Version v01, 2023-01-25

1. Measure the brace billet properities (L, W, D, m, fres) for the bracewood billet, and enter the description, date and properties on the "Brace Properties Sheet". Data entry cells are tagged green. This sheet calculates the density and the Young's modulus for the wood/billet being used.

2. On the "Single Elements" sheet, enter the bracing dimensions desired, taken on the section crossing the top at the 50mm mark forward of the saddle. Enter the width of the top at that section and the thickness of the top. This sheet calculates the individual element's I, *AT ITS CENTROID*, and the EI for each brace

3. From the previously entered data the "System" sheet calculates the new neutral axis for the soundboard system, and translates each of the seven elements to provide it's contribution to I *at the new neutral axis*. From that it calculates the new Equivalent I for the braced soundboard system.

4. The "results and database" sheet pulls together all the calculated results into a tabular form to match Table 4.4-2 in the book. If using a different wood than spruce, don't forget to change the brace dimensions to accomodate "equivalent material" as described on page 4-49. Also make the change in the cell for "Typical modulus of rupture" from the spruce I have in there, to match the wood type.

5. For building the reference database, just copy the results line and "paste values and source formatting" into the next free line of the database.

Calculate Young's Modulus for the Selected Bracewood billets

E=(((f*L^2)/(1.0279*D))^2)*rho   EQN 44-4

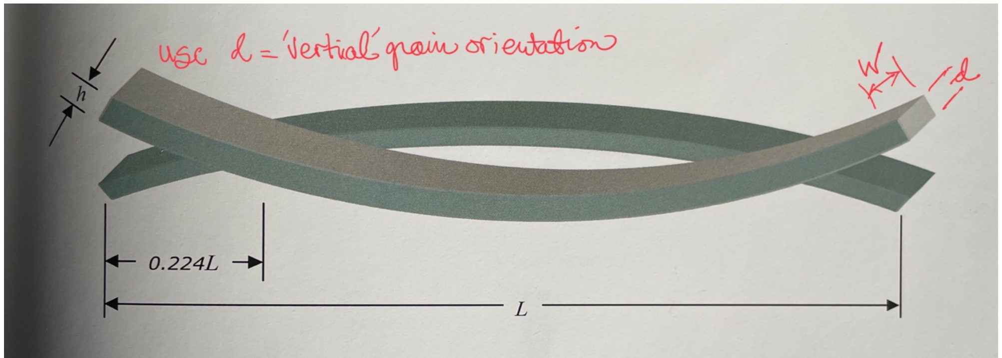


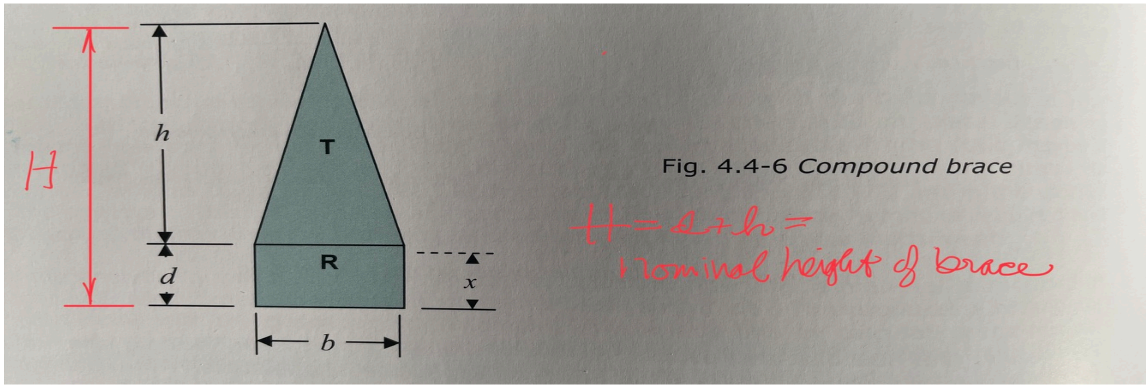
Fig. 4.4-7 *A free-free vibrating beam*

Note: Test the billet with the D dimension in the direction of the closet to vertical grain, as it will be used in the guitar

Material under test	Date	length, L (m)	width, W (m)	depth, D (m)	mass, m (kg)	volume, v (m^3)	density, rho (kg/m^3)	first mode resonance, f (hz)	Young's Modulus, E (Pa)	Young's Modulus E, (Gpa)
tweak mass and frequency to get back to the Design book values to show all the correct intermediate results in the PDF print out	2023-01-23	0.508	0.026	0.051	0.2964	6.74E-04	440.0	1061	11999889674	12.0

d

Single Brace Calculations for X-braces and Finger Braces



For validation used these values from Figure4.4-19.Replace these in the data entry cells with the actual planned/measured values when working with the current guitar.

