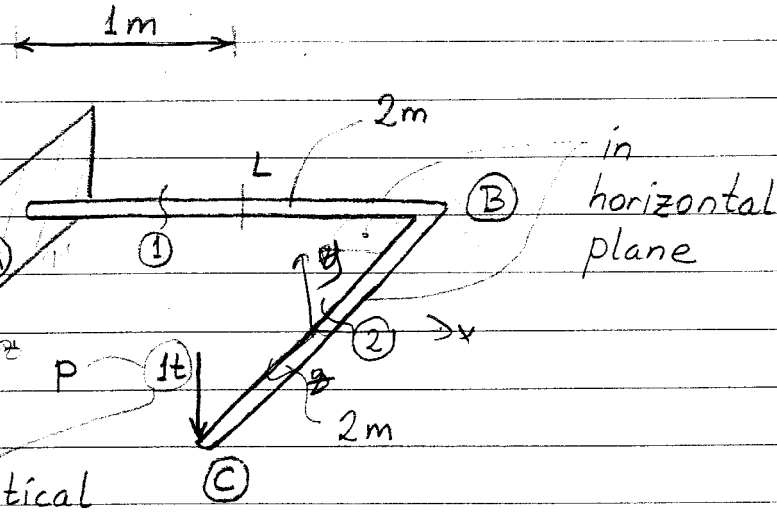
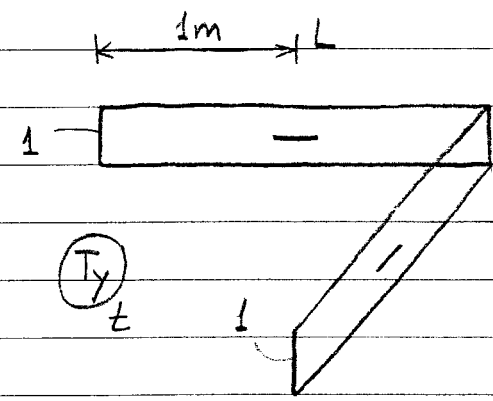
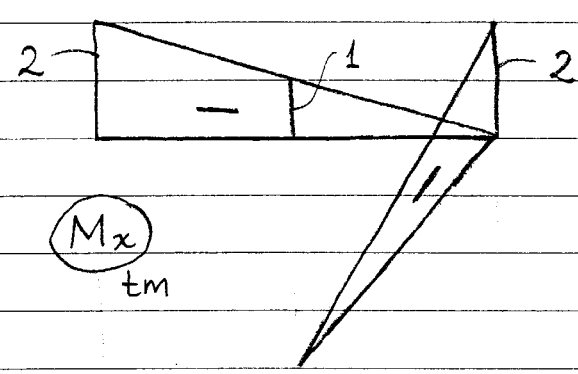
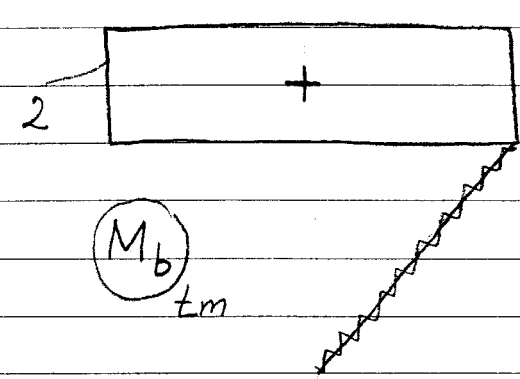
EXAMPLE:

