Seminar on
General and Lateral Forces

Architectural Registration Exam

By Marty Snyder

University of North Carolina at Charlotte
January 14/15/06 and 21/22/06
David Thaddeus





DAY 1 — 1/14/06

ARE

DAVID THADDEUS / UNCC

- 1996 – LAST PAPER EXAM
- 1997 – 1ST COMPUTER EXAM

- TEST: TAKE IN MARCH ... AT LATEST
  - TAKE GENERAL FIRST (IN FEBRUARY)
  - LATERAL FORCES SECOND

- WOOD, STEEL & CONCRETE — STUDY THESE. MATERIAL & METHODS.

- GO AHEAD & SCHEDULE YOUR EXAM. THIS WILL MAKE YOU STUDY & STAY ON SCHEDULE.

- SITE: 71% IN 2004
- LATERAL FORCES: 77% IN 2004

RESOURCES

- ALS / KAPLAN
- BALLAST: GEN. & LATERAL BOOKS
- ARCHIFLASH CARDS — MAKE YOUR OWN CARDS!

- CHING: VISUAL DICTIONARY OF ARCHITECTURE

- STRUCTURAL TECHNOLOGY BY ROBERT MARKS — USEFUL BUT GENERAL.

- SALVADORI: (2) BOOKS

- ARE FORUM.ORG: DIVIDED INTO DIVISIONS

- HAVE A STUDY PARTNER.

- **FORCE, LOAD, STRESS & MOMENTS**

  - FUNDAMENTALS ON CONCEPTS ARE MORE IMPORTANT!

  - **LOADS**

    - LIVE, DEAD, SNOW, WIND, UNIFORM, CONCENTRATED (POINT)
    - AXIAL
    - PERPENDICULAR
    - REACTIONS
    - EARTHQUAKE
    - SHEAR
    - THERMAL – EXPANSION & CONTRACTION
    - ECCENTRIC / CONCENTRIC
    - HYDROSTATIC ⟶ FOUNDATIONS
    - IMPACT
    - RAIN ⟶ PONDING

      - WATER = 8.33 #/GAL OR 62.4 #/CUBIC FT
      - CONCRETE = 150 #/CU. FT.
      - WOOD = 35-40 #/CU. FT.
      - STEEL = 490 #/CU. FT. (IT'S DENSER)

- LOADS

  - GRAVITATIONAL LOADS:

    - DEAD LOADS – BUILDING ITSELF CONC > STEEL
    - LIVE LOADS – PEOPLE, FURNITURE, MOVABLE EQUIPMENT

    - DEAD LOAD: FIND INFORMATION IN BOOKS & TABLES

      = THE STRUCTURE, FIXED EQUIPMENT & FIXED PARTITIONS

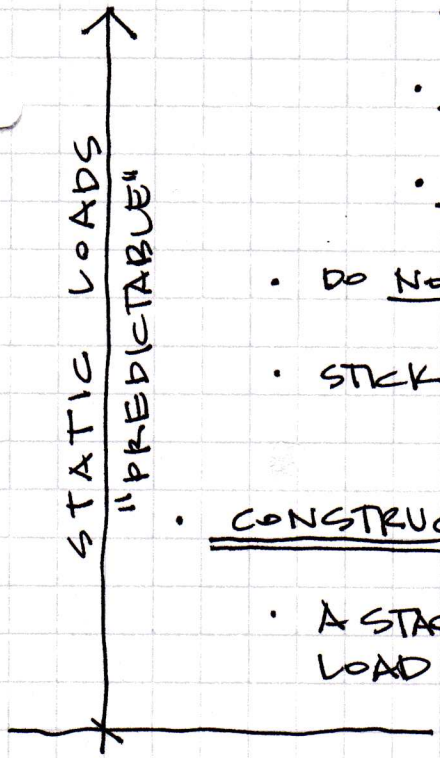
    - LIVE LOAD: IN CODE – IT'S BASED ON OCCUPANCY

      - ASSEMBLY: 100 #/FT^2 (PUBLIC)
      - OFFICE: 50 #/FT^2 (PRIVATE)
      - LIBRARY: 125-150 #/FT^2 (STACKS)
      - HOME DEPOT: 300 #/FT^2
      - RESIDENTIAL: 20 #/FT^2

    - DO NOT GET HUNG UP ON CODE SPECIFIC ITEMS.
    - STICK WITH THE GENERAL...

  - CONSTRUCTION LOADS:

    - A STACK OF PLYWOOD ON THE ROOF = A TEMPORARY LOAD DURING CONSTRUCTION.



- **ENVIRONMENTAL LOADS:**

CODE

- RAIN (PONDING) : CREATES PROGRESSIVE COLLAPSE
  : LONG SPAN STRUCTURES
  - LOCAL CODES - GIVE STATISTICS
- SNOW
- THERMAL
- WIND
- SEISMIC
- HYDROSTATIC
- LOAD FACTORS
  - LIVE LOADS ARE FACTORED "HIGHER" THAN DEAD LOADS.
- MISCELLANEOUS
  - IMPACT — VIBRATION
  - BLAST LOADS — EXPLOSION
  - TERRORISM — "REDUNDANT STRUCTURE"

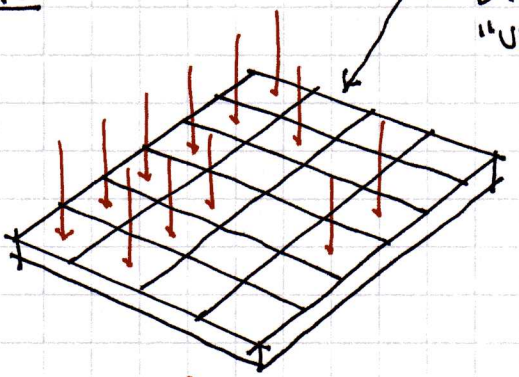
"SCARY" DYNAMIC
"UNPREDICTABLE"

- METHOD OF APPLICATION / DELIVERY OF LOAD

  - FLOOR / DECK / ROOF = PLATE
  - BEAM = LINE
  - COLUMN = POINT

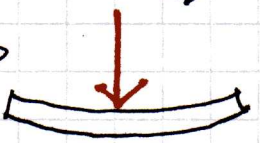
(A) PLANAR DISTRIBUTION

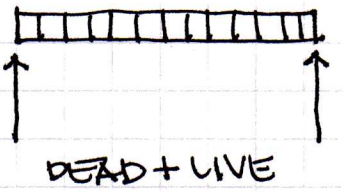
- SLAB, DECK



$= \#/Ft^2$

- PERPENDICULAR LOAD IS WEAKER THAN AXIAL LOAD



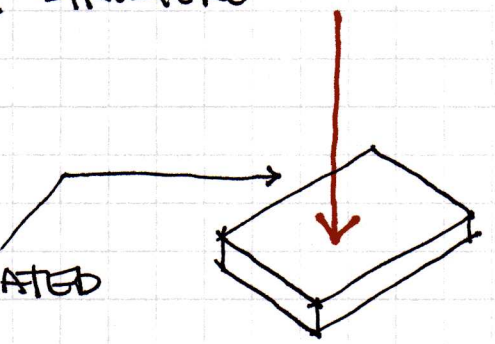


- FLATTER = WEAKER
- FLAT = SHEAR & BENDING



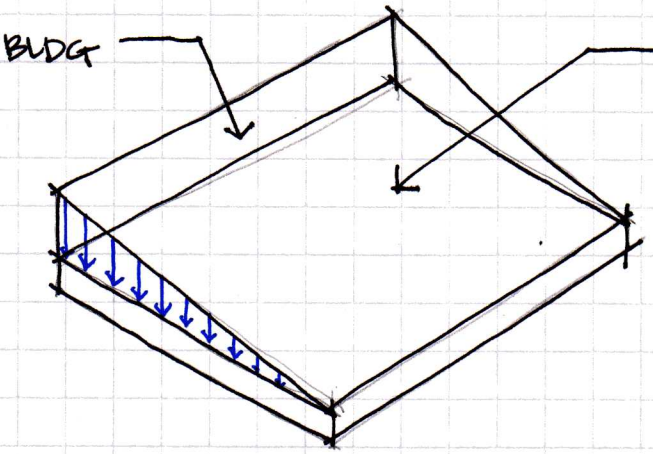
ROOF = SNOW, RAIN
FLOOR = LIVE, DEAD

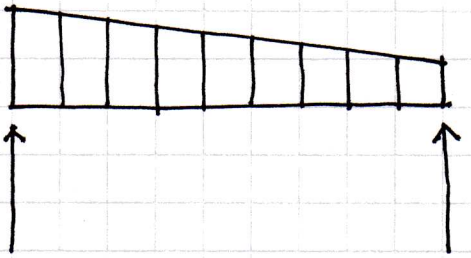
- AXIAL LOAD = SMALLER STRUCTURE
- PLANAR LOAD = NEEDS MORE STRUCTURE
- LOADING ON THE WEAK AXIS
- UNIFORMALLY APPLIED



- CAN'T LOAD WITH A CONCENTRATED LOAD
  - MUST ADD A BEAM
  - BEAMS HANDLE BOTH UNIFORM & CONCENTRATED LOADS

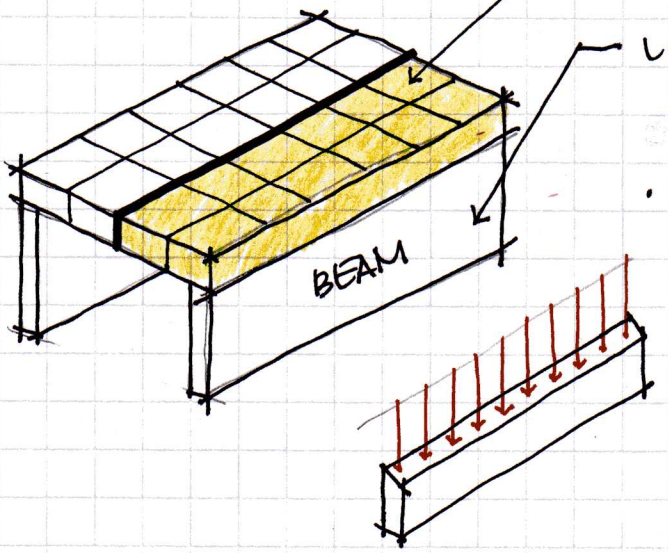
- ROOF LOAD IS LIGHTER THAN FLOOR LOAD.





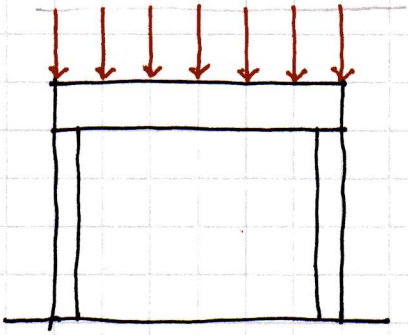
SNOW = 100 #/FT²
ROOF = 20 #/FT²

- UNIFORM LOAD

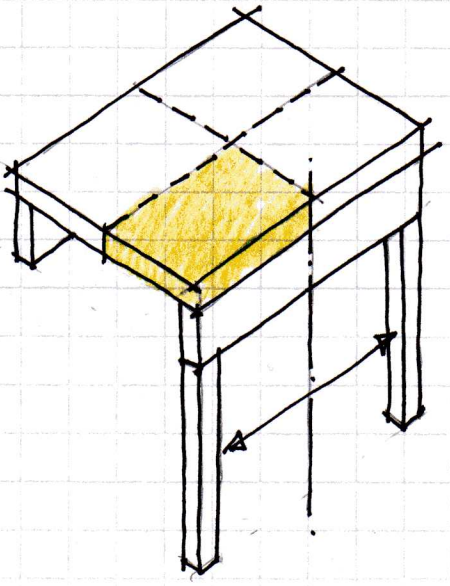


- BEAM CARRIES UNIFORM LOAD IN #/FT.

(1 KIPS = 1000#)



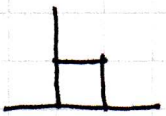
- NOW ADD COLUMNS



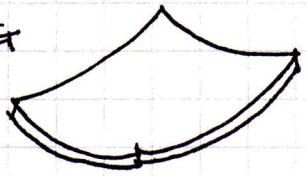
- LOAD IS ALONG AXIS OF COLUMN

AXIAL LOADING

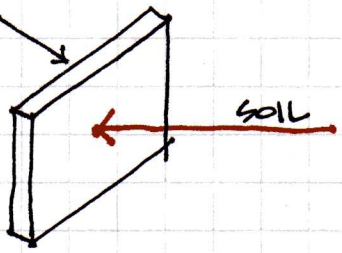
- LOAD PERPENDICULAR TO PLANE :



  - PERPENDICULAR = SHEAR & BENDING



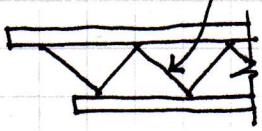
  - FLOOR, ROOF, DECK, SLAB
  - BASEMENT WALL
  - FOUNDATION PAD



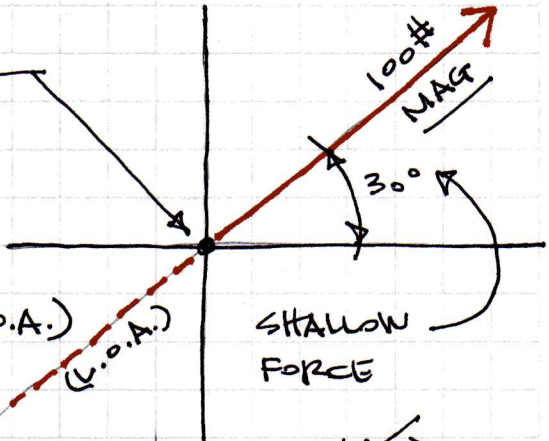
- LOAD LINEAR TO PLANE : BEAMS, JOISTS, GIRDER, WALLS TRUSS

- LOAD ALONG LINEAR PLANE : = AXIAL
  - COLUMN, PILE, CABLES, TIE RODS, BRACING

TRUSS :



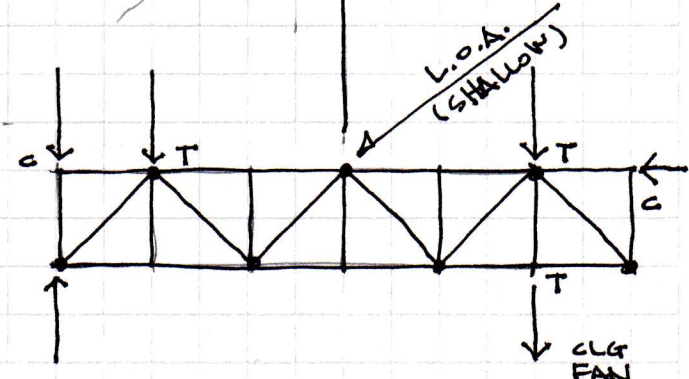
- MATH
  LOADS — HOW THEY WORK



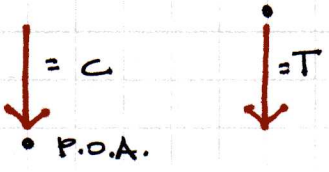
- LOADS
  - FORCES
    - POINT OF APPLICATION : (P.O.A.)
    - MAGNITUDE
    - LINE OF ACTION (DIRECTION) : (L.O.A.)
    - SENSE (ARROW HEAD)

- STEEPER = VERTICAL ACTIONS
  16 : 12

- SHALLOW = MORE KICK
  3 : 12

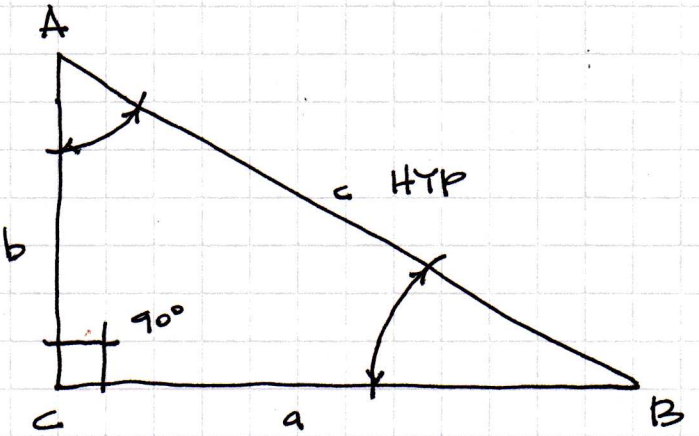


- ARROW HEAD
  - COMPRESSION OR TENSION
  - SHALLOW = HORIZONTAL



- **SOH CAH TOA** → FOR 90° **ONLY**

$S = \frac{O}{H}$ $C = \frac{A}{H}$ $T = \frac{O}{A}$

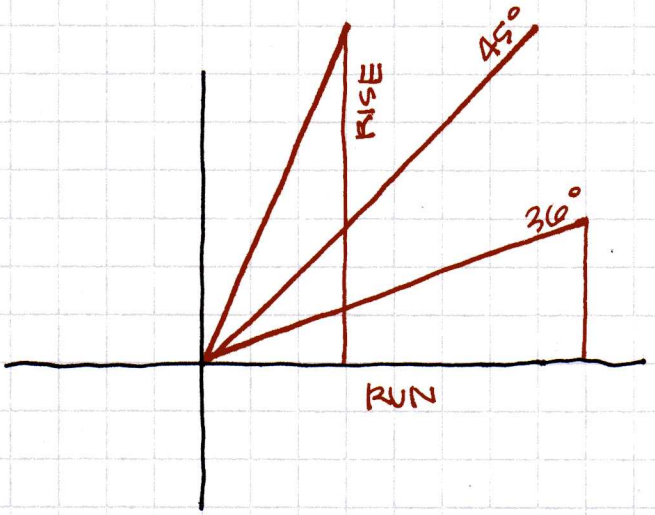


- $\text{SIN } A = \frac{\text{OPP}}{\text{HYP}} = \frac{a}{c}$
- $\cos A = \frac{\text{ADJ}}{\text{HYP}} = \frac{b}{c}$
- $\text{TAN } A = \frac{\text{SIN } A}{\cos A} = \frac{\text{OPP}}{\text{ADJ}} = \frac{a}{b}$
- SIN & COS = LESS THAN 1

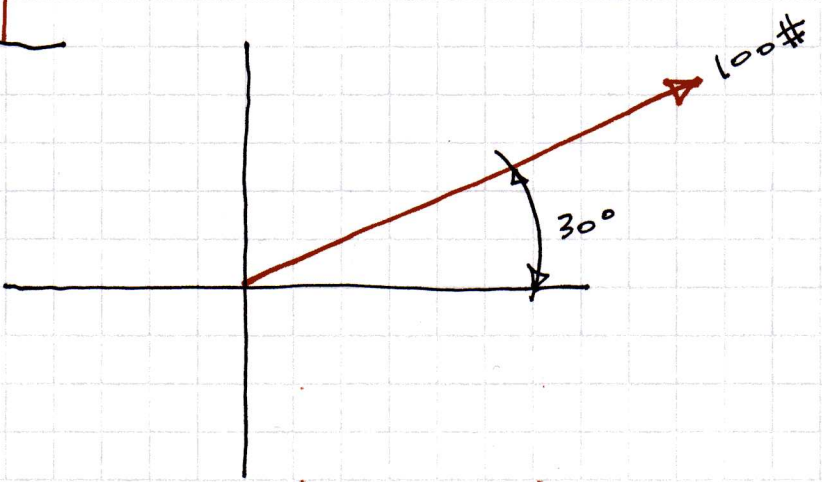
- LOOK AT SIN, COS & TAN DIFFERENTLY.
  - SIN = RISE
  - COS = RUN
  - TAN = SLOPE

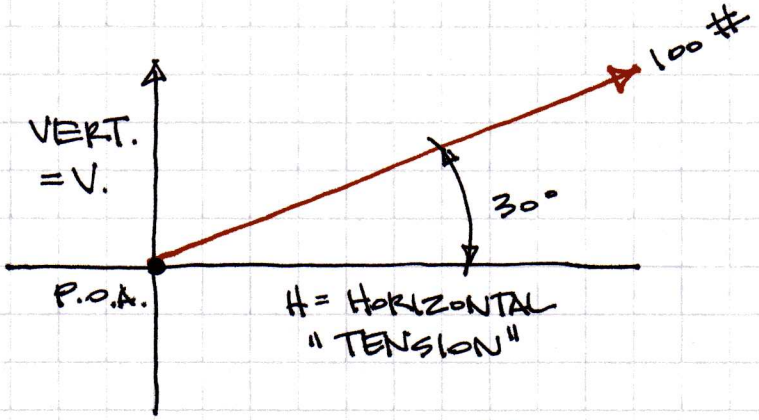
SIN of 0 = 0
SIN of 90 = 1
SIN of 270 = -1

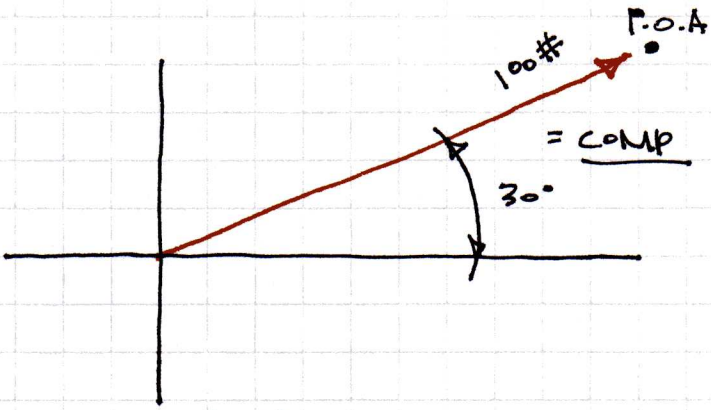
COS of 270 = 0
COS of 180 = -1



- LESS THAN 45° = LARGER RUN
  COS > SIN
- MORE THAN 45° = LARGER RISE
  SIN > COS







(ANGLE IS LESS THAN 45°)

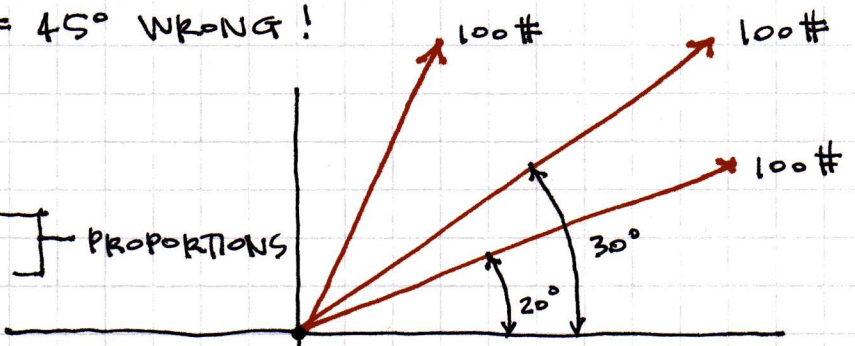
(1) COMPONENTS = HORIZ. OR VERTICAL.

* HORIZONTAL IS BIGGER THAN VERTICAL (RUN)

	H	V
a	~~40~~	~~60~~
b	~~75~~	~~25~~
c	42	42
d		

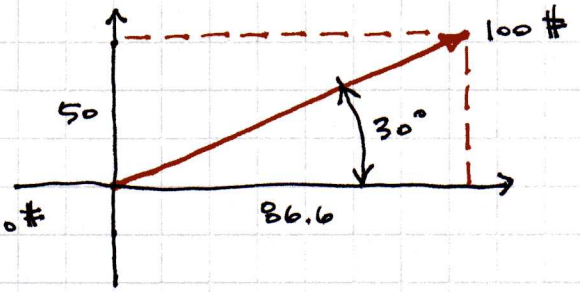
• ELIMINATE ANSWERS
• 75 + 25 = 100 (WRONG)!
= 45° WRONG!

(RISE) SIN 30° = .5
COS 30° = .866
} PROPORTIONS

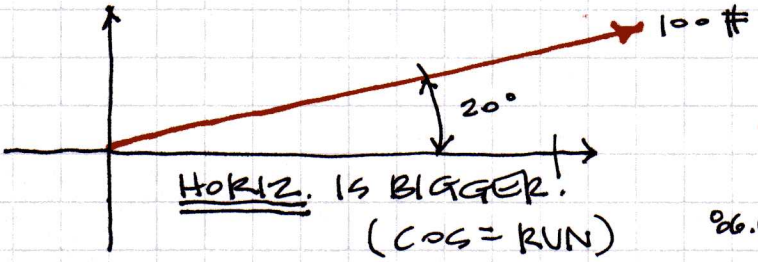


• 100 # X .5 = 50 # VERTICAL
• 100 # X .866 = 86.6 # HORIZONTAL

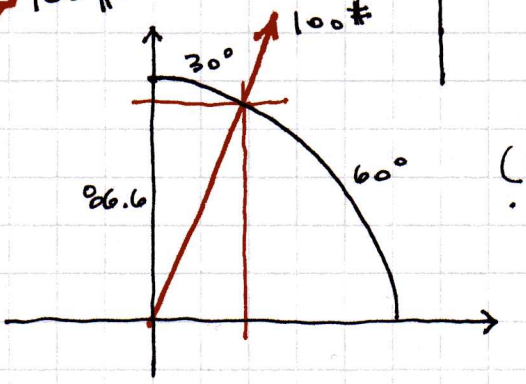
20° = LARGER HORIZ.



$50^2 + 86.6^2 = 100^2$

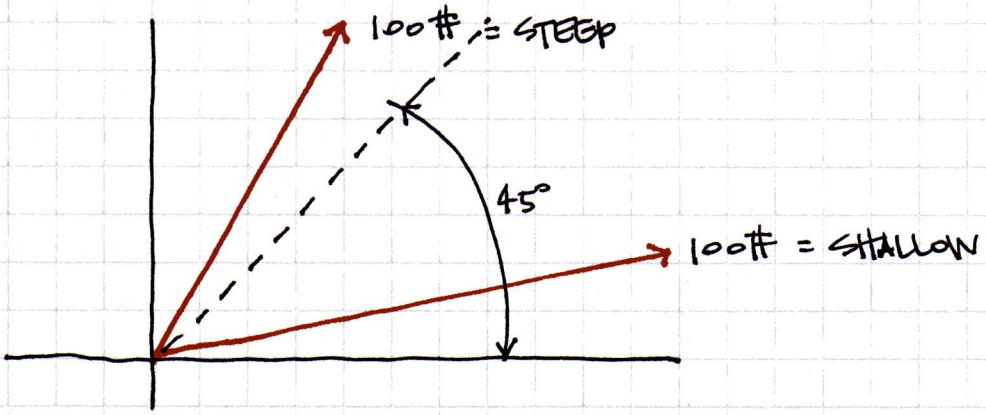


HORIZ. IS BIGGER!
(COS = RUN)



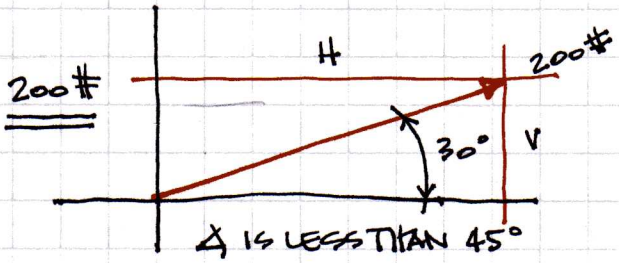
(SIN = RISE)
• VERT IS BIGGER!

• ONE IS BIGGER THAN THE OTHER : HORIZONTAL OR VERTICAL
• COMPONENTS : HORIZ. OR VERT.

