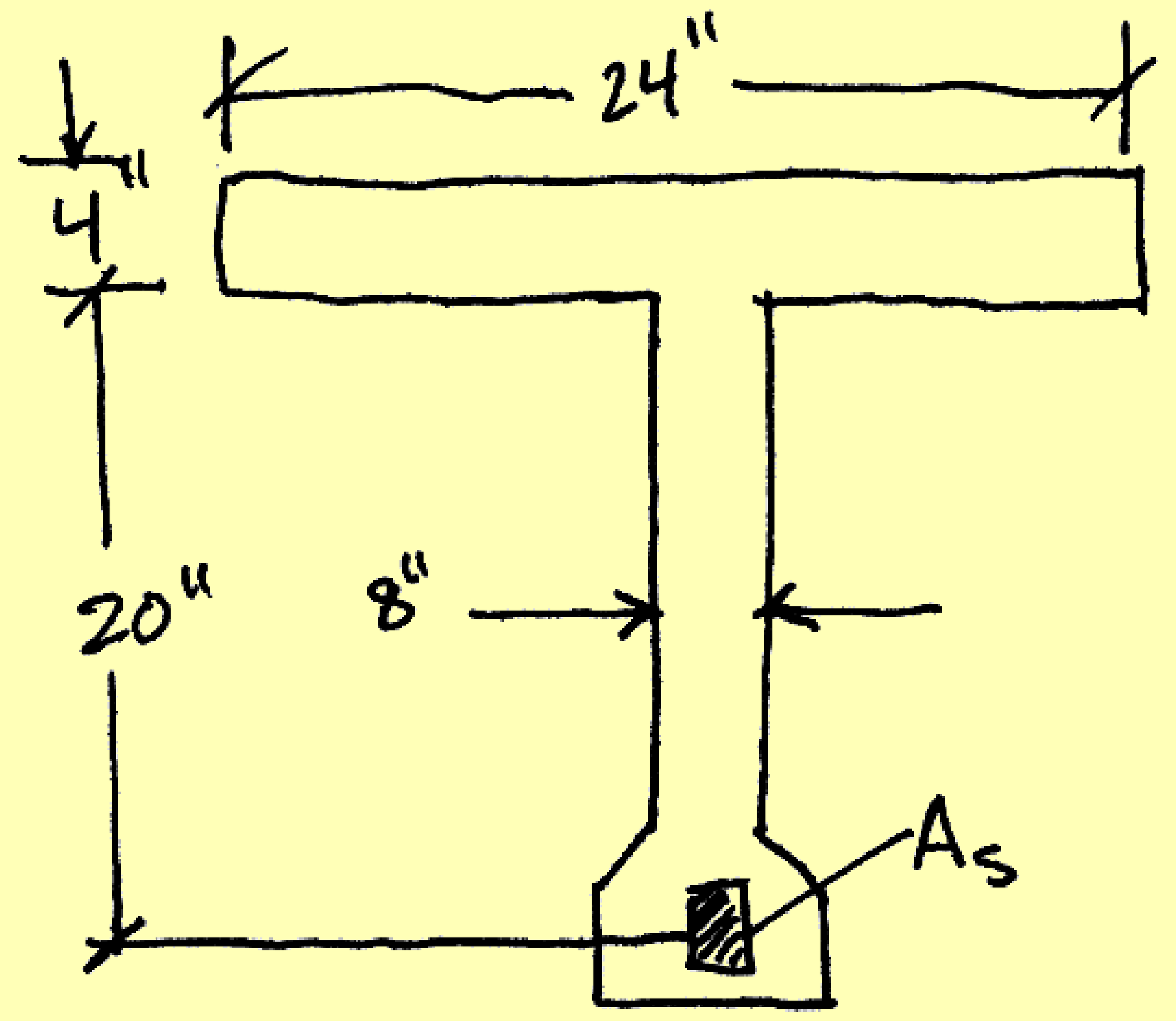
EXAMPLE: 15.3.A

GIVEN:



$\overline{M} = 712$ K·FT

$f'_c = 4000$ psi

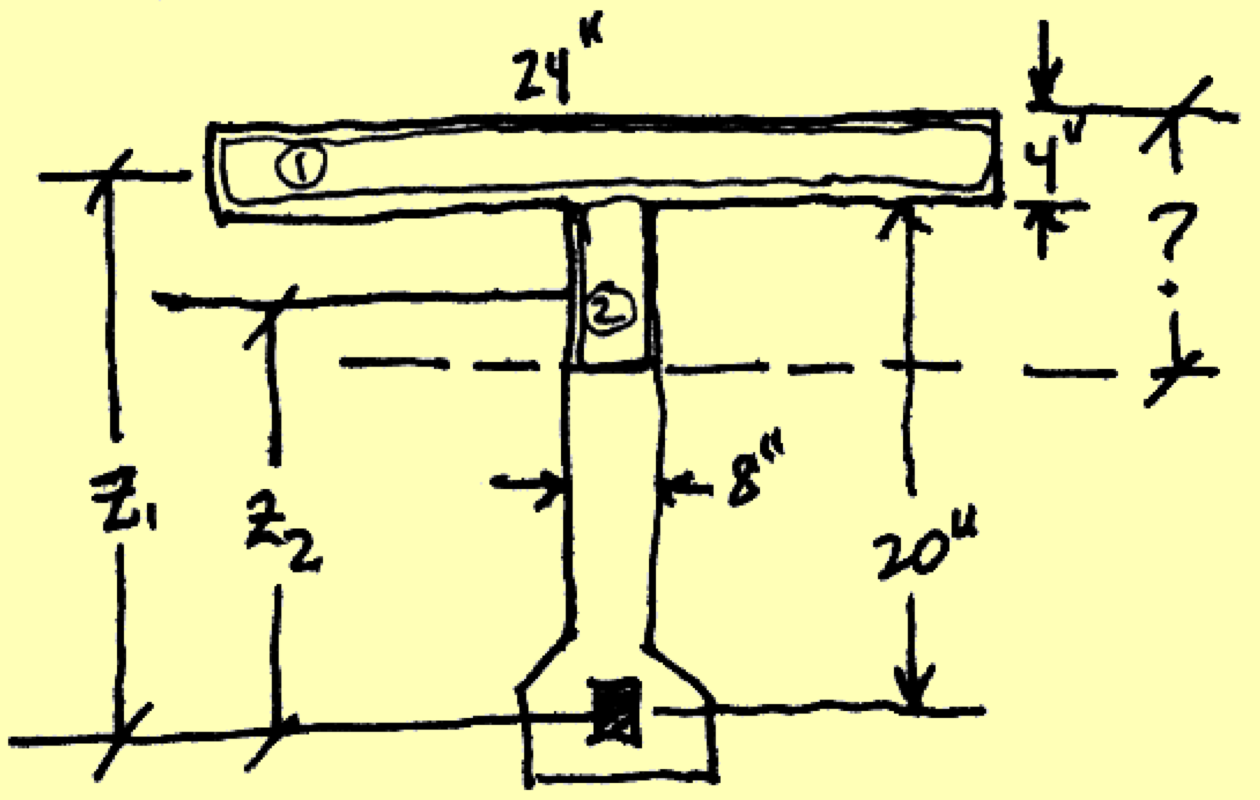
$f_y = 60{,}000$ psi

FIND A_s

$$M_{DES.} = \overline{M} = \frac{M_u}{\phi} = 712 \text{ K·FT}$$

SEE ENGEL p. 226

1. NON-RECTANGULAR SECTION - MUST CHECK THE MOMENT CARRYING CAPACITY OF THE SECTION BY PARTS:



$M_1 = 0.85 f'_c A_{c_1} Z_1$

$M_1 = 0.85(4000)(24 \times 4)(24-2)$

$M_1 = 7.181 \times 10^6$ IN·LB

$\underline{M_1 = 598.4 \text{ K·FT}}$

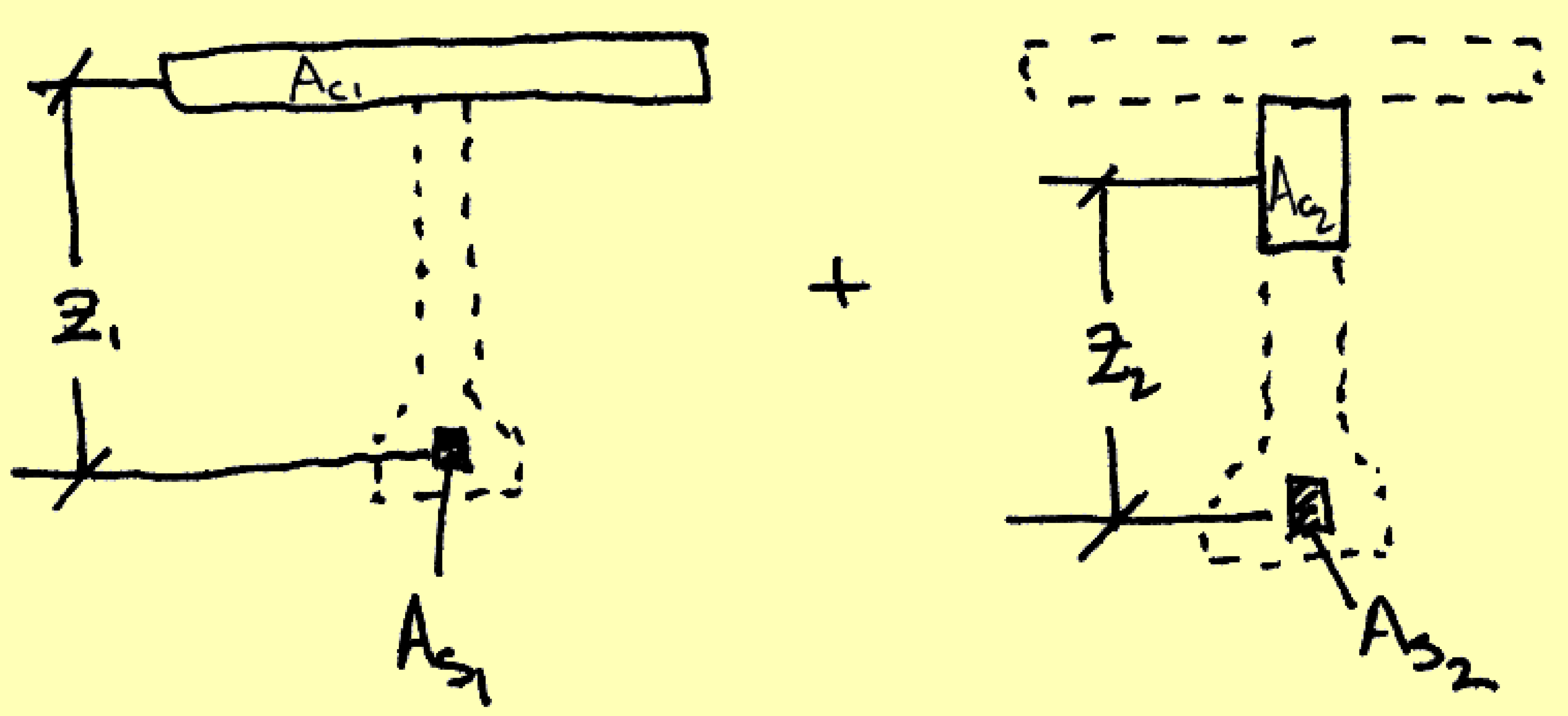
$M_{DES} - M_1 = M_2 \therefore$

$M_2 = 712 - 598.4$

$\underline{M_2 = 113.6 \text{ K·FT}}$

$M_2 = 1.363 \times 10^6$ IN·LBS

WE NOW HAVE A TWO-PART SYSTEM OF RECTANGULAR COMPONENTS WHICH WE CAN USE TO SOLVE FOR THE TOTAL AREA OF STEEL