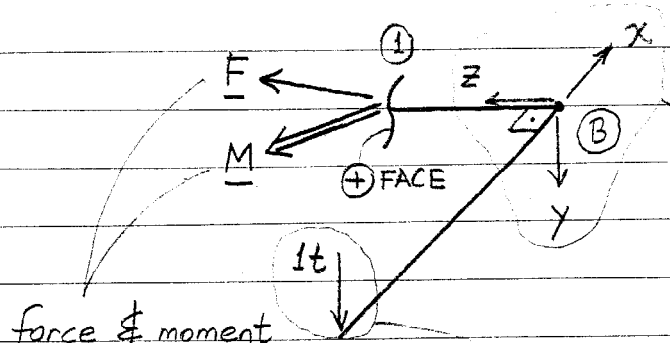

1m
BUILT-IN
2m
L
in
horizontal
plane
DIAG. ?
A
1
B
2
P
1t
2m
C
vertical


1m
L
1
—
1
T_y
t


2
1
2
—
M_x
tm


2
+
M_b
tm

part A-B: * —z— *



chosen for A-B

right handed

force & moment resultants

$P = 1 * \underline{j} = (0, 1, 0)$

force EE:

$$\sum \underline{F} = \underline{0}$$

$$\Rightarrow \underline{F} + \underline{P} = \underline{0}$$

$$\Rightarrow \boxed{\underline{F} = -\underline{P}}$$

(T_x, T_y, N) $(0, 1, 0)$

$$\Rightarrow (T_x, T_y, N) = -(0, 1, 0)$$

$$\Rightarrow \boxed{\begin{aligned} T_x &= N = 0 \\ T_y &= -1t \end{aligned}}$$

moment EE:

$$\sum \underline{M}_{①} = \underline{0}$$

$$\Rightarrow \underline{M} + \overrightarrow{①C} \times \underline{P} = \underline{0}$$

$$\Rightarrow \underline{M} = -\overrightarrow{①C} \times \underline{P}$$

① → (0, 0, z)
C → (-2, 0, 0)
⇒ $\vec{①C} = (-2, 0, -z)$

$$\Rightarrow \underline{M} = - \begin{vmatrix} \underline{i} & \underline{j} & \underline{k} \\ -2 & 0 & -z \\ 0 & 1 & 0 \end{vmatrix}$$

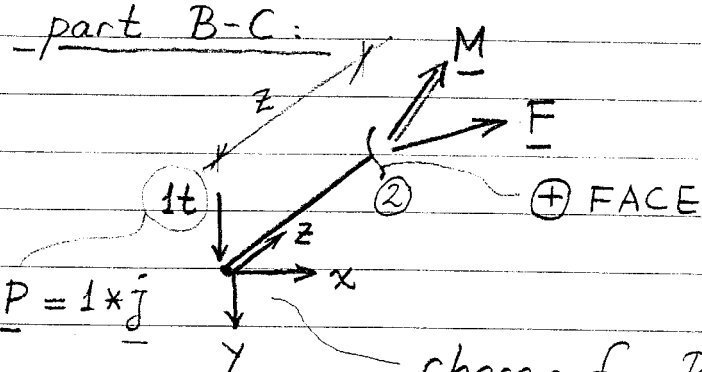
$$\Rightarrow \underline{M} = -(z, 0, -2) \ tm$$

$\underline{M} \rightarrow (M_x, M_y, M_b)$

$\Rightarrow M_x = -z$ (linear)
- B ⇒ z = 0 ⇒ $M_x = 0$
- A ⇒ z = 2 ⇒ $M_x = -2$ tm

$M_y = 0$
$M_b = 2$ tm

part B-C:



⇒ $\underline{P} = (0, 1, 0)$

force EE:

(T_x, T_y, N) $(0, 1, 0)$

$\underline{F} + \underline{P} = \underline{0} \Rightarrow \underline{F} = -\underline{P}$

$$\Rightarrow \begin{cases} T_x = N = 0 \\ T_y = -1t \end{cases}$$

moment EE :

$$\sum \underline{M}_{②} = \underline{0}$$

$$\Rightarrow \underline{M} + \overrightarrow{②Ⓒ} \times \underline{P} = \underline{0}$$

$$\Rightarrow \underline{M} = -\overrightarrow{②Ⓒ} \times \underline{P}$$

$② \rightarrow (0, 0, z)$

$Ⓒ \rightarrow (0, 0, 0)$

$$\Rightarrow \overrightarrow{②Ⓒ} = (0, 0, -z)$$

$$\Rightarrow \underline{M} = - \begin{vmatrix} \underline{i} & \underline{j} & \underline{k} \\ 0 & 0 & -z \\ 0 & 1 & 0 \end{vmatrix}$$