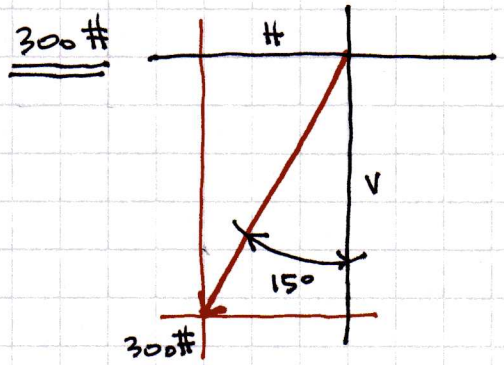


PG 3 – GREEN HANDOUT

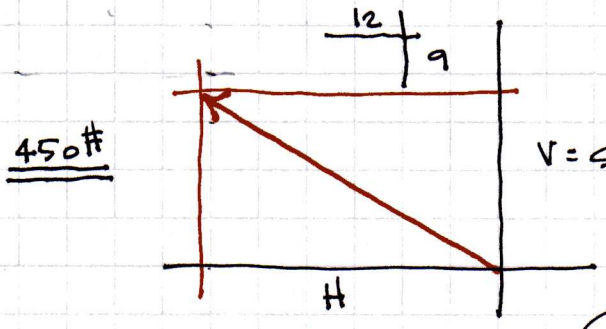
- TRANSMISSIBILITY – FORCE SLIDES ON THE LINE OF ACTION (L.O.A.) W/OUT CHANGES IN THE REACTIONS.
- FORCE ADDITION:
- RESULTANT:
  - POINT
  - LINE OF ACTION (L.O.A.)
  - MAGNITUDE
  - ARROW HEAD



SIN 30° = .5 x 200# = 100# V = RISE
COS 30° = .866 x 200# = 173.2 # H = RUN

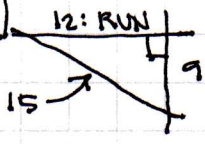


SIN 15° = .258 x 300# = 77.6# H = RUN
COS 15° = .965 x 300# = 289.7 # V = RISE



SIN = RISE
COS = RUN

FIND INVERSE TAN! NOT THE ANGLE



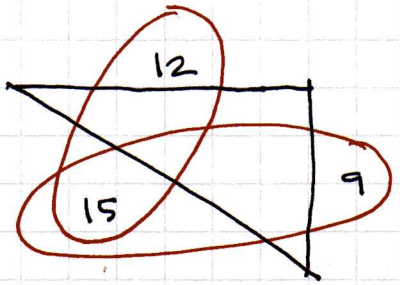
$9^2 + 12^2 = \sqrt{\quad}$
$= 15$
V = 9 H = 12
b = 15

$\frac{9}{V} = \frac{12}{H} = \frac{15}{450}$
$\angle 270$ $\angle 360$

$15H = 12 \times 450$
$H = 360\#$

$15V = 9 \times 450$
$V = 270\#$

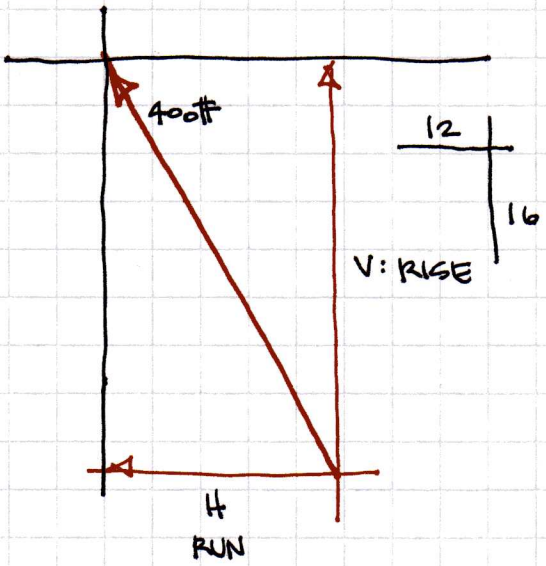
• DO THIS QUICKER!

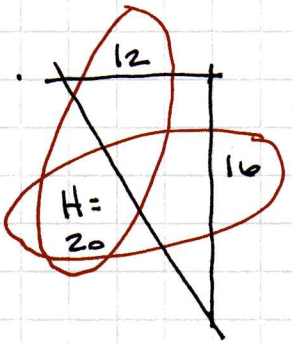


$\frac{12}{15} \times 450 = 360\#$

$\frac{9}{15} \times 450 = 270\#$

400#





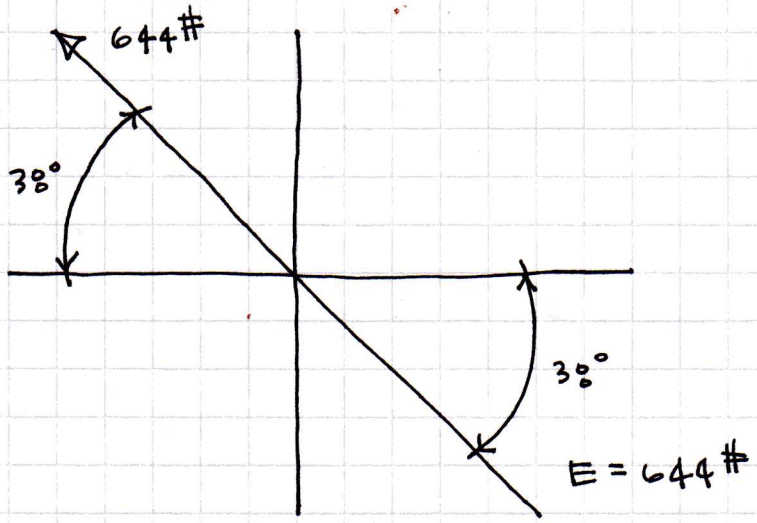
$12^2 + 16^2 = \sqrt{\quad}$

$= 20$

$\frac{12}{20} \times 400 = 240\#$ H = RUN

$\frac{16}{20} \times 400 = 320\#$ V = RISE

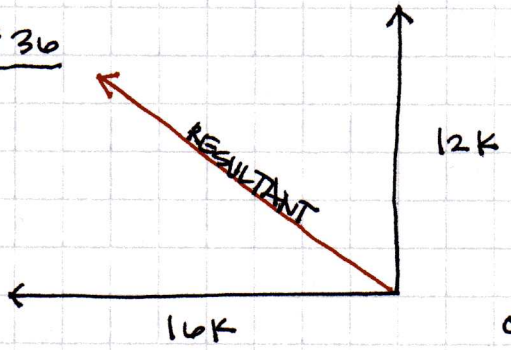
• EQUILIBRANT = EQUAL & OPPOSITE



- PG 40 – BLUE HANDOUT

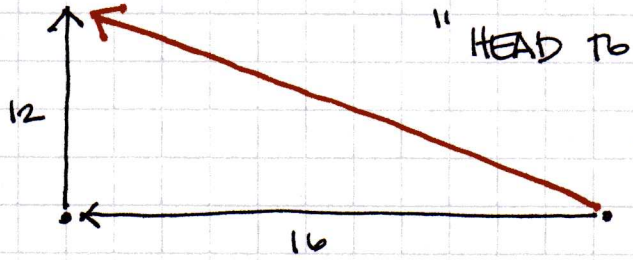
~~A) 20 @ 36.9~~
B) 20 @ 143.1
~~C) 20 @ 53.3~~
~~D) 20 @ ___~~ ELIMINATE

#36



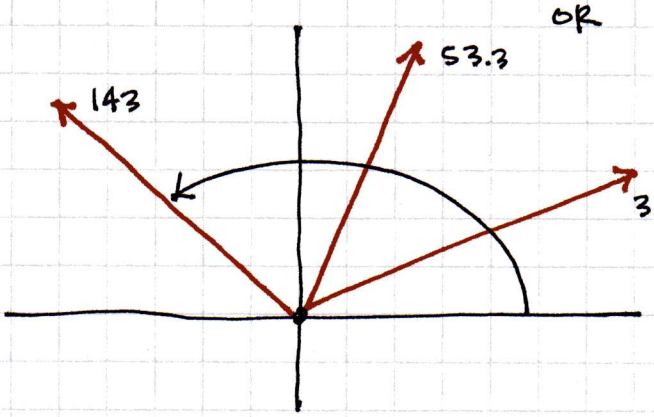
Q. FIND THE RESULTANT.

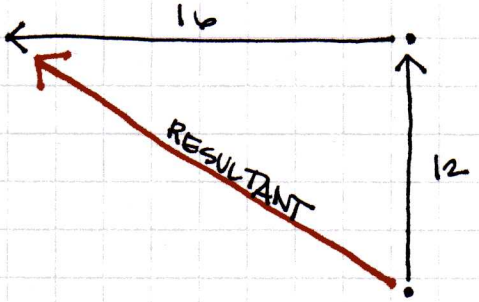
"HEAD TO TAIL"



* RESULTANT = TAIL 1ST TO HEAD LAST

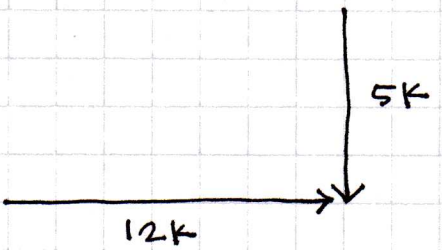
OR

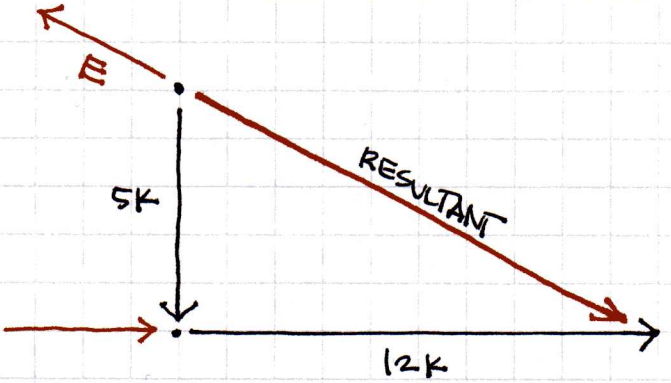


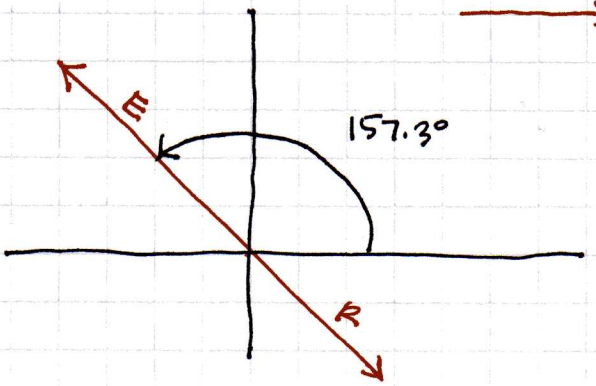


#37 "EQUILIBRANT"

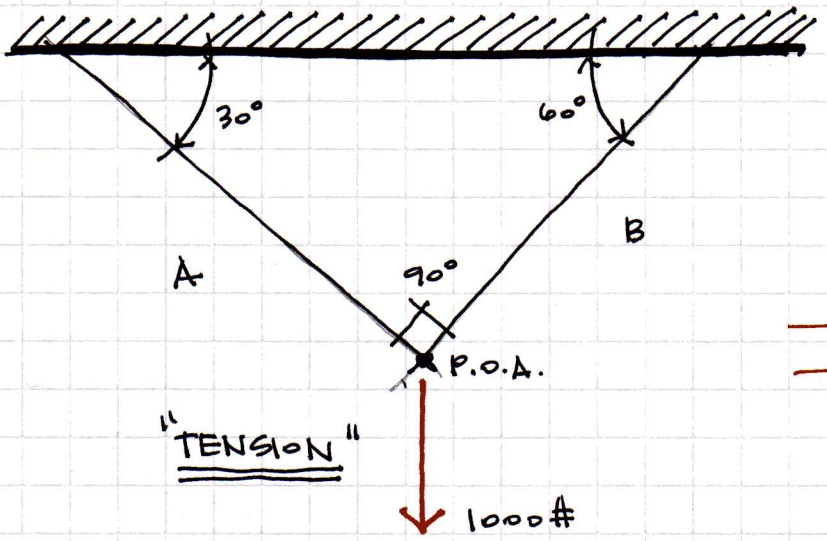
E = OPPOSITE THE RESULTANT







E = EQUILIBRANT
R = RESULTANT

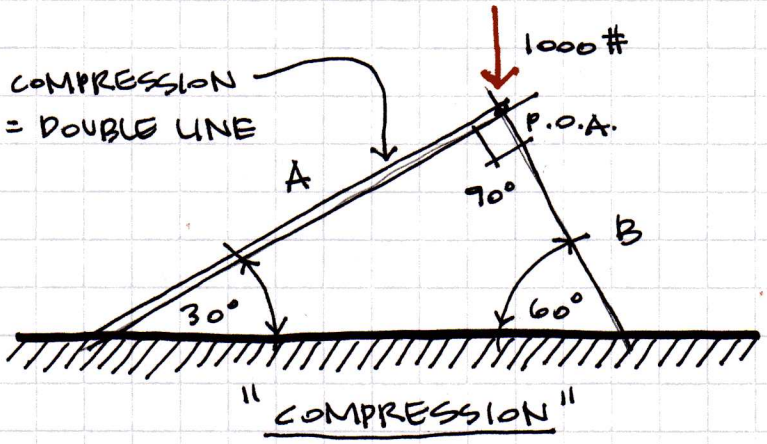


SIN = RISE (VERTICAL)
COS = RUN (HORIZONTAL)

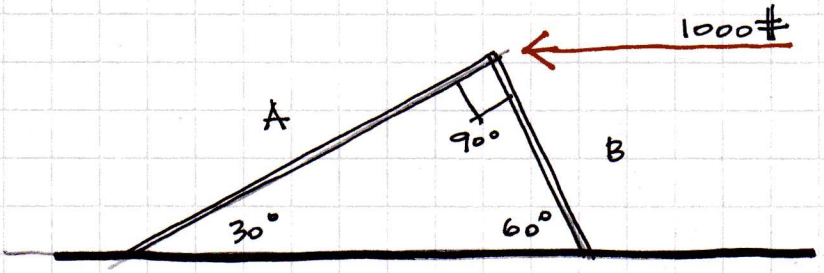
	A	B
~~A~~	~~600#~~	~~300#~~
~~B~~	~~500#~~	~~500#~~ = 45° NO!
C	49.2#	256#
D		

- STEEPER ANGLE = GREATER FORCE

THEREFORE B > A (60° IS STEEPER)

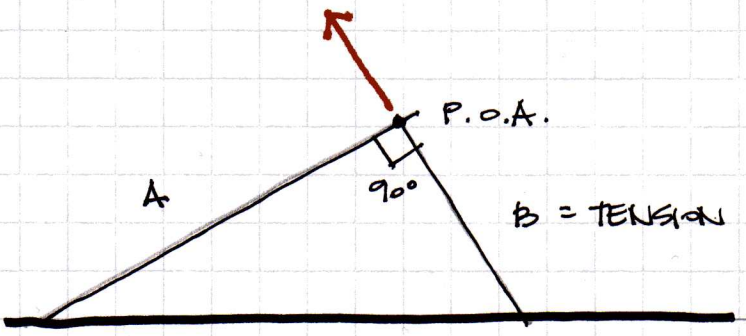


B > A B = 60° ANGLE

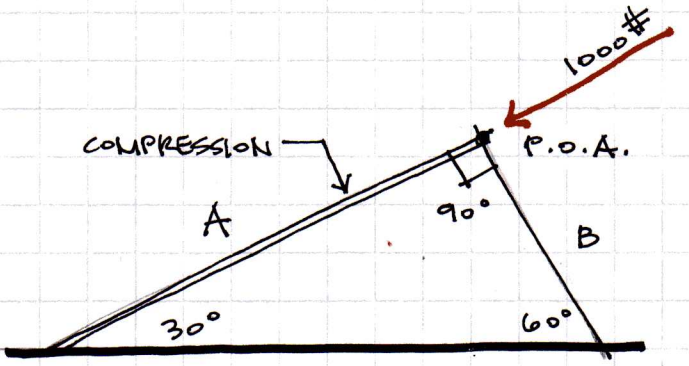


A > B

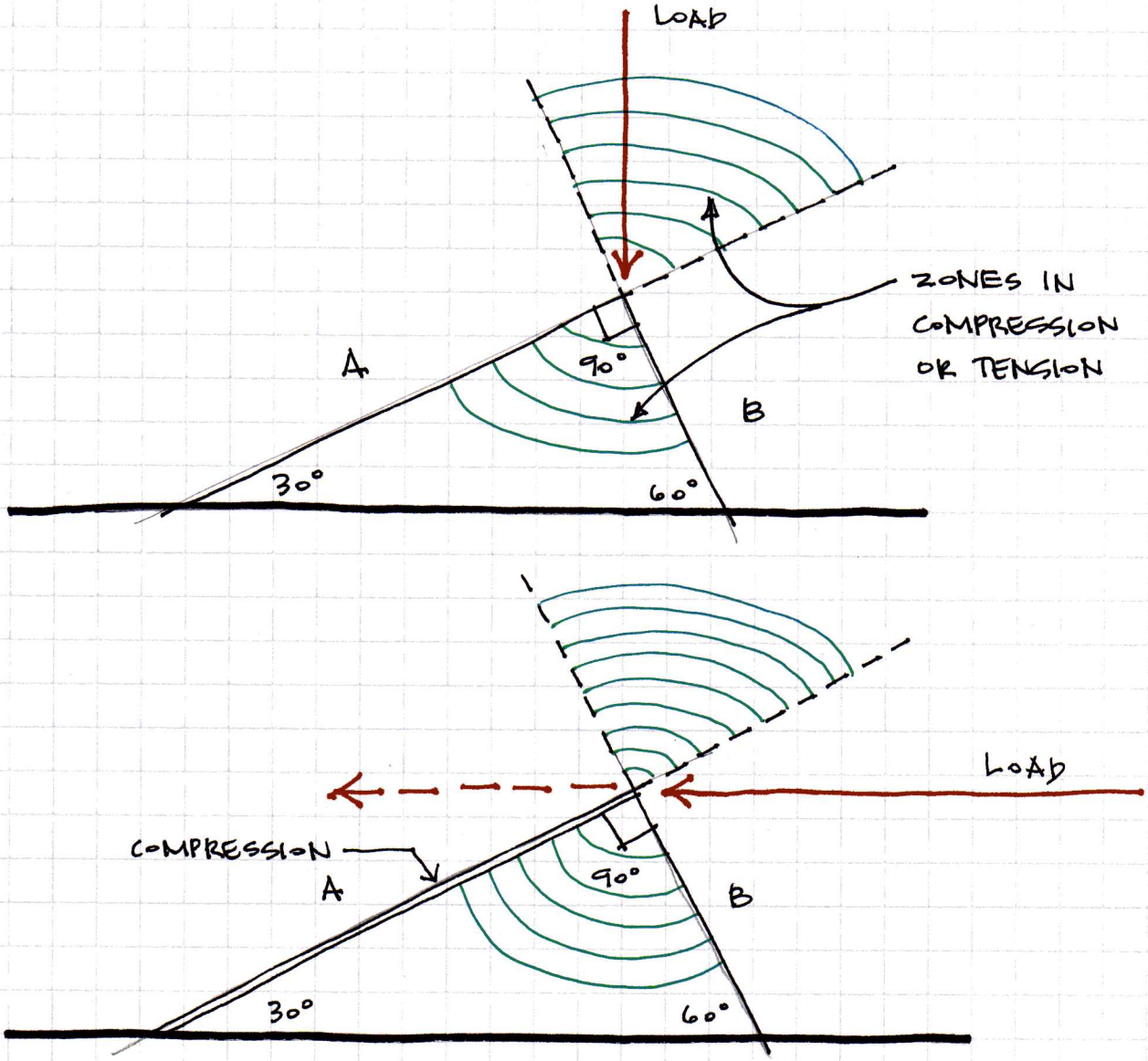
- SHALLOW ANGLE IS GREATER.



A IS DOING NOTHING

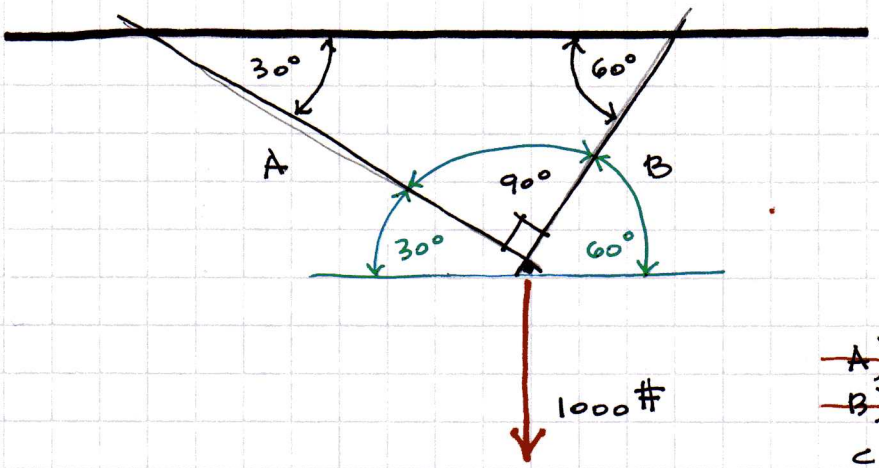


B = 0 ... IT'S DOING NOTHING



A = COMPRESSION
B = TENSION

* LOAD FALLS OUTSIDE THE QUADRANTS THEREFORE — YOU MUST LOOK AT BOTH A & B SEPARATELY.

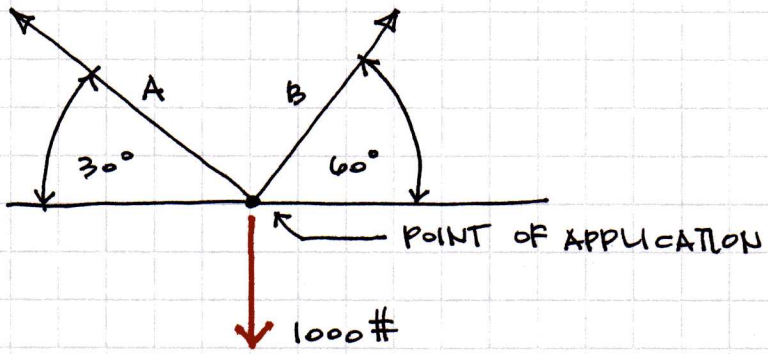


HEAD TO TAIL

B > A

* B HAS A STEEPER SLOPE

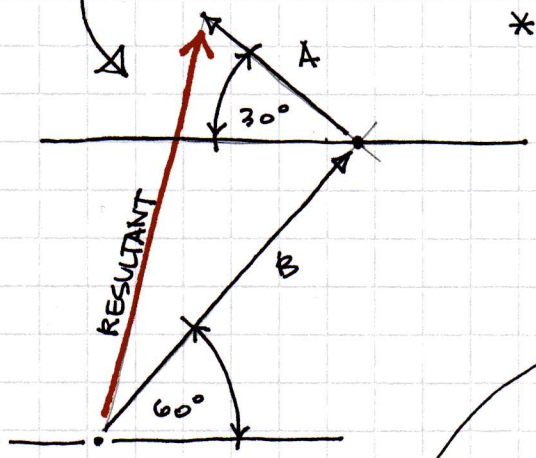
	A	B	
~~A)~~	~~600~~	~~300~~	A > B No!
~~B)~~	~~500~~	~~500~~	45° No!
C)	49.2	256	



A + B + 1000 = 0

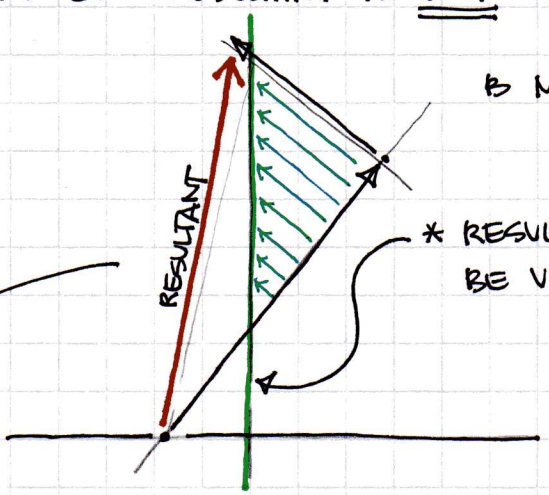
A + B = 1000 ↑ UP

HEAD TO TAIL



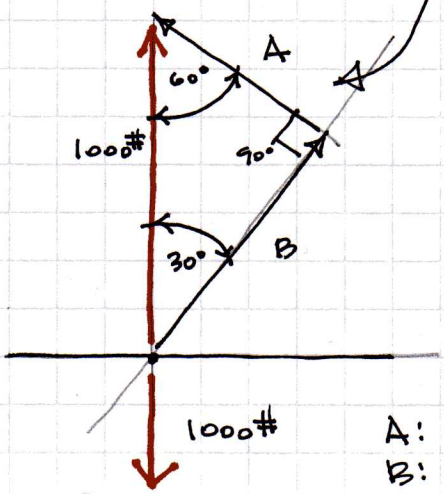
RESULTANT A + B

* HOWEVER : RESULTANT IS NOT VERTICAL!



B MUST BE > A

* RESULTANT MUST BE VERTICAL.



SIN 30° = .5

COS 30° = .866

SIN 30° = $\frac{\text{OPP}}{\text{HYP}} = \frac{A}{1000\#}$ = .5 × 1000#

A = 500#

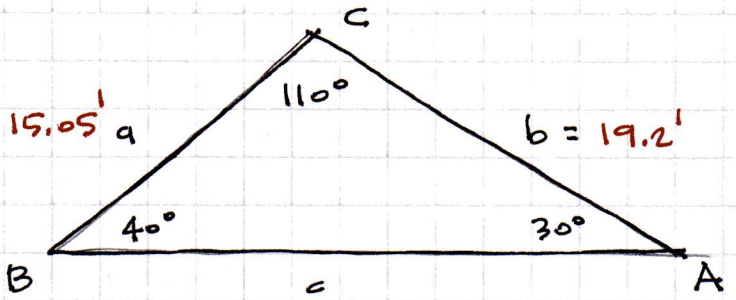
COS 30° = $\frac{\text{ADJ}}{\text{HYP}} = \frac{B}{1000\#}$ = .866 × 1000#

B = 866#

A: TAKES MORE HORIZ. LOAD

B: TAKES MORE VERT. LOAD

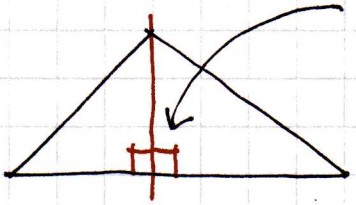
B > A



HYPO = MUST HAVE 90° TO DO $A^2+B^2=C^2$

* THERE'S NO 90°!

$\frac{110°}{28} = \frac{40°}{B} = \frac{30°}{A}$ NO!



NO! DON'T PUT IN PERPENDICULAR! THERE'S NOT ENOUGH TIME DURING EXAM TO DO THIS!

$$\frac{\sin 110}{28} = \frac{\sin 40}{b} = \frac{\sin 30}{a}$$

- **LAW OF SINES** : WHEN YOU DON'T HAVE A 90° ANGLE.

SIN 110 = .93
SIN 40 = .64
SIN 30 = .5

$\frac{\sin 110}{28} = \frac{\sin 40}{b}$

$b \times .93 = .64 \times 28'$

$b = \frac{.64 \times 28'}{.93} =$ 19.2'

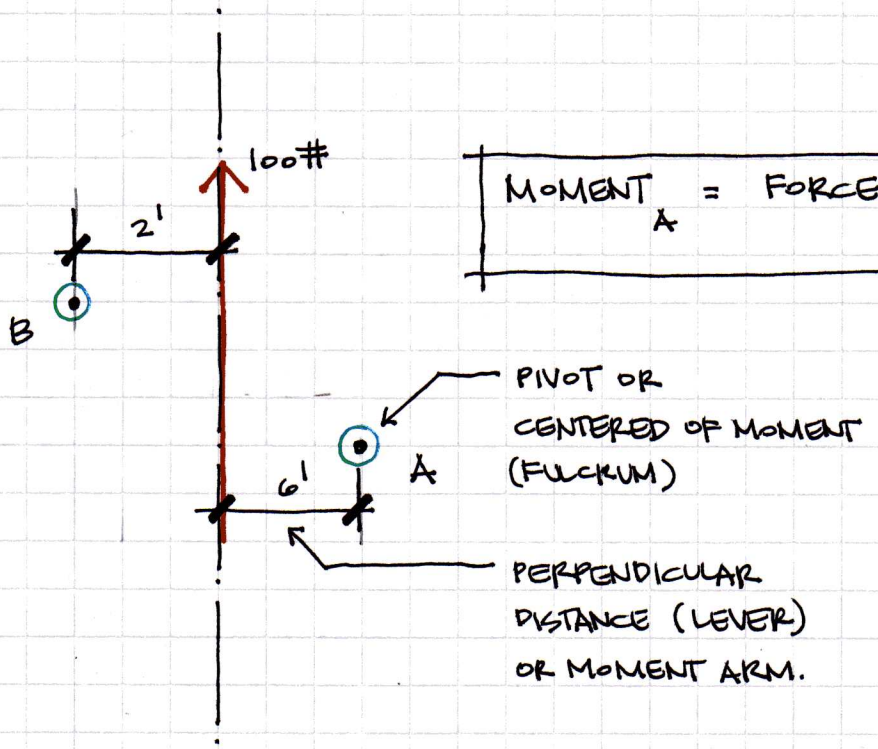
$a = \frac{.93}{28'} = \frac{.5}{a}$ $\quad .93a = 28' \times .5$

$a = 15.05'$

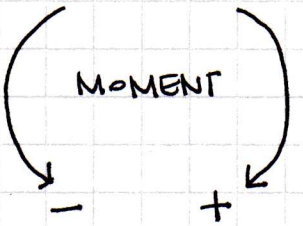
- **MOMENTS** : TENDENCY TO ROTATE AS CAUSED BY A FORCE ABOUT A CERTAIN POINT.