finger braces, hf	0.0080	m
finger braces, bf	0.0060	m
x-braces, hx	0.0080	m
x-braces, dx	0.0070	m
x-braces, bx	0.0080	m
soundboard thickness, ds	0.0028	m
soundboard width @50mm, bs	0.2800	m

The Finger braces are just the Triangle shape:

hf =	0.008	m	Af =	2.40E-05	m2
bf =	0.006	m			

Itf (X-X) = (bf*hf^3)/36 (FIG 4.4-5)

Itf(X-X) =	8.53E-11	m^4	EI =	1.02E+00	Nm^2

The x-braces are the compound shape from FIG 4.4-6

hx =	0.008	m	At =	3.20E-05	m2
dx =	0.007	m	Ar =	5.60E-05	m2
bx =	0.008	m			

Itx (X-X) = (bx*hx^3)/36 (FIG 4.4-5)

Itx(X-X) = 1.14E-10 m^4

Irx (X-X) = (bx*dx^3)/12 (FIG 4.4-5)

Irx(X-X) = 2.29E-10 m^4

Neutral axis of the compound shape: xb = ((At*(dx+(hx/3)))+(Ar*(dx/2)))/(At+Ar)

xb = 5.74E-03 m

Ix = the second moment of area for the compound shape x-brace

Ix = (Itx+At*((dx+hx/3)-xb)^2)+(Irx+Ar*(xb-(dx/2))^2) from EQU 4.4-2

Ix =	1.12E-09	m^4	EI =	1.34E+01	Nm^2

Intermediate values for xb

At	3.20E-05	m^2
(Dx+hx/3)	9.67E-03	m, neutral axis for triangle
At(Dx+hx/3)	3.09E-07	m^3
Ar	5.60E-05	m
dx/2	3.50E-03	m, neutral axis for rectangle
Ar(dx/2)	1.96E-07	m^3
numerator	5.05E-07	m^3
Denominator	8.80E-05	m^2
xb	5.74E-03	m

Intermediate values for Ib

Itx	1.14E-10	m^4
At	3.20E-05	m^2
(dx+hx/3)-xb	3.92E-03	m, offset of triangle neutral from brace neutral
Irx	2.29E-10	m^4
Ar	5.60E-05	m^2
(xb-(dx/2))	2.24E-03	m, offset of rectangle neutral from brace neutral
Ib	1.12E-09	m^4

The soundboard is a rectangle with the thickness dimension ds and the width at the 50mm mark

ds =	2.80E-03	m	As =	7.84E-04	m2
bs =	2.80E-01	m			

neutral axis of the soundboard, xs

xs = 0.0014 m

Is (X-X) = (bs*ds^3)/12 (FIG 4.4-5)

Is(X-X) =	5.12E-10	m^4	EI =	6.15E+00	Nm^2

Calculation of I for the System of the Braced Soundboard

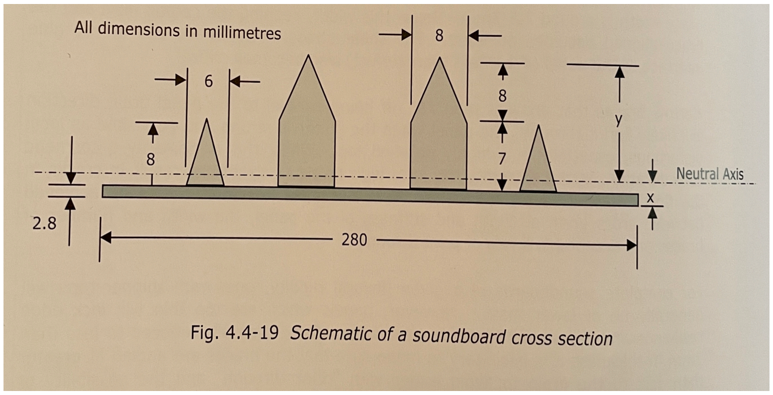


Fig. 4.4-19 *Schematic of a soundboard cross section*

Note: Each of the individual braces must be translated to the Neutral Axis of the soundboard/braced system to be able to add the I's. Trevor's figure doesn't call out the distances in the across axis dimension. I believe that this is because we are interested only in the moment of area around the single axis positioned 50 mm forward of the saddle. Each Ib is the individual brace's contribution to the resistance to rotation around that axis, so I think they just add directly once they've been translated to the neutral axis.

Used the values in Figure 4.4-19 on the "singles" sheet to create and test the workbook, validated it against the results in Table 4.4.2. Update the cells in the "Singles" sheet for the actual top and braces being evaluated.

