4Runner 26.0mm Downey-Blazeland Load Capacity .mcdx

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GIVEN: Torsion bar geometry values and suspension travel range for the 2nd Gen 4Runner (y)

- Torsion bars functional length (L) = 37.00 (41.875 inches Sway-A-Way)
- Torsion bar diameter (D): OEM = 22.5mm, OME = 23.4mm, SAW = 25mm, Downey = 26mm
- Upper A-Arm length (A) with Blazeland installed is +3.5" OEM = 8.5+3.5 = 12.0 inches
- Suspension travel range (y) approximatley 10 inches.

FIND:

- Angular deflection as a function of the wheel travel
- Find the effective forshortening of the A-arm as it deviates from horizontal orientation.
- Torsional Deflection as a function of angular movement based on travel range.
- The effective spring rate (K) with forshortened A-arm length superimposed.
- The load capacity (LC) of two torsion bars for various compressed distances and plot curve.

ASSUMPTIONS:

- Material Chrome Vanadium UNS G61500 or Chrome Silicon UNS G92540
- The shear modulus (G) for Chrome Vanadium and Chrome Silicon (c/o Murphy & Read Spring Mfg.) 11,500,000 psi
- A-Arm at horizontal to ground establishes full arm length (A)

SOLUTION: Variables $L := 37\ in$ $D := 26\ mm$ $G := 11500000\ psi$ $A := 12.0\ in$

$D = 1.02\ in$

$$y := \begin{bmatrix} 10.0 \\ 9.0 \\ 8.0 \\ 7.0 \\ 6.0 \\ 5.50 \\ 5.0 \\ 4.0 \\ 3.0 \\ 2.0 \\ 1.0 \\ 0.01 \end{bmatrix} in \qquad \alpha := \operatorname{asin}\left(\frac{y}{A}\right) \qquad y' := \begin{bmatrix} 5.0 \\ 4.0 \\ 3.0 \\ 2.0 \\ 1.0 \\ 0.01 \\ 1.0 \\ 2.0 \\ 3.0 \\ 4.0 \\ 5.0 \\ 6.0 \end{bmatrix} in$$

y' value sets values from horizontal as 0.01. Top-out is 6.0 and bottom-out is 5.0

$$\alpha' := \operatorname{asin}\left(\frac{y'}{A}\right) \qquad A' := \cos(\alpha') \cdot A = \begin{bmatrix} 10.91 \\ 11.31 \\ 11.62 \\ 11.83 \\ 11.96 \\ 12 \\ 11.96 \\ 11.83 \\ 11.62 \\ 11.31 \\ 10.91 \\ 10.39 \end{bmatrix} in$$

A' is the foresohortened length of the A-arm for angles that deviate from horizontal.

ANSWER: Torsional deflection for a torsion bar (Engineering Tool Box), Force developed with forshortenend effective A-Arm length, Spring rate (K) with F calculated using A', Load Capacity (LC). All as a function of wheel travel (y).

$$T := \frac{\alpha \cdot G \cdot \pi \cdot D^4}{32 \cdot L} \qquad F := \frac{T}{A'} \qquad K := \frac{F}{y} \qquad LC := 2\ F$$

$$y = \begin{bmatrix} 10 \\ 9 \\ 8 \\ 7 \\ 6 \\ 5.5 \\ 5 \\ 4 \\ 3 \\ 2 \\ 1 \\ 0.01 \end{bmatrix} in \qquad T = \begin{bmatrix} 2750 \\ 2368 \\ 2037 \\ 1739 \\ 1462 \\ 1329 \\ 1200 \\ 949 \\ 705 \\ 467 \\ 233 \\ 2 \end{bmatrix} ft \cdot lbf \qquad F = \begin{bmatrix} 3025 \\ 2511 \\ 2104 \\ 1763 \\ 1467 \\ 1329 \\ 1204 \\ 962 \\ 729 \\ 496 \\ 256 \\ 3 \end{bmatrix} lbf$$

$$K = \begin{bmatrix} 302.5 \\ 279 \\ 263 \\ 251.9 \\ 244.5 \\ 241.7 \\ 240.8 \\ 240.5 \\ 242.8 \\ 247.9 \\ 256.2 \\ 268.6 \end{bmatrix} \frac{lbf}{in} \qquad LC = \begin{bmatrix} 6051 \\ 5022 \\ 4208 \\ 3527 \\ 2934 \\ 2658 \\ 2408 \\ 1924 \\ 1457 \\ 992 \\ 512 \\ 5 \end{bmatrix} lbf$$