: A FORCE CAUSES THE ROTATION.

- MOMENTS



M_A = FORCE X PERPENDICULAR DISTANCE
FT

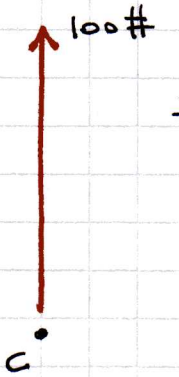


* MOMENT AT POINT "A" = $M_A = 100\# \times 6'$ $M_B = 100\# \times 2'$

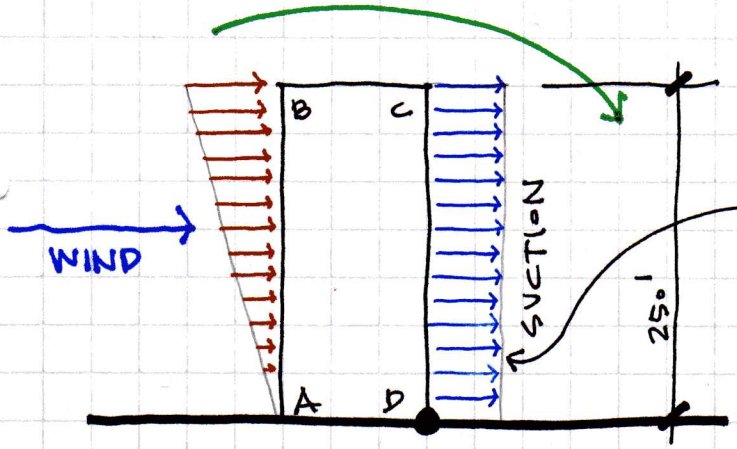
$M_A = 600\#$ FT $M_B = 200\#$ FT

→ ALSO #IN, K FT, K IN

POINT "A" IS CLOCKWISE = POSITIVE
POINT "B" IS COUNTERCLOCKWISE = NEGATIVE.



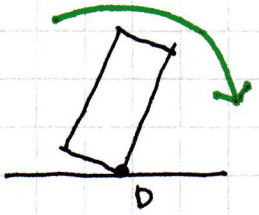
* MOMENT AT POINT "C" = 0



* OVERTURNING = A MOMENT

LEEWARD SIDE = A UNIFORM LOAD THAT IS CONSTANT.

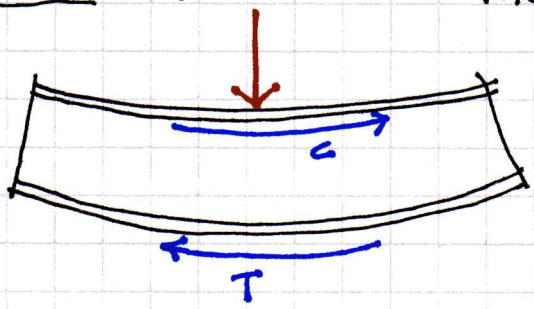
ROTATION ABOUT POINT "D"



- WEIGHT = <u>DEAD WEIGHT</u> - DETERMINES WHO IT TURNS OVER.
- HEAVIER BUILDING = LESS LIKELY TO TURN OVER.
- WEIGHT OF BUILDING = DEAD LOAD.
- STABLIZING MOMENT MUST BE > NOT EQUAL TO THE OVERTURNING MOMENT.

<u>PG 31</u> BIG BOOK

- <u>COUPLE</u> IS HOW DEEP IS THE BEAM



C = COMPRESSION

T = TENSION

- <u>STRESS & STRAIN:</u>
  - BENDING STRESS = INVISIBLE
  - DEFLECTION = STRAIN = VISIBLE
- PERPENDICULAR TO AXIS = LESS EFFICIENT
- ALONG AXIS = MOST EFFICIENT

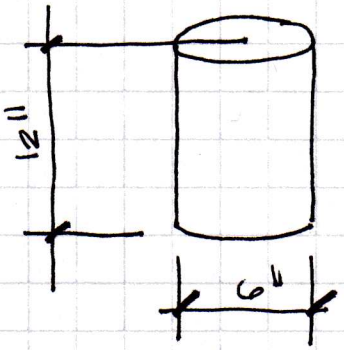
$$\text{STRESS} = \frac{\text{LOAD}}{\text{AREA}} \qquad F = \frac{P}{A}$$

DESCRIBES THE MATERIAL

F = STRESS (psi, ksi, PSF, KSF)
P = LOAD (# OR K)
A = CROSS SECTIONAL AREA (IN^2 OR FT^2)

- STRAIN GAUGE = HOW STRAIN IS MEASURED
  = A CHANGE OF LENGTH OR SHAPE.

- STRESS IS CALCULATED NOT MEASURED.



$$F = \frac{P}{A}$$

3000 psi = STRENGTH OF MATERIAL IN COMPRESSION
(F_c = 3000 psi)

- SOIL REPORT
  - BEARING STRESS
  - BEARING PRESSURE F_p = 3000 PSF

- ALLOWABLE STRESS: WHAT IS IT? STAMP ON MATERIAL IS A GIVEN.

PGS 33A & 33B

- F = STRESS F_c & F_T = AXIAL

  F_b & F_v = PERPENDICULAR

C = COMPRESSION T = TENSION b = BENDING V = SHEAR

- READ MATERIALS & METHODS! WOOD, STEEL & CONCRETE

REBAR = 40,000 psi 40 ksi OR 60 ksi

- WIDEFLANGE GRADE A36 OR A50
  THE DIFFERENCE = ADD CARBON : MORE CARBON = STRONGER STEEL, BUT BRITTLE!

- WIDEFLANGE MATERIAL IS FLEXIBLE.

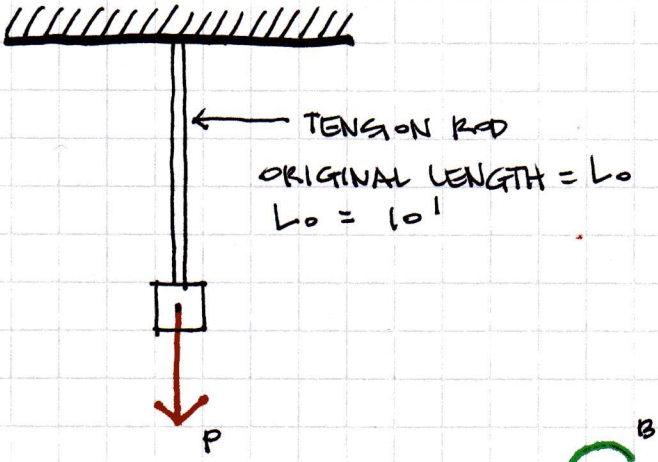
- CONCRETE = LOTS OF DIFFERENCES IN MIXTURE.

- REVIEW PG 33 D

- **HOOKE'S LAW**

STRETCH = STRAIN (STRAIN IS MEASURED)

- STEEL IS ELASTIC - IT GOES BACK TO ITS INITIAL SHAPE.
- HOWEVER, STEEL IS ELASTIC UP TO A CERTAIN POINT.

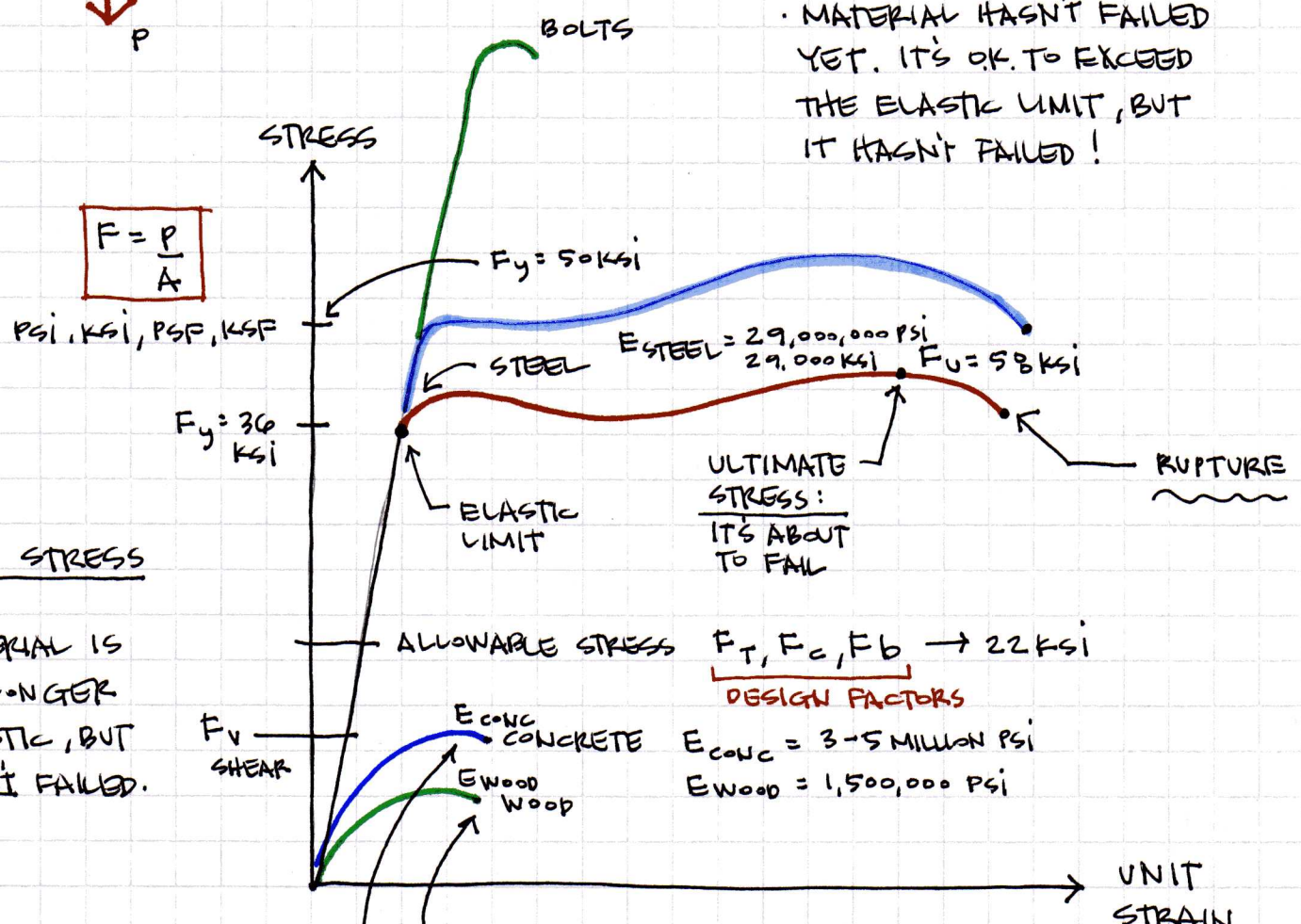


ELASTIC LIMIT

- MATERIAL HASN'T FAILED YET. IT'S O.K. TO EXCEED THE ELASTIC LIMIT, BUT IT HASN'T FAILED!

$$F = \frac{P}{A}$$

PSI, KSI, PSF, KSF



YIELD STRESS

- MATERIAL IS NO LONGER ELASTIC, BUT HASN'T FAILED.

- 2% CARBON IN STEEL BUT... ADD CARBON MAKES IT STRONG, BUT BRITTLE

WOOD IS ELASTIC

CONC IS GOOD IN COMP, BAD IN TENSION.

DELTA L → $\frac{\Delta L}{L_o}$ = IN/IN

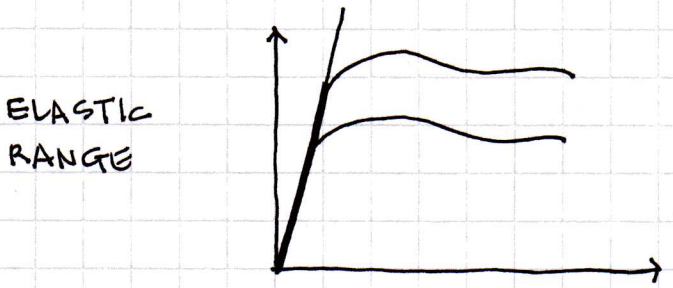
E_{STEEL} = 29,000,000 PSI
E_{CONC} = 3-5,000,000 PSI
E_{WOOD} = 1,500,000 PSI

F_U = THE ULTIMATE STRESS
F_y = THE YIELD STRESS

- STRESS AT ABOUT 36 ksi — MATERIAL FAILS, BUT DOESN'T BREAK. (THERE'S PERMANENT DAMAGE, BUT NOT FAILURE).

LOAD
- ALONG AXIS = (C) COMPRESSION → SHORTENING
  (T) TENSION → ELONGATION
- PERPENDICULAR LOAD = (M) BENDING MOMENT → DEFLECTION
  (V) SHEAR → TEARING, RIPPING OR BREAKING.

- DEFLECTION = STRAIN → HOW MUCH DID IT GO DOWN (INTERNAL STRESS)
- BENDING
  - ALLOWABLE STRESS of STEEL A36 = 22 ksi → LOOK IN THE MANUALS
    A50 = 30 ksi



E = MODULUS OF ELASTICITY
= THE SLOPE OF THE LINE
= STEEPER RISE TO RUN = STRONGER MATERIAL
RESISTS LOTS OF THINGS

- INDEX OF DEFORMATION

= psi, ksi

E: WOOD = 1,500,000 psi — DIFF. SPECIES OF WOOD
CONC = 3-5,000,000 psi — CONC IS DIFFERENT
STEEL = 29,000,000 psi — ALL STEEL = SAME E!

- **AXIAL LOADS** : LOADS ALONG THE AXIS

  - DIRECT STRESS EQUATION = $F = \frac{P}{A}$

    "CALCULATED"

F = AXIAL STRESS (psi, ksi, PSF, KSF)

P = AXIAL LOAD (#, K)

F_c = COMPRESSION

F_T = TENSION

- F = AXIAL STRESS (psi, ksi, PSF, KSF)
  P = AXIAL LOAD (#, K)
  A = CROSS SECTIONAL AREA (in^2, FT^2)

UNIT STRAIN = ① $\frac{\Delta L}{L_o}$

"MEASURED"

ΔL = CHANGE IN LENGTH (in)
L_o = ORIGINAL LENGTH BEFORE LOADED (FT) (CONVERT TO INCHES)
* DON'T USE FEET

- **MODULUS OF ELASTICITY**

RISE = STRESS $E = \frac{\text{STRESS}}{\text{STRAIN}}$ $\frac{P/A}{\Delta L/L_o}$ ⟶ ② $\Delta L = \frac{P L_o}{A E}$

Δ = DELTA

α STEEL = .0000065

ΔL = CHANGE IN AXIAL LENGTH (in)
P = AXIAL LOAD (#, K)
L_o = ORIGINAL LENGTH (~~FT~~ ⟶ in) (UNDEFORMED)
A = CROSS SECTIONAL AREA (in^2)
E = MODULUS OF ELASTICITY (psi, ksi)

- **TEMPERATURE CHANGES**

  - CHANGE IN LENGTH DUE TO TEMPERATURE

$$\Delta L = \alpha (\Delta t) L_o$$

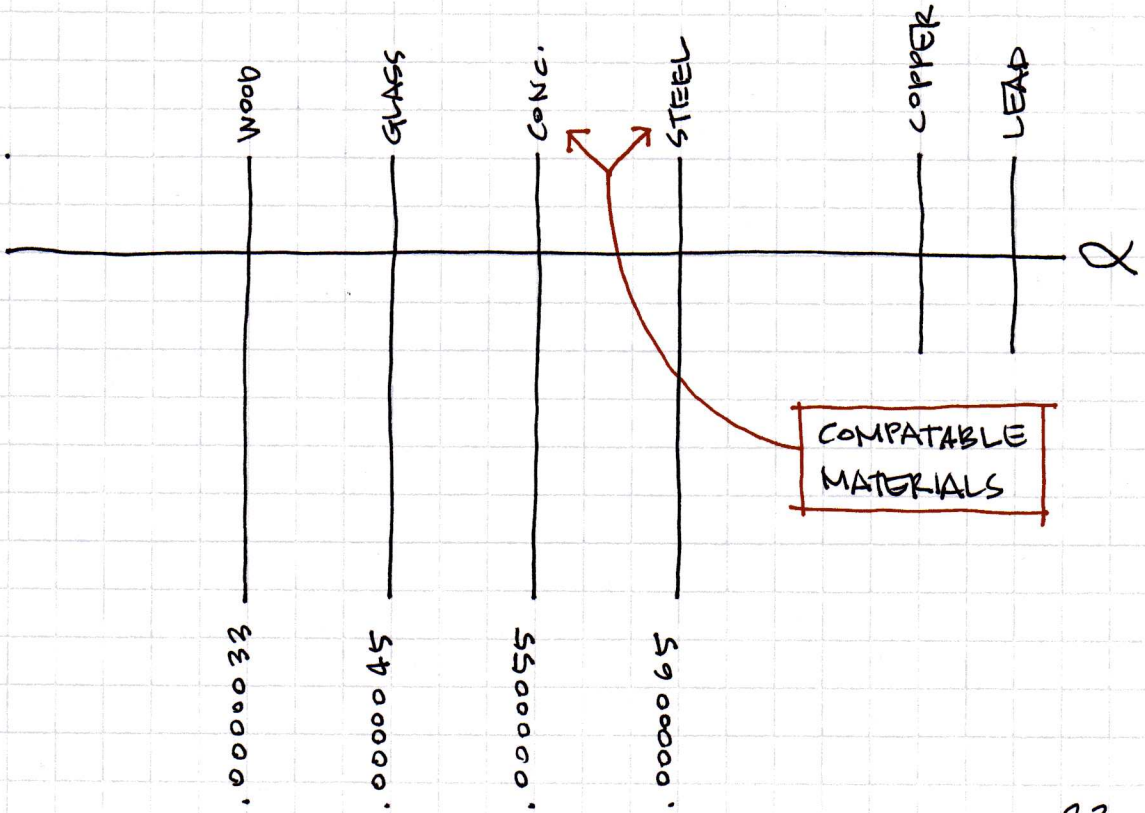
ALPHA — THETA

$$\Delta L = \alpha (\Delta t) L_o$$

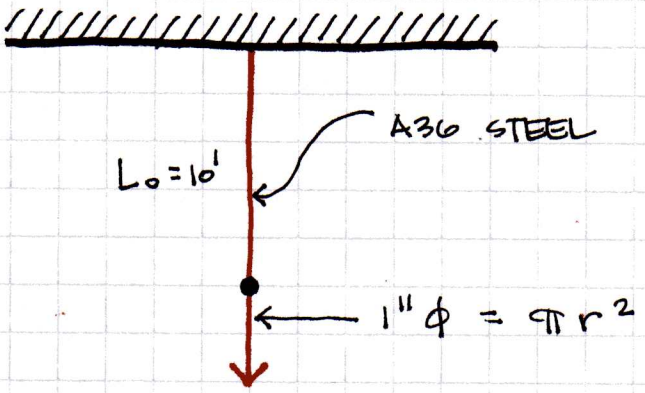
α = COEFFICIENT OF THERMAL EXPANSION
ΔT = CHANGE IN TEMPERATURE
(TEMP. DIFFERENTIAL = F°)
L_o = ORIGINAL LENGTH (in)
ΔL = SHORTENING BASED ON TEMPERATURE.

- GLASS
- WOOD
- CONCRETE
- ① ALUMINUM — EXPANDS MORE THAN STEEL (HIGHEST α)
- ② STEEL — NEXT HIGHEST
- ~~LEAD~~
- ~~COPPER~~ — EXPANSION & CONTRACTION MOST (METALS)
- CARDBOARD

α



α STEEL = .0000065



$E = 29,000,000$

$F_T = 22$ KSI OR 22,000 PSI

- CALCULATE ALLOWABLE TENSILE LOAD ON THIS ROD

$$F = \frac{P}{A}$$

$F = \frac{P}{A}$ $\quad P = F_T \times A$

$P = 22{,}000 \frac{\#}{in^2}$ OR 22 KSI

$A = \pi r^2$

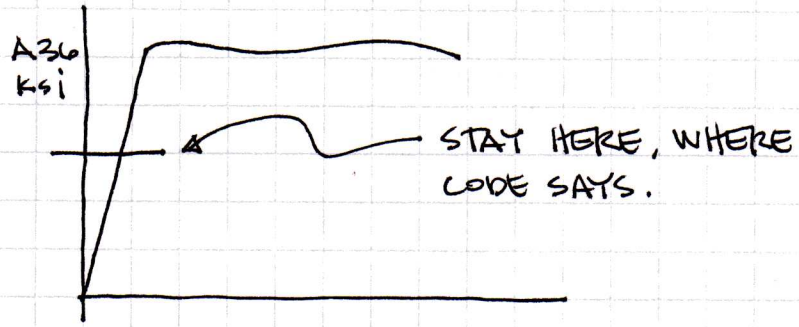
$\pi r^2 = \pi \left(\frac{d}{2}\right)^2$

$$\text{AREA} = \frac{\pi d^2}{4} = \frac{\pi (1)^2}{4} = .78 \text{ SQ.IN } (.78\ in^2)$$

$F = \frac{P}{A}$

$P = F_T \times A$

$P = 22{,}000 \frac{\#}{in^2} \times .785\ in^2$



$P = 17{,}270\#$ * DON'T GO OVER 22,000# !

IF.... 14,000 # CALCULATE ACTUAL STRESS $F = \frac{P}{A} = \frac{14{,}000\#}{.785\ in^2}$

$= 17{,}834$ PSI

IF $P = 15{,}000\ \#$

$1'' \phi = (.785\ in^2)$

$L_o = 10'$

* CALCULATE ELONGIATION = $\boxed{\Delta L = \frac{PL_o}{AE}} = \frac{15{,}000\ \# \times 10'}{.785\ in^2 \times 29{,}000{,}000\ psi}$

$\boxed{\Delta L = \frac{PL_o}{AE}}$ $\quad \Delta = \frac{15{,}000\ \# \times 10\ FT}{.785\ in^2 \times 29{,}000\ ksi}$ (WATCH YOUR UNITS!)

$\boxed{10\ FT \times 12''/FT = 120\ in}$

$\Delta = \frac{15\ K \times 120\ in}{.785\ in^2 \times 29{,}000\ ksi}$

(CONVERT K TO #) $\quad \Delta = \frac{15{,}000\ \# \times 120\ in}{.785\ in^2 \times 29{,}000{,}000\ psi} = \frac{1{,}800{,}000}{22{,}765{,}000}$

$\Delta = .079''$

PUNCH IN 29 EE 6 ON CALCULATOR.

• CALCULATE UNIT STRAIN = ELONGIATION STRETCH

$\frac{\Delta L}{L_o} = \frac{.079\ in}{10\ FT} = \frac{.079\ in}{120\ in} = .000658\ in/in$ ORIGINAL LENGTH

(CONVERT 10 FT TO INCHES)

• NO EXTERNAL LOAD APPLIED

* TEMPERATURE CHANGE: $40° \rightarrow 90° = 50°$ CHANGE

$\boxed{\Delta L = \alpha (\Delta T) L_o}$

$\boxed{\alpha\ STEEL = .0000065}$

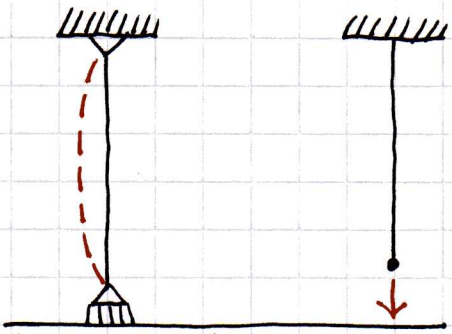
$\boxed{10' = 120''}$

$= .0000065 \times (50°) \times 120\ in$

$= .039\ in$ (THE ROD ELONGIATES)

$120'' + .039'' = 120.039''$

- COLUMN

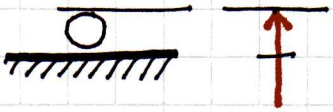


$$F = \frac{P}{A}$$

- SUPPORT CONDITIONS

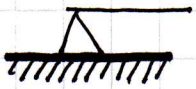
PG 69

- ROLLER SUPPORT

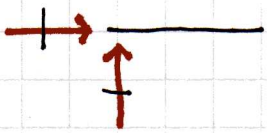


- PREVENTS UP & DOWN MOVEMENT. IT MOVES HORIZONTALLY ONLY

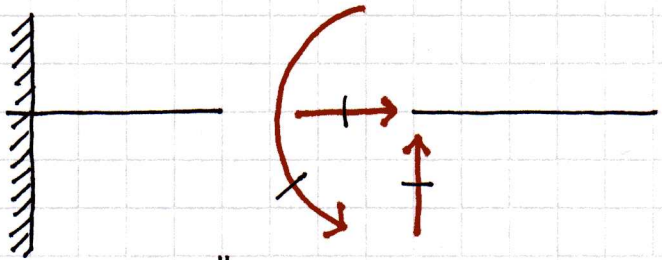
- PIN / HINGE SUPPORT



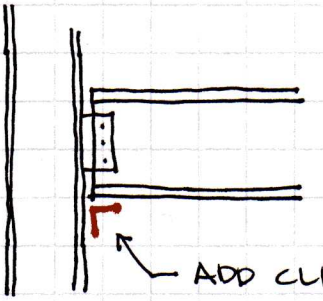
- NO UP & DOWN OR LEFT OR RIGHT



- FIXED SUPPORT
  - MOMENT RESISTING SUPPORT
  - RIGID SUPPORT
  - CANTILEVER SUPPORT



- WEB IS FOR SHEAR
- FLANGES IS FOR ROTATION
- WELD FLANGE = MOMENT CONNECTION



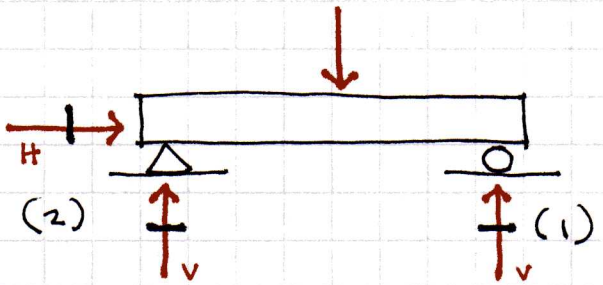
= RIGID CONNECTION

- LONG SPAN ⟶ DEALS WITH EXPANSION & CONTRACTION

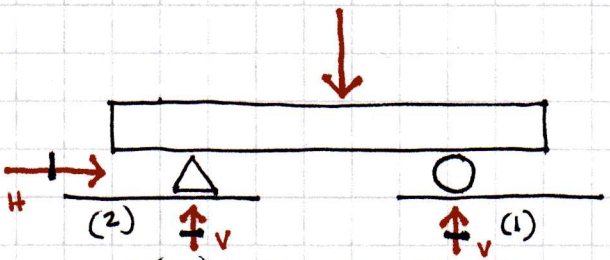
· PG 69 IN GREEN BOOK

· STATICALLY DETERMINATE

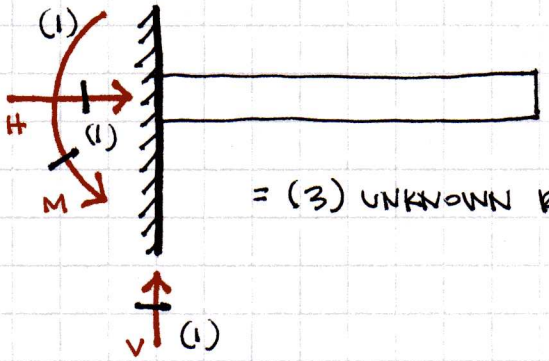
= (3) UNKNOWN REACTIONS



= (3) UNKNOWN REACTIONS



= (3) UNKNOWN REACTIONS



= (3) UNKNOWN REACTIONS

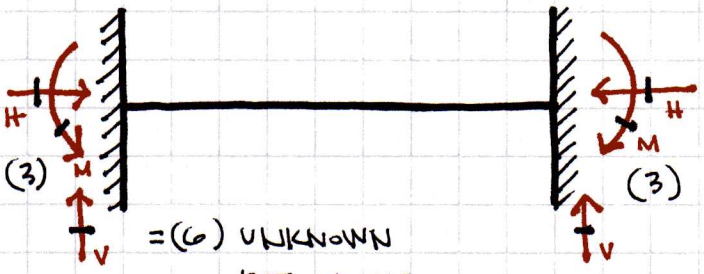
H = HORIZONTAL
V = VERTICAL
M = MOMENT

· STATICALLY INDETERMINATE

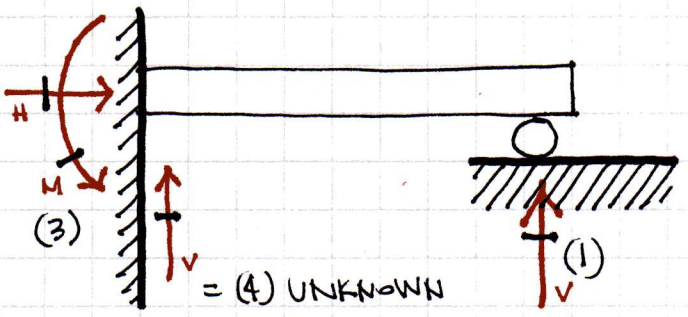
= (4) UNKNOWN REACTIONS

· STRUCTURES ARE CALLED STATICALLY INDETERMINATE WHEN:

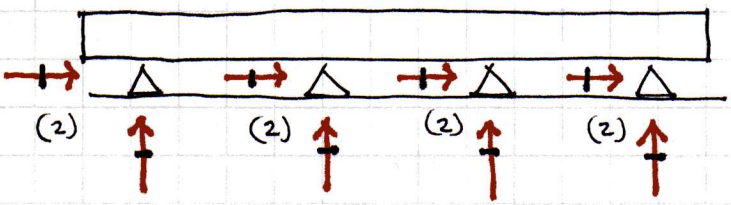
1. THEY ARE STABLE
2. THE EXTERNAL & INTERNAL FORCES DUE TO A GIVEN LOADING CAN NOT BE COMPLETELY CALCULATED USING THE EQUATIONS OF EQUILIBRIUM.