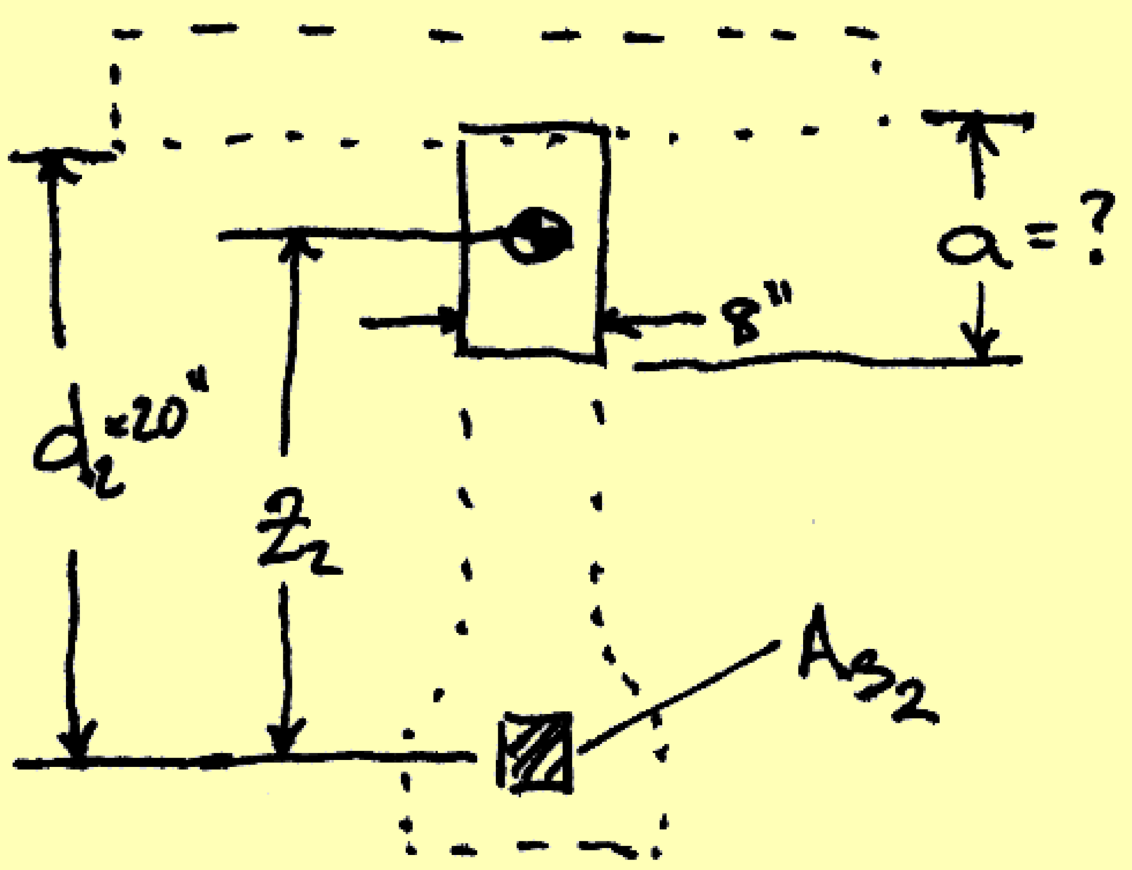


PART ①

$$A_{s_1} = \frac{M_1}{f_y\left(d_1 - \frac{a_1}{2}\right)} = \frac{7.181 \times 10^6}{(60{,}000)(24-2)}$$

$$\underline{A_{s_1} = 5.44 \text{ IN}^2}$$

EXAMPLE 15.3.A cont



USE THE ITERATIVE PROCESS TO FIND A_{s_2} AND a: FOR THE INITIAL ESTIMATE OF A_{s_2}, GUESS $z_2 \approx 0.9 d_2$ FOR GOOD BEHAVIOR

1. $$A_{s_2} = \frac{M_2}{f_y(0.9 d_2)} = \frac{1.363 \times 10^6}{(60{,}000)(0.9)(20)}$$

$$A_{s_2} = 1.26 \text{ IN}^2$$

$$a = \frac{A_s f_y}{0.85 f'_c \cdot b} = \frac{(1.26)(60{,}000)}{(0.85)(4000)(8)} = 2.18 \text{ IN}$$

2. $$A'_{s_2} = \frac{M_2}{f_y\left(20 - \frac{2.18}{2}\right)} = 1.22 \text{ IN}^2$$

$$a' = \frac{1.22 f_y}{0.85 f'_c \cdot b} = 2.69 \text{ IN}$$

3. $$A''_{s_2} = \frac{M_2}{f_y\left(20 - \frac{2.69}{2}\right)} = 1.2179 \text{ IN}^2 \approx \underline{1.22 \text{ IN}^2} \text{ DONE}$$

CHECK AGAINST THE LIMIT OF a

$$\text{Lim. } a = 0.85\left[\frac{87}{87 + f_y}\right] d\,(.75)$$

$$\text{Lim } a = 0.85\left[\frac{87}{87 + 60}\right](24)(.75)$$

$$\text{Lim } a = 9.06 \text{ IN}$$

$$a_{BEAM} = 4^{IN} + 2.69^{IN} = 6.69$$

∴ BEAM IS SAFELY UNDER-REINFORCED

TOTAL STEEL AREA

$$A_{TOTAL} = A_{s_1} + A''_{s_2} = 5.44 + 1.22 = 6.66 \text{ IN}^2$$

$$\boxed{A_{TOTAL} = 6.66 \text{ IN}^2}$$