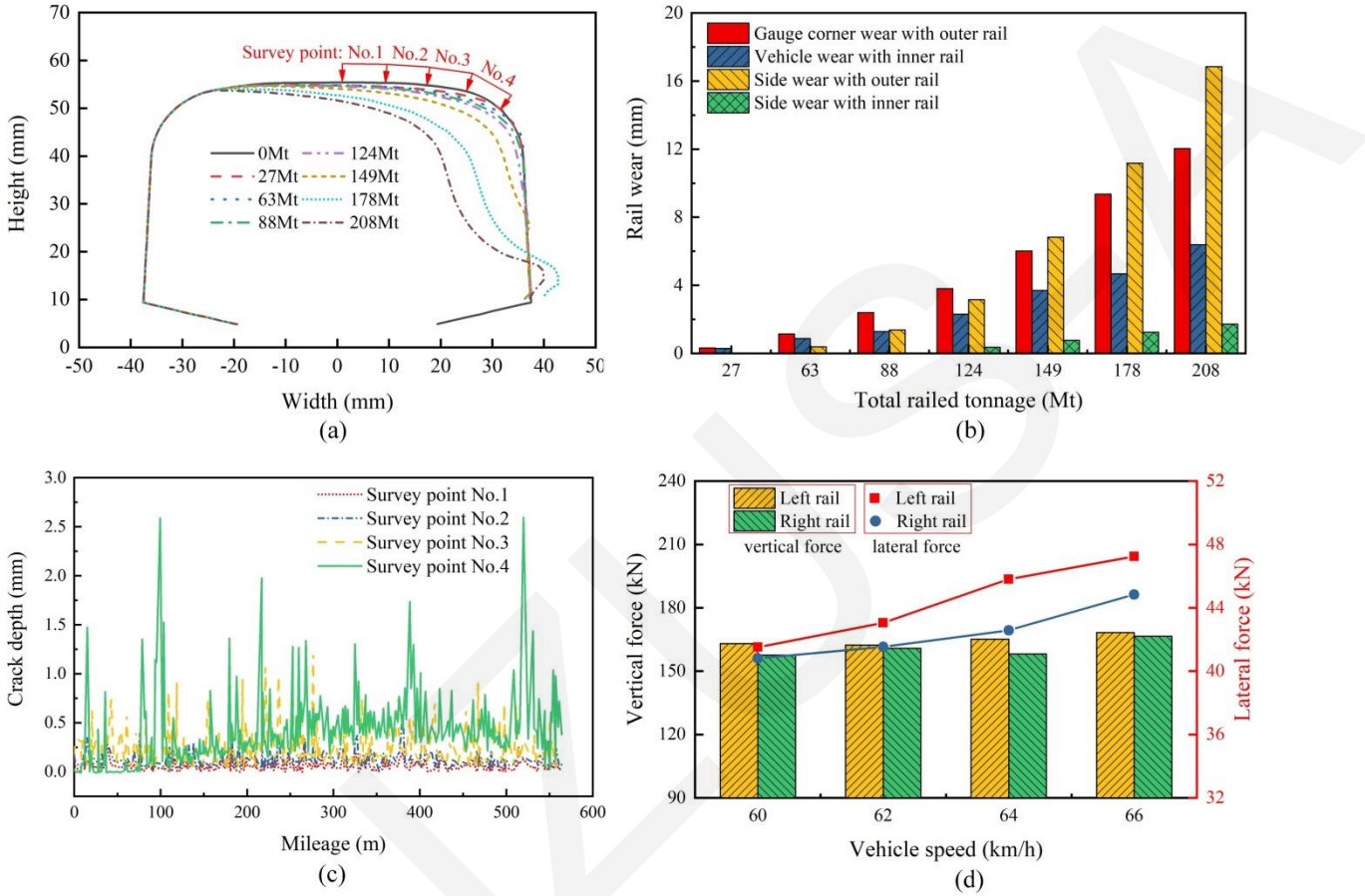


Fig. 1. 测试结果。（a）钢轨廓形变化（b）钢轨累计磨耗（c）钢轨疲劳裂纹 （d）轮轨相互作用力

Three Representative Activities

■ Mechanics gets closer to quantum mechanics

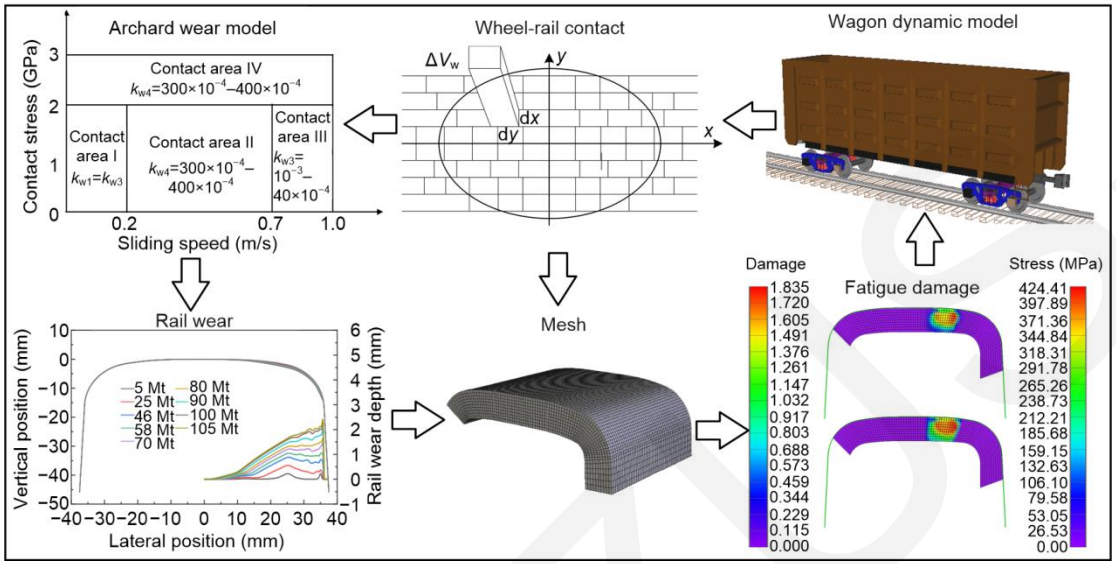


Fig. 2. A 20-MHz nanomechanical resonator capacitively coupled to a single-electron transistor.

