Effect of Twist on Tensile Properties of Braided Rope

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2.671

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Friday PM

Acknowledgements:

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Background

http://www.atlantic-avitaillement.com/wp-content/uploads/aussiere-cordage.jpg

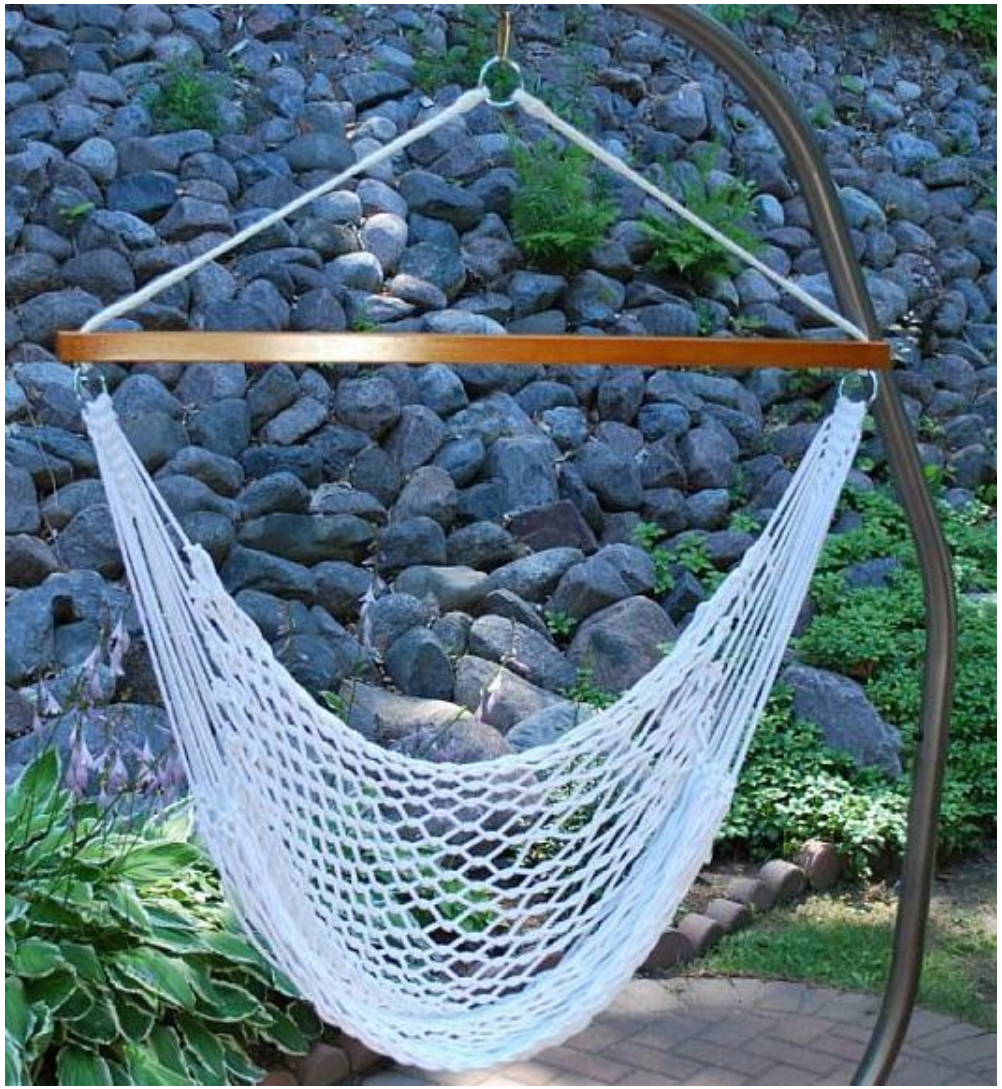
http://royalmarine.ae/wp-content/uploads/2015/04/construction1.png

HMPE: High-modulus polyethylene braided rope for marine applications

Loses strength + elasticity with twist [1]

[1] Davies, Peter, Durville, Damien, and Do Vu, Thanh. “The influence of torsion on braided rope performance, modelling and tests.” Applied Ocean Research. Vol. 59 (2016) pp. 417–423. DOI 10.1016/j.apor.2016.07.003.

