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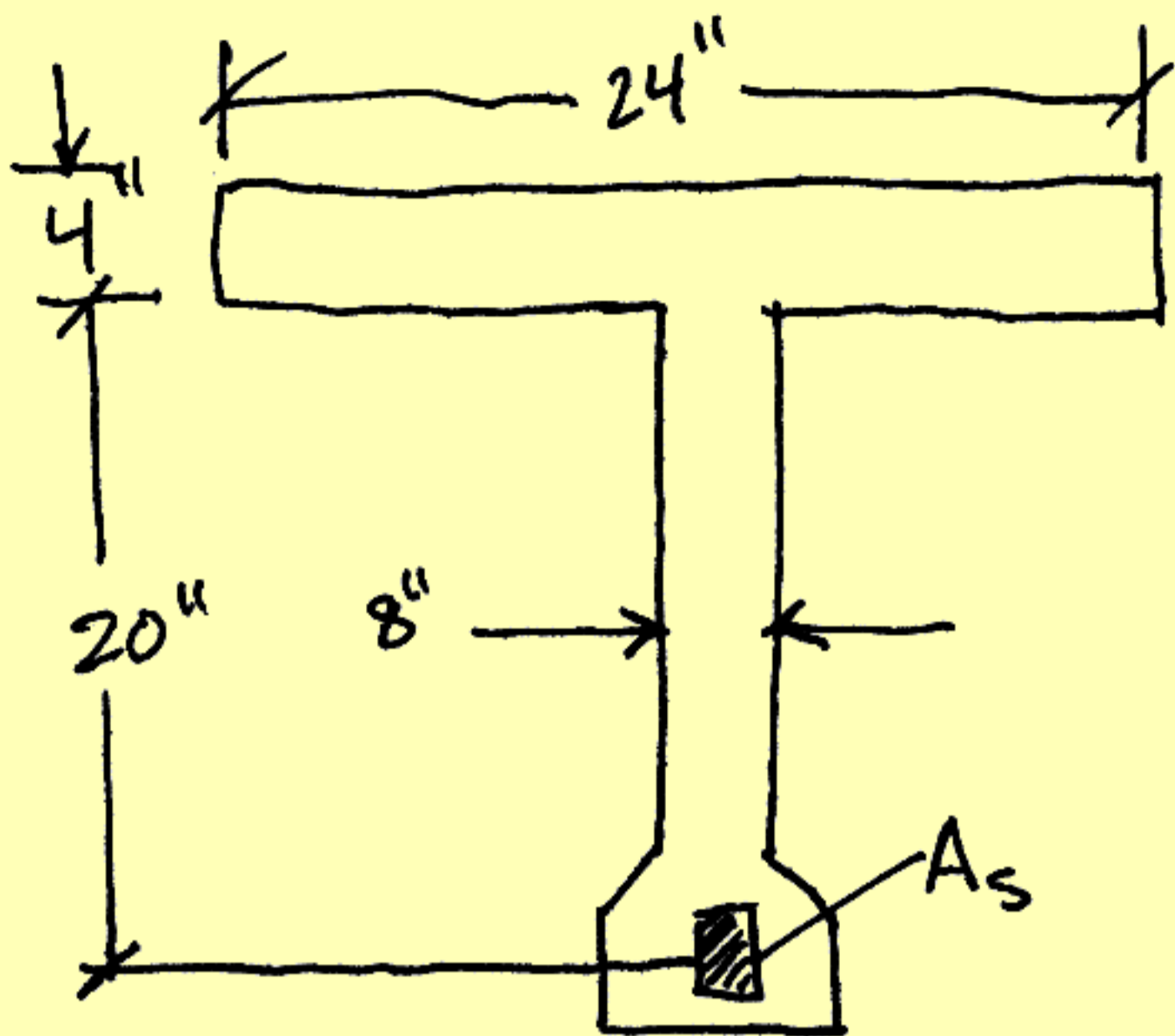
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EXAMPLE: 15.3.A

