Shear stress

$$\tau = \frac{VQ}{Ib}$$

I beam

centroid : 132.84 mm

for glue:

$Q = 1.27\,mm \times 100\,mm \times ((200 - 132.84) - (1.27 \div 2)) = 8448.675\,mm^3$

$\tau = 2\,MPa$

$V = \frac{\tau I b}{Q} = \frac{2\,MPa \cdot 1.6754 \times 10^6\,mm^4 \cdot 1.27\,mm}{8448.675\,mm^3} = \underline{503.69\,N}$

glue

for max shear wood/matboard:

$Q = 1.27 \times (148.73 - 132.84) \div 2 \times (132.84) \div 2 = 5602.753\,mm^3$

(148.73 -

$\tau = 4\,MPa$

$V = \frac{\tau I b}{Q} = \frac{4\,MPa \cdot 1.6754 \times 10^6\,mm^4 \cdot 1.27\,mm}{5602.753\,mm^3} = \underline{1519.08\,N}$

Mat board

Pi beam

centroid: 119.467 mm

for glue:

$Q = 1.27\,mm \times 100\,mm \times ((200 - 119.467) - (1.27 \div 2)) = 10147.046\,mm^3$

$\tau = 2\,MPa$

$V = \frac{\tau I b}{Q} = \frac{2\,MPa \cdot 2.6759 \times 10^6\,mm^4 \cdot 1.27\,mm \times 2}{10147.046\,mm^3} = \underline{1339.66\,N}$

glue

for wood/Matboard:

$Q = 1.27 \times (119.467 \div 2) \times 2 \times (119.467 \div 2) = 9062.951\,mm^3$

$\tau = 4\,MPa$

$V = \frac{\tau I b}{Q} = \frac{4\,MPa \cdot 2.6759 \times 10^6\,mm^4 \cdot 1.27\,mm \times 2}{9062.951\,mm^3} = \underline{2999.81\,N}$

Matboard

Pi beam is stronger, but more weight/mass was used for pi than for I beam.

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Flexural stresses

I beam: $\bar{y} = 132.84\,mm$ $I = 1.6754 \times 10^6\,mm^4$

$h = 200\,mm$

$\sigma_t = 30\,MPa$

$\sigma_c = 6\,MPa$

$$\sigma_t = \frac{My}{I}$$

$$M = \frac{\sigma_t \cdot I}{y}$$

$$= \frac{30MPa \cdot 1.6754 \times 10^6\,mm^4}{132.84\,mm}$$

$$= 3.78223 \times 10^5\,N \cdot mm \approx \underline{3.78223 \times 10^2\,kN \cdot mm}$$

$$M = \frac{wl^2}{8}$$

$$W = \frac{8M}{L^2} = \underline{3.35267\,N/mm}$$

$$\sigma_c = \cancel{\frac{My}{h-I}} \quad \frac{M(h-y)}{I}$$ $M = \underline{1.49678 \times 10^2\,kN \cdot mm}$

$$M = \frac{\sigma_c I}{(h-y)}$$

$$\frac{wL^2}{8} = \frac{\sigma_c I}{h-y}$$

$$w = \frac{8\sigma_c I}{L^2(h-y)} = \frac{8 \cdot 6MPa \cdot 1.6754 \times 10^6\,mm^4}{(950mm)^2\,(200mm - 132.84mm)} = \underline{1.32679\,N/mm}$$ (lower)

Pi beam:

$M = \underline{6.71960 \times 10^2\,kN \cdot mm}$

$$\sigma_t = \frac{My}{I}$$

$$\frac{wL^2}{8} = \cancel{\frac{My}{I}}\ \frac{\sigma_t I}{y}$$

$$W = \frac{8\sigma_t I}{L^2 y} = \frac{8 \times 30MPa \times 2.6759 \times 10^6\,mm^4}{(950mm)^2 \cdot 119.467\,mm} = \underline{5.9564\,N/mm}$$

$M = \underline{1.99364 \times 10^2\,kN \cdot mm}$

$$\sigma_c = \frac{M(h-y)}{I}$$

$$w = \frac{8\sigma_c I}{L^2(h-y)} = \frac{8 \cdot 6MPa \cdot 2.6759 \times 10^6\,mm^4}{(950mm)^2 \cdot (200-119.467)mm} = \underline{1.76728\,N/mm}$$

Pi beam can withstand more weight for flexural stress, however, different amount of material was used to construct the two beams.

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