Motivation



http://www.outdoorlivingdecor.com/media/img/wonderful-hanging-rope-chair-hammock-293-best-images-about-i-hanging-chairs-on-pinterest-macrame.jpg

http://hippshelp.com/wp-content/uploads/2012/06/tree-tire-swing.jpg

DIY projects, smaller ropes: not well studied

Does it also lose strength/elasticity? How much?

Theory

Twisting makes load sharing uneven [1]

untwisted

twisted

Twisting introduces torsion [2]

$$\tau = c_1 F d + c_2 F d^2 \frac{d\phi}{dz} + c_3 G d^4 \frac{d\phi}{dz} \ldots.$$

τ = torsion, F = tension, ϕ = rotation, z = length, d = diameter, G = shear modulus, c_i = rope properties

[1] Davies, Peter, Durville, Damien, and Do Vu, Thanh. "The influence of torsion on braided rope performance, modelling and tests." Applied Ocean Research. Vol. 59 (2016) pp. 417–423. DOI 10.1016/j.apor.2016.07.003.

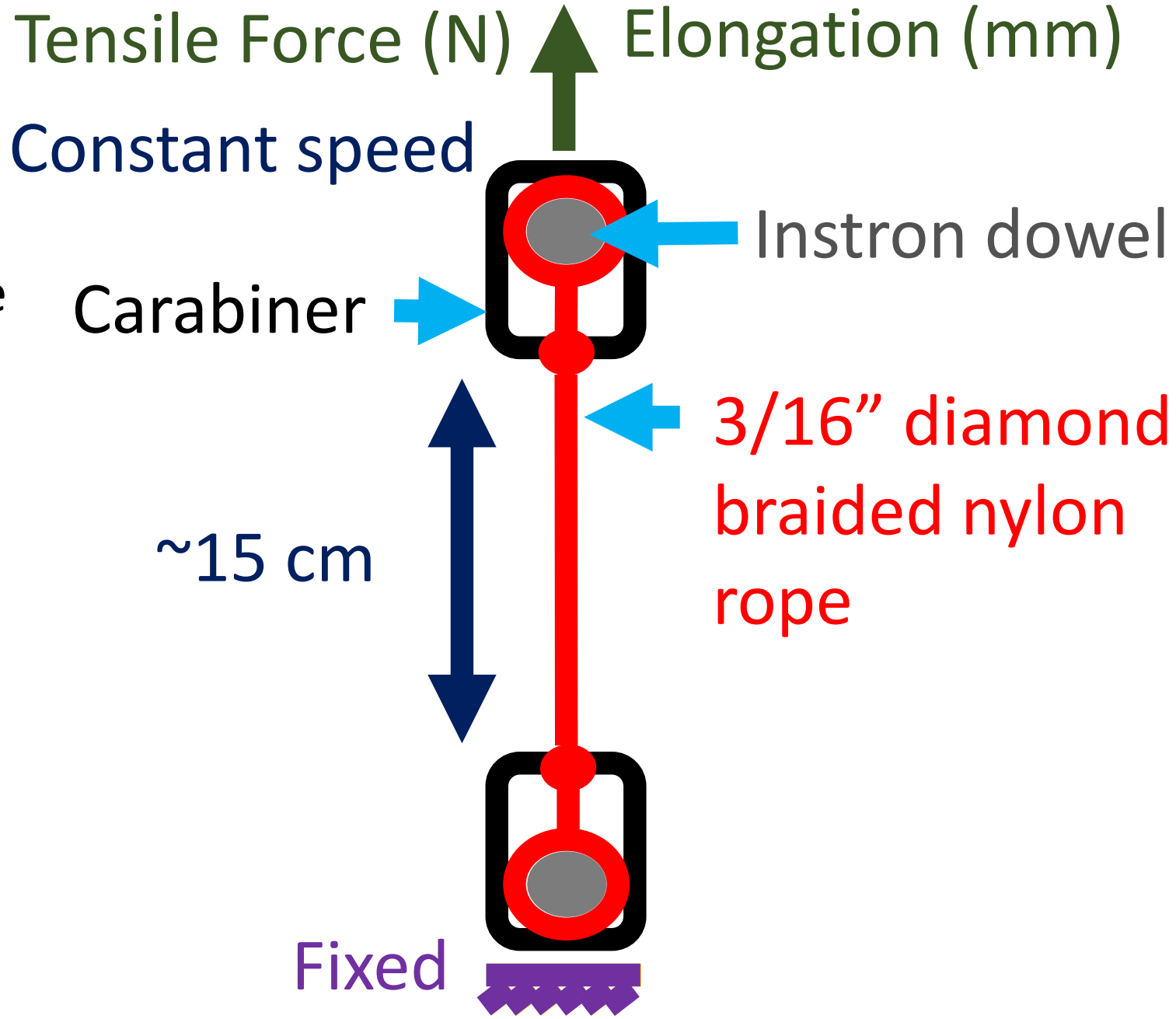
[2] Chaplin, C.R., Rebel, G., and Ridge, I.M.L, "Tensions/Torsion Interactions in Multicomponent Mooring Lines." Offshore Technology Conference 2000: pp 1-8. Houston, TX, May 1-4, 2000. DOI 10.4043/12173-MS.