GIVEN:



$$\bar{M} = 712 \text{ K}\cdot\text{FT}$$

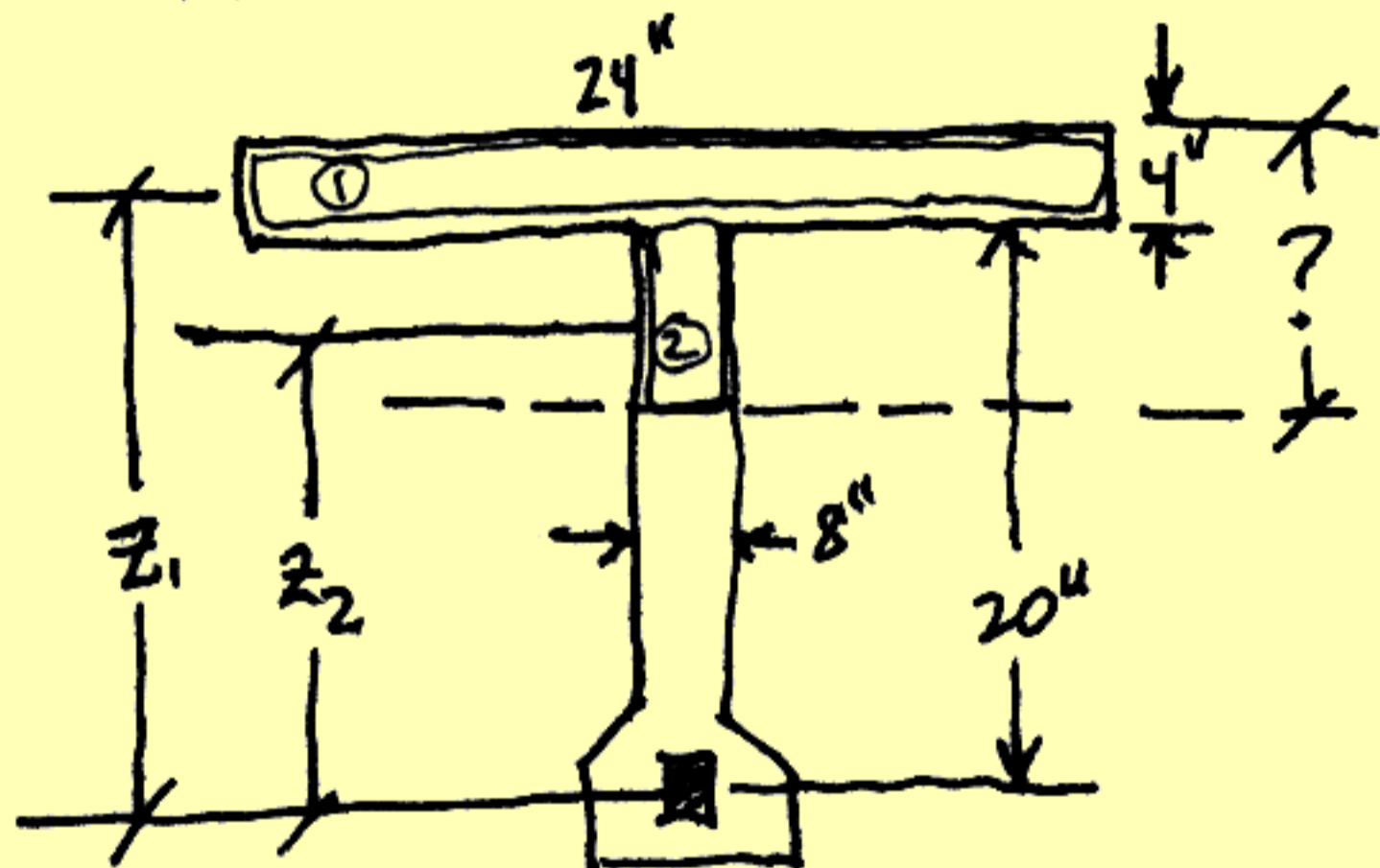
$$f'_c = 4000 \text{ PSI}$$

$$f_y = 60,000 \text{ PSI}$$

FIND A_s

$$M_{DES.} = \bar{M} = \frac{M_u}{\phi} = 712 \text{ K}\cdot\text{FT} \quad \text{SEE ENGEL P. 226}$$

