DESIGN FORMULAS FOR TIMBER DECKING

Source: *Timber Construction Manual*, 5th ed., p. 308, American Institute of Timber Construction.

Layup … Allowable Area Load (σ) Based On

Layup	Bending	Deflection
Simple Span	$\sigma_b = \frac{8F_b'}{\ell^2}\frac{d^2}{6}$	$\sigma_\Delta = \frac{384}{5}\frac{\Delta E'}{\ell^4}\frac{d^3}{12} = 76.8\frac{\Delta E'}{\ell^4}\frac{d^3}{12}$
Two-Span Cont.	$\sigma_b = \frac{8F_b'}{\ell^2}\frac{d^2}{6}$	$\sigma_\Delta = 185\frac{\Delta E'}{\ell^4}\frac{d^3}{12}$
Controlled Random Layup (Glued Lam. Decking)	$\sigma_b = \frac{20F_b'}{3\ell^2}\frac{d^2}{6} = \frac{6.67F_b'}{\ell^2}\frac{d^2}{6}$	$\sigma_\Delta = 130\frac{\Delta E'}{\ell^4}\frac{d^3}{12}$

Where,

σ = allowable area load,

F_b' = allowable bending stress (design value adjusted by appropriate factors),

d = actual decking thickness,

ℓ = c.t.c. span,

Δ = allowable deflection,

E' = modulus of elasticity adjusted by appropriate factors,

Alternately, the deflection equations may be rewritten in terms of a deflection limit,

Load Limited by Deflection (Deflection Limit)

Simple Span $$\sigma_\Delta = \frac{384}{5}\frac{\Delta E'}{\ell^4}\frac{d^3}{12} = \frac{384}{5}\left(\frac{\Delta}{\ell}\right)\frac{E'}{\ell^3}\frac{d^3}{12}$$

Two-Span Cont. $$\sigma_\Delta = 185\left(\frac{\Delta}{\ell}\right)\frac{E'}{\ell^3}\frac{d^3}{12}$$

Controlled Random Layup $$\sigma_\Delta = 131\left(\frac{\Delta}{\ell}\right)\frac{E'}{\ell^3}\frac{d^3}{12}$$

Where $\left(\frac{\Delta}{\ell}\right)$ is a deflection limit (ratio), such as 1/180, 1/240, 1/360, etc.

<u>EXAMPLE</u>

(By Jeff R. Filler, P.E., Advance Professional Engineering, www.WoodEngineering.com .)

Determine the total allowable load for 10 ft span, Nominal 3 x PP (Ponderosa Pine) decking, based on L/180 total load deflection.

From Filler King brochure, PP decking has $F_b^{'}$ = 1485 psi (snow load duration) and E = 1,150,000 psi, and the thickness is 2-3/16 in. = 2.1875 in.

SIMPLE SPAN

Based on flexure (bending) … $\sigma_b = \frac{8F_b^{'}}{\ell^2}\frac{d^2}{6} = \frac{8\left(1485\frac{lb}{in.^2}\right)}{\left(10\,ft\right)^2}\frac{\left(2.1875\,in.\right)^2}{6} = 95\,psf$

Based on deflection … allowable deflection is 10 ft x 12 in. / ft divided by 180 = 0.667 in.

$$\sigma_\Delta = 76.8\frac{\Delta E'}{\ell^4}\frac{d^3}{12} = 76.8\frac{0.667in.\left(1,150,000lb/in.^2\right)}{\left(10x12\,in.\right)^4}\frac{\left(2.1875\,in.\right)^3}{12} = 0.248\frac{lb}{in.^2}\ldots$$

Converting to 0.248 psi x 144 sq. in. / sf = 36 psf …

We see that deflection controls (36 psf < 95 psf), which is generally the case except for shorter spans; so, the allowable load for simple span is 36 psf.

Note that the Filler King brochure publishes 35 psf. The above formulas are based on solid laminated wood; whereas the brochure values may take into consideration slight section losses at the tongues, grooves, and edges.

FOR 2-SPAN CONTINUOUS

Based on bending we get the same 95 psf (formulas are identical for flexure).

Based on deflection, all other things equal, we get 36 x 185 / 76.8 = 86 psf.

Deflection still controls.

Filler King brochure gives 84 psf.

Note that the 2-span continuous layup is much *stiffer* than the simple layup (though not stronger).

FOR CONTROLLED RANDOM LAYUP.

Based on flexure (bending) … $\sigma_b = \dfrac{20F_b^{'}}{3\ell^2}\dfrac{d^2}{6} = \dfrac{20\left(1485\dfrac{lb}{in.^2}\right)}{3\left(10\,ft\right)^2}\dfrac{\left(2.1875\,in.\right)^2}{6} = 79\,psf$

Based on deflection … using a deflection limit of 1/180 and using the deflection limit form …

$$\sigma_\Delta = 130\left(\frac{\Delta}{\ell}\right)\frac{E'}{\ell^3}\frac{d^3}{12} = 130\left(\frac{1}{180}\right)\frac{\left(1{,}150{,}000\,lb/in.^2\right)}{\left(10x12\,in.\right)^3}\frac{\left(2.1875\,in.\right)^3}{12} = 0.419\frac{lb}{in.^2} \ldots$$

Converting to 0.419 psi x 144 sq. in. / sf = 60 psf.

Deflection still controls (over flexure).

Note that the `strength' of the controlled random length layup is less than for simple or two-span. The two-span continuous layup is the stiffest. All other things equal, since most conditions are controlled by stiffness, the two-span layup can support the greatest loads.

Since manufactured pieces from Filler King are limited to 24 ft in total length, the spans in the two-span tables are limited to 12 ft.

Since the controlled random layup allows for the use of various size pieces (more efficient use of source materials), and since the spans may exceed 12 ft, the controlled random layup is often the most economical layup.

NOTE: the allowable loads calculated are total loads and must include self weight. Allowable applied loads would be the calculated values minus self weight. Also, the above calculations do not take into consideration the effects of roof or member slope.