CALCULATIONS

(1). Calculating Total load;

$$w_{total} = w_{live} + w_{dead} \quad (i)$$

$$w_{dead} = \gamma \times A \quad (ii)$$

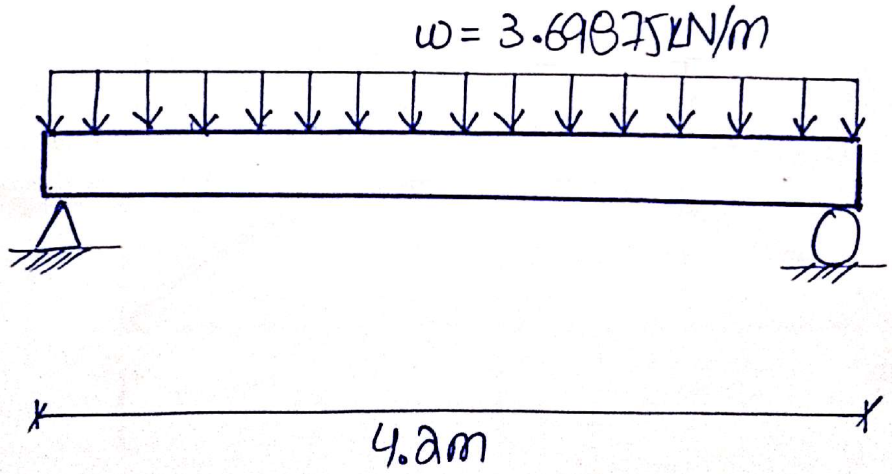
$\gamma = 5.3\ kN/m^3$ ∵ Structural Timber

$A = 0.15 \times 0.25 = 0.0375\ m^2$

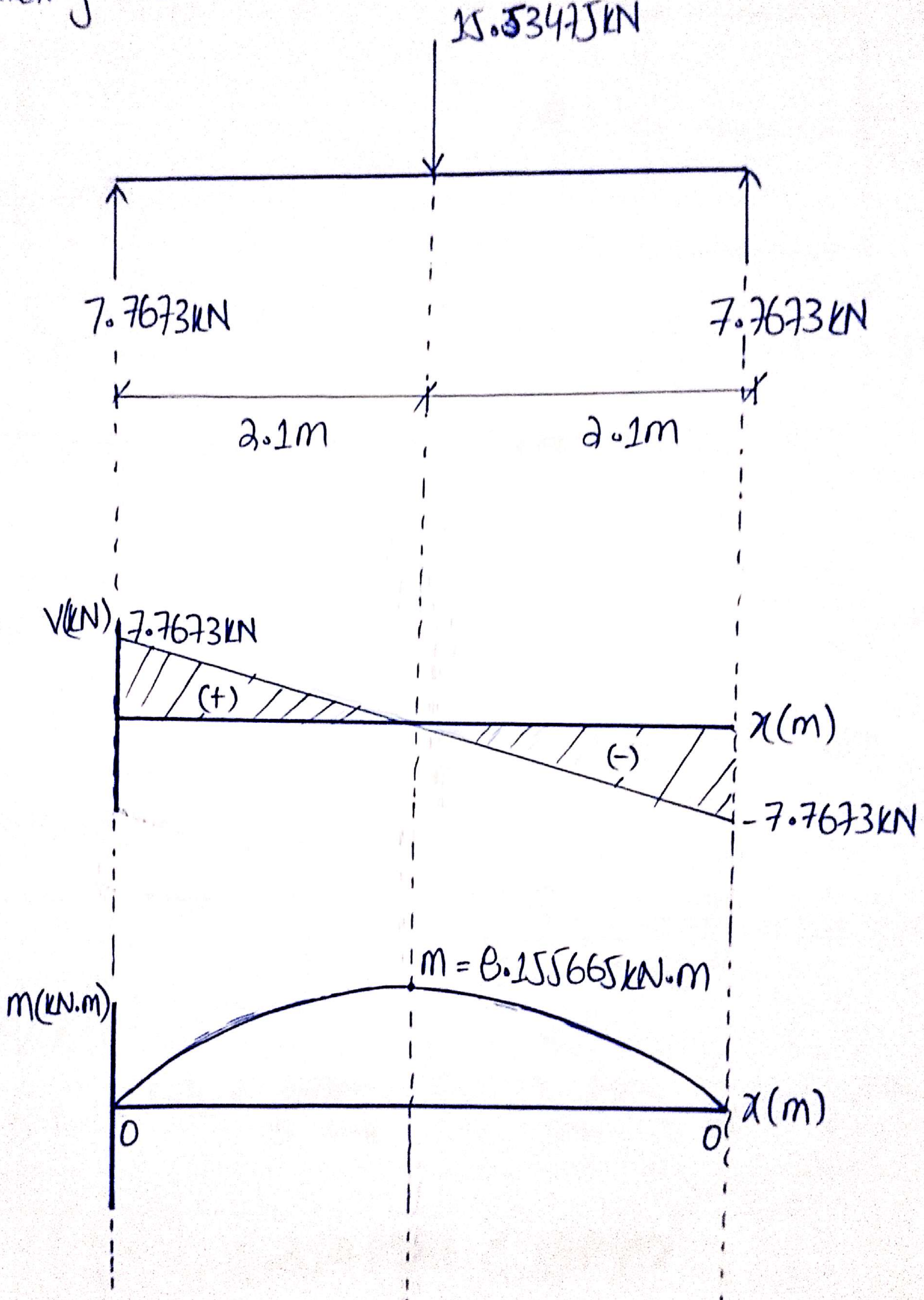
$w_{dead} = 5.3 \times 0.0375 = 0.19875\ kN/m$