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



$$M_1 = 0.85 f'_c A_{c1} z_1$$

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

$$M_1 = 7181 \times 10^6 \text{ IN}\cdot\text{LB}$$

$$M_1 = 598.4 \text{ K}\cdot\text{FT}$$

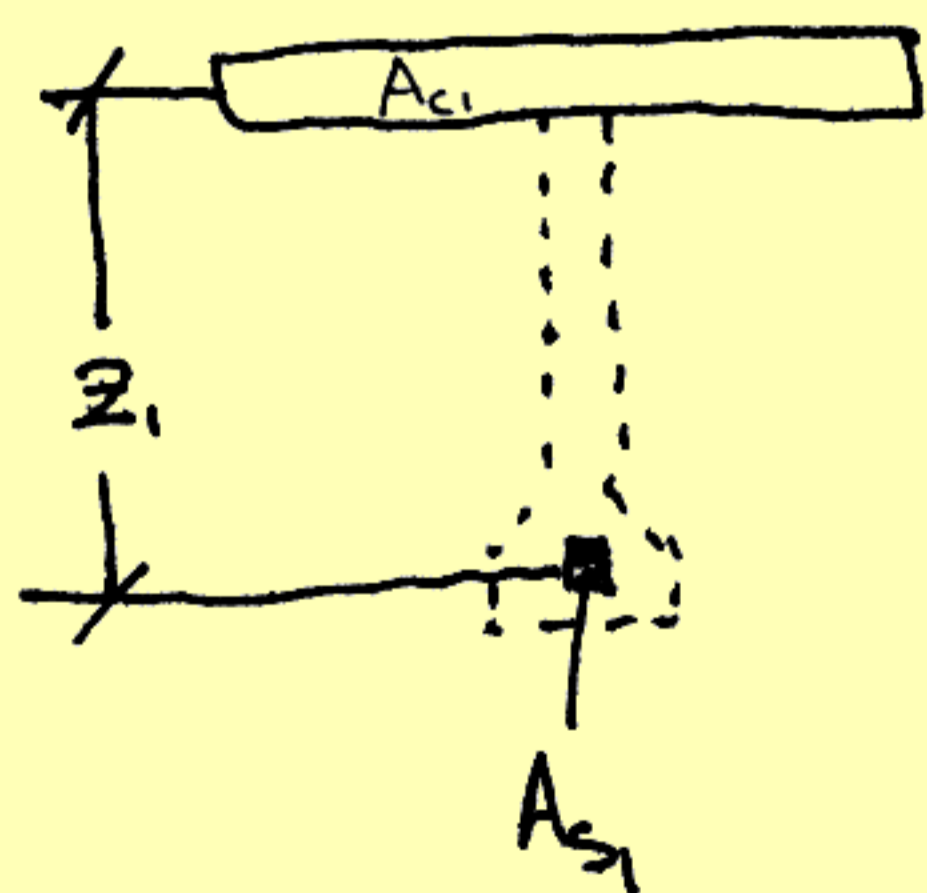
$$M_{DES} - M_1 = M_2 \quad \therefore$$

