Evaluators Handout

EcoShield

Team 10126

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1 Force Analysis

1.1 Force Acting on the Brace Members

The 26.9 cm diagonal is Member 1, and the 30.6 cm diagonal is Member 2.
The axial force acting on the diagonals =

$$F = \frac{P}{2\sin(\theta)}$$

Where

P = 2 kg × 9.8 N = 19.6 N

θ = 45° For Member 1, and 38.3° For Member 2

by substituting

For Member 1: $F = \frac{19.6N}{2\sin(45°)} = 13.86N$

For Member 2: $F = \frac{19.6N}{2\sin(38.3°)} = 15.87N$

1.2 The Stress on The Brace Members

The axial Stress acting on the diagonals =

$$\sigma = \frac{F}{A}$$

Where

F = 13.86N For Member 1, And F = 15.87N For Member 2.

A (cross-sectional area) = 40 mm × 40 mm = 1600 mm^2

by substituting

For Member 1: $\sigma = \frac{13.86\ N}{1600\ \mathrm{mm2}} = 0.00866\ N/mm2$

For Member 2: $\sigma = \frac{15.87\ N}{1600\ mm2} = 0.00986\ N/mm2$

Table 1: Mechanical testing for casuarina

Property	Casuarina	
	Glauca	Cunn.
Compressive strength parallel to the grain (N/mm^2)	32.2	11.4
Compressive strength perpendicular to the grain (N/mm^2)	7.4	4.9
Bending strength (N/mm^2)	62.1	32.4
Tensile strength parallel to the grain (N/mm^2)	163.0	-
Tensile strength perpendicular to the grain (N/mm2)	5.9	-
Specific Gravity	0.63	0.50

The applied stress on the brace members is much lower than the compressive and tensile strength of the structural material (casuarina wood), as shown in **Table 1.**

2 Thermal conductivity properties

2.1 Calculating thermal Resistance for each material

The prototype wall consists of two layers: an external bamboo layer (Layer 1) and an internal rice-straw insulation layer (Layer 2).

The thermal resistance of each wall layer is calculated using the equation:

$$R = \frac{L}{k}$$

Where

The material thickness for Layer 1 is L = 0.01 m, and for Layer 2, L = 0.04 m.

The material thermal conductivity for the Layer 1 is K = 0.149 W/m·K and for Layer 2 = 0.05 W/m·K

By substituting

For Layer 1:

$$R = \frac{0.01}{0.149}$$

So, the thermal resistance for the bamboo layer is 0.0667 m^2·K/W.

For Layer 2:

$$R = \frac{0.04}{0.05}$$

So, the thermal resistance for the Rice straw layer is 0.80 m^2·K/W.

2.2 Total Thermal Resistance of the Wall

The total thermal resistance of the composite wall is equal to the sum of the thermal resistances of the individual layers:

$$R_{\text{Total}} = R_{\text{Bamboo}} + R_{\text{Rice straw}}$$

By substituting:

R_{Total} = 0.067 + 0.80 = 0.87 m²·K/W

2.3 Overall Heat-Transfer Coefficient (U value)

The overall heat-transfer coefficient (U value) (W/m²·K). =

$$U = \frac{1}{R_{\text{total}}}$$

By substituting:

$$U = \frac{1}{0.87}$$

So, the U value for the walls is 1.15 W/m²·K

The calculated U-value indicates that the composite bamboo and rice-straw wall has high thermal resistance and low heat-transfer capability. In comparison, the U-value of conventional brick walls is approximately 2 W/m²·K, which highlights that the proposed wall system demonstrates significantly better thermal performance. This reduced heat-transfer rate limits the amount of heat transmitted into the interior space, a result that was further confirmed through experimental testing.

3 Fluid Dynamics of Cross-Ventilation

3.1 Calculating the effective area for the openings

The prototype has two different openings with different sizes, so the effective area is calculated using this equation:

$$(A)_{eff} = \sqrt{\frac{1}{\left(\frac{1}{(C_{d1}A_1)^2} + \frac{1}{(C_{d2}A_2)^2}\right)}}$$

Where:

C_d (discharge coefficient) = 0.6
A_1 (area of inlet opening) = 190 cm^2
A_2 (area of outlet opening) = 150 cm^2
$A_{eff\,=}$ 0.00763 m^2

3.2 The volumetric air flow rate

It is necessary to calculate the volumetric air flow rate in the prototype to know whether the amount of air entering the prototype is sufficient or not, so it was calculated using this equation:
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$$Q = (C_d A)_{eff} V \sqrt{(\Delta C_p)}$$

Where

C_d = 0.6
A_{eff} = 0.00763 m^2
Wind speed = 4m/sec
Windward face: C_p (pressure coefficient) ≈ + 0.6
Leeward face: C_p ≈ - 0.4
Total C_p = 1

By substituting:

$$Q = (0.004578) \times 4 \times 1$$

So, the airflow rate = 0.018312 m^3/sec

3.3 The air changes per hour

The ACH indicates how many times the entire volume of air is replaced with fresh air in one hour. It is essential because it shows how effective the design is at refreshing indoor air. It also helps determine if the size of the openings is sufficient. It is calculated using this equation:

$$\mathrm{ACH} = \frac{(\mathrm{Q} \times 3600)}{\mathrm{V}}$$

Where

Q = 0.0183 m^3/sec
V (the prototype's volume) = 0.09 m^3
The 3600 represents how many seconds are in an hour

By substituting

$$ACH = \frac{0.0183 \times 3600}{0.09}$$

Then, air changes per hour = 732, which is normal for such a small prototype.