$w_{total} = 3.5\ kN/m + 0.19875\ kN/m = 3.69875\ kN/m$

(2). Solving the timber beam;



(3). Making SFD and BMD :



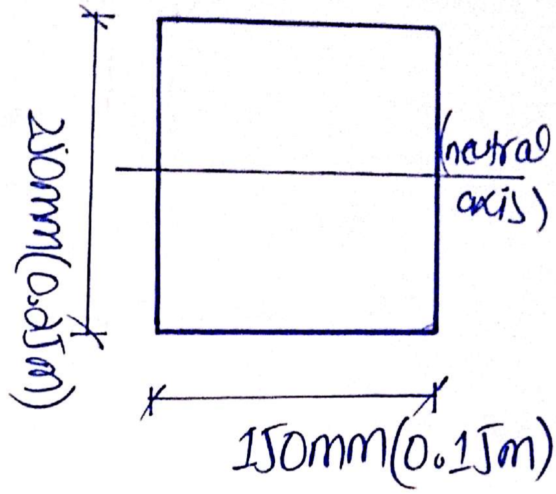
∵ Moment = Area under the (SFD).

(4). Solving for section modulus and moment of Inertia:

$$I = \frac{bh^3}{12} \quad \text{-} (f)$$

$$I = \frac{(0.15)(0.25)^3}{12}$$

$$I = 1.9531 \times 10^{-4} m^4$$



$$P = c = \frac{h}{2} \quad \text{-} (f)$$

: c=P at extreme fiber from neutral axis.

$$c = 0.125 m$$

Now,

$$S = \frac{I}{c} = \frac{1.9531 \times 10^{-4}}{0.125} = 1.5625 \times 10^{-3} m^3$$

(5). Flexure formula:

$$\sigma_{max} = \frac{Mc}{I} = \frac{0.15566 \times 0.125}{1.9531 \times 10^{-4}} = 5.219\ MPa$$

(6). Safety:

$$F.S = \frac{\sigma_{allow}}{\sigma_{fail/max}} = \frac{5.219}{12} = 0.43$$

$$5.219\ MPa < 12\ MPa$$

RESULTS & CONCLUSION

Is the beam safe, unsafe, or borderline under bending?