$$\Rightarrow \underline{M} = -(z, 0, 0)$$

$$(M_x, M_y, M_b)$$

$$\Rightarrow \boxed{M_x = -z}$$

$Ⓒ \Rightarrow z = 0 \Rightarrow M_x = 0$

$Ⓑ \Rightarrow z = 2 \Rightarrow M_x = -2\,tm$

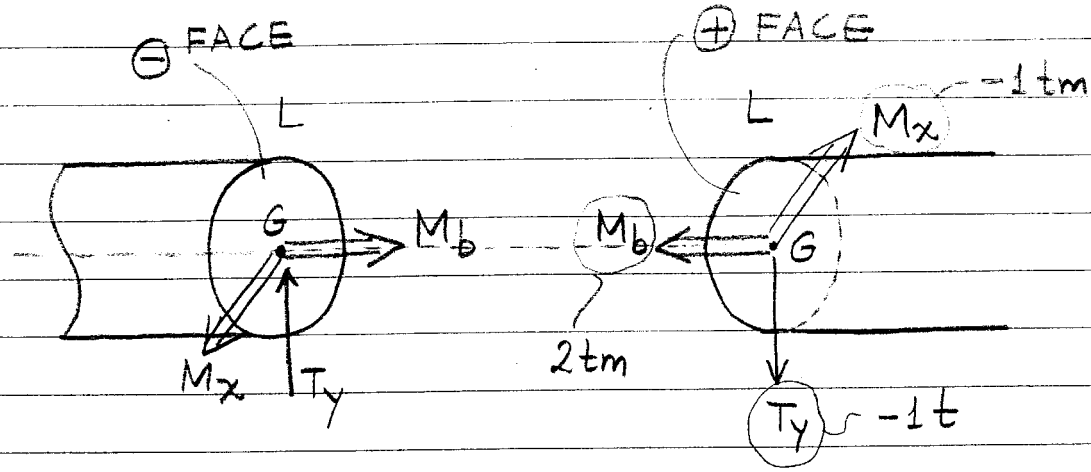
$$\boxed{M_y = M_b = 0}$$

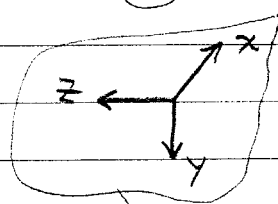
Interpretation of T_y, M_x, M_b :

L → a CS at the mid-pt of A-B

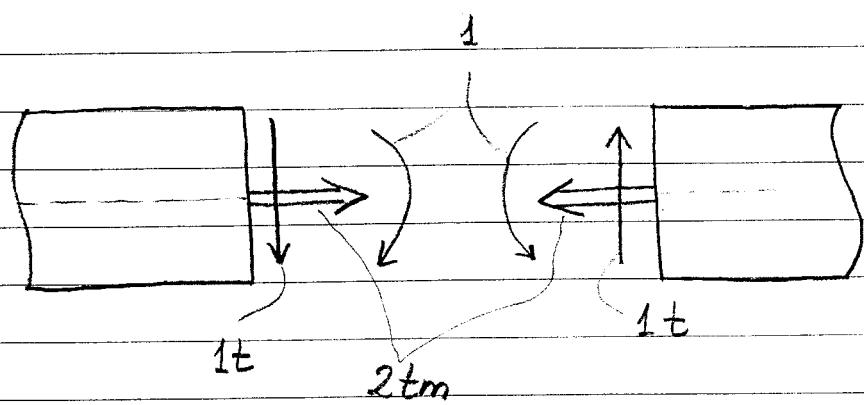
$\Rightarrow T_y = -1\,t$, $M_x = -1\,tm$,