=(6) UNKNOWN REACTIONS



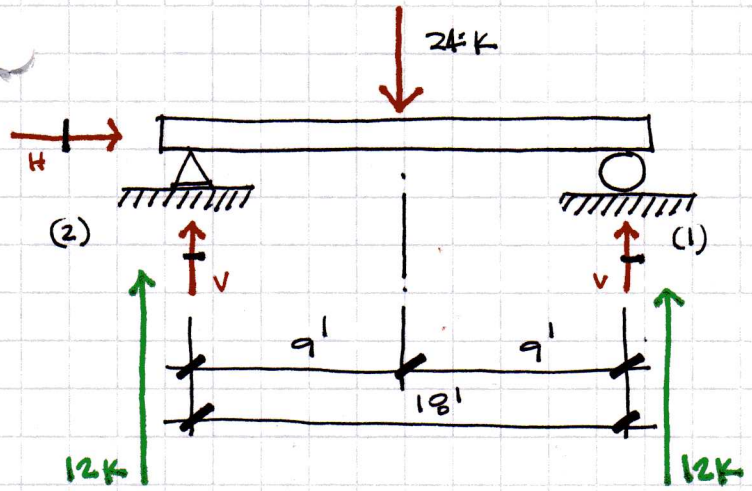
= (4) UNKNOWN REACTIONS



= (8) UNKNOWN REACTIONS

"A CONTINUOUS BEAM"

• CALCULATE REACTIONS

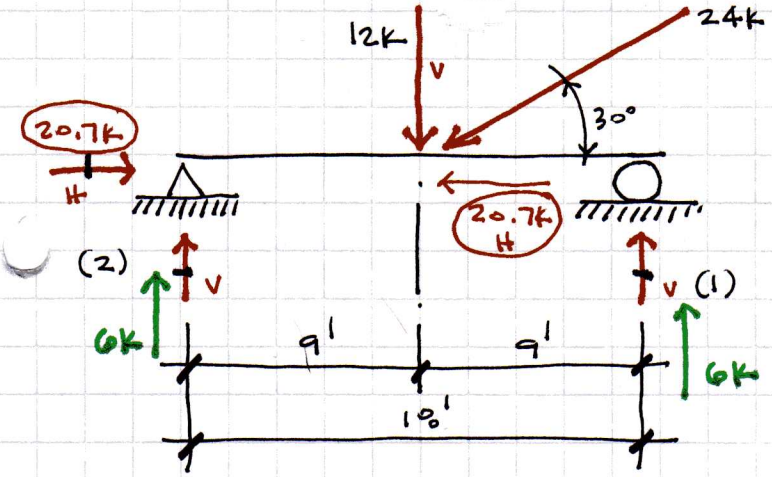


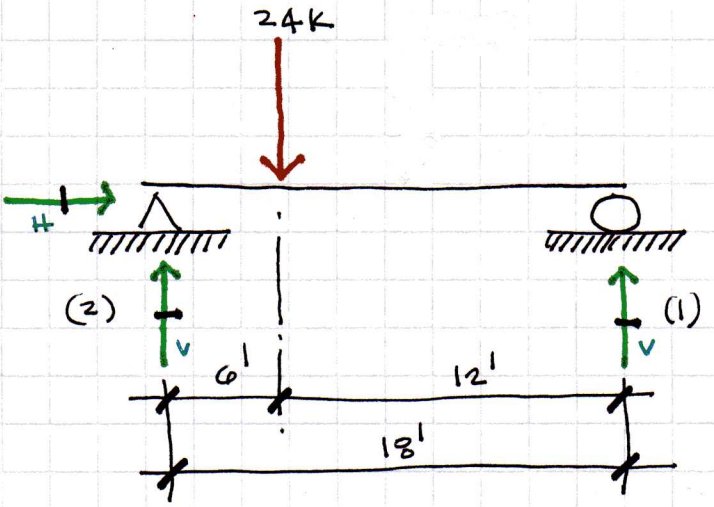
$\Sigma F_H = 0$

$\Sigma F_V = 0$

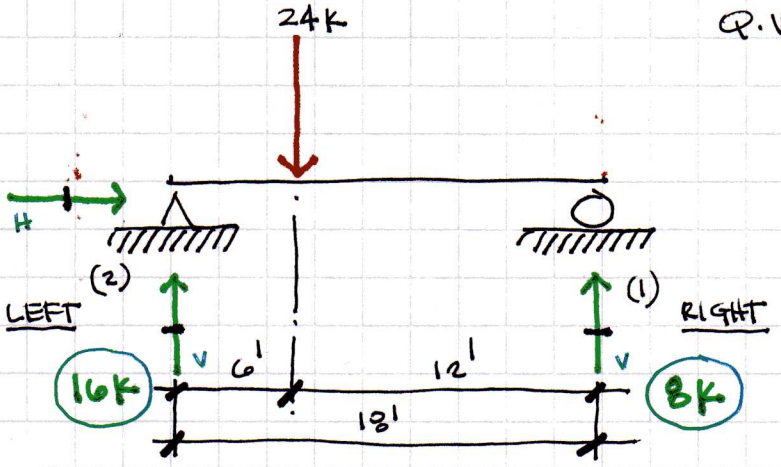
$\Sigma M = 0$

(3) UNKNOWN REACTIONS
= STATICALLY DETERMINATE





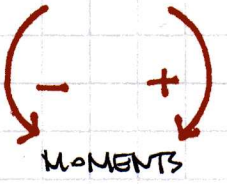
(3) UNKNOWN REACTIONS



(3) UNKNOWN REACTIONS

Q. WHICH REACTION IS BIGGER? LEFT OR RIGHT

$\Sigma M_{LEFT} = 0$



$= (24K \times 6') - (R \times 18') = 0$

$24 \times 6 = 18 \times R$

$R = 24K \times \frac{6'}{18'}$

$24K \times \frac{6}{18}$

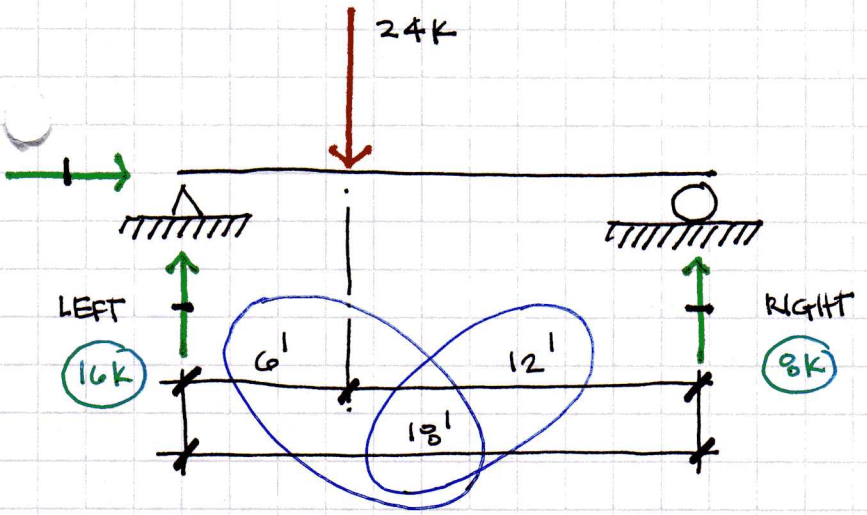
$-\frac{24K}{8K}$

$16K$

$\boxed{R = 8K}$

* ROTATION IS ON THE JOINT.

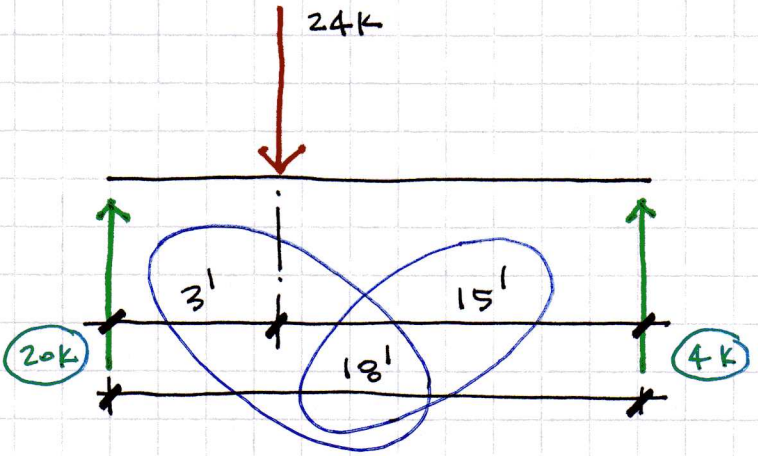
• LETS CALCULATE THIS PROBLEM QUICKER!



$24k \times \frac{6'}{18'} = 8k$

$24k \times \frac{12'}{18'} = 16k$

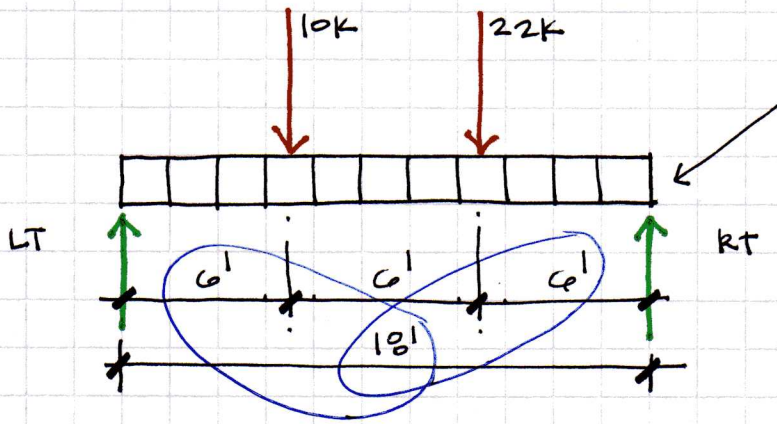
16 + 8 = 24



$24k \times \frac{3'}{18'} = 4k$

$24k \times \frac{15'}{18'} = 20k$

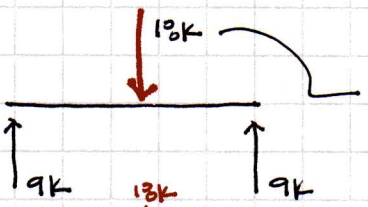
20 + 4 = 24



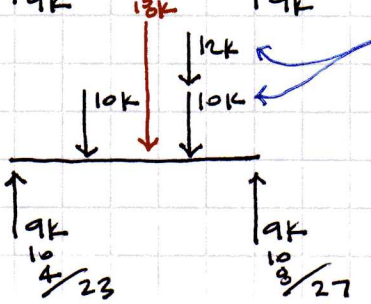
A UNIFORM LOAD = ω

ω = 1K/FT

W = 18K (18' x 1K/FT)



$10K \times \frac{6'}{18'} = 3.33$	$10K \times \frac{12'}{18'} = 6.67$
$22K \times \frac{6'}{18'} = 7.33$	$22K \times \frac{12'}{18'} = 14.67$

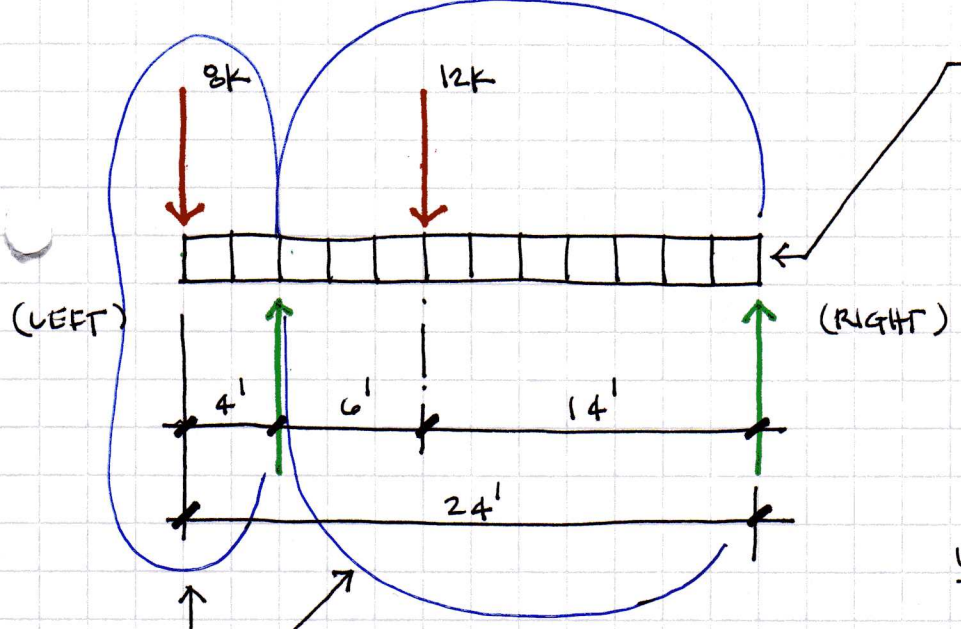


(BREAK 22K INTO 12+10)

* ISOLATE THE 12K ↓ LOAD

$12K \times \frac{6'}{18'} = \frac{4K}{R}$ $12K \times \frac{12'}{18'} = \frac{8K}{L}$

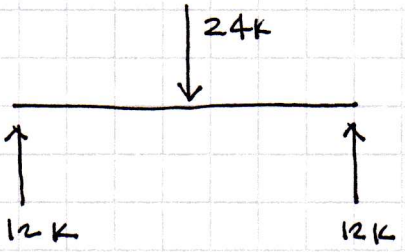
18K = 9K + 9K	20K = 10K + 10K
12K = 4K + 8K	



UNIFORM LOAD
$w = 1K/FT$
$W = 24' \times 1K/FT = 24K$

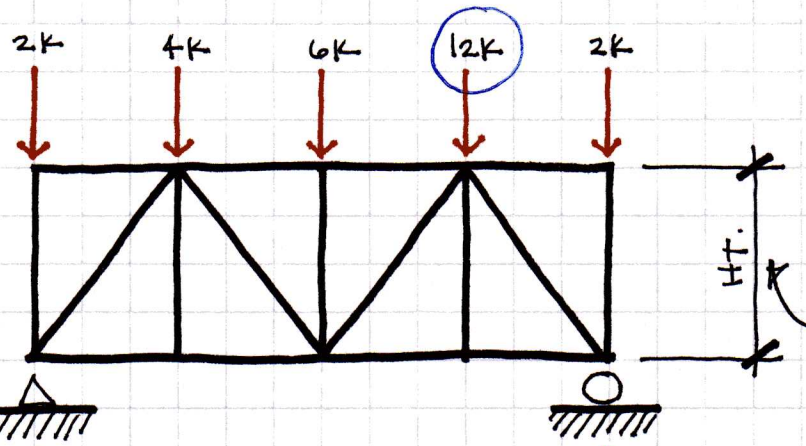
8K STAYS ON THE LEFT

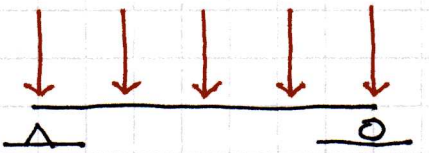
UNIFORM LOAD = 24K



* BREAK THIS INTO (2) AREAS

LEFT SIDE = 8K + 4 = 12K AT LEAST





YOU DON'T NEED TO KNOW THE HEIGHT UNTIL YOU PUT ON A HORIZ. LOAD.

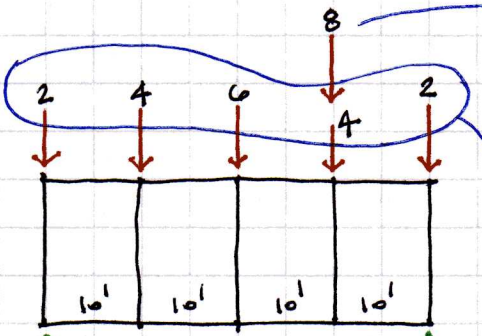
(2) LEFT

(3) UNKNOWN REACTIONS = STATICALLY DETERMINATE

(1) RT.

EQ. EQ. EQ. EQ.

· LOOK AT THE PROBLEM
THE RIGHT SIDE IS BIGGER

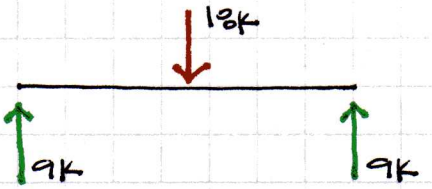


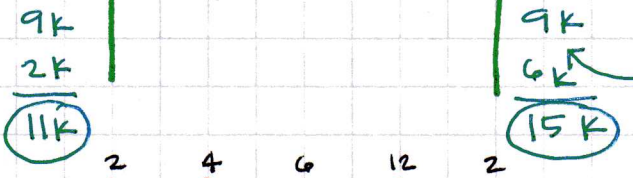
$\frac{10'}{40'} \times 8K = 2K$

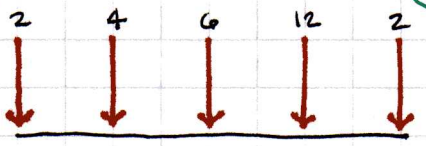
$\frac{30}{40} \times 8K = 6K$

* REMEMBER: RIGHT SIDE IS BIGGER

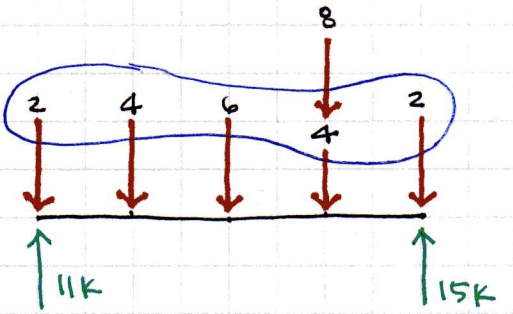
$2 + 4 + 6 + 4 + 2 = 18K$





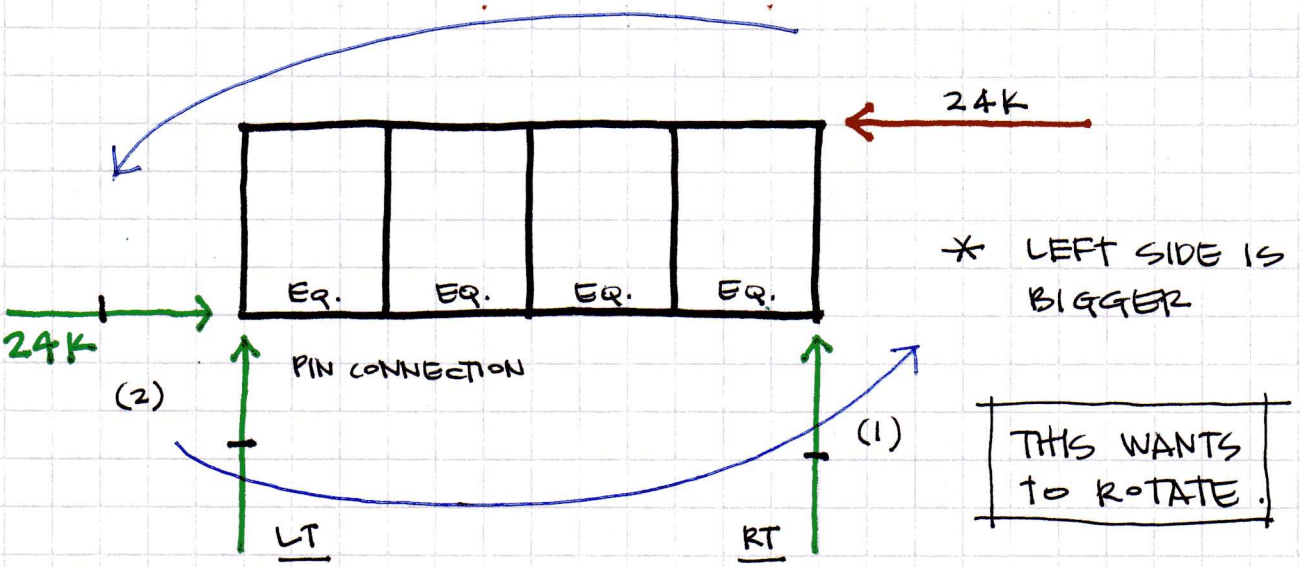


CONVERT TO THIS



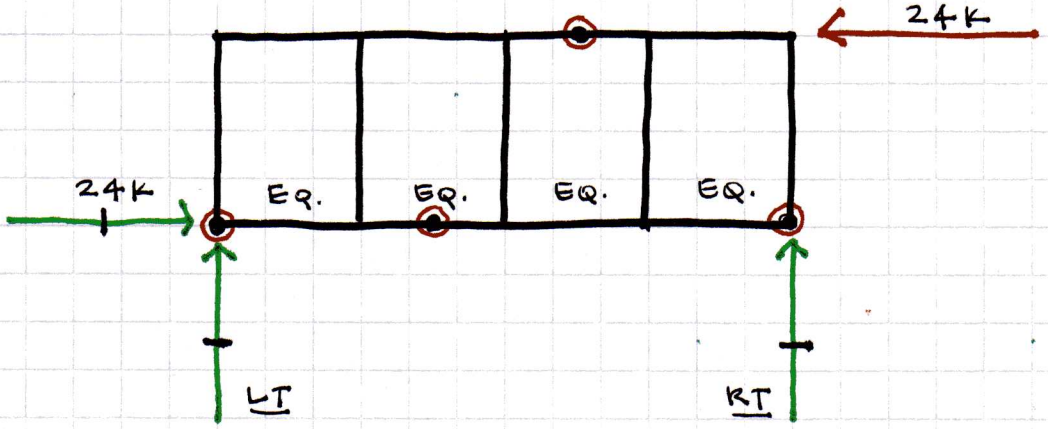
* LOOK FOR SYMMETRY IN THE REACTION!

· ADD A HORIZONTAL LOAD !



* LEFT SIDE IS BIGGER

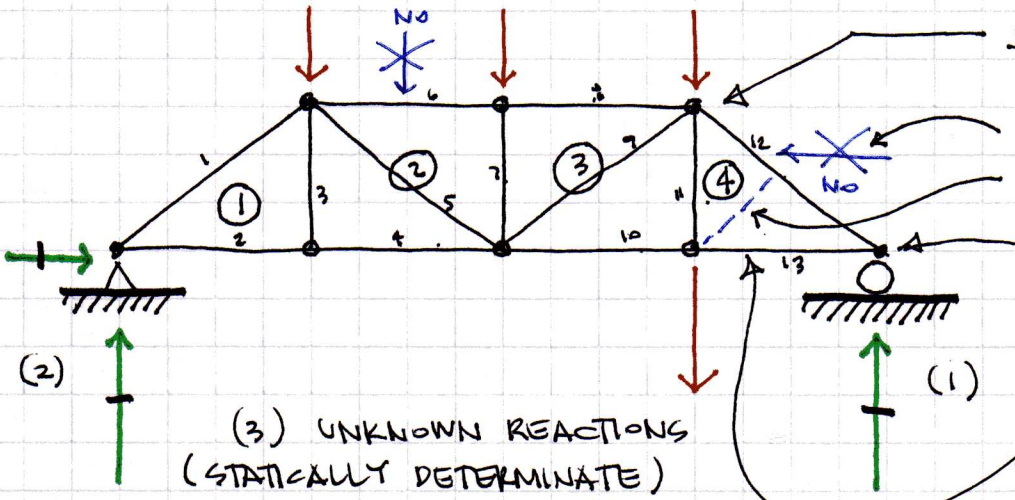
THIS WANTS TO ROTATE.

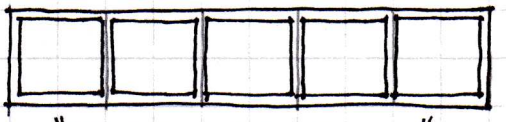


- **TRUSSES** = ABOUT TENSION & COMPRESSION ONLY!

HONEST TRUSS

= ALL JOINTS ARE PINNED
- THERE WILL BE A MOMENT, WHICH YOU ALLOW
- ROTATION IS ALLOWED.





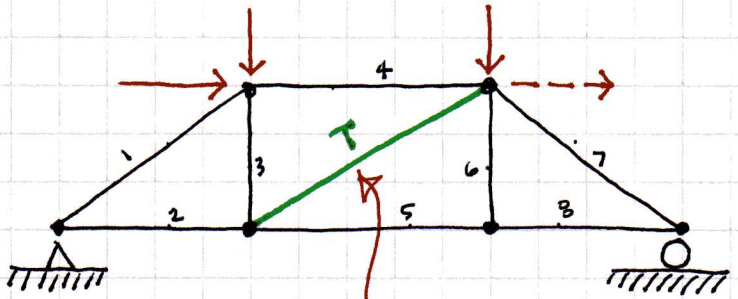
"VERENDELL TRUSS"
(ALL JOINTS ARE FIXED)
= 1 BEAM ← WELDED

- LOAD ON PANEL POINTS ONLY!
- PURE AXIAL LOADS = TENSION (T) OR COMPRESSION (C)
- $M + 3 = j \times 2$

M = # MEMBERS
j = JOINTS
> TRIANGULATION

IF... M = 13 j = 8

$M = 13 + 3 = 16$
$j = 8 \times 2 = 16$



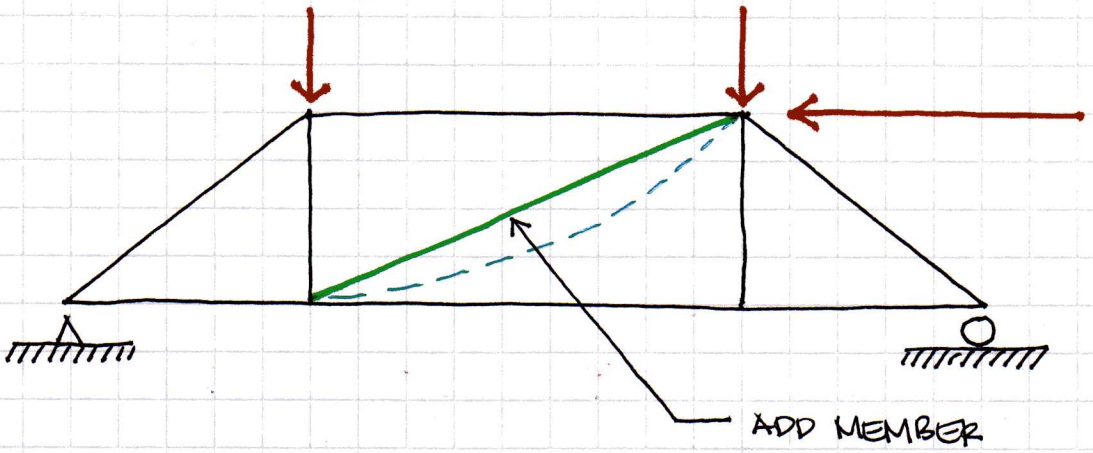
$M = 8 + 3 = 11$
$j = 6 \times 2 = 12$
> DOESN'T WORK
(IT WILL RACK!)