First have to calculate the neutral axis of the compound shape using first moment of area: sum of the products of individual areas times their individual centroid distance to the reference axis is equal to the total area summed times the distance to the systems neutral axis.

1. number the braces from left to right as 1,2,3,4
2. do the area contributions from the triangle gables and the rectangles on the x-braces seperately, i.e.A1, A2T, A2R, A3T, A3R, A4, As
3 calc the distance from the reference axis for each elements centroid
4. sum the products of the element area and its centroid's distance
5. divide that by the sum of the element areas
6. result is the equivanent system neutral axis.

A1 =	2.40E-05	m^2	**x1 =**	5.47E-03	m	**A1*x1=**	1.31E-07	m^3
A2T =	3.20E-05	m^2	**x2T=**	1.25E-02	m	**A2T*x2T=**	3.99E-07	m^3
A2R =	5.60E-05	m^2	**x2R=**	6.30E-03	m	**A2R*x2R=**	3.53E-07	m^3
A3T =	3.20E-05	m^2	**x3T=**	1.25E-02	m	**A3T*x3T=**	3.99E-07	m^3
A3R =	5.60E-05	m^2	**x3RF=**	6.30E-03	m	**A3R*x3R=**	3.53E-07	m^3
A4 =	2.40E-05	m^2	**x4 =**	5.47E-03	m	**A4*x4=**	1.31E-07	m^3
As =	7.84E-04	m^2	**xs =**	1.40E-03	m	**As*xs=**	1.10E-06	m^3
denominator =	1.01E-03	m^2				numerator=	2.86E-06	m^3
xsystem =	2.84E-03	m						

Now have to translate each of the individual elements to the new xsystem axis to determine it's I contribution to the system.
For each element, the contributing I is calculated as its intrinsic I plus the square of the distance of it's centroid from the xsystem axis

Element	Intrinsic I		Dist to neutral axis		new I @ neutral axis	
1	8.53E-11	m^4	2.63E-03	m	2.51E-10	m^4
2T	1.14E-10	m^4	9.63E-03	m	3.08E-09	m^4
2R	2.29E-10	m^4	3.46E-03	m	8.99E-10	m^4
3T	1.14E-10	m^4	9.63E-03	m	3.08E-09	m^4
3R	2.2867E-10	m^4	3.46E-03	m	8.99E-10	m^4
4	8.53E-11	m^4	2.63E-03	m	2.51E-10	m^4
S	5.12E-10	m^4	-1.44E-03	m	2.14E-09	m^4
			Equivalent I for the Braced Soundboard		1.06E-08	m^4

Results

Note: to build the database history, just copy the results row and do a "Paste Special -> valuees and source formatting" into next available row in the database

Assumed applied moment 10 Nm This is the string torque applied for determining the stress, as arrived at on page 4.34. If you need a different value, here is where it goes.

Sample Description (from Brace Properties sheet)	Date	Brace Density (kg/m^2)	Young's Modulus (Gpa)	Typical Modulus of Rupture (Mpa)	Allowable Stress: 50% MOR (Mpa)	Equivalent EI for Braced Soundboard (Nm^2)	Equivalent I for Braced Soundboard (m^4)	Neutral Axis position, x (mm)	Max Distance of Brace Material from neutral axis,y (mm)	Actual Peak stress (Mpa)	Peak Stress/Allowable Stress (%)
tweak mass and frequency to get back to the Design book values to show all the correct intermediate results in the PDF print out	2023-01-23	440	12.00	70	35	127.2	1.06E-08	2.84	14.96	14.12	40

Database

												Notes:
Spreadsheet validation run: real billet but tweaked the mass and freq to give me the 480 kg/m2 and 12.00 E from Table 4.4-2	2023-01-23	440	12.00	70	35	127.2	1.06E-08	2.84	14.96	14.12	40	validates with Table 4.4-2
Guitar D002 - LMII Sitka Spruce Billet #1 Good quality, well quarter-sawn. Measured in the mostly vertical direction.	2023-01-23	444	12.81	70	35	135.7	1.06E-08	2.84	14.96	14.12	40	
Guitar D002 - LMII Sitka Spruce Billet #1 Good quality, well quarter-sawn. Measured in the mostly horizontal direction.	2023-01-23	444	11.71	70	35	124.1	1.06E-08	2.84	14.96	14.12	40	
Guitar D002 - LMII Sitka Spruce Billet #2 Good quality, well quarter-sawn. Measured in the mostly vertical direction.	2023-01-23	456	13.49	70	35	142.9	1.06E-08	2.84	14.96	14.12	40	
Guitar D002 - LMII Sitka Spruce Billet #2 Good quality, well quarter-sawn. Measured in the mostly horizontal direction.	2023-01-23	456	11.64	70	35	123.4	1.06E-08	2.84	14.96	14.12	40	