$M_b = 2\,tm$



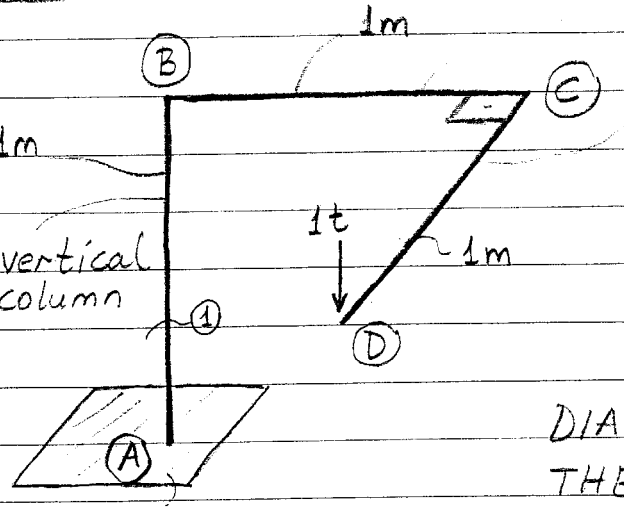


was used for A-B



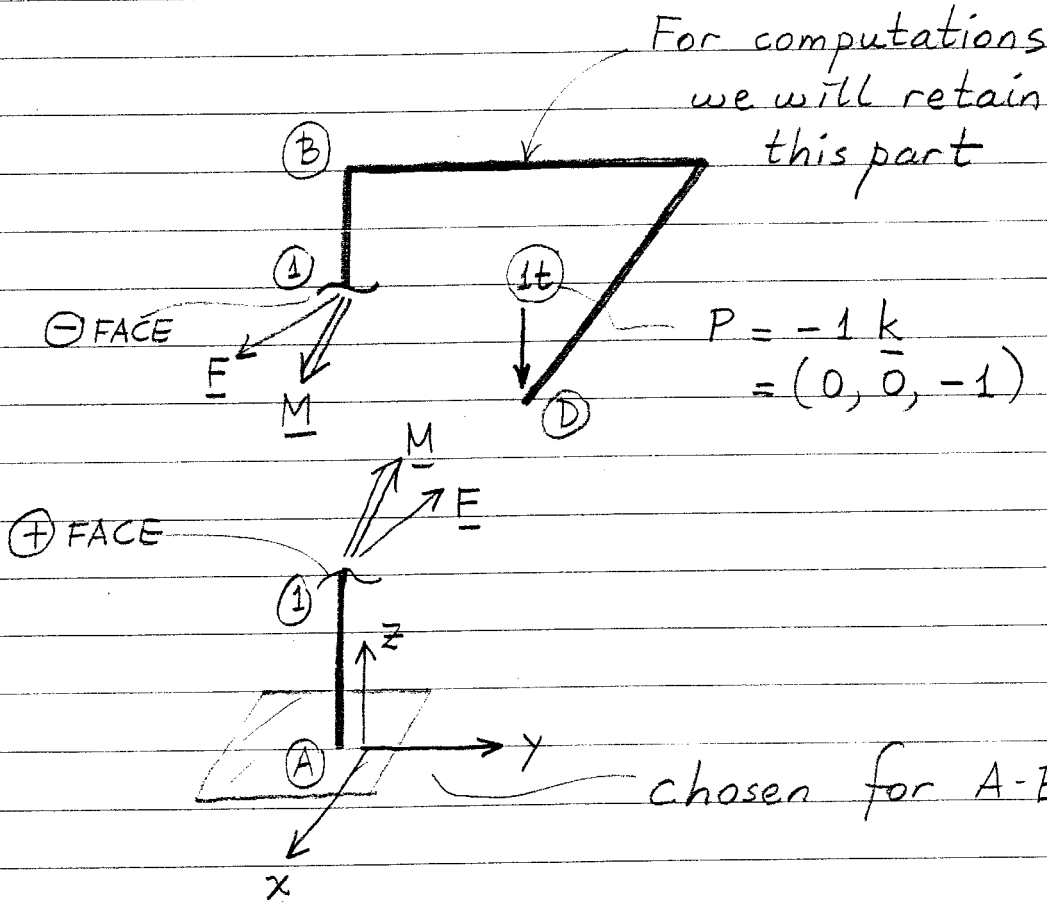
The twisting moment acting in the bar A-B is caused by the eccentricity of the vertical load P wrt the axis of A-B.