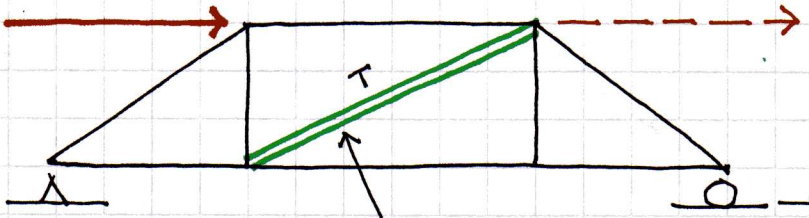
MUST ADD A MEMBER

$M = 8 + 1 = 9$ MEMBERS

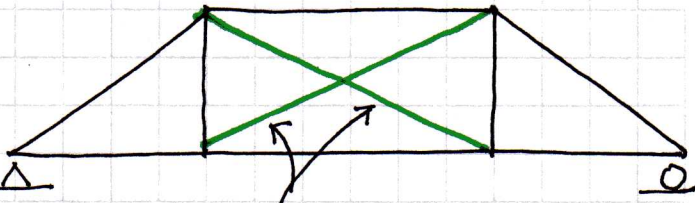
$M = 9 + 3 = 12$
$j = 6 \times 2 = 12$
> WORKS!

· HONEST TRUSS

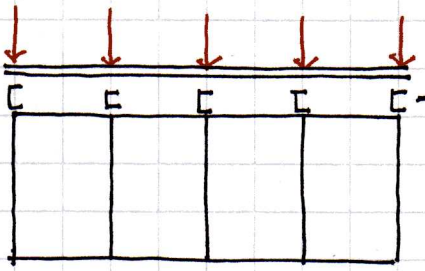




THICK MEMBER HANDLES TENSION & COMPRESSION.

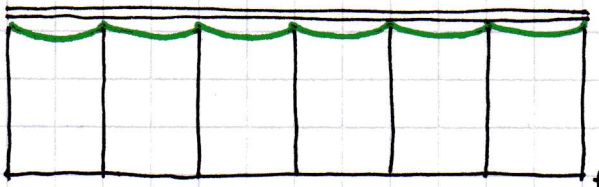


CABLES



ADD PURLINS TO DISTRIBUTE LOADS
· PLACES LOADS ON THE PANEL POINTS

T & C



T, C & BENDING

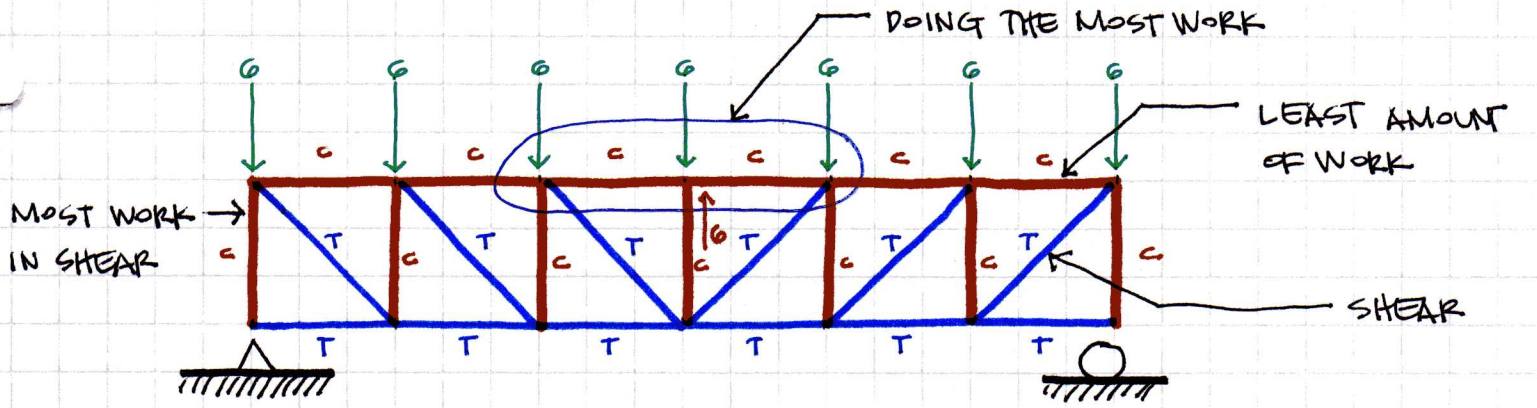
THIS TRUSS BECOMES A BEAM

YOU DON'T WANT THIS!

• NORMALLY LOADED — SIMPLY SUPPORTED

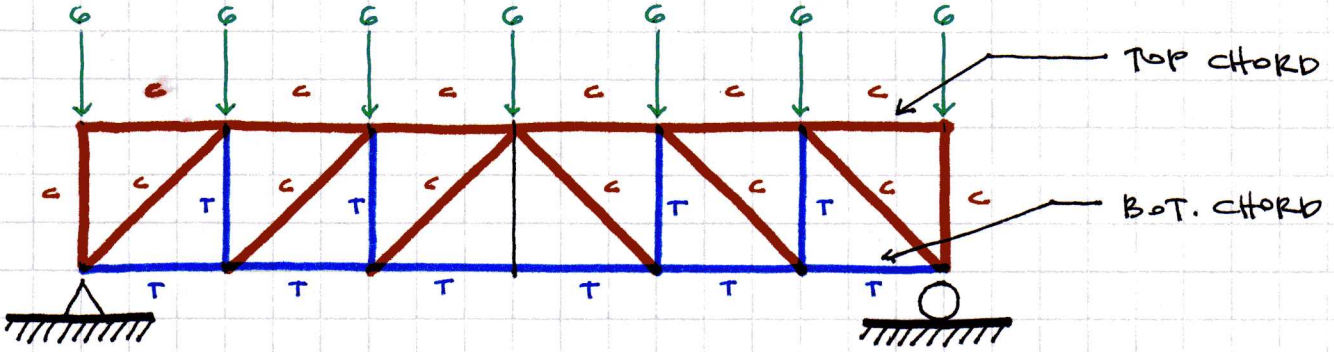
= COMP.

= TENSION



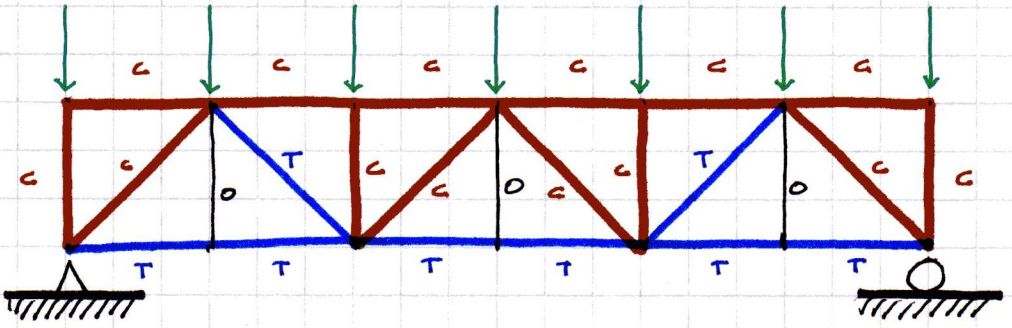
TRUSS A

SMALLEST ⟶ LARGEST



TRUSS B

• TRUSS DOES ONLY T & C ⟶ NO BENDING UNLESS JOINTS ARE WELDED.



TRUSS C

• WIDE FLANGE :

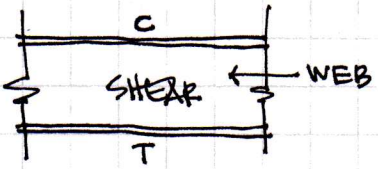
TOP = COMPRESSION

BOT = TENSION

WEB = SHEAR

FLANGE = BENDING

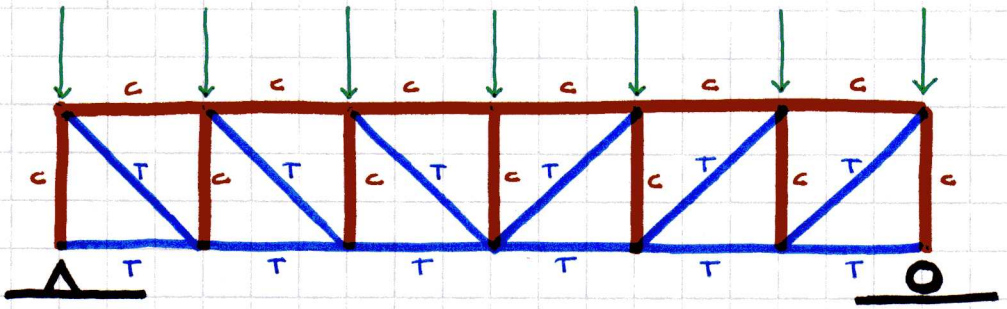
WEB = SHEAR



· SIZE THE MEMBERS OF THE TRUSS :

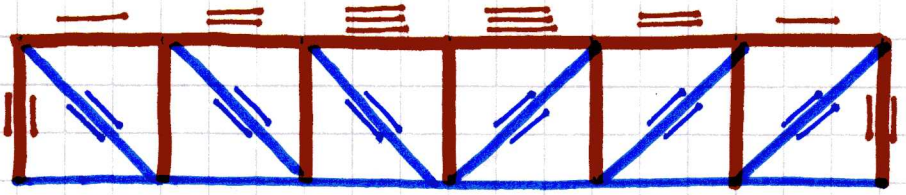
: COMPRESSION

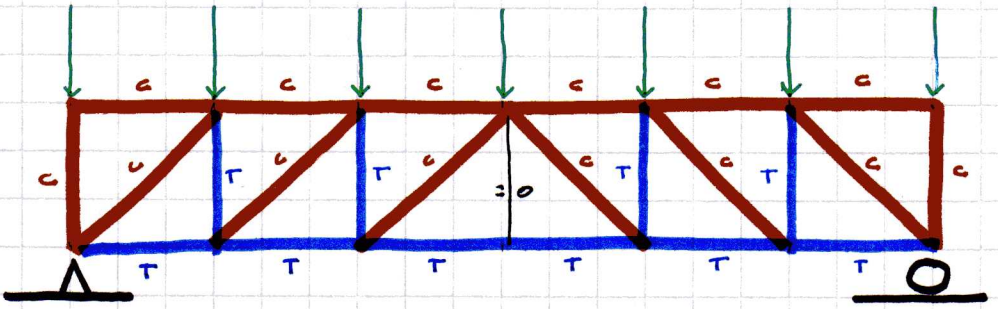
: TENSION



SMALLEST MEMBERS (OUTSIDE) → LARGEST MEMBERS (INSIDE) ← SMALLEST MEMBERS (OUTSIDE)

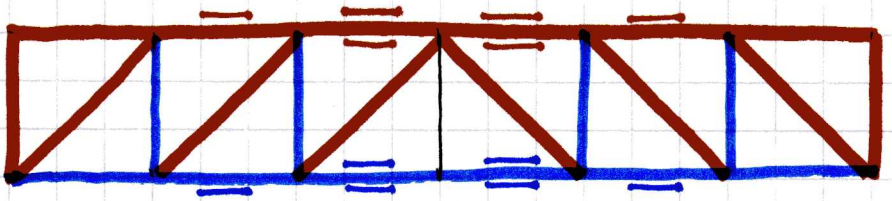
TRUSS A



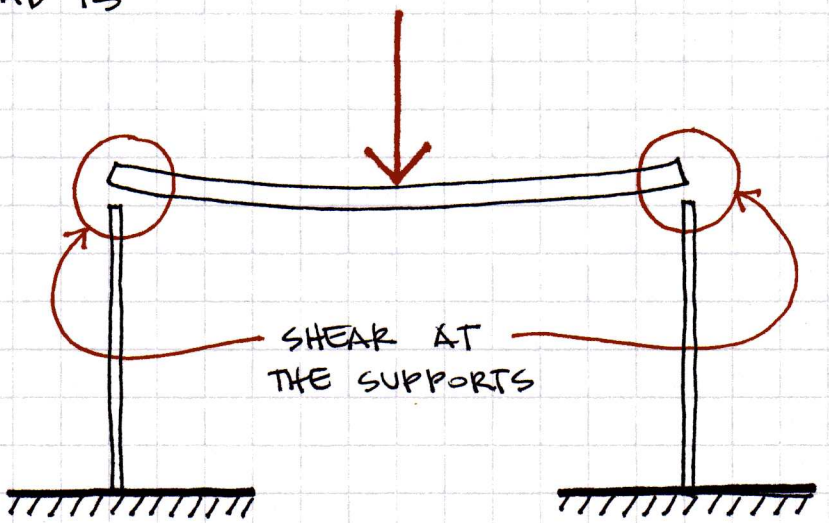


SMALLEST MEMBERS (OUTSIDE) → LARGEST MEMBERS (INSIDE) ← SMALLEST MEMBERS (OUTSIDE)

TRUSS B



- BENDING IS WORSE IN THE MIDDLE WHERE THE LOAD IS



END OF DAY 1

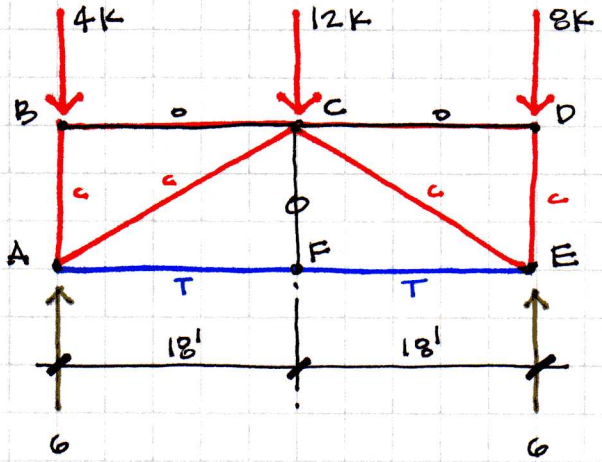
DAY 2 — 1/15/06

ARE

- GO THRU THE BLUE BOOK THIS WEEK
- READ UP ON WOOD, STEEL & CONCRETE.

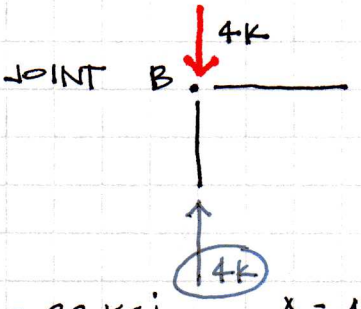
- TRUSSES
  - HONEST TRUSS
  - ALL JOINTS ARE PINNED

PG. 17 GREEN HANDOUT



$$F = \frac{P}{A}$$

FORCE IN A = 4



F_C = ?

F_T = ?

A36 = 22 KSi STEEL

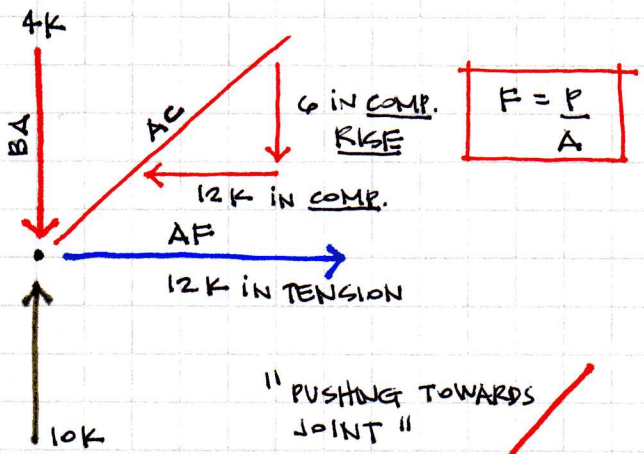
$A = \frac{4000\#}{22{,}000\#}$

SHRINKS = $\Delta L = \frac{PL}{AE}$ $E = 29{,}000{,}000$ psi

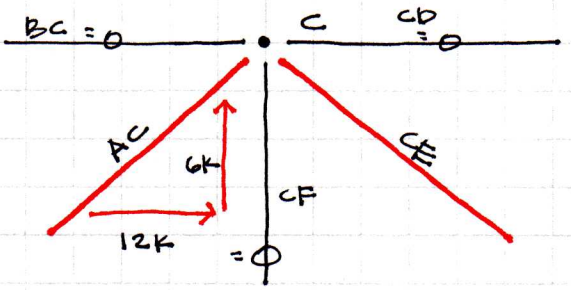
- ZOOM INTO JOINTS !

METHOD OF JOINTS = SUM HORIZ. & VERTICAL = 0

METHOD OF SECTIONS

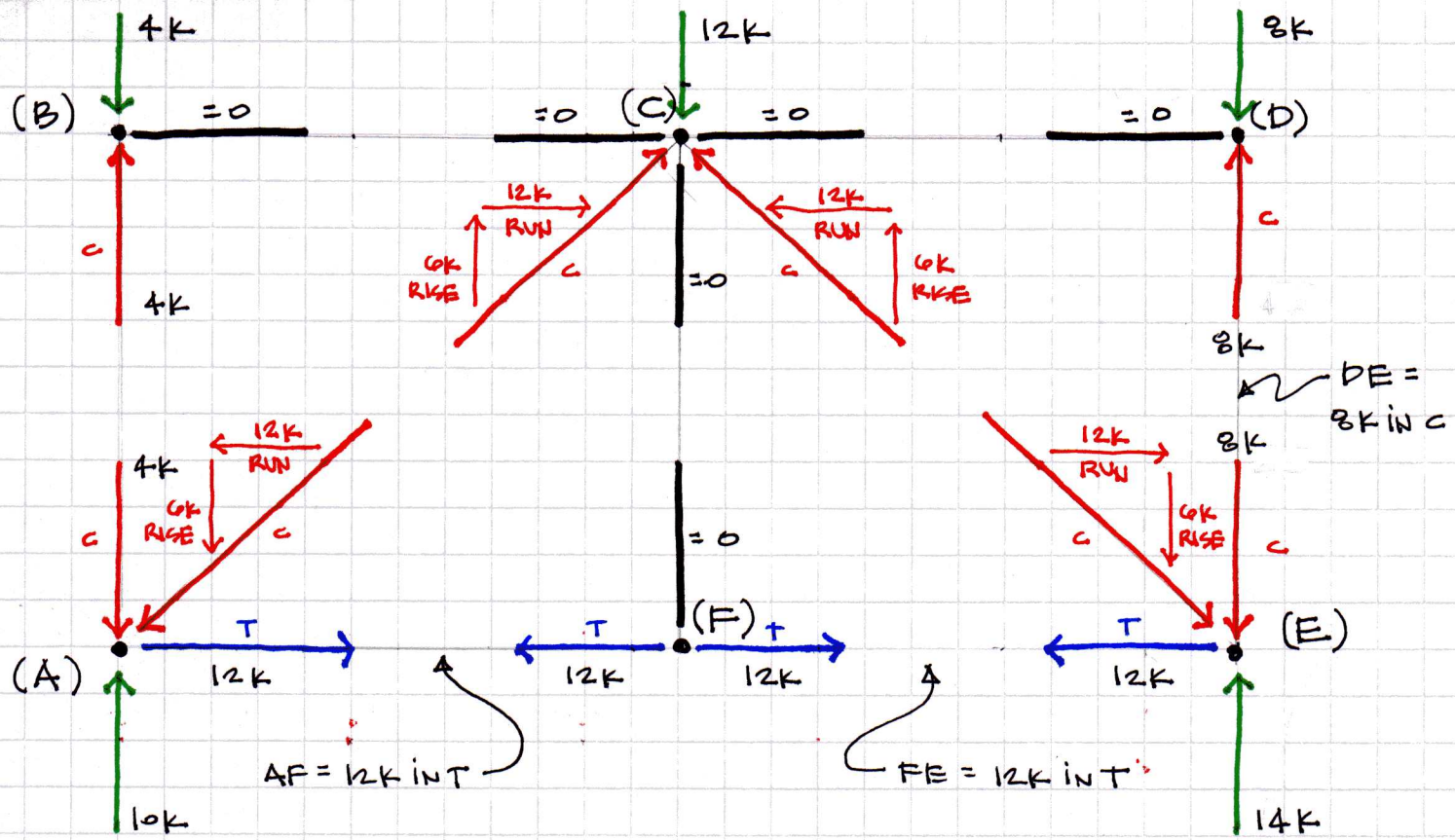


$F = \frac{P}{A}$



"PUSHING TOWARDS JOINT" → COMPRESSION

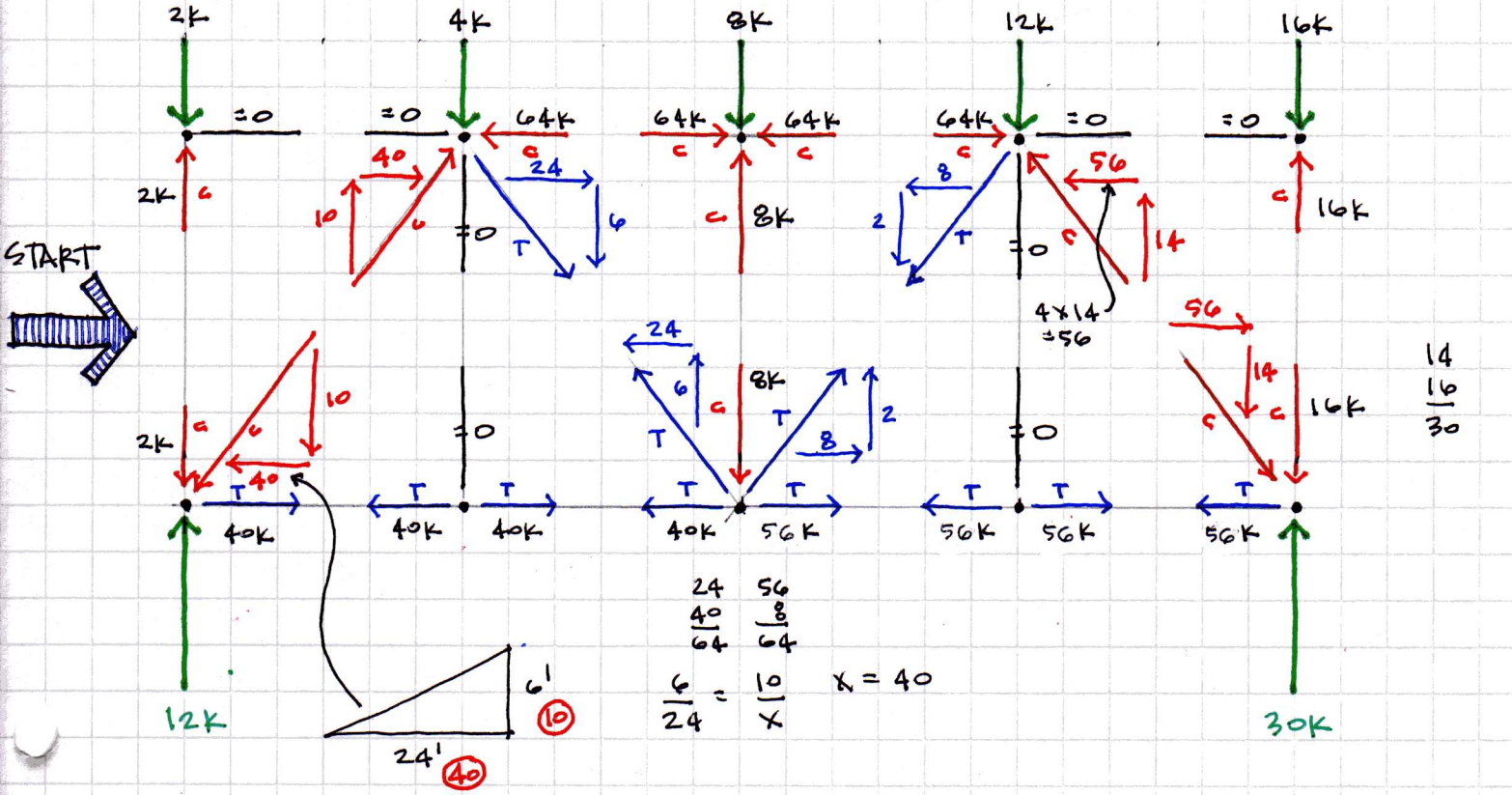
"PULLING AWAY FROM JOINT" → TENSION



: COMPRESSION

: TENSION

PG. 17 GREEN HANDOUT



24 56
40 8
64 64

$\frac{6}{24} = \frac{10}{x}$ $x = 40$

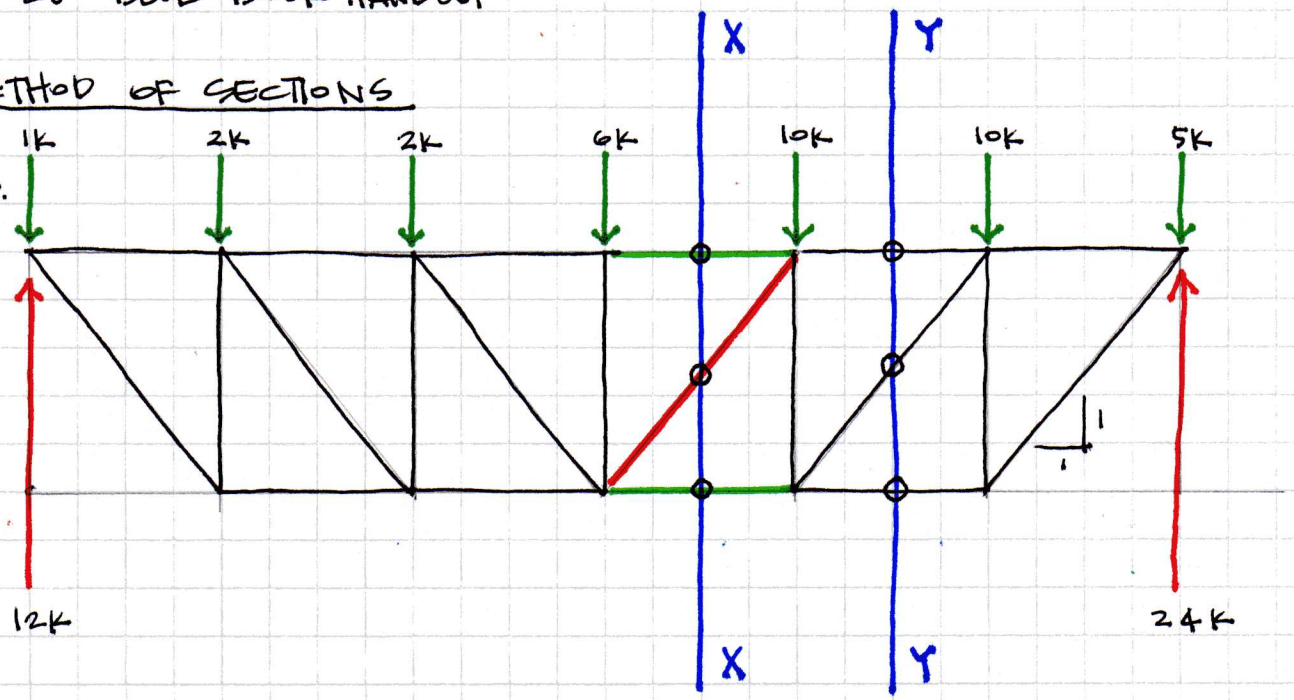
14
16
30



- PG 28 BLUE BOOK HANDOUT

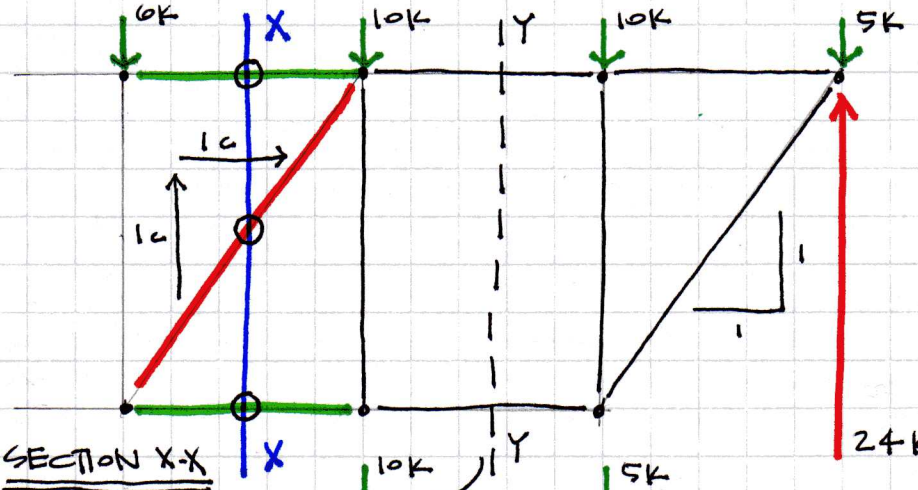
METHOD OF SECTIONS

#16.



