cbecimat26
26° Congresso Brasileiro de Engenharia e Ciência dos Materiais
22 a 26 de novembro de 2026
Costão do Santinho
Florianópolis-SC

Robustness of multicriteria material selection for bicycle frames under varying design priorities

Garrett, G. S. R.[1]; Viveiros, D. C.[2]; Oliveira, J. F. F. S.[1]; Hoefel, S. S.[1]
1. Universidade Federal do Piauí (UFPI); 2. Universidade Estadual de Campinas (Unicamp)

Introduction

A material ranked first for one preference structure can lose that position when criterion weights change and the many available normalization techniques make it hard to choose one. The paper carries out a material selection for a bicycle frame using a multicriteria decision-making for different criterion-weight combinations and normalization techniques. The objective is to distinguish a nominal winner, a candidate that wins over a large part of the sampled domain, and a candidate that maintains favorable ranking positions.



Figure 1. Bicycle frame.

Methodology

Material properties were normalized. A simple additive weighting method was used to produce the rankings using multiple combinations of weights.

Results and Discussion

The numerical inputs are taken from table 1 of Maleque and Dyuti (2010) and normalized using the vector and complementary cost normalization.

Material	s_i^* (MPa)	d_i^* (proxy)	c_i^* (−)	$z_{s,i}$	$z_{d,i}$	$z_{c,i}$
Steel 1020	296	7.8	1	0.2263	0.1818	0.9602
Ti-alloy	965	4.3	10	0.7378	0.5489	0.6022
CFRP	544	2	22.5	0.4159	0.7902	0.1049
KFRP	621	2.3	3.75	0.4748	0.7587	0.8508
GFRP	102	1.5	3.25	0.0780	0.8426	0.8707

Table 1. Normalized values. *Maleque and Dyuti (2010).

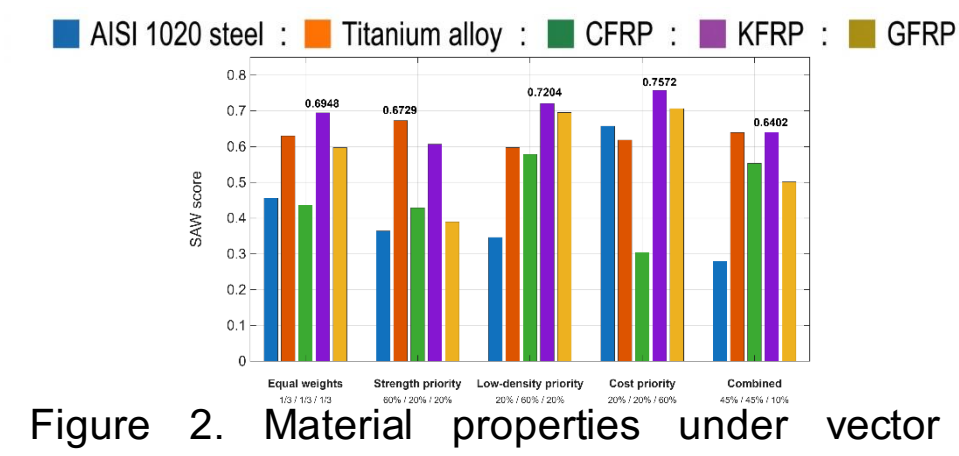


Figure 2. Material properties under vector normalization.

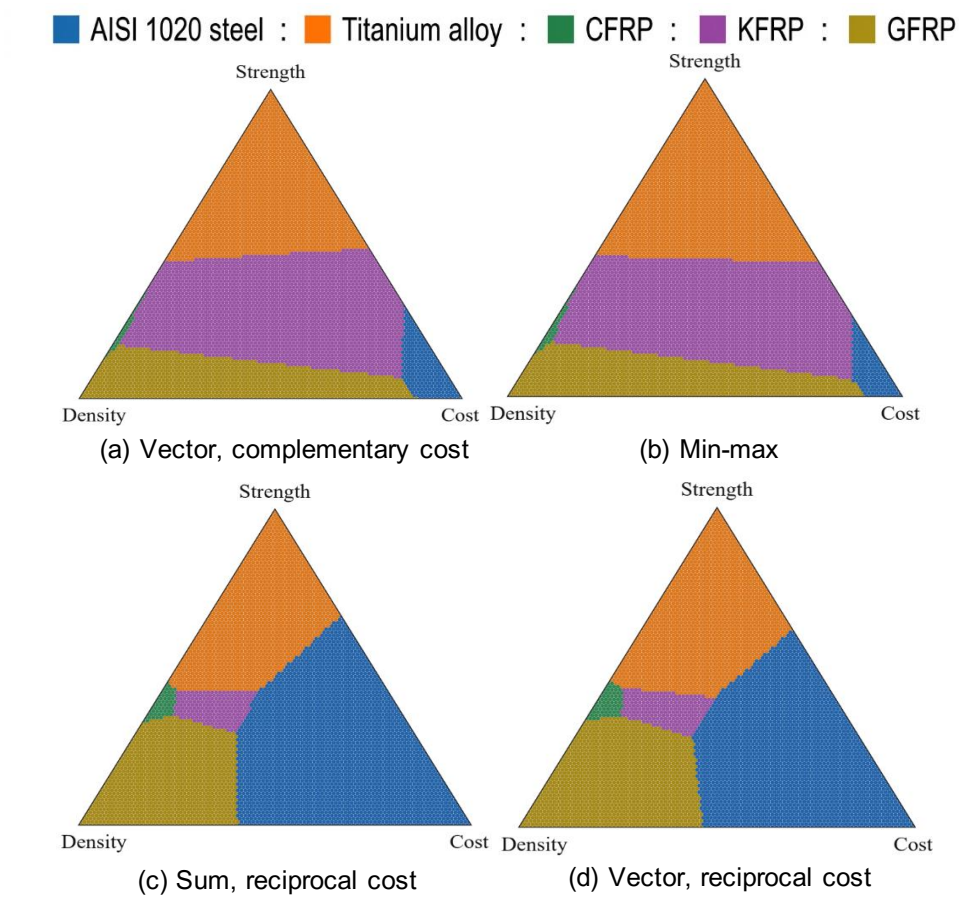


Figure 3. Admissible weight space for different normalizations.

Conclusions

The results show that material selection depends on criterion weights and normalization methods. KFRP performs favorably under vector and min-max normalization, but its winning region decreases substantially when reciprocal cost normalization is applied. These findings highlight the importance of evaluating different normalization procedures in multicriteria material selection.

References and Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. The authors express their gratitude for the funding of the School of Mechanical Engineering of the State University of Campinas, and the Laboratory of Modelling in Computational Engineering (LAMEC) of the Federal University of Piauí.

MALEQUE, M. A.; DYUTI, S. **Materials for bicycle frame system–a case study on the development of selection method**. 2010.

LIMA, Felipe Tomazelli; SOUZA, Vinicius MA. A large comparison of normalization methods on time series. **Big Data Research**, v. 34, p. 100407, 2023.

BUDIMAN, Edy; HAIRAH, Ummul. Comparison of linear and vector data normalization techniques in decision making for learning quota assistance. **Journal Information of Technology and its Utilization**, v. 4, n. 1, p. 22-28, 2021.