EXAMPLE:



in horizontal plane

DIAG. FOR THE COLUMN A-B ?



force EE :

$-\underline{F} + \underline{P} = 0$

(T_x, T_y, N) — $(0, 0, -1)$

$\Rightarrow \underline{F} = \underline{P}$

$$\Rightarrow \boxed{\begin{array}{l} T_x = T_y = 0 \\ N = -1 \end{array}}$$

moment EE:

$$\sum \underline{M}_{①} = \underline{0} \Rightarrow -\underline{M} + \overrightarrow{①Ⓓ} \times \underline{P} = \underline{0}$$

$$\Rightarrow \underline{M} = \overrightarrow{①Ⓓ} \times \underline{P}$$

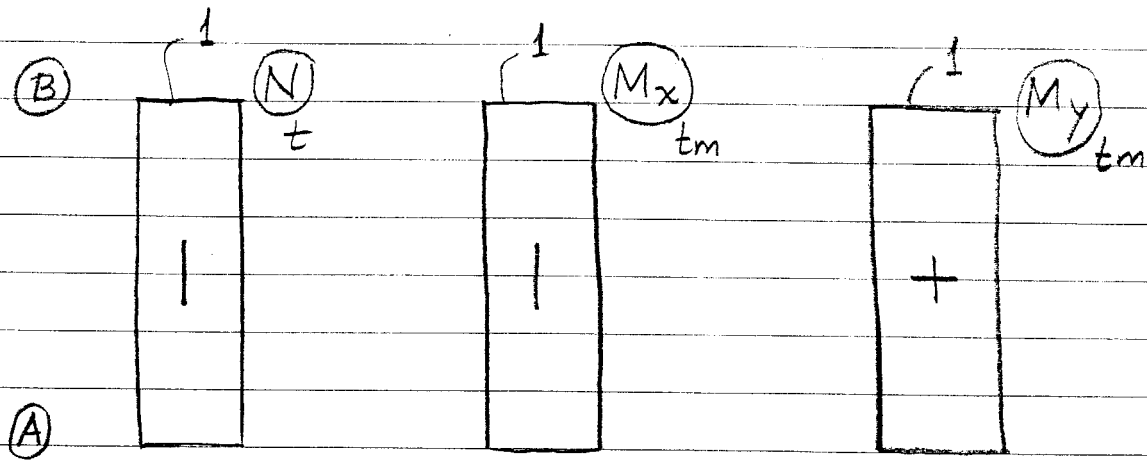
$$\left.\begin{array}{l} ① \rightarrow (0,0,z) \\ Ⓓ \rightarrow (1,1,1) \end{array}\right\} \Rightarrow \overrightarrow{①Ⓓ} = (1,1,1-z)$$

$$\Rightarrow \underline{M} = \begin{vmatrix} \underline{i} & \underline{j} & \underline{k} \\ 1 & 1 & 1-z \\ 0 & 0 & -1 \end{vmatrix}$$

(M_x, M_y, M_b):

$$\Rightarrow \underline{M} = (-1, 1, 0)$$

$$\Rightarrow \boxed{\begin{array}{l} M_x = -1 \text{ tm} \\ M_y = 1 \text{ tm} \\ M_b = 0 \end{array}}$$

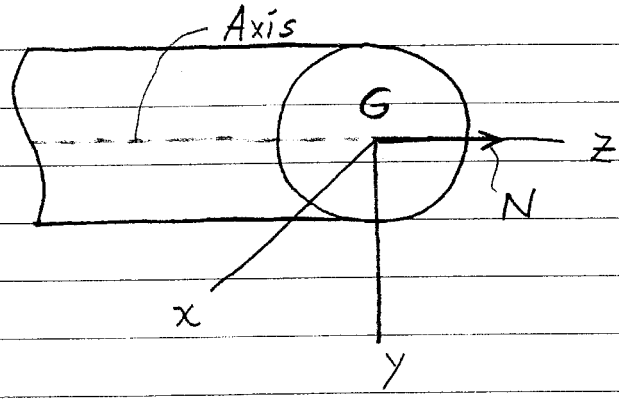


CHAPTER 3

AXIAL LOADING AND DEFORMATION

In this chapter the analysis for the structural elements subjected to axial forces will be studied.

