CIV102 - STRUCTURES and MATERIALS

Topic: Stone and Masonry

1) Stone

- good in compression
- fairly weak in tension
- at joints no tensile strength
- You can't pull on a stone

2T3 student said → Stone is anti-rope

Advantages

- Material is cheap
  - ↳ but cutting stones = expensive
- last long time

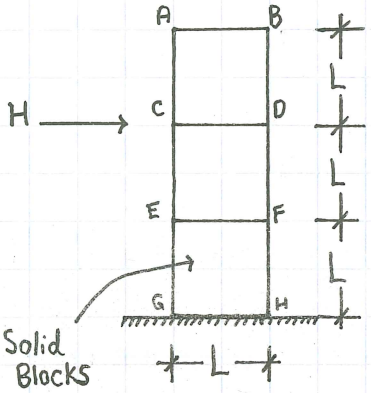
How do we design?

Allowable Stress / Tensile = Zero MPa
Allowable Stress \ Compressive = $\frac{\text{Strength}}{\text{FOS}}$

Shear is often ignored

Design Methods

1) Combined Stresses

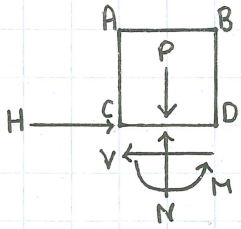


Each block weighs P kN

Joints Will be Weaker Spots

Look at Joint C-D

F.B.D.

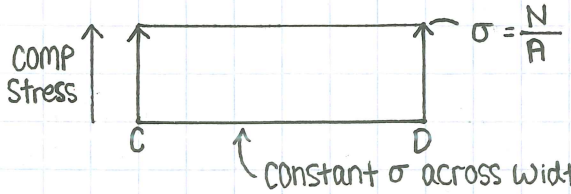


$\Sigma F_x = 0$

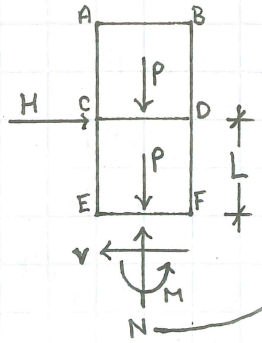
$V = H$

$\Sigma M = 0$

$N = P$



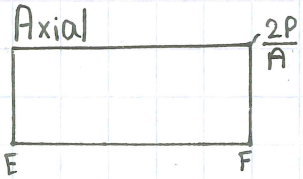
EF

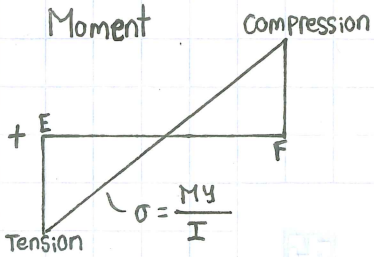


$V = H$

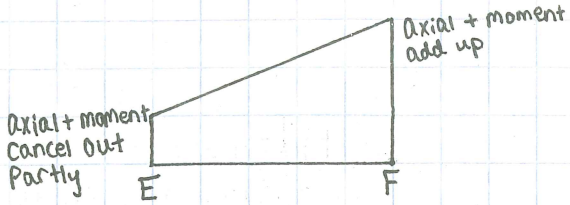
$N = 2P$

$M = HL$

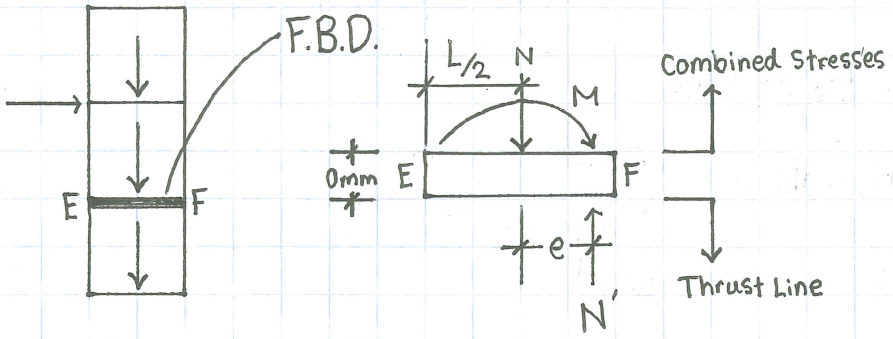




Take Sum of Axial + Moment Stress



2) Thrust Line



$\Sigma F_y = 0$

$0 = -N + N' \Rightarrow N = N'$

$\Sigma M_{centroid} = 0 = -m + Ne$

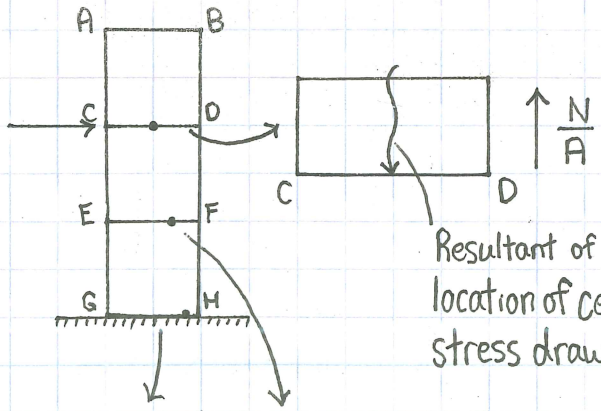
$\Rightarrow e = \frac{M}{N}$

e = eccentricity from thrust line to centroid

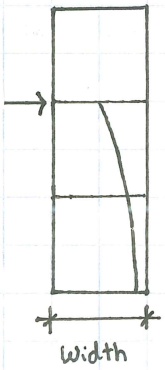
For combined σ (M+N) take sum of stresses and compare to allowable