The given beam has a σ_{max} of 5.21MPa which is less than the maximum bending 12MPa and this Beam is safe under Bending. However, load during weekends have increased and the engineers analyzed the Beam during less crowded date. The overall load must have increased during weekends close to Borderline thats why crack have appeared. If the Beam had exceeded the limit than it would have collapsed earlier.

Based on mechanics understanding, explain why cracks likely appeared at the bottom fiber?

In a simply supported Beam under gravity load, the beam "sags." This cause the upper fiber to remain in compression while the bottom fiber experiences tension. Timber is weaker in tension so the cracks have appeared at the Bottom fiber.

→ Although the theoretical stress is below the limit but the presence of cracks indicate a borderline or excess load during weekends so we would redesign.

CALCULATIONS

(1). calculating Total load;

$$w_{Total} = w_{live} + w_{dead} \sim (I)$$

$$w_{dead} = \gamma \times A \sim (i)$$

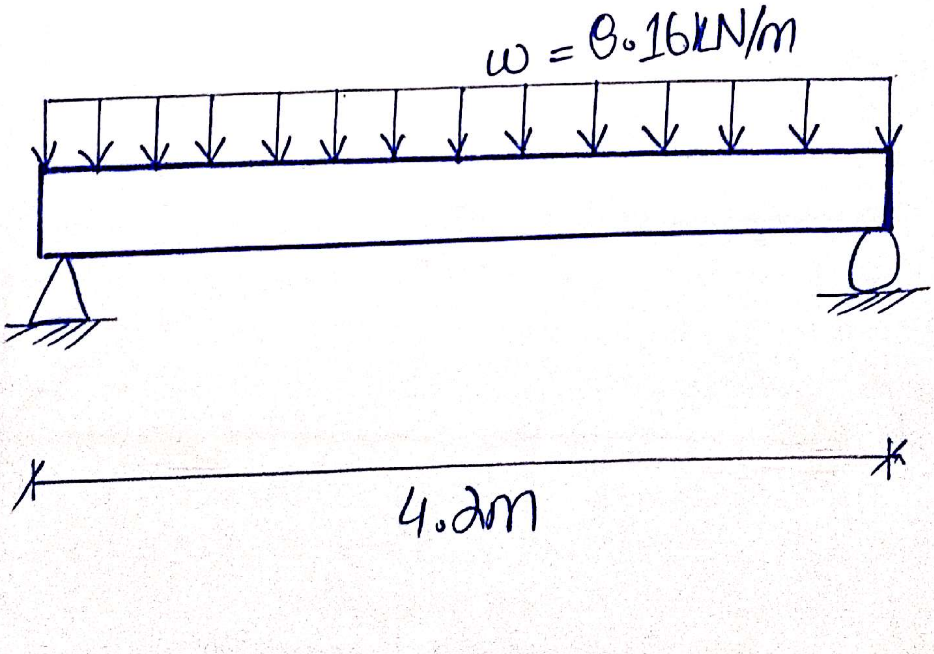
$\gamma = 6kN/m^3$ ∵ Glulam laminated wood