- LOAD IS NOT EVEN
- DONT ASSUME TENSION YET!

- SECTION CUT IN TRUSS — THRU NO MORE THAN (3) MEMBERS!
- MUST BE IN EQUILIBRIUM.



SECTION X-X

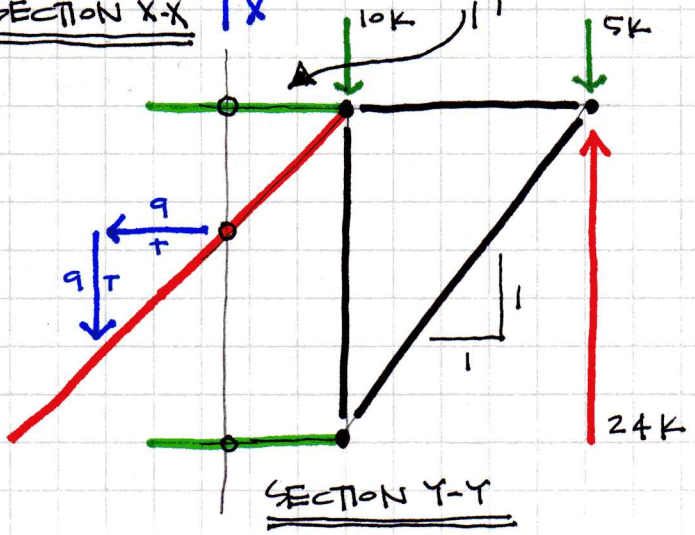
= (3) UNKNOWNS

$25\downarrow + 24\uparrow = 1\uparrow$

$10 + 10 + 5 = 25\downarrow$

$1^2 + 1^2 = \sqrt{\quad}$

= 1.414 IN COMP



SECTION Y-Y

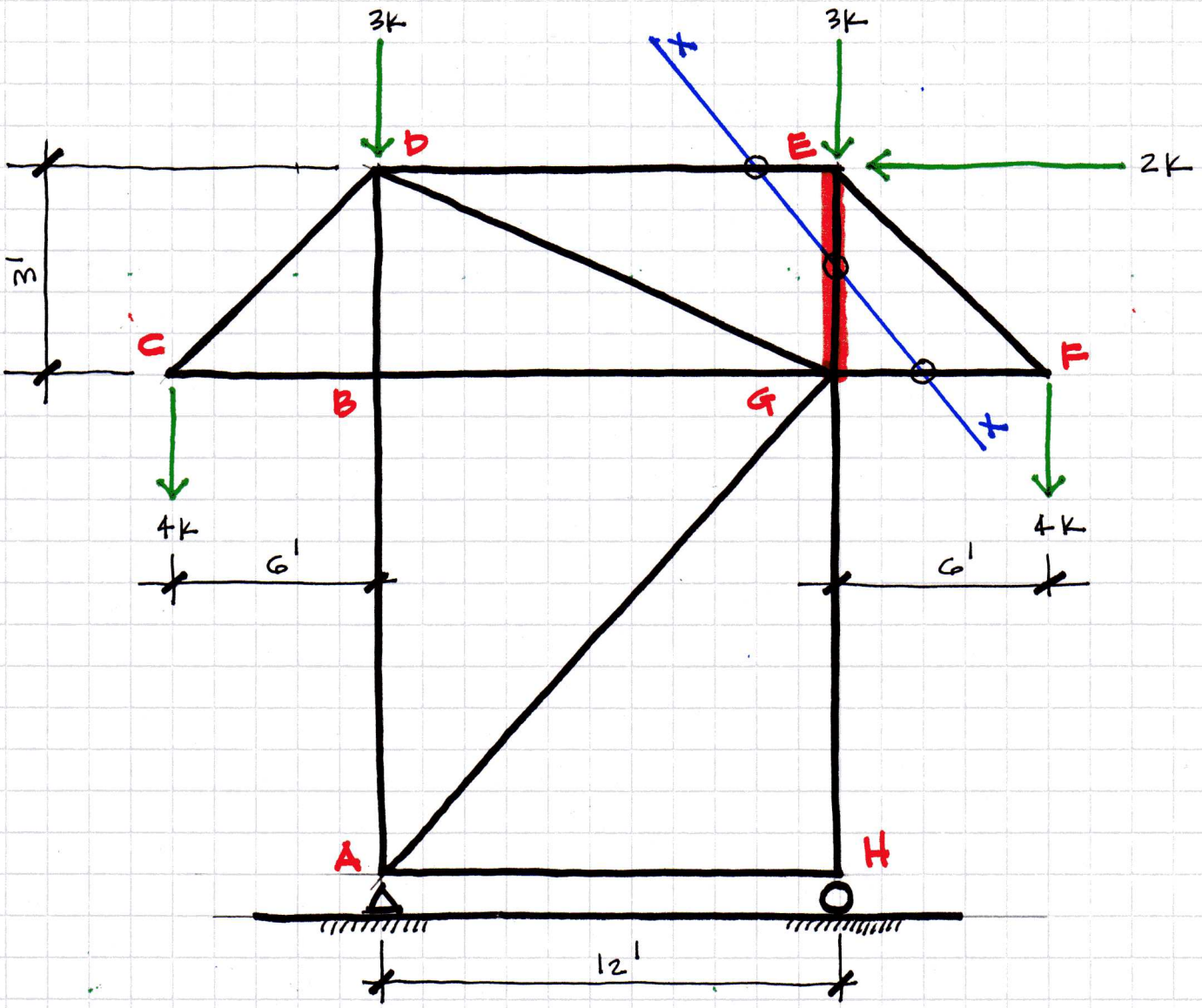
$10 + 5 = 15$

$24 - 15 = 9$

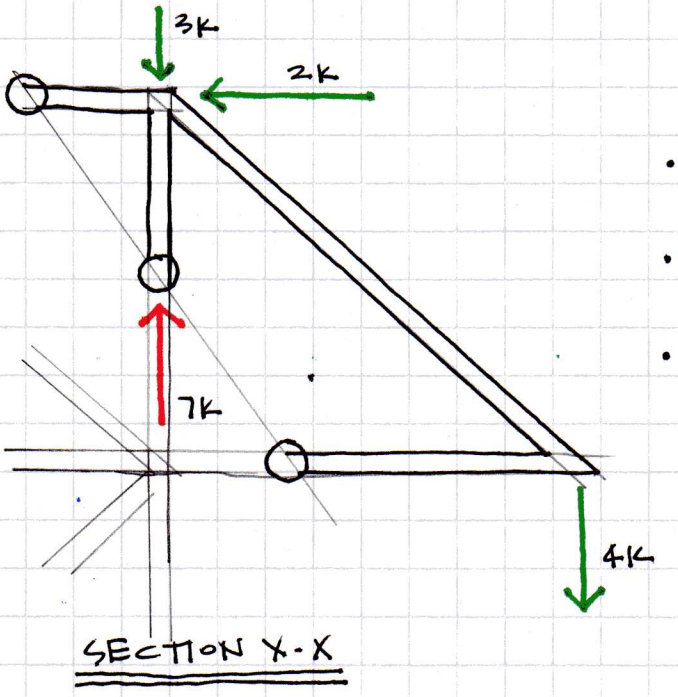
$10 - 5 = 9 = 24\downarrow$

$9^2 + 9^2 = c^2$

= 12.73 IN TENSION



• FORCE IN EG = METHOD OF SECTION * YOU MUST HAVE (3) MEMBERS



SECTION X-X

3 + 4 = 7 ⟶ MUST HAVE 7 ↑

• SUM MUST = 0 7 = 7

• FORCE IS THE LOAD = 7

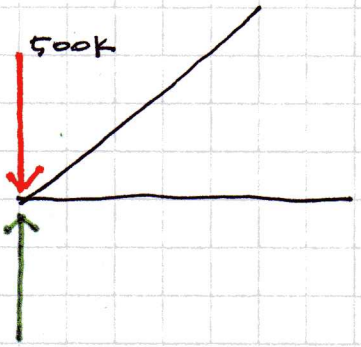
• 7 IN COMPRESSION - ITS POINTING TOWARD THE JOINT

- MAXWELL DIAGRAM

  - GRAPHIC METHOD TO SOLVE A TRUSS
  - USES BOWES NOTATION.

PG 29 BLUE HANDOUT

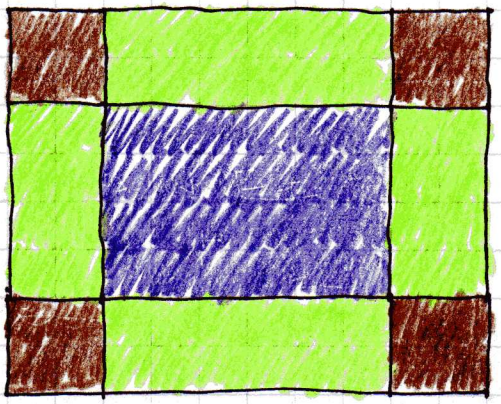
25



"CLASSICAL TERRORISM"

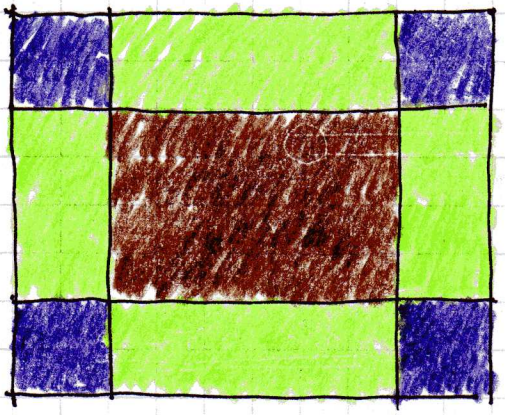


PG 29 # 20
PG 18 GREEN BOOK
PG 19 GREEN HANDOUT

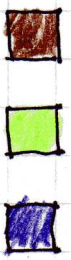


"WIND" WISE ON COLUMNS





"GRAVITATIONAL" WISE ON COLUMNS



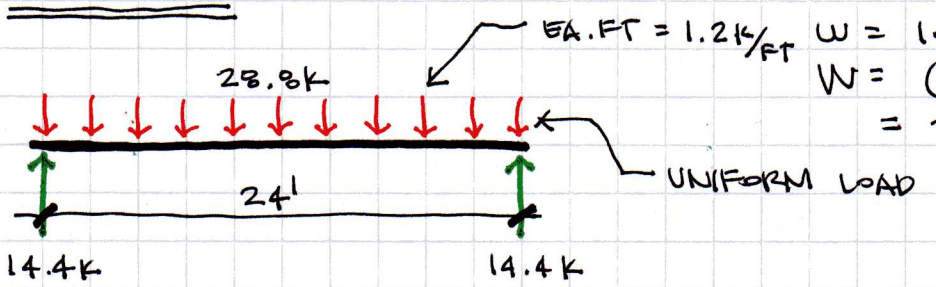
- COLUMN IS AN AXIAL LOADED MEMBER

$$F = \frac{P}{A}$$

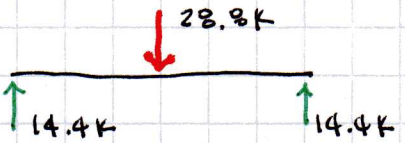
P = LOAD
A = AREA

- FREE BODY DIAGRAMS

BEAM B2



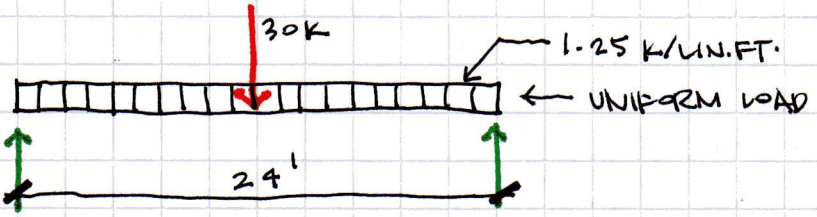
W = 100#/FT²
W = (12' x 24') x 100#/FT²
= 28.8K (GRANDTOTAL)



100#/FT² = INCLUDES THE WEIGHT OF BEAM B2 → (NOT W/ CONCRETE)

w = WT / EACH FOOT W = 28.8K ÷ 24' = 1.2K/FT

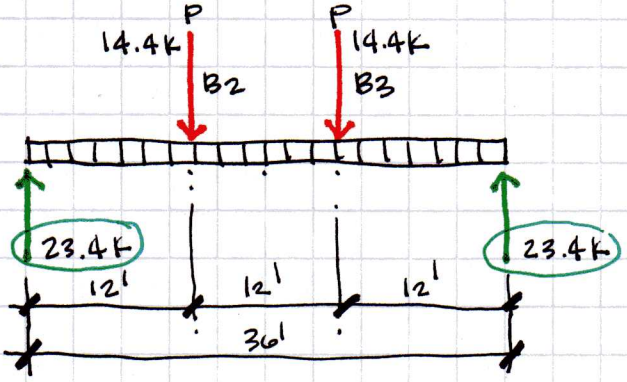
BEAM G5



w = 1.25 K/LIN.FT (UNIFORM LOAD COEFFICIENT)
W = 30K

TRIBUTARY AREA
= 12.5' x 24' = 300 FT²
300 x 100 = 30,000#
OR 30K
30K ÷ 24' = 1.25 K/LIN FT.

GIRDER G4

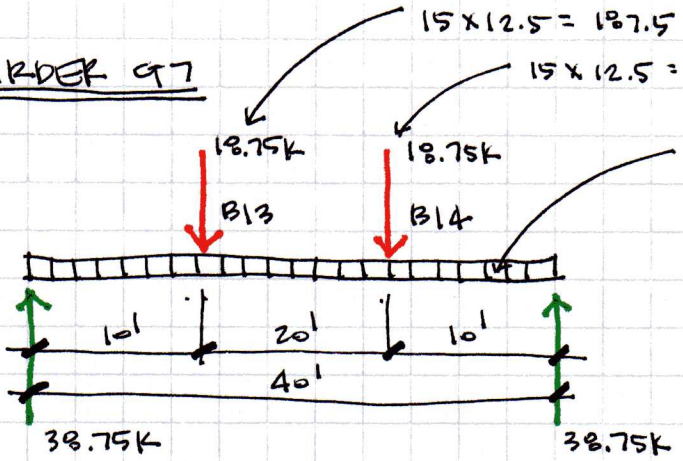


5 X 36 X 100 = 18,000#/FT²
OR 18K/FT² (UNIFORM LOAD)

w = 14.4 + 14.4 + 18/2 = 23.4K
W = 18K

REACTIONS: $\frac{18K + 14.4 + 14.4K}{2}$
= 23.4K

GIRDER G7



10 x 40 x 100 = 40,000 # / FT²
= 40K / FT²

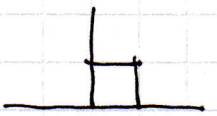
187.5 x 100 = 18.75 K

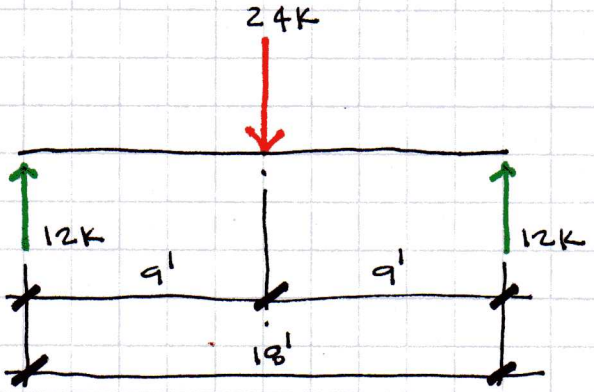
$\frac{18.75 + 18.75}{2} + 40 =$ 38.75

w = 38.75
W = 40K

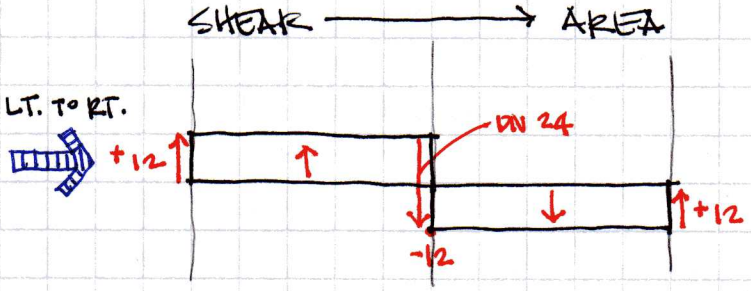
SHEAR

- SHEAR ALONG A BEAM, GIRDER OR JOIST IS DEFINED AS THE SUM OF FORCE TO THE LEFT OF ANY LOCATION ALONG THE BEAM.





- REACTION = 12 & 12 ↑ UP
- SHEAR IS WORST AT THE ENDS OR SUPPORTS.
- MAX SHEAR IS AT THE SUPPORT



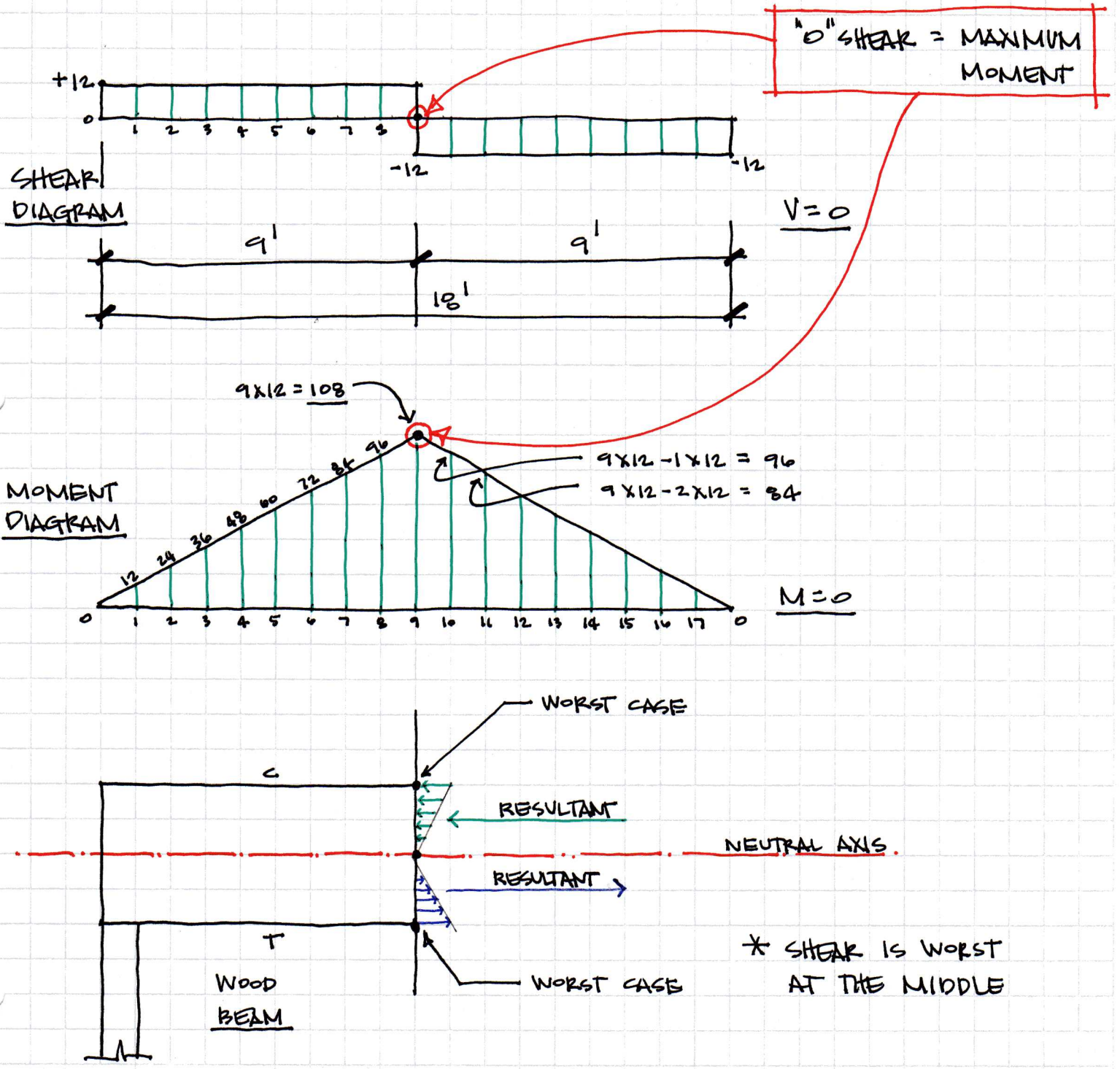
- SHEAR WILL DICTATE AREA OF BEAM
- BENDING MOMENT DETERMINES THE DEPTH OF THE BEAM.
- SHEAR = V

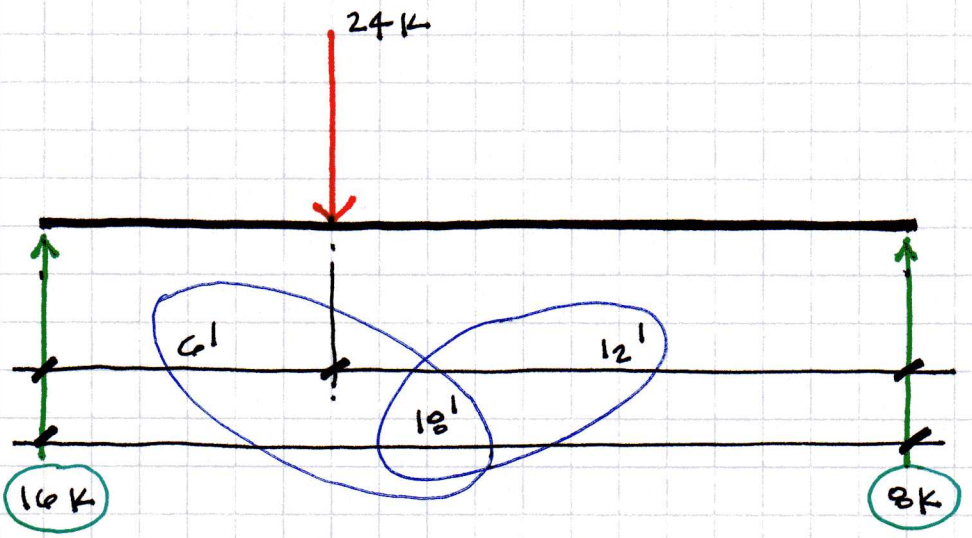
- BENDING MOMENT IS ALONG THE BEAM IS DEFINED AS THE SUM OF (FORCE x DISTANCE)(PERPENDICULAR) TO THE LEFT OF ANY LOCATION ALONG THE SPAN OF A BEAM

- BENDING MOMENT → DEPTH NEEDED FOR BEAM.

- BENDING MOMENT ⟶ DEPTH
  (FLEXURE)

- BENDING MOMENT IS THE SUM OF AREAS IN THE SHEAR DIAGRAM.





1/3 / 2/3 RULE

1/3 OF 24 =

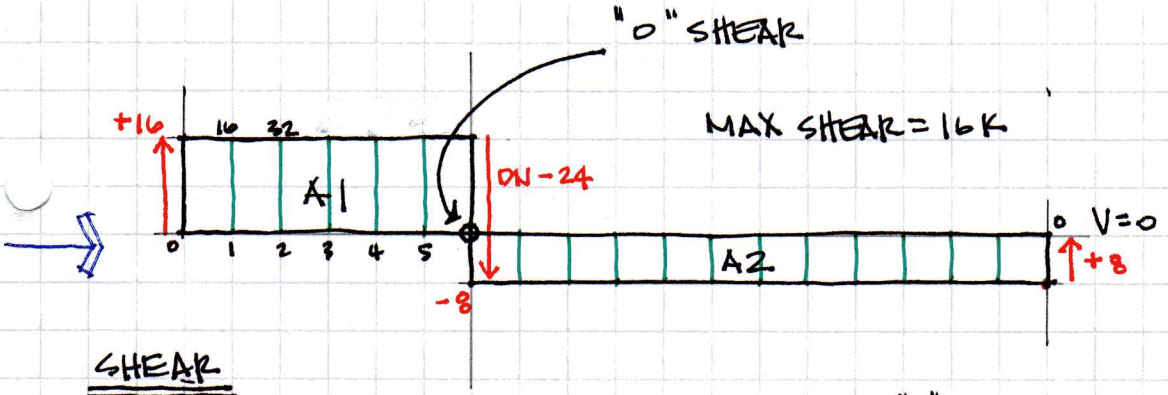
2/3 OF 24 =

$\frac{6}{18} \times 24 =$ 8K

$\frac{12}{18} \times 24 =$ 16K

F.B.D.

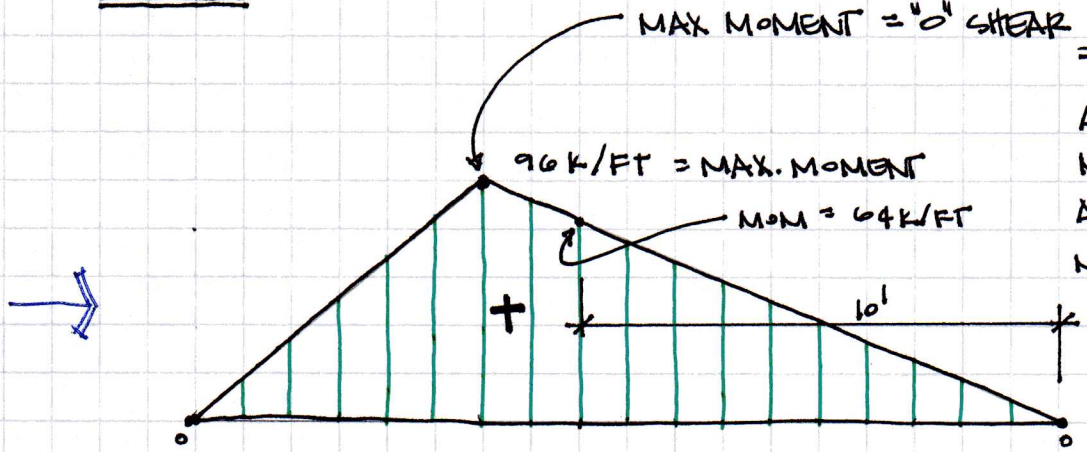
* BIGGEST REACTION ON LEFT SIDE



MAX SHEAR = 16K

+16
− 24
= -8

SHEAR



SUM OF AREAS

A1 = 16 x 6 = +96 K/FT

M1 = + 96 K/FT

A2 = -8 x 12 = − 96 K/FT

M2 = 0

M=0 "ALWAYS ADDS UP TO ZERO!"

