Supplementary Material

1 DEFINITION OF THE HEIGHT $h(x)$ OF THE TAPERED BEAM

In Figure S1 the function $h(x) = \frac{h_0}{l}\left[(1-\alpha)l + 2\alpha x\right]$ is evaluated for some values of α.

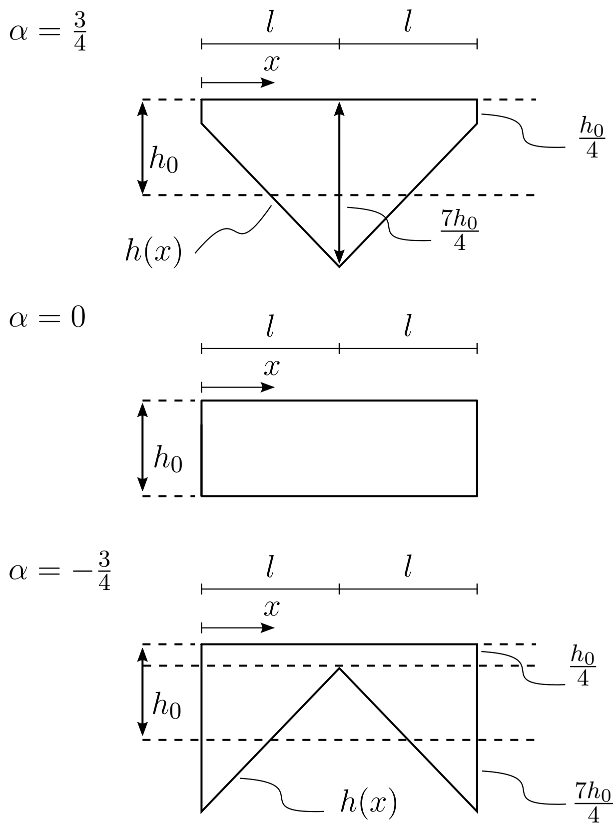

Figure S1. $h(x)$ for $\alpha = \{\frac{3}{4}, 0, -\frac{3}{4}\}$

2 DERIVATION FOR THE MID-SPAN DEFLECTION w_l OF THE TAPERED BEAM

The bending moment is introduced as the integration of the shear force:

$$Q(x) = -qx + C_1 \tag{S1}$$

$$M(x) = -\frac{1}{2}q\,x^2 + C_1 x + C_2 \tag{S2}$$

The tapered beam has a rectangular cross section. The height $h(x)$ along the length is defined as

$$h(x) = \frac{h_0}{l}\left[(1-\alpha)l + 2\alpha x\right]. \tag{S3}$$

With these definitions the material law $\kappa = \frac{M}{EI}$ is introduced:

$$\kappa(x) = -\frac{12\left(-\frac{1}{2}q\,x^2 + C_1x + C_2\right)l^3}{Ebh_0^3\left((\alpha-1)\,l - 2\alpha x\right)^3} \tag{S4}$$

The integration of κ provides the rotation

$$\phi(x) = \frac{-6\left((l-2x)\,\alpha - l\right)^2 l^3 q \ln((-l+2x)\,\alpha + l) + 8EbC_3h_0^3\,(l-2x)^2\,\alpha^5}{8E\left((l-2x)\,\alpha - l\right)^2 h_0^3 b\,\alpha^3} + \tag{S5}$$

$$+\,\frac{8C_3E\,\alpha^3 bh_0^3l^2 - 9l^3\left(l^2q + \left(-\frac{8qx}{3} - \frac{4C_1}{3}\right)l + \frac{16C_1x}{3} + \frac{8C_2}{3}\right)\alpha^2 - 9l^5q}{8E\left((l-2x)\,\alpha - l\right)^2 h_0^3 b\,\alpha^3} + \tag{S6}$$

$$+\,\frac{18l^4\left(ql - \frac{4}{3}qx - \frac{2}{3}C_1\right)\alpha - 16EblC_3h_0^3\,(l-2x)\,\alpha^4}{8E\left((l-2x)\,\alpha - l\right)^2 h_0^3 b\,\alpha^3}. \tag{S7}$$

The integration of ϕ leads to the deflection

$$w(x) = \frac{-18l^3\left(\left(ql - \frac{2}{3}qx - \frac{4}{3}C_1\right)\alpha - ql\right)\left((l-2x)\,\alpha - l\right)\ln((-l+2x)\,\alpha + l) + 3l^5q}{16E\,\alpha^4 b\,h_0^3\left((l-2x)\,\alpha - l\right)} + \tag{S8}$$

$$+\,\frac{8E\,h_0^3 b\,(l-2x)\,(lC_3 - 2C_3x + 2C_4)\,\alpha^5 - 16E\,h_0^3 bl\,(lC_3 - 2C_3x + C_4)\,\alpha^4}{16E\,\alpha^4 b\,h_0^3\left((l-2x)\,\alpha - l\right)} + \tag{S9}$$

$$+\,\frac{8C_3E\,\alpha^3 b\,h_0^3 l^2 + 3l^3\left(l^2q + (-8qx + 4C_1)\,l + 8q\,x^2 + 8C_2\right)\alpha^2 - 6l^4\,(ql - 4qx + 2C_1)\,\alpha}{16E\,\alpha^4 b\,h_0^3\left((l-2x)\,\alpha - l\right)}. \tag{S10}$$