$$A = 0.15 \times 0.40 = 0.06m^2$$

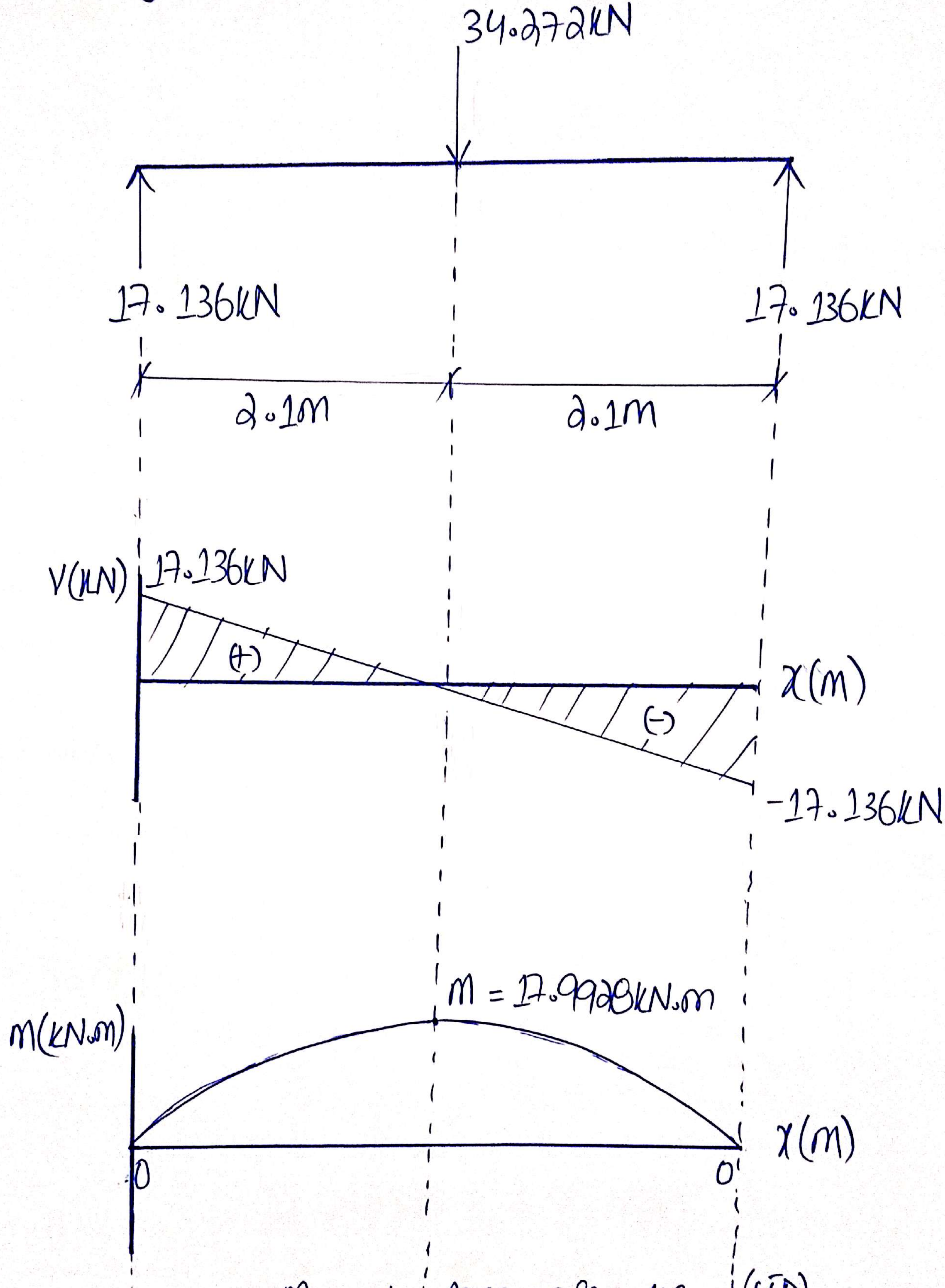
$$w_{dead} = 6 \times 0.06 = 0.36kN/m$$

$$w_{Total} = 7.8kN/m + 0.36kN/m = 8.16kN/m$$

(2). Solving the New Beam;