Setup

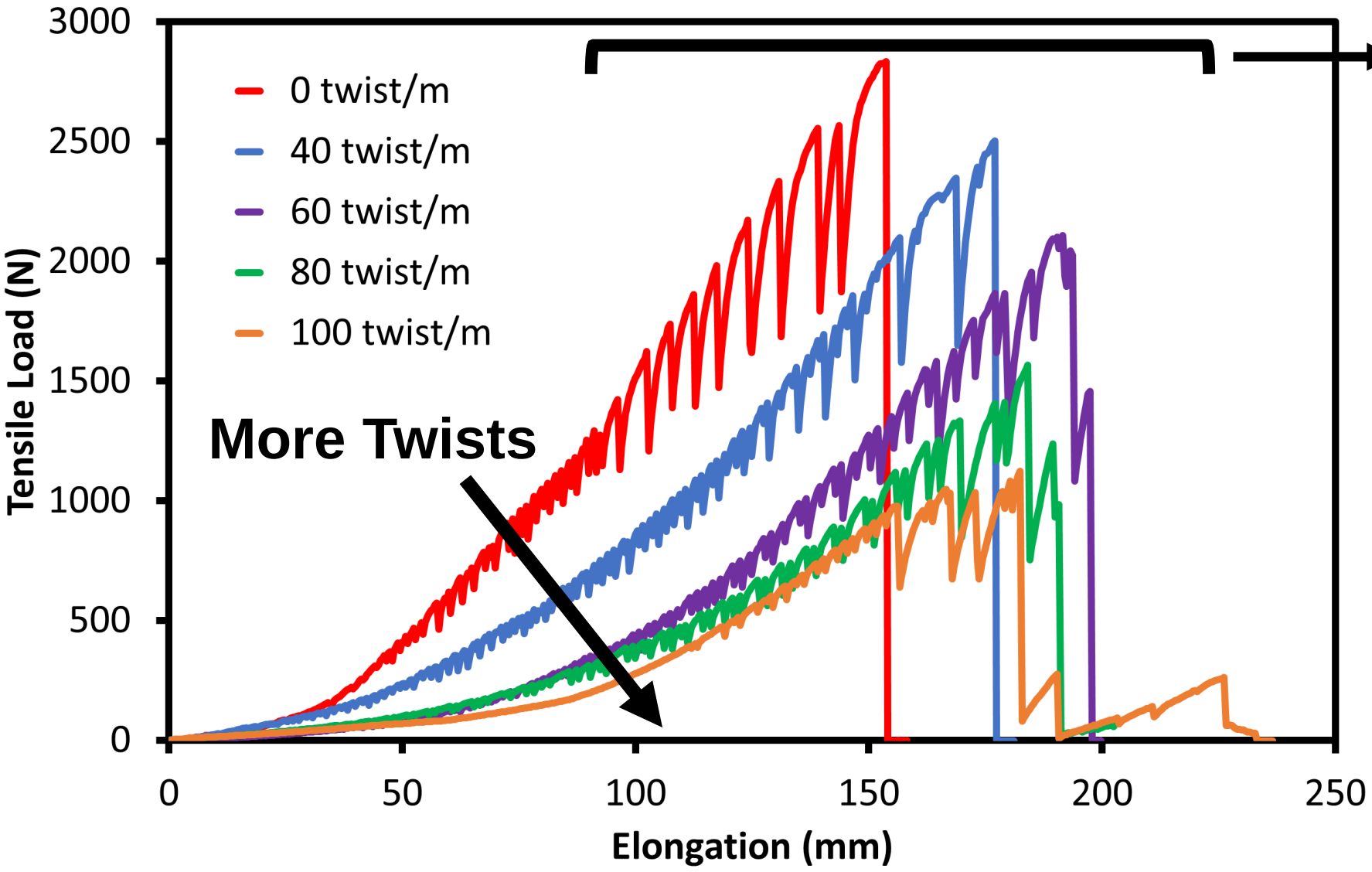
Tension-testing to failure with Instron

5 levels of twist, 0-100 twist/m

4 trials each, 20 samples total