$$\sigma_{Total} = \frac{N}{A} + \frac{My}{I}$$

Thrust line has only an axial force not necessarily at centroid of X-section

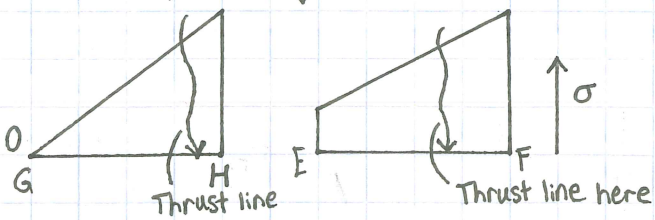


Trace the Thrust Line

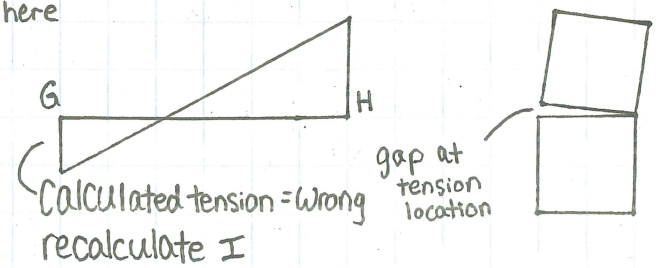


If thrust line is in middle 1/3 of width → no tensile stress = Kern

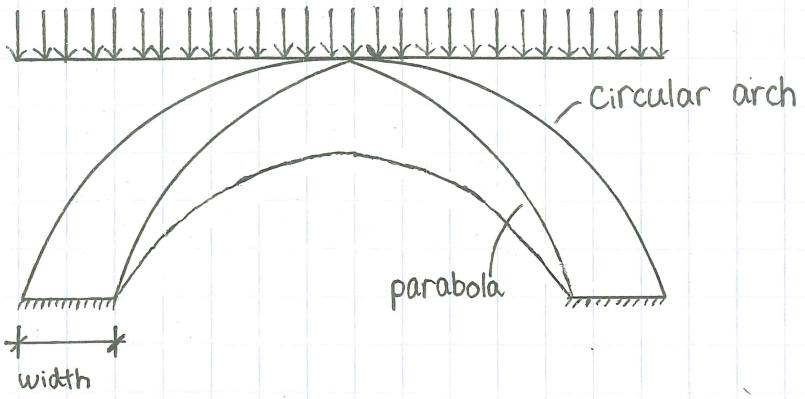
If thrust line goes outside width it will collapse



If thrust line is closer than 1/3 from edge



If shape matches thrust line I get an arch



What shape is best for an arch?

Robert Hooke 1675

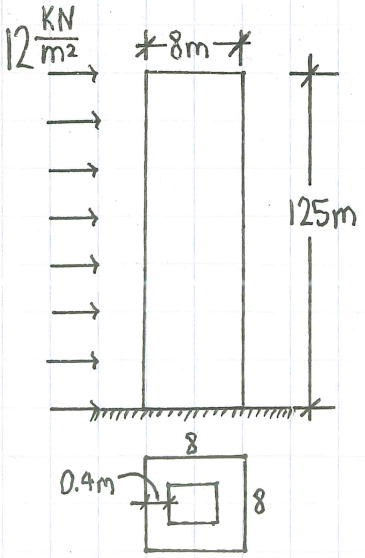
"As hangs the flexible cable, so inverted should the touching parts of an arch stand."

Allowable compressive stress for stone or brick = $\frac{\sigma_{compressive}}{F.O.S.}$ ← from table

$\sigma_{Tensile\ Allowable}$ = zero!

Example

Chimney at St. Rollox

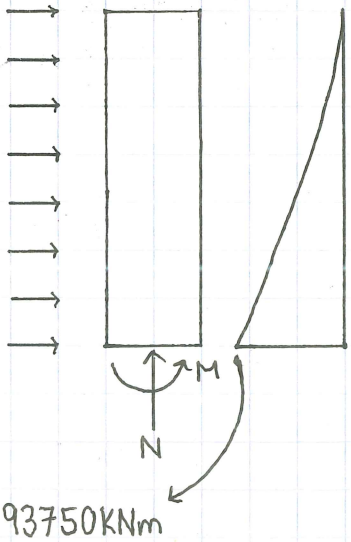


$I = 117.4 m^4$

$A = 12.1 m^2$

$\gamma = 26 \frac{KN}{m^3}$

FBD



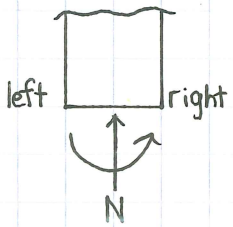
$M = 93750 KNm$

$N = A\gamma h = 12.1 \cdot 26 \cdot 125$

$= 39520 KN$

M_{max}, N_{max} @ Bottom

∴ Calculate there



$\frac{N}{A} = 3.25 MPa$ compression

$\sigma_{left} = 3.25 - \frac{My}{I}$

$= 0.06 MPa$ (comp)

$\sigma_{right} = 3.25 + \frac{My}{I}$

$= 6.44 MPa$