$$M_2 = 712 - 598.4$$

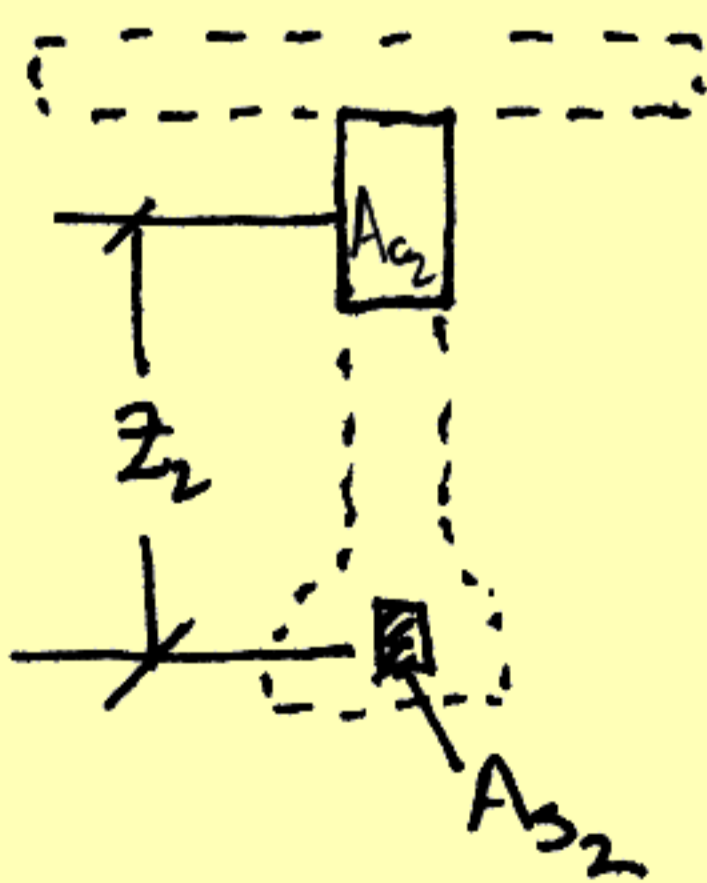
$$M_2 = 113.6 \text{ K}\cdot\text{FT}$$

$$M_2 = 1.363 \times 10^6 \text{ IN}\cdot\text{LBS}$$

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



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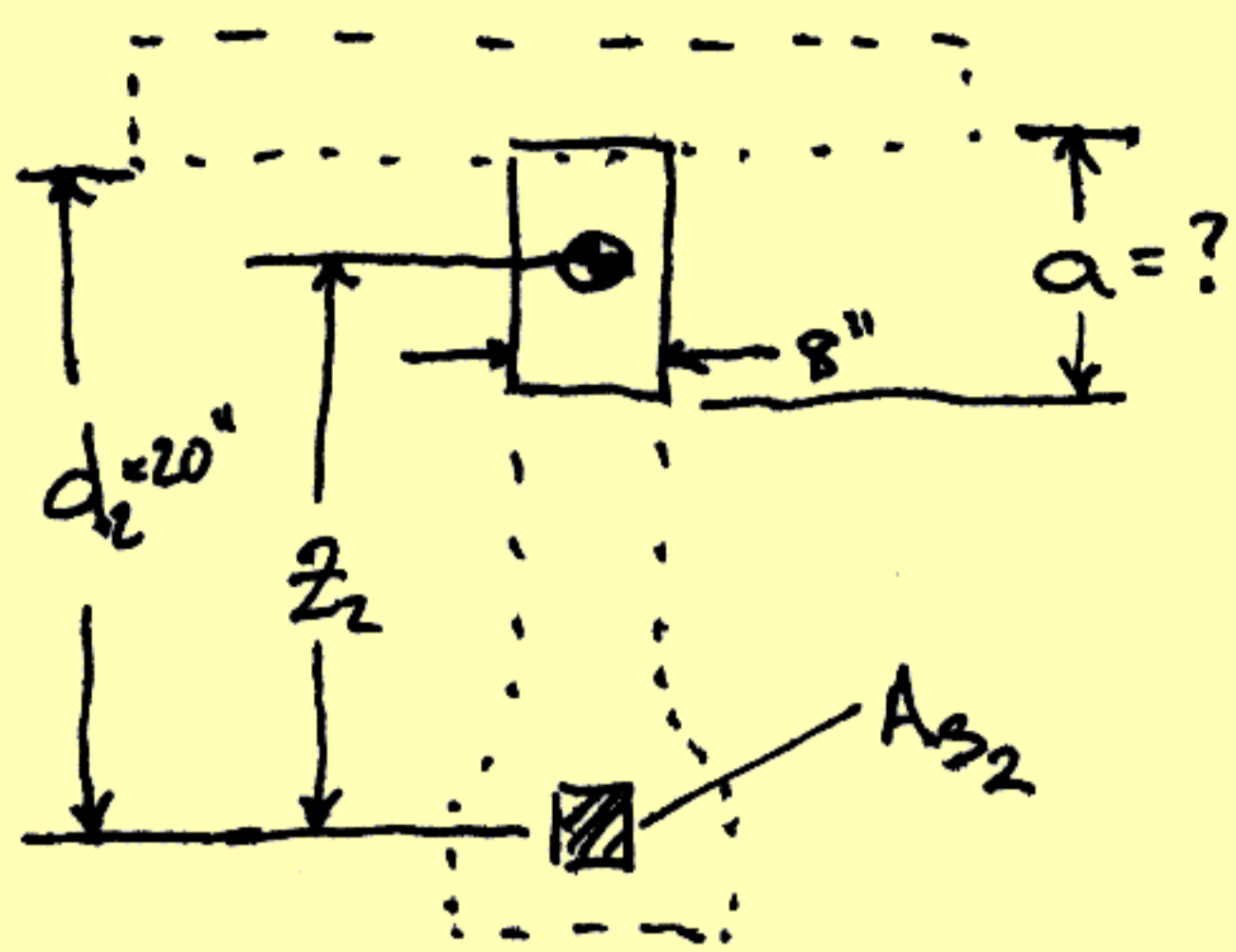