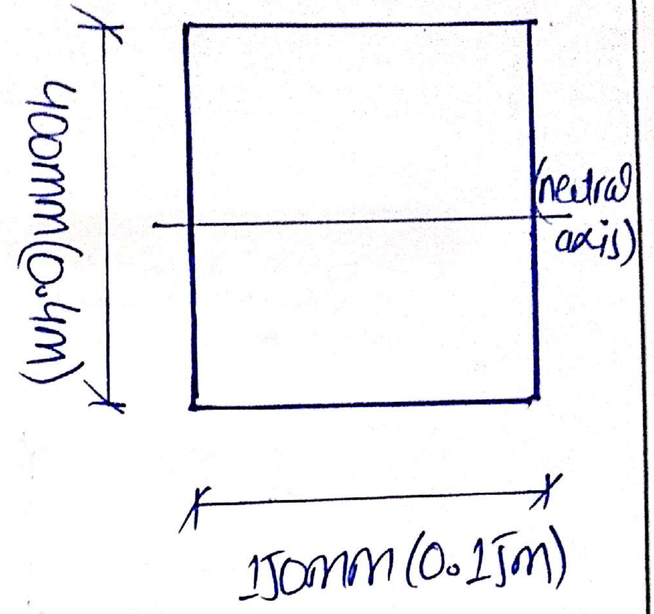


(3). making SFD and BMD :



∴ Moment = area under the (SFD).

(4). Section modulus and Moment of Inertia;



$$I = \frac{bh^3}{12}$$

$$I = \frac{(0.15)(0.4)^3}{12}$$

$$I = 8 \times 10^{-4}\, m^4$$

$$c = \frac{h}{2}$$ ∵ P.O.C at extreme fiber

$$c = 0.2m$$

Now,

$$S = \frac{I}{c} = \frac{8\times10^{-4}}{0.2} = 4\times10^{-3}\, m^3$$

(5). Flexure Formula;

$$\sigma_{max} = \frac{Mc}{I} = \frac{17.9928 \times 0.2}{8\times10^{-4}} = 4.44\,MPa$$

(6). Safety;

$$F.S = \frac{\sigma_{allow}}{\sigma_{fail}} = \frac{4.4}{9.9} = 0.44$$

4.44MPa < 9.90MPa

RESULTS AND CONCLUSION

MATERIAL JUSTIFICATION	
Structural Timber	**Glued Laminated Wood (Glulam)**
Contains natural defects (knots, splits) that create weak points.	Defects are dispersed or removed during manufacturing.
Allowable stress limited to approx. 12 MPa due to defects.	High-grade Glulam achieves 16.5+ MPa allowable stress.
Limited by the diameter of the log. Hard to find large sections (e.g., >300mm deep).	Made by stacking layers; can be manufactured to any depth (e.g., 400mm).
Custom sizes are expensive/rare.	Easy to fabricate large sections for heavy loads.
Solid logs twist and cup as they dry over time.	Kiln-dried laminations are glued with opposing grains to resist warping.
Preservatives may not penetrate deep into the heartwood.	Individual laminations can be treated before gluing for deep protection.

Conceptual Reflection of the new Beam?

Our analysis under the assumed load of 7.8kN/m revealed that the original timber beam was critically stressed at 11MPa thus using 92% of the Beam's capacity during weekends leading to cracks. Our new Beam is asthetically pleasing, cost effective and easy to fit. With an allowable stress of 9.90MPa, it utilizes only 44% of it's strength during peak days thus representing the best possible engineering solution.

EXPLAINATION

How does section modulus influences bending capacity?

The section modulus(S) is a geometric measure of a beam's resistence to Bending. According to the formula; $\sigma = M/S$, stress and section modulus are inversly proportional. This means that for a given load, a higher section modulus results in lower stress.

Why are deeper beams more efficient than wider ones?

Deeper Beam are more effective because if we double the width it would double the strength but if we double the depth, we increase the strength 4 times(2^2).

$$S = \frac{bd^2}{6} \Rightarrow \frac{b(2d)^2}{6} = \boxed{S' = 4S}$$

Why are bottom fibers in maximum tension?

Under sagging, the curvature deforms under hook's law upto proportional limit causing compression at top and tension at bottom fiber. The fiber at the extreme end experience maximum deformation and experiencing max tensile stress at bottom fiber that's where cracks also originate.