MOMENT

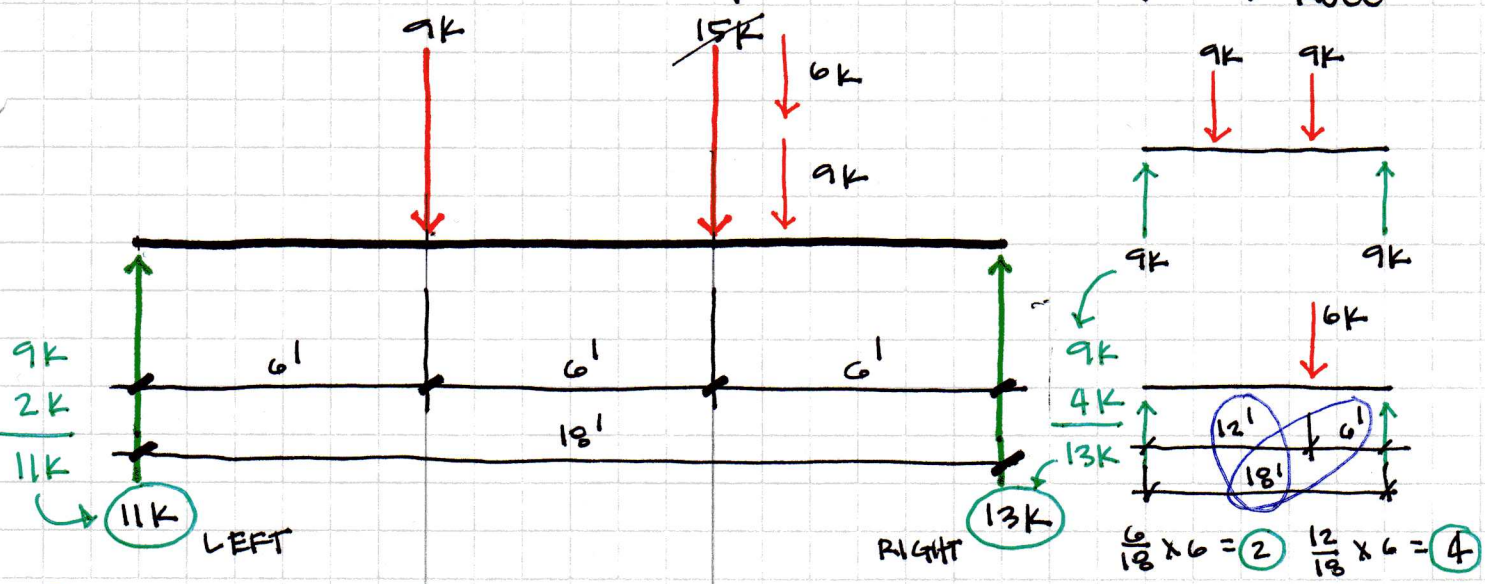
"POSITIVE MOMENT" → COMP. ON TOP/TENSION ON BOTTOM

* MAXIMUM MOMENT = 0 SHEAR

* SHEAR DETERMINES AREA

BREAK THIS 15K DOWN TO 9 & 6

1/3 · 2/3 RULE



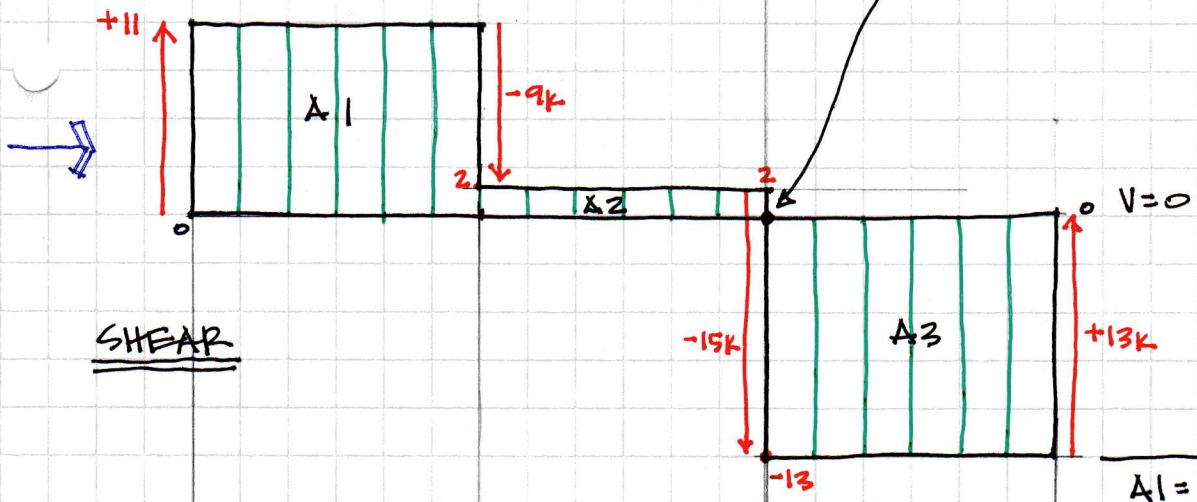
F.B.D.

* BIGGEST REACTION ON RIGHT SIDE.

MAX MOMENT = "0" SHEAR

SUM AREAS ABOVE

= SUM AREAS BELOW



SHEAR

SUM OF AREAS

A1 = +11 x 6 = 66 K/FT

M1 = 66

A2 = 2 x 6 = 12K/FT

M2 = 66 + 12 = 78

A3 = -13 x 6 = -78 K/FT

M3 = A1 + A2 + A3 = 0

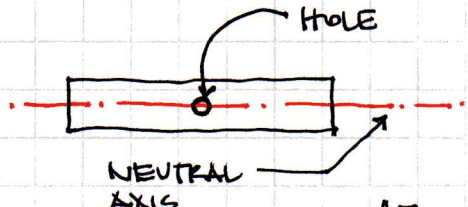
+78 + -78 = 0

M = 0



MOMENT

* MAX. MOMENT DETERMINES DEPTH OF BEAM — WHICH IS 78 K/FT



MAX SHEAR = AREA OF BEAM

MAX. MOMENT = DEPTH OF BEAM

w = 1 #/FT (1 x 18' = 18 K/FT)

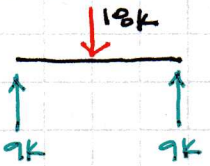
W = 18 K

- UNIFORM LOADS



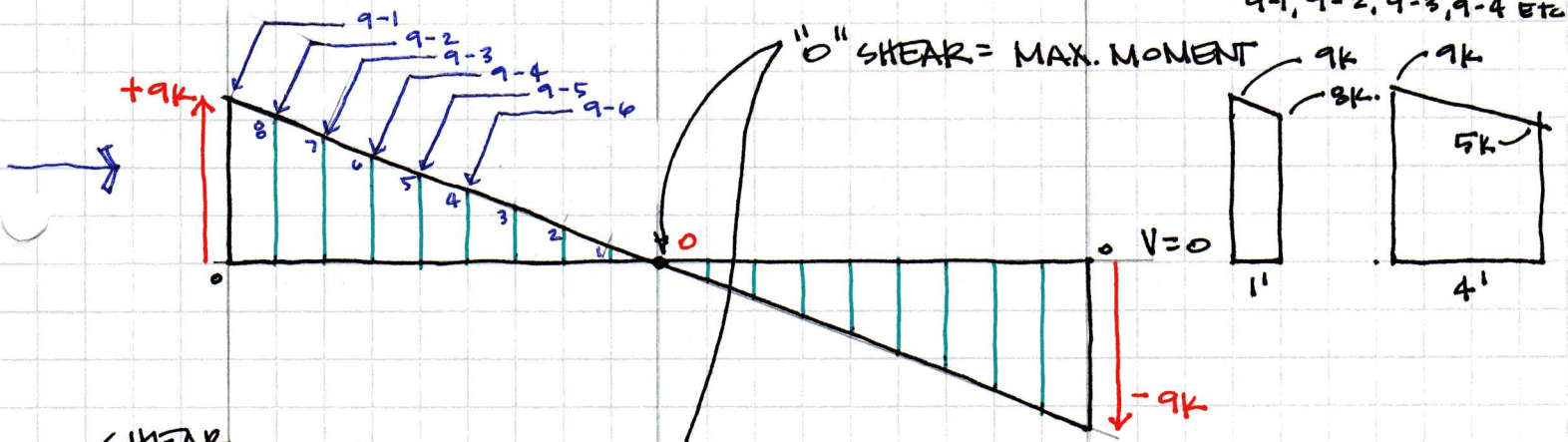
F.B.D.

REACTIONS (9+9=18)

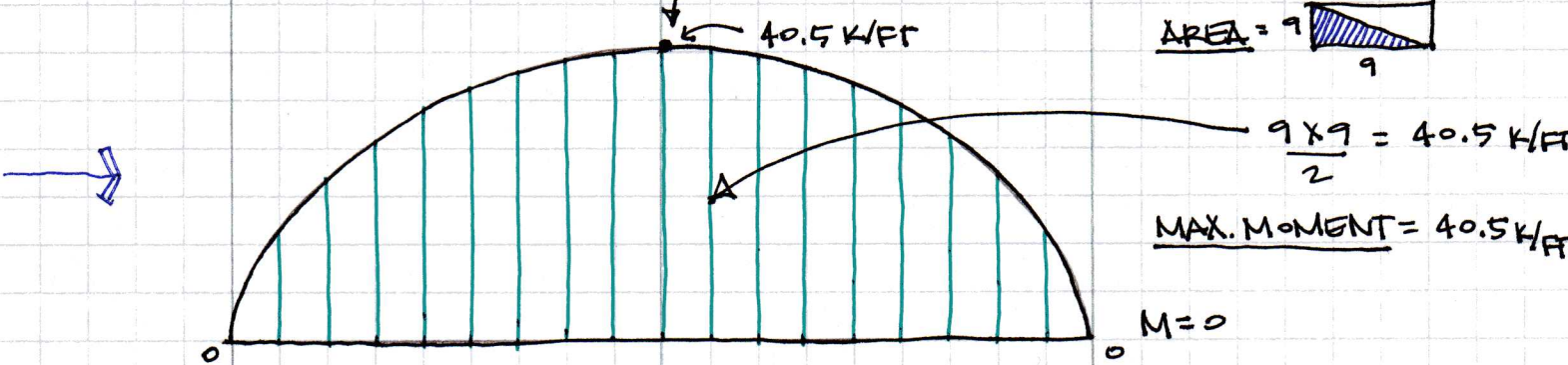


* MOVE LEFT 1FT -1K

9-1, 9-2, 9-3, 9-4 ETC



SHEAR



AREA = $\frac{9 \times 9}{2}$ = 40.5 K/FT

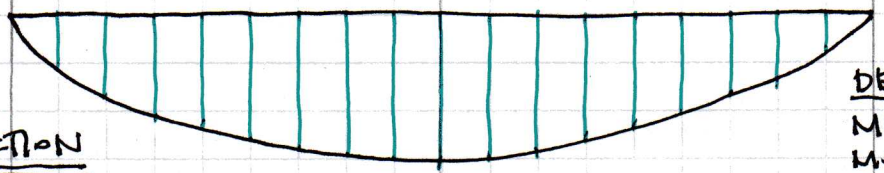
MAX. MOMENT = 40.5 K/FT

MOMENT = A "PARABOLA"

UNIFORM LOAD

MOMENT =

SHEAR =

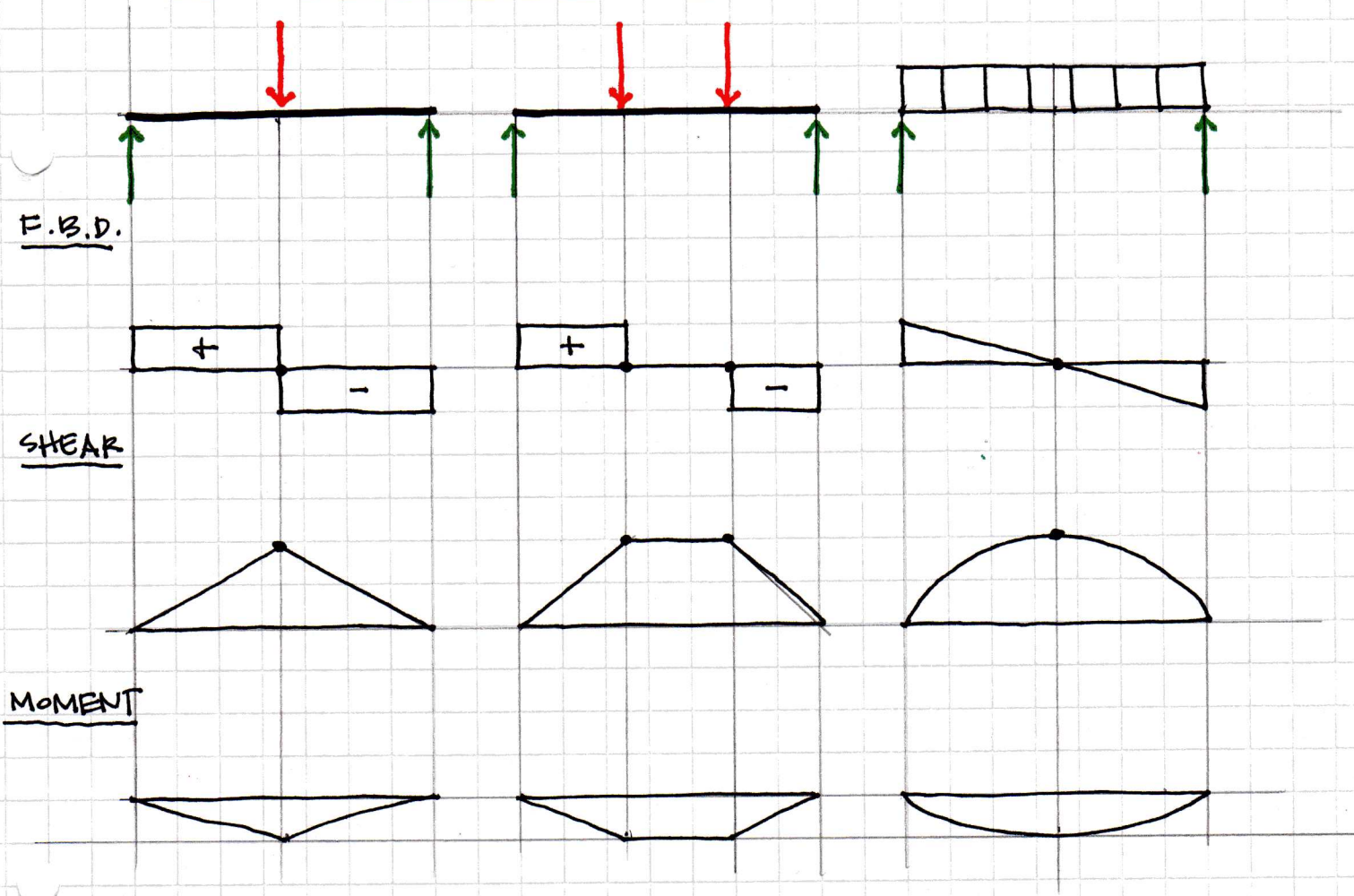


DEFLECTION

DEFLECTION = MIRROR OF MOMENT DIAGRAM.

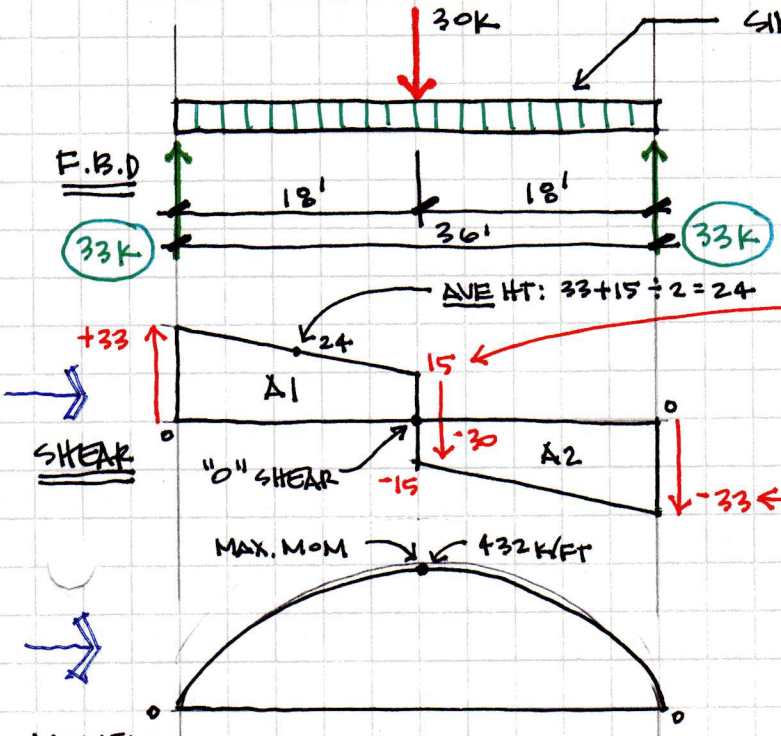
CONCENTRATED LOAD

UNIFORM LOAD



MAX. SHEAR = "0" MOMENT
MAX. MOMENT = "0" SHEAR

• BOTH UNIFORM & CONCENTRATED LOAD



W = 1K/FT (1 X 36' = 36 K/FT)
W = 36 K (36,000# UNIFORM LOAD)

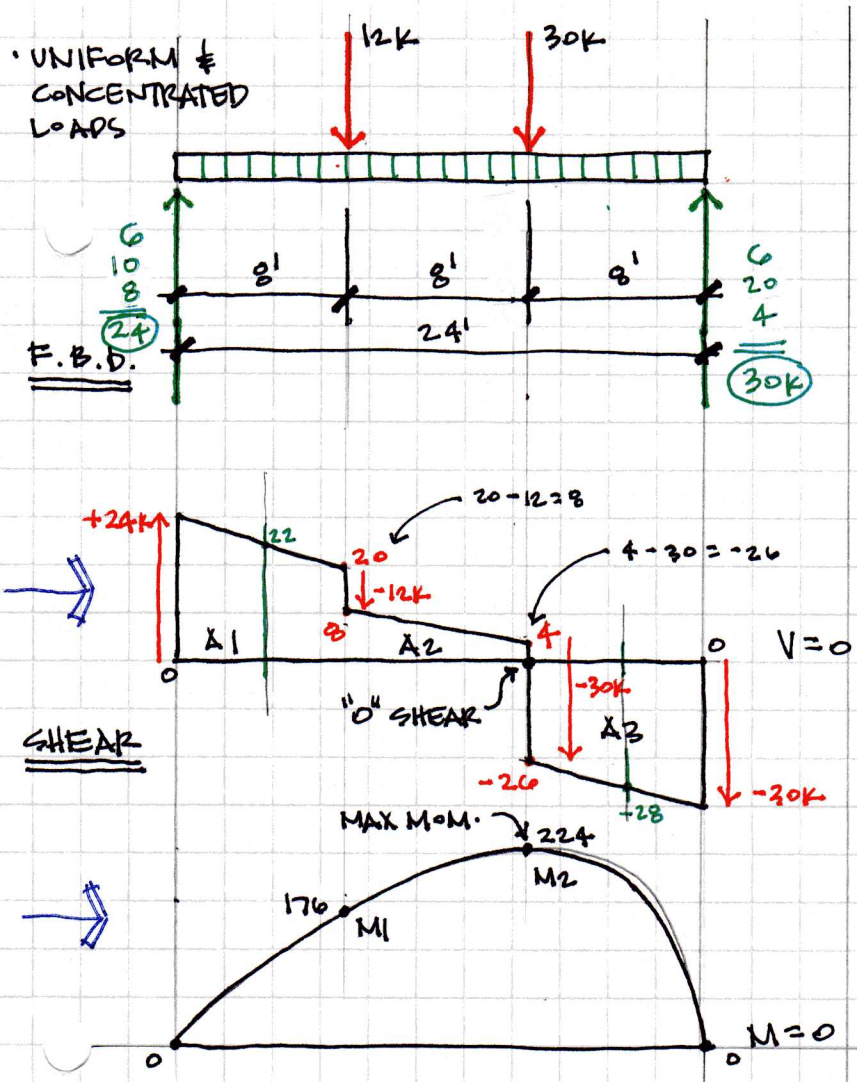
REACTION
: 36K + 30K LOAD = 66K ÷ 2 = 33K

33 - 18 = 15
-15 - 18 = -33

SUM FORCES = 0
REACTIONS = LOADS

AVE. HT.

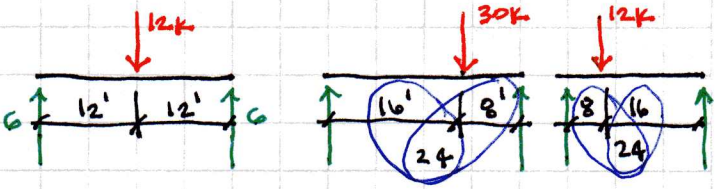
SUM OF AREAS
A1 = 24 K X 18' = 432 K/FT
M1 = +432 K/FT
A2 = -432 K/FT
M2 = 0



W = .5K/FT (.5 x 24 = 12K)

W = 12K

W = 12K + 12K + 30K = 54K



$\frac{8}{24} \times 30 = 10L$ $\frac{8}{24} \times 12 = 4R$

$\frac{16}{24} \times 30 = 20R$ $\frac{16}{24} \times 12 = 8L$

SUM OF THE AREAS

A1 = 22 x 8 = 176 K/FT

M1 = 176 K/FT

A2 = 6 x 8 = 48 K/FT

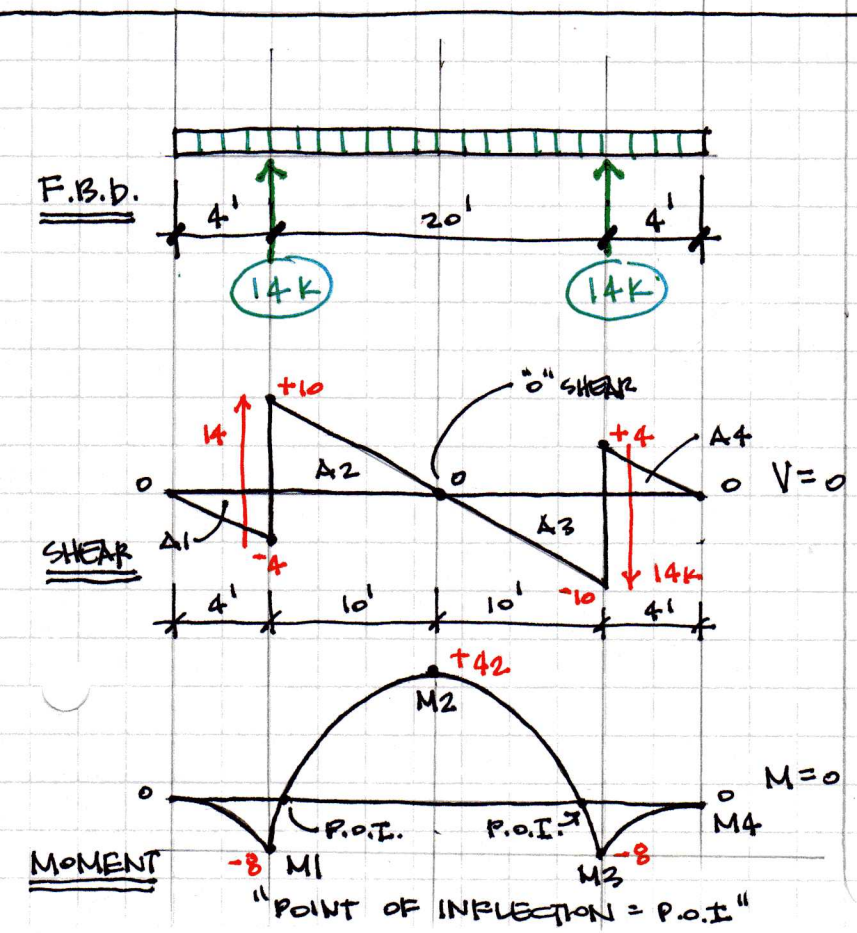
M2 = 176 + 48 = 224 K/FT

A3 = 28 x 8 = 224 K/FT

M3 = 0

AVE OF A1 = 24 + 20 ÷ 2 = 22K

AVE OF A3 = -26 + -30 ÷ 2 = -28K



W = 1K/FT (1K x 28FT = 28K)

W = 28K

REACTIONS

28K ÷ 2 = 14K

SUM OF THE AREAS

A1 = -4 x 4 ÷ 2 = -8 K/FT

M1 = -8 KFT

A2 = +10 x 10 ÷ 2 = +50 K/FT

M2 = -8 + 50 = +42 K/FT

A3 = -10 x 10 ÷ 2 = -50 K/FT

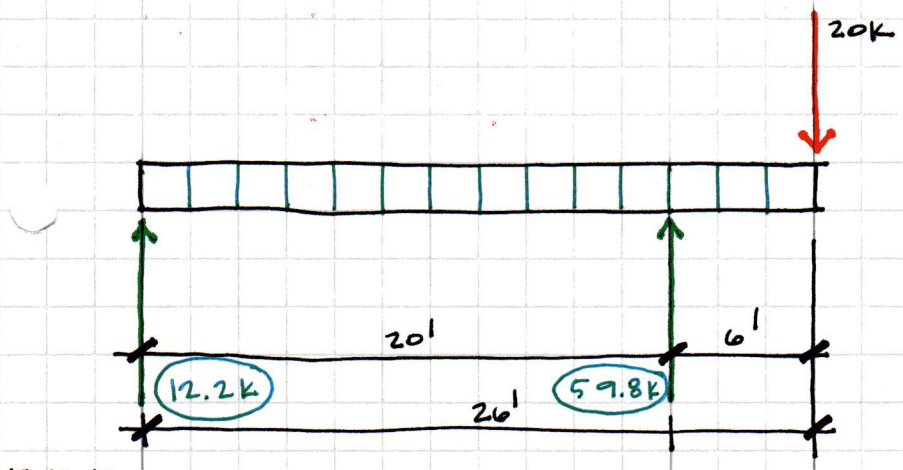
M3 = -8 KFT

A4 = +4 x 4 ÷ 2 = 8 K/FT

M4 = 0

NO UP CUPS





F.B.D.