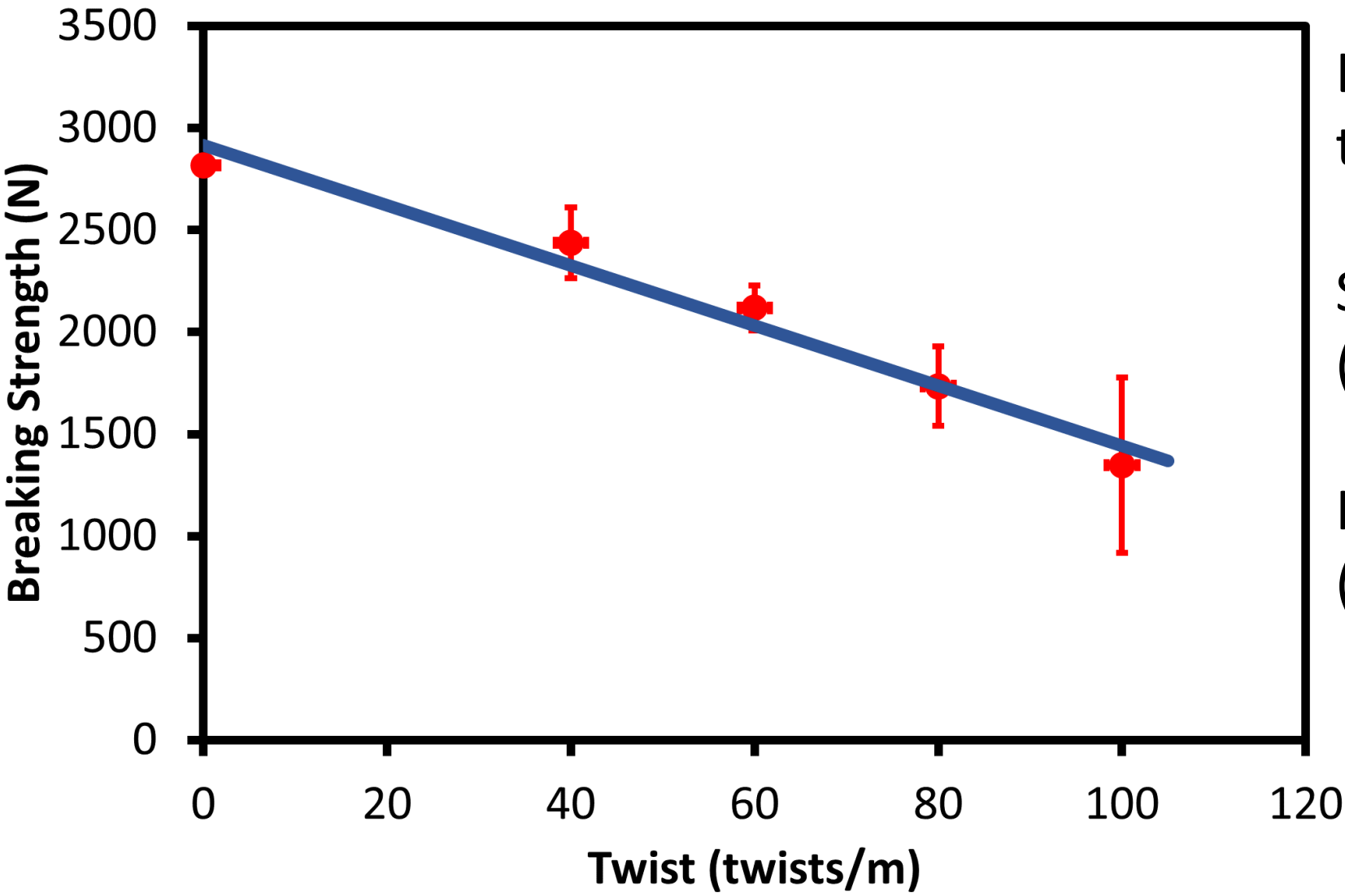
Results – Sample Data from Each Condition



Oscillations:
Rope slipping

greater twist
=
greater
elongation
(for equal load)

