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Constitutive Modeling Of Elastomeric Materials: A Numerical Comparison Between Hooke's Law, Neo-Hookean And Mooney-Rivlin Models

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Introduction

Railway elastomeric components, such as rail pads and shear pads, undergo complex multiaxial deformation, rendering conventional linear elastic models insufficient. Selecting formulations requires balancing nonlinear stiffness, strength, and cost. This study develops a sequential computational framework integrating Ashby multicriteria screening and genetic algorithm optimization with multiaxial hyperelastic calibration and finite element verification.

Methods

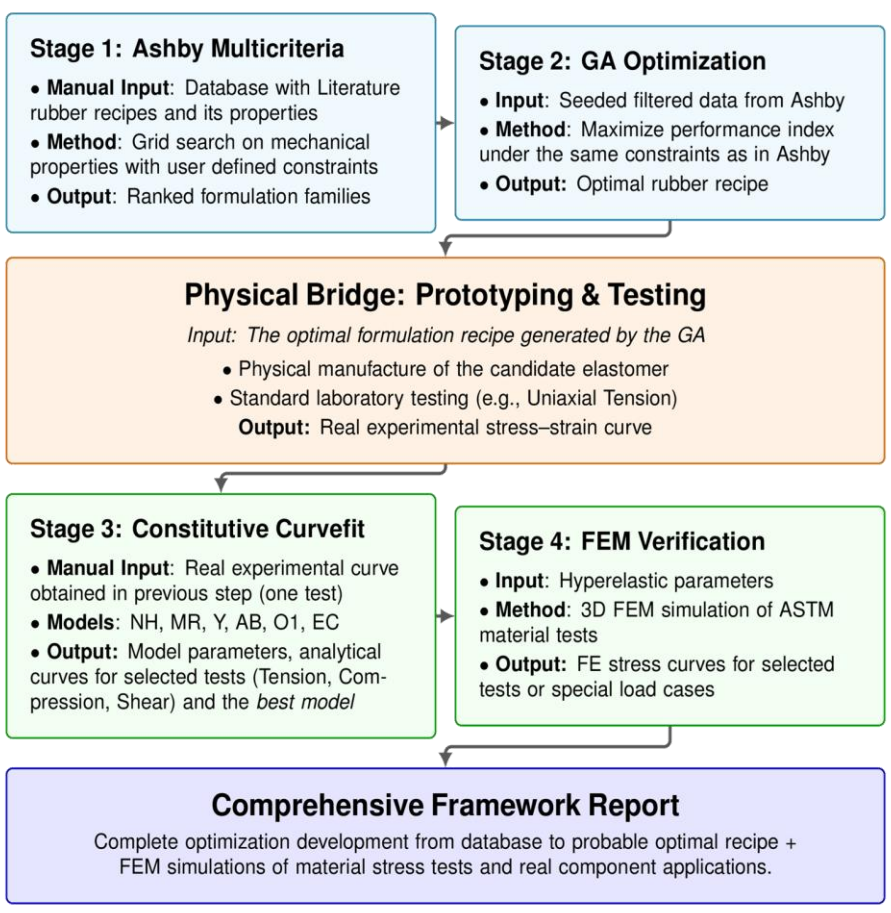


Figure 1. Developed Framework based on [03] with data from [01] and [02].

Results and Discussion

The seeded genetic algorithm achieved a performance index of 0.8089, converging toward a carbon black/waste tire dust recipe of approximately 23/7 phr.

This increased tensile strength to 24.09 MPa (+4.5%) over discrete Ashby ranking while keeping cost at 37.98 $/kg.

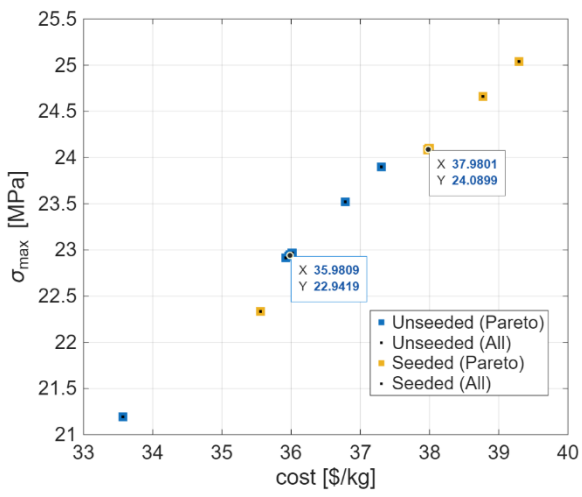


Figure 2. Cost X Yeild Stress trade-off with and without seeded GA.

Yeoh and improved Eight-Chain models provided the lowest analytical errors across tension, compression, and shear (tensile RMSE down to 0.0374 MPa). First-order formulations (Neo-Hookean and Mooney-Rivlin, tensile RMSE = 1.4285 MPa) failed to reproduce large-strain stiffening.

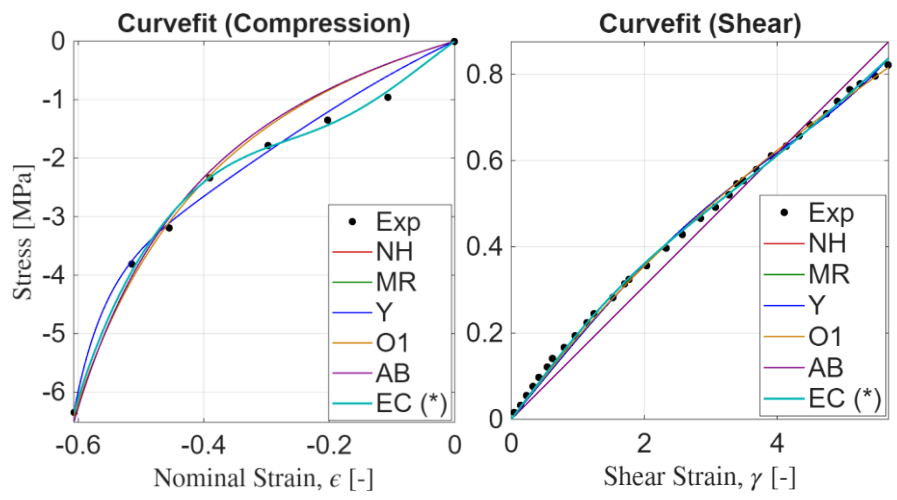


Figure 3. Curvefitting results.

Conclusion

The framework successfully connected formulation optimization to finite element verification. Seeded genetic optimization yielded an optimal compound of approximately 23/7 phr carbon black/waste tire dust. Higher-order Yeoh and Eight-Chain models reproduced multi-mode experimental curves with minimal error, showing close agreement in virtual COMSOL tests.

References and Acknowledgements

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