Here is a quick solution. Detailed soln on later pages.

\[ M = \frac{K}{S_r} = \frac{K_0 \max}{E_c} \]

Given geometry, properties, find \( M_{\max} \)?

Do calc. twice, take smaller value

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Minimal version of BJ 11.25, use units of N, m
EB = 105E9; EA = 70E9;
SigB = 160E6; SigA = 100E6;
cA = 0.015; cB = 0.021;
yB = 0.018;
w = 0.030; hB = 0.006; AB = w*hB;
hA = 0.030;
k = 2*EB*((w*hB^3/12) + yB*2*AB) ... \& k = "EI" net. 
+ EA*((w*hA^3/12) + 0);
MmaxA = k*SigA/(EA*cA), MmaxB = k*SigB/(EB*cB)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%Output
MmaxA = 1.6272e+03
MmaxB = 1.2398e+03

\[ M_{\max} = 1.24 \text{ KN.m} \]
B&T 11.25  Detailed Solution

Neutral Axis in middle.

\[ E_B = 105 \text{ GPa} \quad \sigma_{yB} = 160 \text{MPa} \]
\[ E_A = 706 \text{ GPa} \quad \sigma_{yA} = 100 \text{MPa} \]

All geometry & properties given. Find \( M \)?

Note, this is 2 problems in 1. First have to find what \( M \) will cause Al to fail. Then find what \( M \) will cause Brass to fail. Then take smaller of the two.

Failure of Al at \( \sigma_{yA} = E_A \varepsilon_{yA} \), \( \varepsilon_{yA} = \frac{\sigma_{yA}}{E_A} \)  \( \text{(1)} \)

But for all pts, in cross section: \( \varepsilon = -\frac{y}{h} \)

\[ \text{biggest } \varepsilon_{max} \Rightarrow \sigma_{failA} = \frac{E_{maxAl}}{C_A} \text{(2)} \]

But for composite beam \( M = \frac{K}{5} \)

\[ \Rightarrow M_{maxA} = \frac{K}{5} \sigma_{failA} \text{(3)} \]

\( 0, 2, 3 \Rightarrow M_{maxA} = \frac{K \sigma_{yA}}{E_A C_A} \text{(4)} \)

Gives max moment if failure due to yield of Al.
Detailed sol'n continued. C

Failure of Brass

Exactly the same logic =)

\[ M_{\text{maxB}} = \frac{K \sigma_y B}{E_B C_B} \] Max Possible moment before Brass yields.

\[ \text{Sol'n:} \quad \min (M_{\text{maxA}}, M_{\text{maxB}}) = M_{\text{max}} \] Failure is when first of two critical loads is reached.

Need section stiffness \( K = "EI" \)

\[ K = "EI" = \sum_{\text{All regions}} E_i (I_i + \bar{y}_i A_i) \] \( L'' b h^3/12 \)

All calculations done in Matlab.

First calc. \( K \) from 7

Then \( M_{\text{maxA}} \) & \( M_{\text{maxB}} \) from 4 & 5

Then \( M_{\text{max}} \) from 6

See following page for arithmetic.
% BJllpoint25
% Use all consistent units of m, N
% -A. Ruina  Nov 16, 2010  (corrected .017->.018)
EB = 105E9; % modulus of Brass = 105 GPa
EA = 70E9; % modulus of Al = 70 GPa
SigB = 160E6; % yield stress of Brass = 160 MPa
SigA = 100E6; % yield stress of Al = 100 MPa
CA = 0.015; % max dist of Al from Neut Axis = 15 mm
cB = 0.021; % max dist of Br from Neut Axis = 21 mm
yB = 0.018; % dist of brass center from NA = 18 mm
w = 0.030; % width of rect beam = 30 mm
hB = 0.006; % height of brass region = 6 mm
hA = 0.030; % height of Al region = 30 mm
AB = w*hB; % area of each brass part

% Find stiffness of cross section = k = "EI" net.

k = 2*EB*(w*hB^3/12 + yB^2*AB) ...
    + EA*(w*hA^3/12 + 0);

MmaxA = k*SigA/(EA*CA); % Max moment is Al yields first
MmaxB = k*SigB/(EB*cB); % Max moment if Br yields first

Mmax = min(MmaxA, MmaxB);

% Check, take Mmax as given, find stresses.
rho = k/Mmax; %"Bending moment's given by EI over rho"

SigAmax = (cA/rho)*EA; % should be < or = SigA
SigBmax = (cB/rho)*EB; % should be < or = SigB

% Uncomment lines above to see what you want.
% Or, to waste time, make a fancy output like this.
disp(['*******************************
    'Output at: datestr(now)]
    'Net bending stiffness of cross section= num2str(k) N m^2]
    'Max moment load to keep Al happy = num2str(MmaxA) N m]
    'Max moment load to keep Br happy = num2str(MmaxB) N m]
    'THE ANSWER, min of above two = num2str(Mmax) N m]
    'CHECKS: ]
    ' rho, (just for fun) = num2str(rho) m^-1]
    'Stresses are less or equal what is allowed?:
    'Stress in Al at given Mmax= num2str(SigAmax) m^-1]
    'Stress in Br at given Mmax= num2str(SigBmax) m^-1]

Output at: 16-Nov-2010 19:01:42
Net bending stiffness of cross section= 1/7085.6 Nm^2
Max moment load to keep Al happy = 1239.774 Nm
Max moment load to keep Br happy = 1239.774 Nm
THE ANSWER, min of above two = 1239.774 Nm
Stresses in Al at given Mmax= 13.7613 m^-1
Stresses in Br at given Mmax= 16.0000 m^-1

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