Results-Breaking Strength

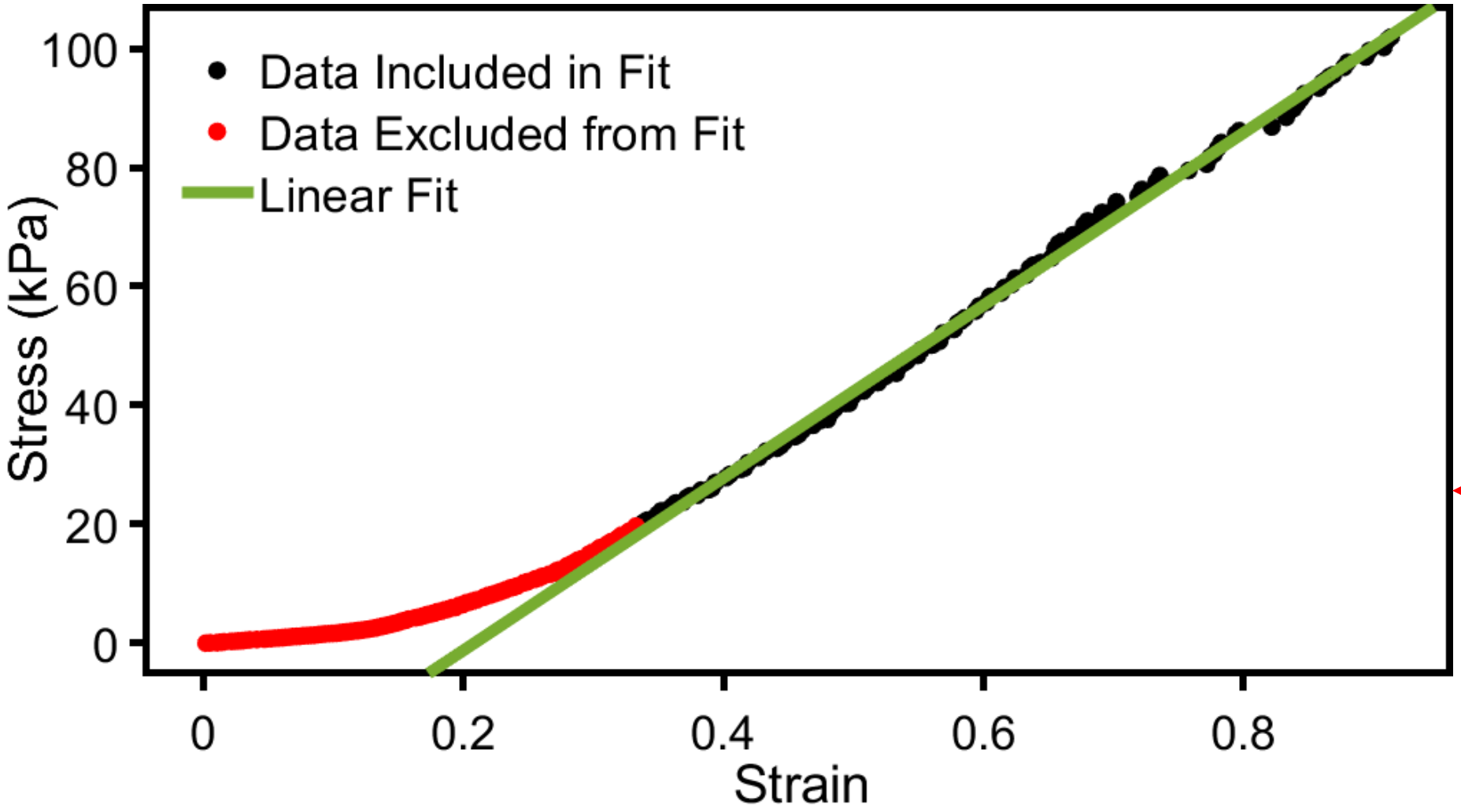


Loses (0.51 ± 0.14) % per twist/m

Slope:
(-14.75 ± 4.1) N-m/twist

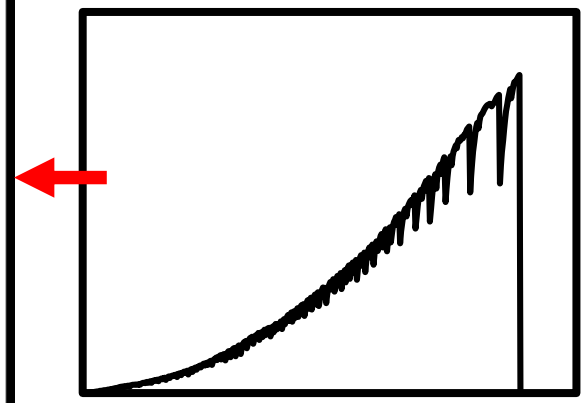
Intercept:
(2920 ± 270) N

Fitting-Elastic Modulus

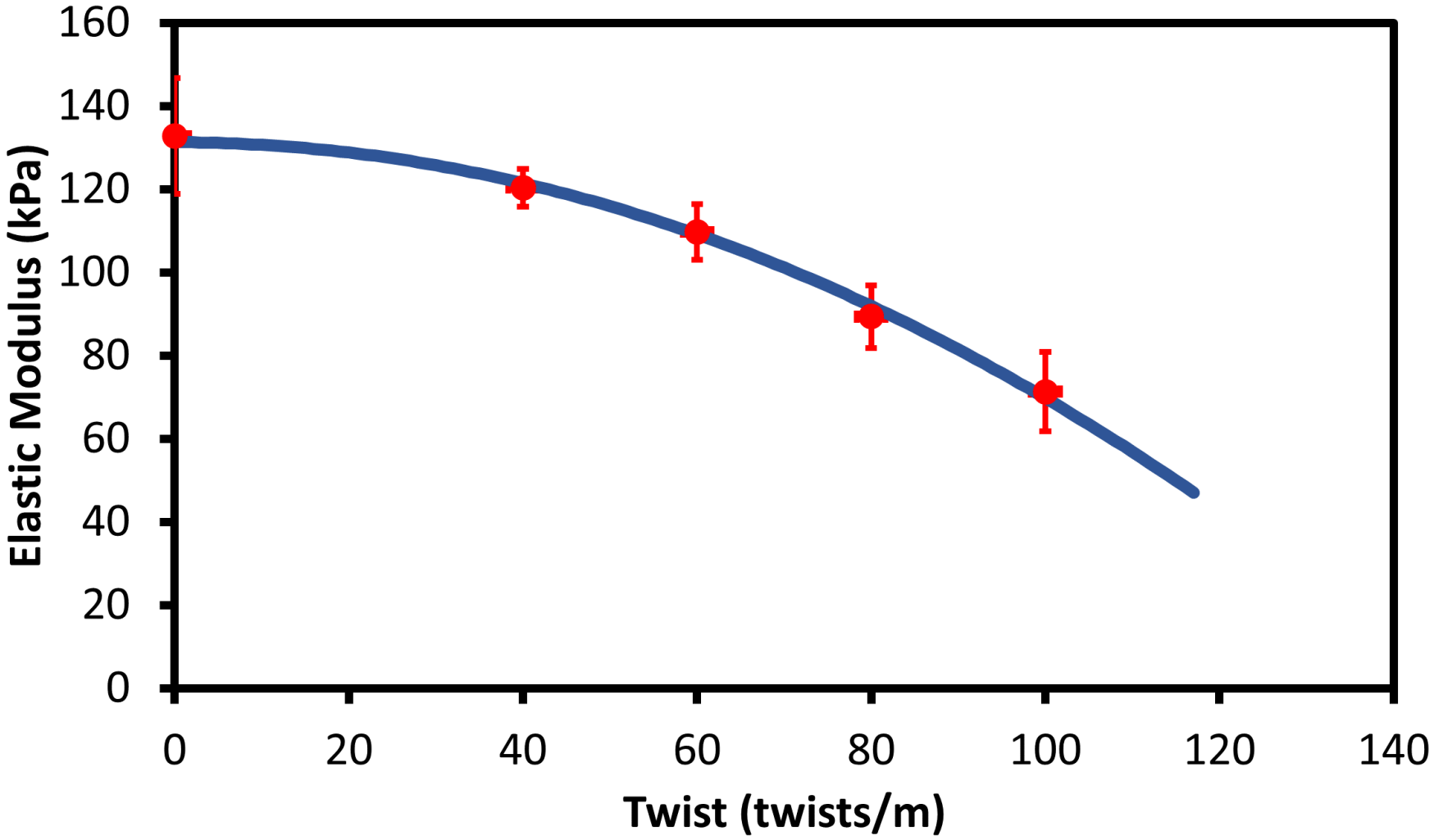


Fit linear portion

Throw away slipping effects



Results-Elastic Modulus



Loses $(4.75 \pm 0.79) \times 10^{-3}$ % per $(\text{twist/m})^2$

Quadratic coefficient: (-6.16 ± 0.83) $\text{Pa-m}^2\text{-twist}^{-2}$

Intercept: (131.3 ± 4.6) kPa

Conclusions

- More resilient than large-diameter HMPE marine ropes
  - Lose 4-7 % strength per twist/m [2]
  - Lose up to 81% elastic modulus at 11.2 twist/m [2]

- Most typical applications: don’t need to worry about twist!

Thanks!

- Questions?