A CS subjected to the axial force N:

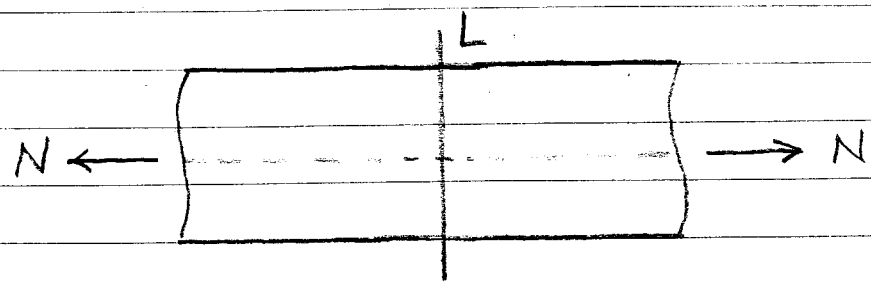


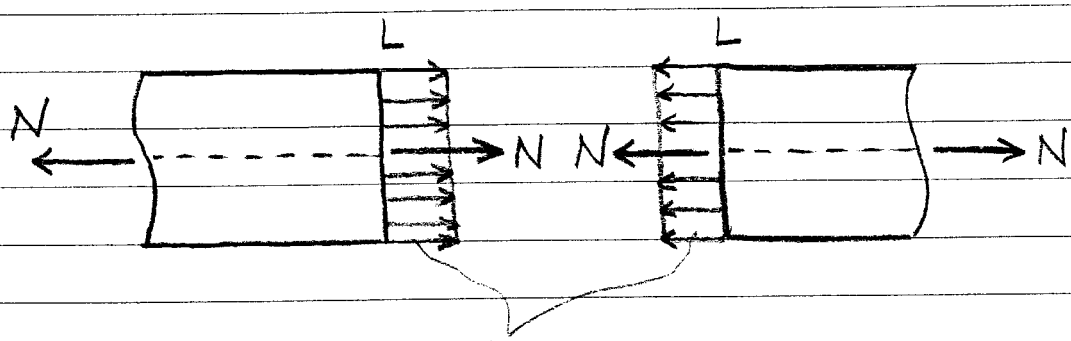
N { ⊕ ⇒ TENSILE → DIRECTED OUTWARDS
  { ⊖ ⇒ COMPRESSIONAL → DIRECTED INWARDS

N → produces (normal stress)$_{NS}$ σ

$$\underbrace{\sigma}_{NS} = \frac{N}{A} \rightarrow \text{normal force per unit area}$$

A → Cross-sectional area$_{CSA}$





NS σ

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

$N \rightarrow$ resultant of σ

$$N = \sigma * A$$

BS

BREAKING STRESS (STRENGTH)

BS is value of σ at which the bar breaks up.

$BS \rightarrow \sigma_B \rightarrow$ material property

AS

ALLOWABLE STRESS

When we design structural elements we wish to be away from BS by a safety

factor (SF). For that we introduce AS which is defined by:

$$\sigma_a = \frac{\sigma_B}{n}$$

σ_a : AS; σ_B : BS; n : SF > 1

In designing the structural elements we require that:

$$\sigma_{max} \leq \sigma_a$$

DE: design equation

σ_{max} : absolutely max. NS occuring in struc. elem.

$\sigma_a > 0$ → material property

σ_a : its value depends on the matl.

$\Rightarrow$ σ_a would be different for concrete, steel, wood etc.

VARIOUS DESIGN PROBLEMS

1) Determination of CSA

knowns	unknown
N	A
σ_a	

→