M. D. LaHaye et al., Science 304, 74 (2004).

Three Representative Activities

- **Mechanics meets chemistry here and there**

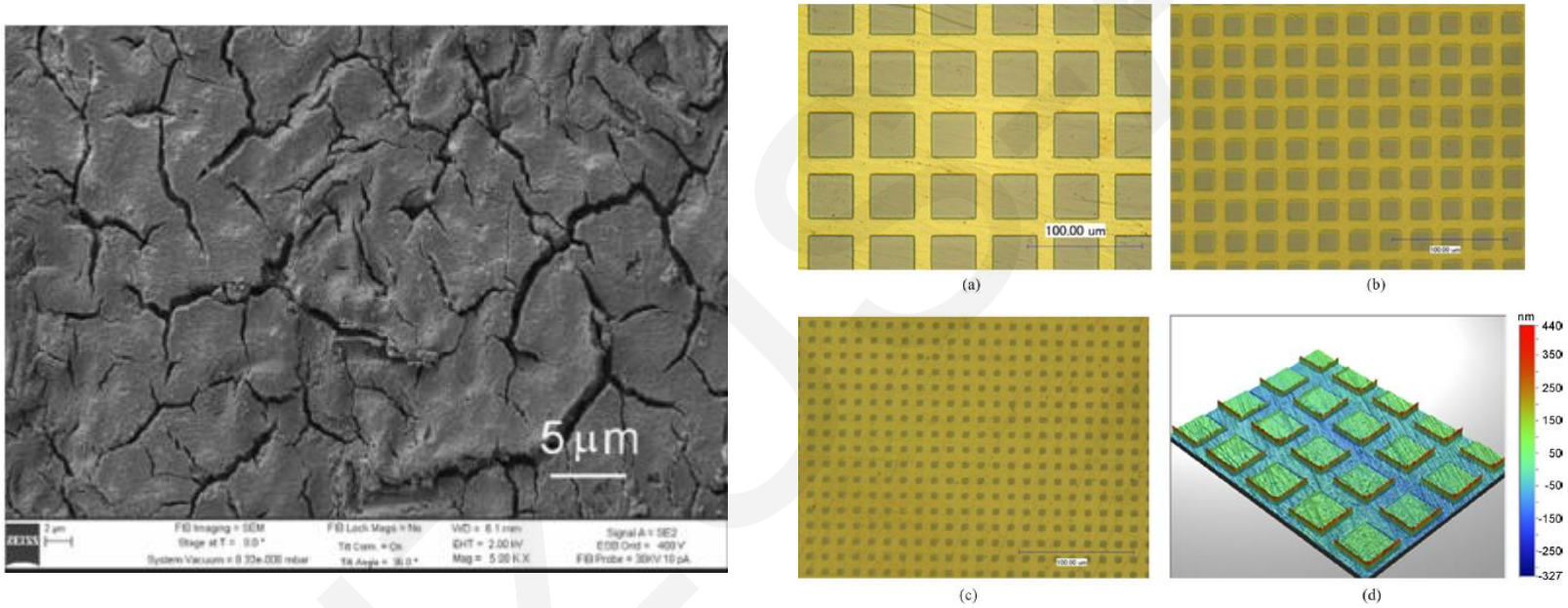


Fig. 3. Surface morphology of Si thin film and the patterns designed according to fracture mechanics analysis.

X. Xiao et al., Journal of Power Sources 196, 1409 (2011).

Three Representative Activities

- **Biomechanics evolves into mechanobiology**

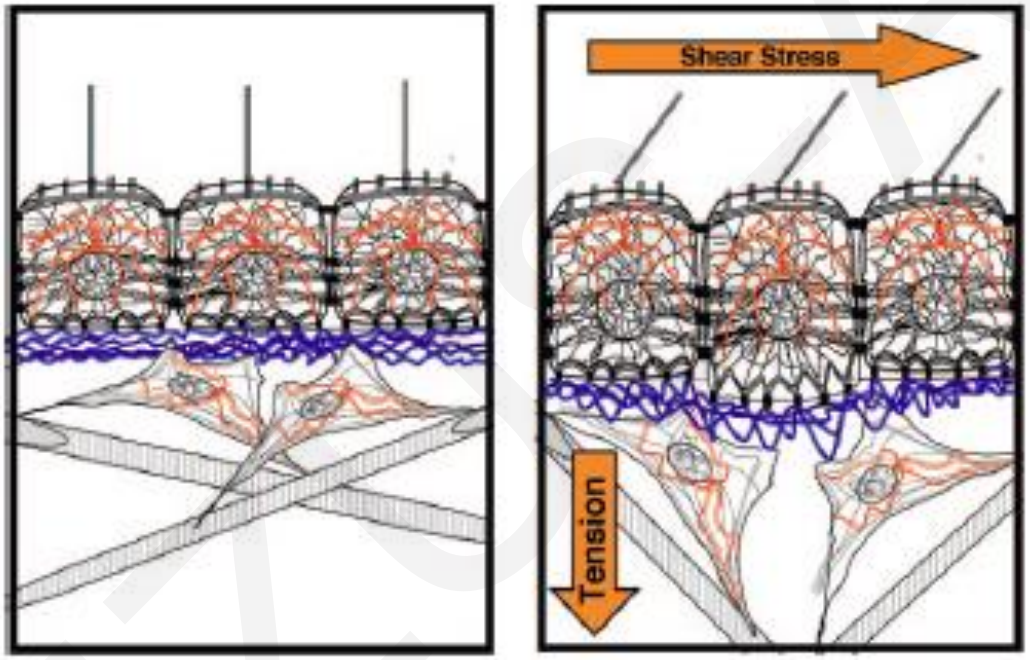


Fig. 4. Cellular mechanoresponsiveness and physical connectivity between ECM, cells, cytoskeletal networks, and nuclei.

D. E. Ingber, The FASEB Journal 20, 811 (2006).

Conclusions

- After reconstructing a rail profile using NURBS curves, we used the coordinates of the rail profile value points as design variables. A numerical optimization model was then established using a PSO-LM-BP neural network, with the objective of reducing rail wear and fatigue damage as constrained by the geometric properties of the rail. An improved genetic algorithm leveraging chaotic microvariations was employed to achieve the solution, resulting in an optimized rail profile.

- The static calculation results and the dynamic calculation results showed that the optimized rail profile demonstrates better dynamic performance. It was found that the optimized rail profile can reduce the maximum wheelset lateral force by 15%, the maximum derailment coefficient by 11%, the maximum wheel-rail contact stress by 10%, and the rail wear power by 26.6%.

- Finally, it was demonstrated that using the CHN75-Opti profile along a R600 m curved section of heavy-haul rail lines can reduce rail-wheel contact stress, hasten the arrival of the wear and fatigue equilibrium state at measuring points 2 to 4, and decrease the wear rate by 22.5% and fatigue cracks by 37.4%, following the fatigue and wear equilibrium state being reached at measuring point 4.