PART ①

$$A_{s1} = \frac{M_1}{f_y (d_1 - \frac{a_1}{2})} = \frac{7.181 \times 10^6}{(60,000) (24 - 2)}$$

$$A_{s1} = 5.44 \text{ IN}^2$$

EXAMPLE 15.3. A cont



USE THE ITERATIVE PROCESS TO FIND A_{s2} AND a : FOR THE INITIAL ESTIMATE OF A_{s2} , GUESS $z_2 \approx 0.9d_2$ FOR GOOD BEHAVIOR

$$1. \quad A_{s2} = \frac{M_2}{f_y (0.9d_2)} = \frac{1.363 \times 10^6}{(60,000)(0.9)(20)}$$

$$A_{s2} = 1.26 \text{ IN}^2$$

$$a = \frac{A_s f_y}{0.85 f'_c \cdot b} = \frac{(1.26)(60,000)}{(0.85)(4000)(8)} = 2.78 \text{ IN}$$

CHECK AGAINST THE LIMIT OF a

$$\text{Lim. } a = 0.85 \left[\frac{87}{87 + f_y} \right] d (1.75)$$

$$\text{Lim } a = 0.85 \left[\frac{87}{87 + 60} \right] (24)(1.75)$$

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

$$a_{\text{beam}} = 4'' + 2.69'' = 6.69$$

\therefore BEAM IS SAFELY UNDER-REINFORCED

$$2. \quad A'_{s2} = \frac{M_2}{f_y \left(20 - \frac{2.78}{2} \right)} = 1.22 \text{ IN}^2$$

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

$$3. \quad A''_{s2} = \frac{M_2}{f_y \left(20 - \frac{2.69}{2} \right)} = 1.2179 \text{ IN}^2 \approx \underline{\underline{1.22 \text{ IN}^2}} \text{ DONE}$$

TOTAL STEEL AREA

$$A_{\text{TOTAL}} = A_{s1} + A''_{s2} = 5.44 + 1.22 = 6.66 \text{ IN}^2$$

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