By applying the following boundary conditions

$$w(x=0) = 0 \tag{S11}$$

$$M(x=0) = 0 \tag{S12}$$

$$\phi(x=l) = 0 \tag{S13}$$

$$Q(x=l) = 0 \tag{S14}$$

the integration constants evaluate to:

$$C_1 = lq \tag{S15}$$

$$C_2 = 0 \tag{S16}$$

$$C_3 = \frac{3l^3\left((\alpha+1)^2\ln(l\,(\alpha+1)) + \frac{7\alpha^2}{2} + 3\alpha + \frac{3}{2}\right)q}{4\alpha^3 Eb\,h_0^3\,(\alpha+1)^2} \tag{S17}$$

$$C_4 = -\frac{3l^4q\left((\alpha+3)\,(\alpha+1)^2\ln(-(\alpha-1)\,l) + (\alpha-1)\,(\alpha+1)^2\ln(l\,(\alpha+1)) + 6\alpha^3 + 4\alpha^2 - 2\right)}{8\alpha^4h_0^3bE\,(\alpha+1)^2} \tag{S18}$$

With these results, the mid-span deflection $w(x = l) = w_l$ yields to

$$w_l = \frac{3ql^4 \left((\alpha + 3)(\alpha + 1)^2 \ln\left(\frac{1+\alpha}{1-\alpha}\right) - 12\alpha^3 - 14\alpha^2 - 6\alpha \right)}{8(\alpha + 1)^2 Ebh_0^3 \alpha^4}. \tag{S19}$$

3 DERIVATION FOR THE ACTUATION FORCE F_{act} OF THE TAPERED BEAM

The actuation force F_{act} is derived in the same way as the mid-span deflection w_l. Only different boundary conditions are applied:

$$w(x = 0) = 0 \tag{S20}$$

$$M(x = 0) = 0 \tag{S21}$$

$$\phi(x = l) = 0 \tag{S22}$$

$$Q(x = l) = -F_{\text{act}} \tag{S23}$$

The integration constants evaluate to:

$$C_1 = -F_{\text{act}} + 25 \tag{S24}$$

$$C_2 = 0 \tag{S25}$$

$$C_3 = \frac{50(1+\alpha)^2 \ln(1+\alpha) + 50(1+\alpha)^2 \ln(5) + 75 + (-12F_{\text{act}} + 175)\alpha^2 + (-4F_{\text{act}} + 150)\alpha}{12800\alpha^3 (1+\alpha)^2} \tag{S26}$$

$$C_4 = \frac{4(1+\alpha)^2 \left(-\frac{75}{4} + \left(F_{\text{act}} - \frac{25}{4}\right)\alpha\right) \ln(-\alpha + 1) - 25(\alpha - 1)(1+\alpha)^2 \ln(1+\alpha)}{2560\alpha^4 (1+\alpha)^2} + \tag{S27}$$

$$+ \frac{+4\left(-\frac{25}{2} + \left(F_{\text{act}} - \frac{25}{2}\right)\alpha\right)(1+\alpha)^2 \ln(5) + 50 + (8F_{\text{act}} - 150)\alpha^3 - 100\alpha^2}{2560\alpha^4 (1+\alpha)^2} \tag{S28}$$

So the deflection $w(x = l) = w_l$ at mid span is:

$$w_l = \frac{4(1+\alpha)^2 \left(-\frac{75}{4} + \left(F_{\text{act}} - \frac{25}{4}\right)\alpha\right) \ln(-\alpha + 1) - 4(1+\alpha)^2 \left(-\frac{75}{4} + \left(F_{\text{act}} - \frac{25}{4}\right)\alpha\right) \ln(1+\alpha)}{2560\alpha^4 (1+\alpha)^2} + \tag{S29}$$

$$+ \frac{(16F_{\text{act}} - 300)\alpha^3 + (8F_{\text{act}} - 350)\alpha^2 - 150\alpha}{2560\alpha^4 (1+\alpha)^2} \tag{S30}$$

F_{act} is expressed analytically with respect to the constraint $w_l = \hat{w}$:

$$F_{\text{act}}(\alpha) = \frac{2Ebh_0^3 \hat{w}\alpha^3 \left(\alpha^2 + 2\alpha + 1\right)}{3l^3 (4\alpha^2 + \Lambda + 2\alpha)} + \frac{ql\left(12\alpha^3 + 2\alpha(7\alpha + 3) + \Lambda(\alpha + 3)\right)}{4\alpha(4\alpha^2 + \Lambda + 2\alpha)}, \tag{S31}$$

$$\text{with} \quad \Lambda = (\alpha + 1)^2 \ln \frac{1 - \alpha}{1 + \alpha}. \tag{S32}$$