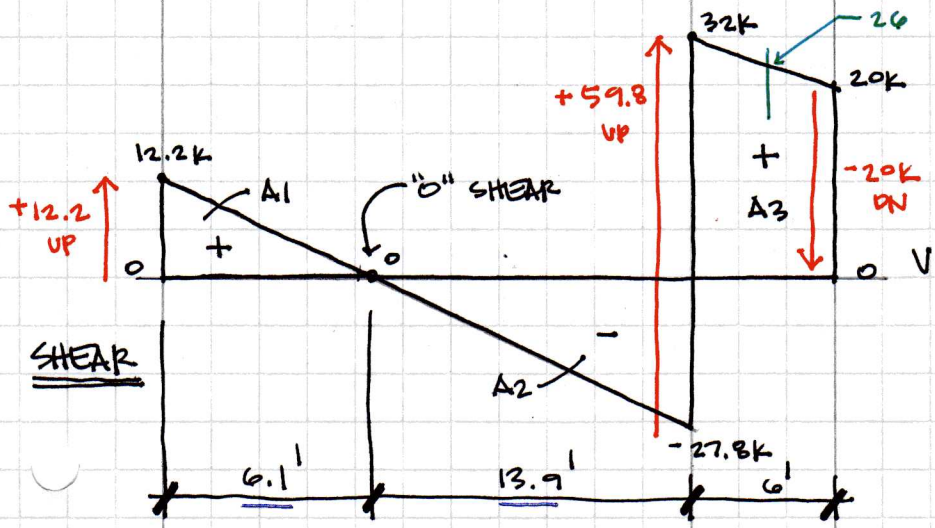
* UNIFORM LOAD W/ 1 POINT LOAD

w = 2K/FT (26x2 = 52K)

W = 52K

* FIND THE REACTIONS

= 52K + 20K LOAD = 72K



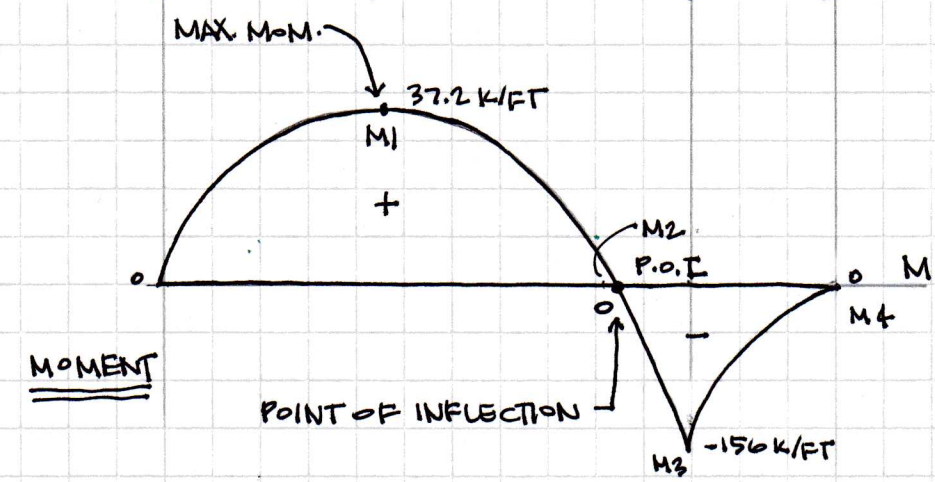
SHEAR

* FIND LOCATION OF ZERO SHEAR

$\frac{27.8K}{2K/FT} = 13.9'$ $\frac{12.2K}{2K/FT} = 6.1'$

SUM OF THE AREAS

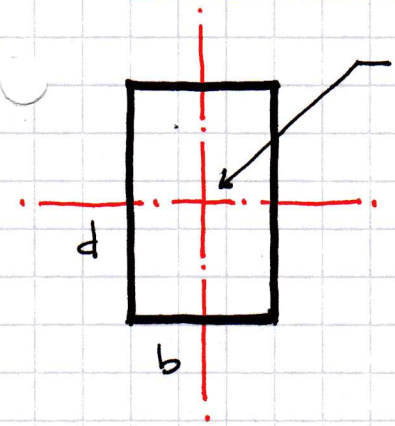
A1	=	12.2 x 6.1 ÷ 2 = 37.2
M1	=	37.2 K/FT
A2	=	13.9 x 27.8 ÷ 2 = -193.21
M2	=	
A3	=	32+20 ÷ 2 = 26 x 6' = 156 K/FT
M3	=	-156 K/FT
A4	=	
M4	=	0



MOMENT

* FLIP THE REBAR IN THE CONCRETE

• GEOMETRY OF THE CROSS SECTION



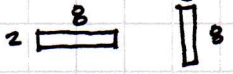
$$A = b \times d = in^2$$ → SHEAR

- MAX SHEAR DETERMINES AREA!
- WIDTH OR DEPTH

WOOD OR CONC

$$S = \frac{b d^2}{6} = in^3$$ SECTION MODULUS

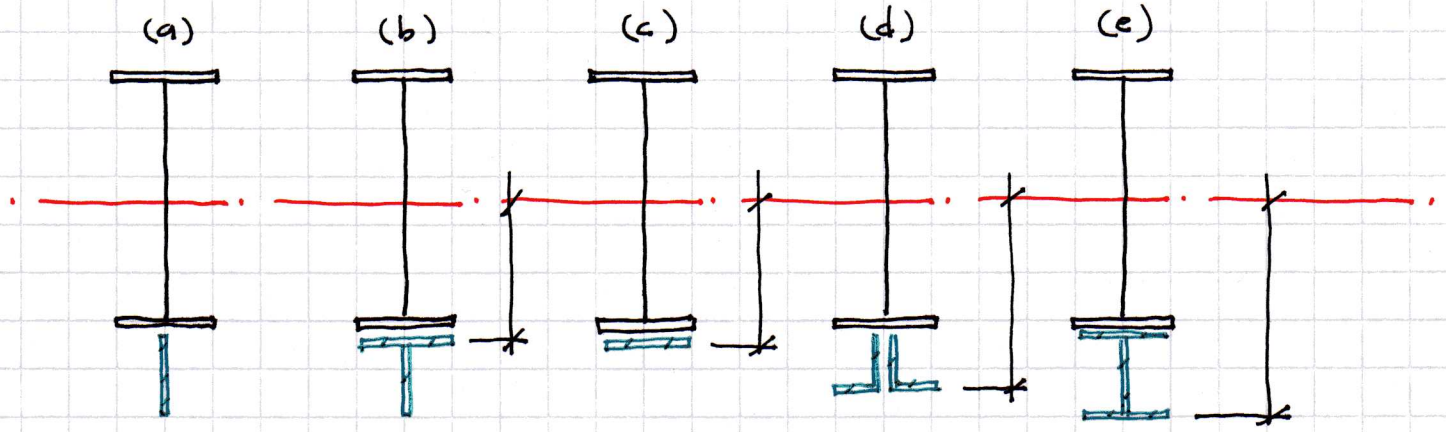
- DETERMINES HOW MUCH BENDING MOM.
- BENDING MOMENT
- DEPTH DETERMINES BENDING MOM.
- ADD DEPTH



$$I = \frac{b d^3}{12} = in^4$$ MOMENT OF INERTIA

- DETERMINES HOW MUCH DEFLECTION YOU WILL ENCOUNTER.
- ABOUT DEPTH
- DEFLECTION
- A FRACTION OF THE SPAN (BY CODE)
  $\frac{L}{240}, \frac{L}{260}$, Etc.

ALS QUESTION



Q. WHICH ONE IS BETTER?

~~a~~

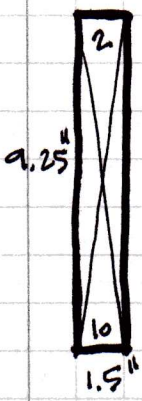
~~b~~

~~c~~

d GOOD

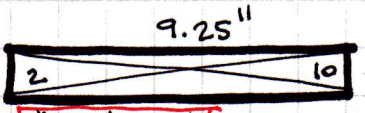
e BEST — WIDEFLANGE

- IDEA IS TO PLACE THE MOST MASS THE FURTHEST FROM THE NEUTRAL AXIS.



$A = b \times d$

$A = 1.5" \times 9.25" = 13.875 in^2$ (SAME)



$A = b \times d$

$A = 1.5" \times 9.25" = 13.875 in^2$

(SAME IN SHEAR)

* AREA = SAME NO MATTER WHAT THE MATERIAL IS.

$S = \frac{bd^2}{6} = \frac{1.5 \times 9.25^2}{6}$

$S = 21.9 in^3$

$S = \frac{bd^2}{6} = \frac{9.25 \times 1.5^2}{6}$

$S = 3.47 in^3$ (BENDS MORE)

$I = \frac{bd^3}{12} = \frac{1.5 \times 9.25^3}{12}$

$= 98.9 in^4$ (40 X STRONGER)

$I = \frac{bd^3}{12} = \frac{9.25 \times 1.5^3}{12}$

$= 2.6 in^4$

A = SHEAR

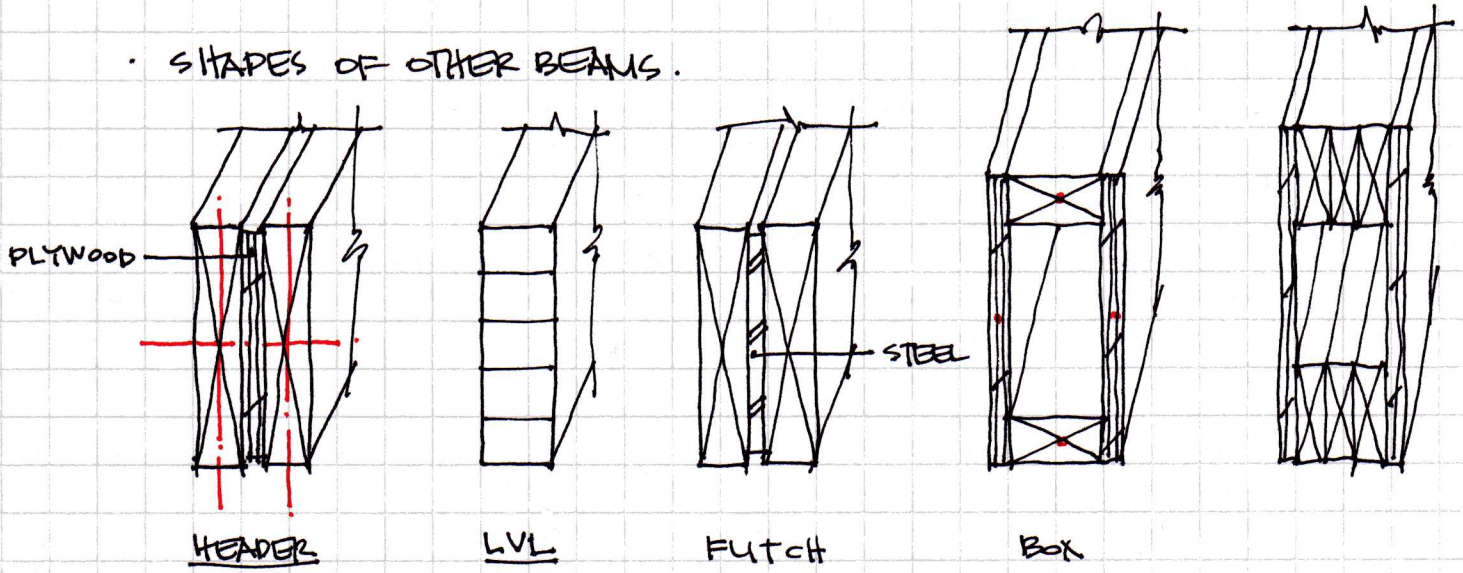
S = BENDING MOMENT (INTERNAL STRESSES)

I = DEFLECTION (PHYSICAL RESULT – WHATS MEASURED)

E = MODULUS OF ELASTICITY (THE MATERIAL)

* BEAMS ARE GOVERNED BY EITHER → SHEAR
↘ BENDING MOMENT

· SHAPES OF OTHER BEAMS.

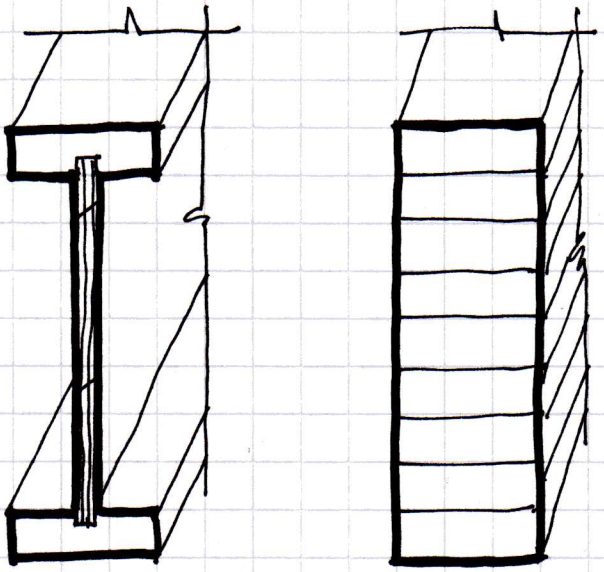


HEADER

LVL

FLITCH BEAM

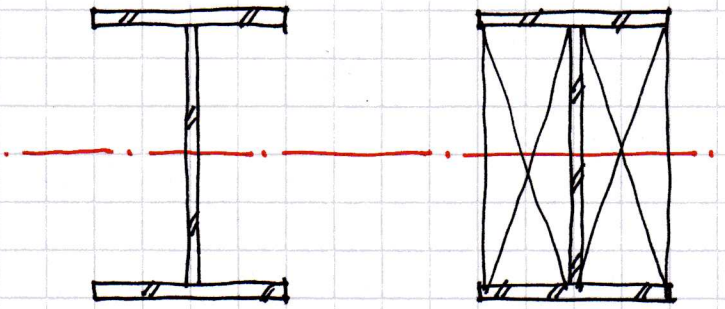
BOX BEAM



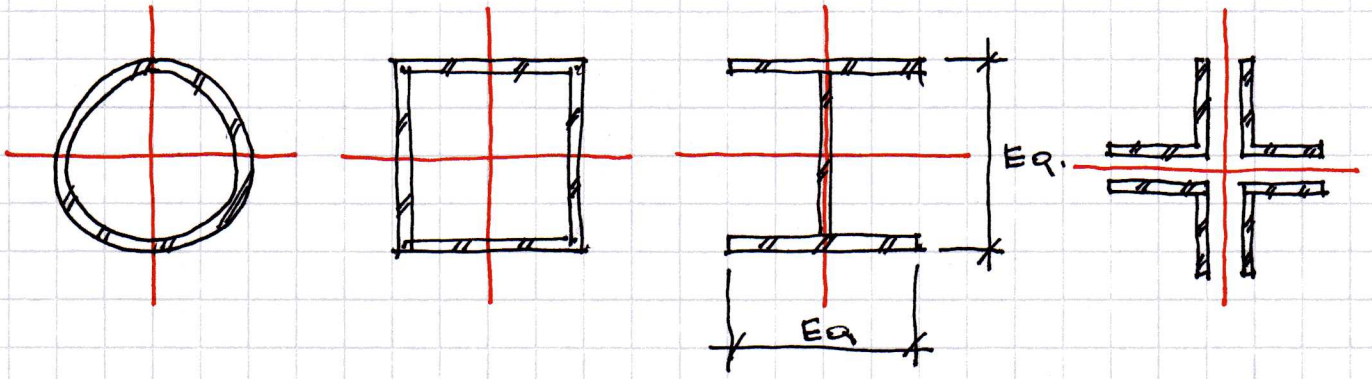
MICROLAM

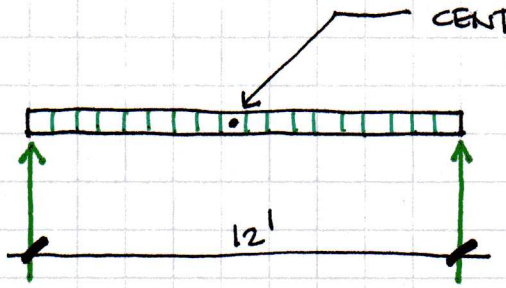
GLUELAM

FOR BEAM — YOU WANT DEPTH ... MOST MATERIAL FURTHEST FROM THE NEUTRAL AXIS.



COLUMNS - MOST MATERIAL @ SAME DISTANCE FROM NEUTRAL AXIS.





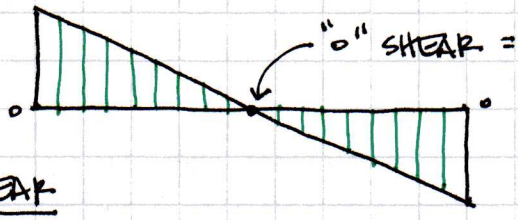
F.B.D.

UNIFORM LOAD

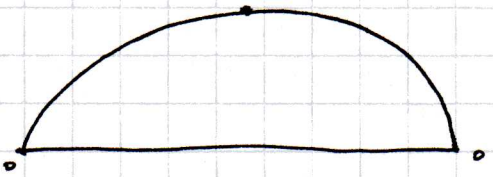
$w = 1000\#/FT$

$W = 1000\# \times 12\,FT = 12\,K$

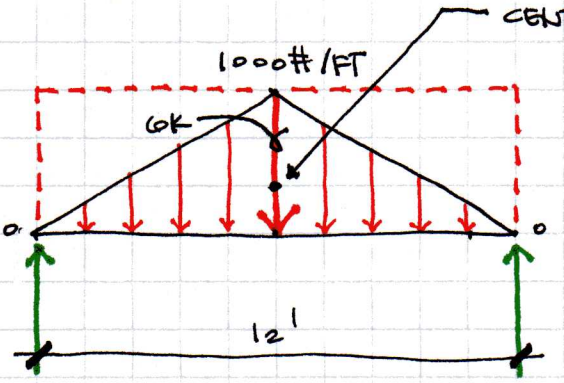
Q. WHAT'S SHAPE OF LOAD DIAGRAM?



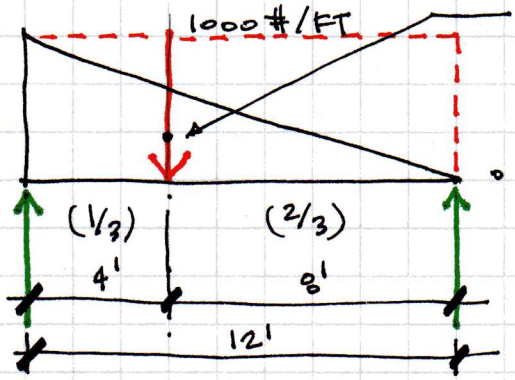
SHEAR



MOMENT



LINTEL



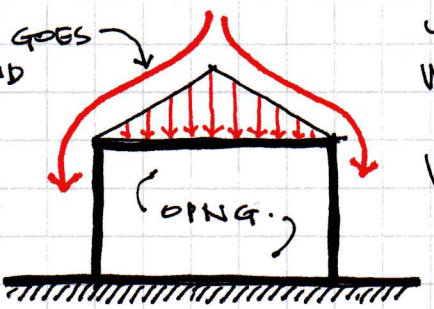
4K SNOW LOAD 2K

$w = 1K/FT \times \frac{12}{2}\,FT$

$W = 6K$

- LOAD IS ABOVE THE OPENING
- LOAD BEARING MASONRY WALL OR LINTEL

* LOAD GOES AROUND OPNG

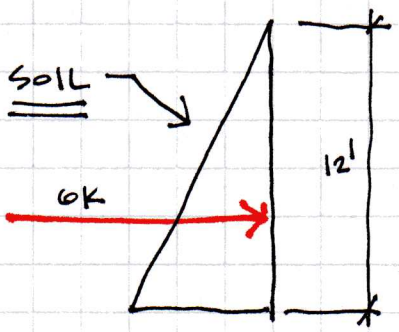


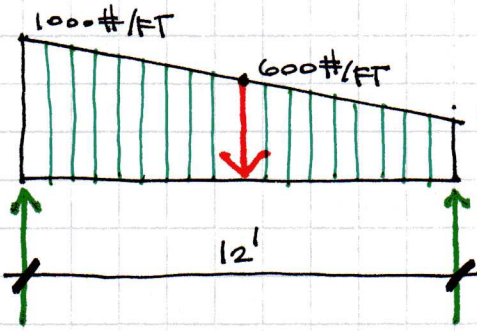
$w = 1K/FT \times \frac{12\,FT^2}{2}$

W = AREA OF LOAD DIAGRAM.

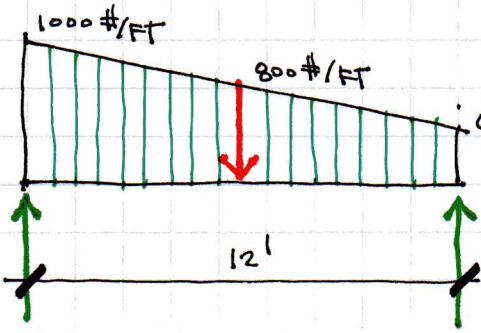
$W = 6K$

Q. FIND THE CENTROID



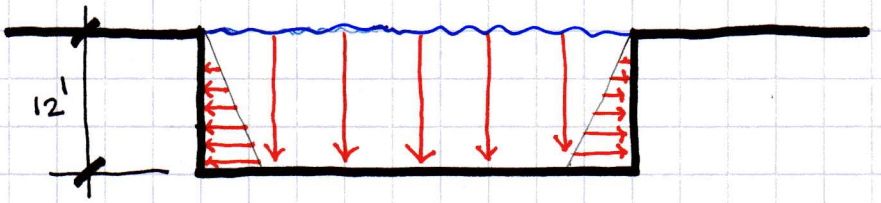


$W = 7.2K$



$W = 9.6K$

- HYDROSTATIC — PRESSURE INCREASES W/ DEPTH



WATER = 62.4 #/CU FT

SWIMMING POOL

PG. 79 GREEN BOOK
- STANDARD LOAD CONFIGURATION.

PG. 80 → WILL BE ON THE EXAM! / ON THE REFERENCE TAB.

PG. 79 Q. WHAT DO WE NEED TO SIZE A BEAM?

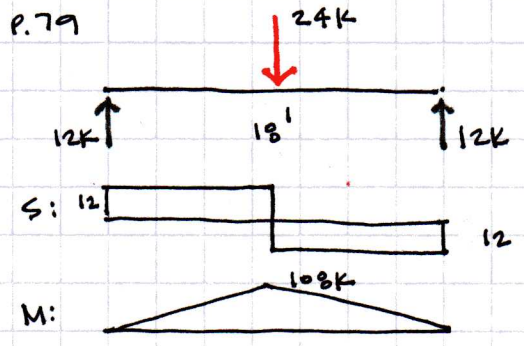
1. SHEAR — AREA OF THE BEAM.
2. BENDING MOMENT — SECTION MODULUS → DEPTH OF BEAM.
3. DEFLECTION.

- SHEAR → AREA → $A = b \times d$ = (in^2)
- BENDING MOMENT → → $S = \frac{bd^2}{6}$ = (in^3)
- DEFLECTION → $I = \frac{bd^3}{12}$ = (in^4)

FREE BODY DIAGRAMS (F.B.D)

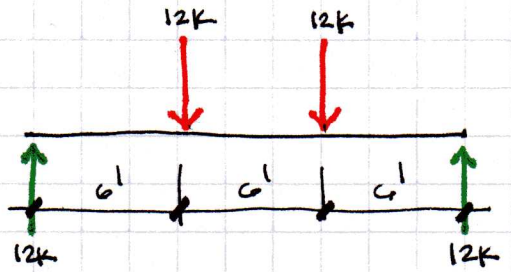
- IF LOAD IS SYMMETRICAL → GO RIGHT TO TABLE
- IF LOAD IS ASYMMETRICAL → MUST DRAW OUT.

P. 79

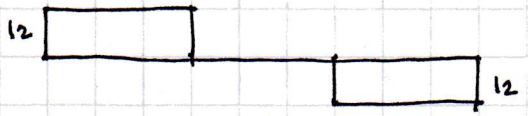


P.79

(2) CONCENTRATED LOADS

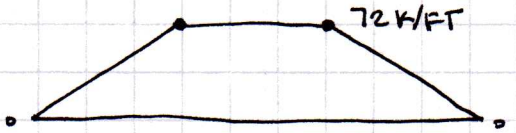


F.B.D



S:

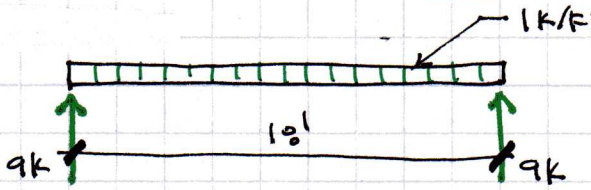
$V_{MAX} = P = 12K$



M:

$M_{MAX} = \frac{PL}{3} = \frac{12K \times 18^{FT}}{3} = 72\ K/FT$

UNIFORM LOAD



F.B.D.

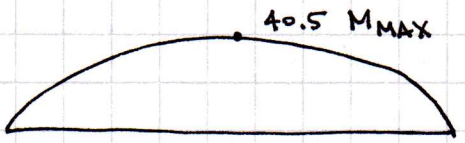
$w = 1K/FT \times 18\ FT$

$W = 18\ K$



S:

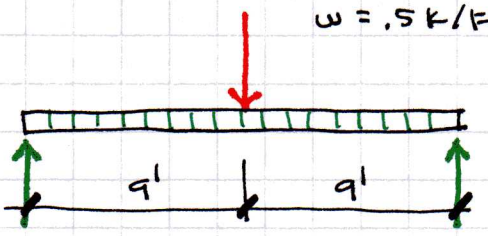
$V_{MAX} = \frac{W}{2} = \frac{18}{2} = 9K$



M:

$M_{MAX} = \frac{WL}{8} = \frac{18 \times 18}{8} = 40.5\ K/FT$

UNIFORM LOAD + (1) CONCENTRATED



$w = .5K/FT \quad .5\ K/FT \times 18' = 9K$

$W = 9K$

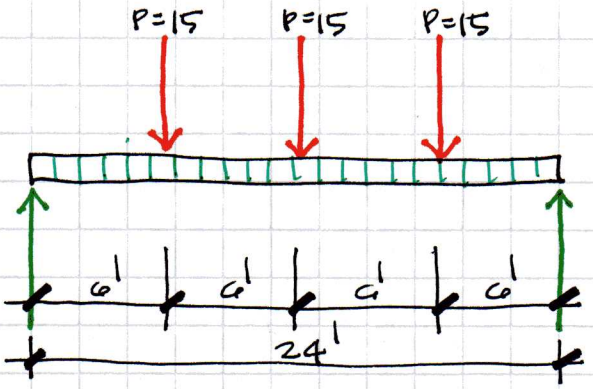
$$V_{MAX} = \frac{W}{2} + \frac{P}{2}$$

$$= \frac{9K}{2} + \frac{16K}{2} = 12.5\ K \quad \underline{AREA}$$

SECTION MODULUS
= DEPTH

$$M_{MAX} = \frac{WL}{8} + \frac{PL}{4}$$

$$= \frac{9K \times 18'}{8} + \frac{16K \times 18'}{4} = 92.25\ K/FT$$



$w = .75\ K/FT$

$.75 \times 24' = 18\ K/FT$

$W = 18K/FT$

NOT 45

$V_{MAX} = \frac{W}{2} + \frac{3P}{2} = \frac{18}{2} + \frac{3 \times 15}{2} = 31.5K$ AREA

$M_{MAX} = \frac{WL}{8} + \frac{PL}{2} = \frac{18 \times 24}{8} + \frac{15 \times 24}{2} = 234\ K/FT$

* USE THE TABLES p.79 !

- **DEFLECTION**
  - ALLOWABLE DEFLECTION (COMES FROM CODE) → $\left(\frac{L}{180}, \frac{L}{240}, \frac{L}{360}, \frac{L}{480}, \frac{L}{720}\right)$
  - OK FOR CEILING TO DEFLECT MORE. $\frac{L}{240}$
  - FLOOR = $\frac{L}{360}$
  - LINTEL = $\frac{L}{720}$
  - WHAT IS IT CARRYING?

FREE BODY DIAGRAM

F.B.D.

LOAD — UNIF/CONC. $\frac{W}{P}$ — SPAN L^3

SPAN IS THE MOST IMPORTANT FACTOR.

- **ACTUAL DEFLECTION** (SEE MANUAL)

$$\Delta = \text{CONSTANT} \times \frac{\left(\frac{W}{P}\right) L^3}{EI} = \frac{\frac{W}{P} \times L^3}{E \times I}$$

INDEX OF MATERIAL

MOMENT OF INERTIA

$\frac{bd^3}{12}$ IMPORTANT

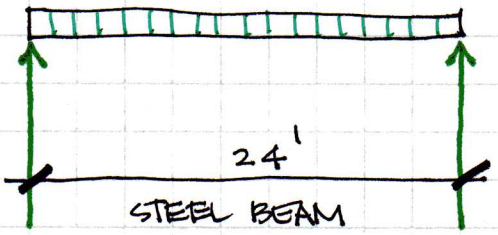
- DOUBLE W (LOAD) = INCREASES THE DEFLECTION
- INCREASE SPAN = INCREASES THE DEFLECTION

- **DEFLECTION**

$$\Delta = \text{CONSTANT} \; \frac{\frac{W}{P} L^3}{EI}$$

NUMERATOR = HIGHER NUMBER = MORE DEFLECTION

DENOMINATOR EXAGERATE THIS # = LESS DEFLECTION



$w = 1\,K/FT$

$W = 24\,K$

$I = 200\,in^4$

$E = 29{,}000{,}000\,psi$

$29{,}000\,KSi$

$$\Delta = \text{CONSTANT} \; \frac{5 \times 24K \times (24\,FT)^3}{384 \times 29{,}000{,}000 psi \times 200\,in^4}$$

START HERE

$$\Delta = \frac{5 \times (24' \times 1000\#) \times (24' \times 12)^3}{384 \times 29{,}000{,}000\#/in^2 \times 200\,in^4}$$

CALCULATOR

y^x KEY: $(24 \times 12) = 288\; y^x\; 3$

$= 1.28''$ of DEFLECTION

NOT IN FEET!

* IF CODE WANTS $\frac{L}{360} = \frac{24'}{360} = \frac{24 \times 12''}{360} = .8''$

MUST DECREASE LOAD OR DEEPEN BEAM!

= GET A DEEPER BEAM → I

$I = 200\,in^4 \longrightarrow 1.28''$

$X \longleftarrow 0.8''$ (INCREASE DEPTH OF BEAM)

No! $\frac{.8}{X} = \frac{1.28}{200}$ $\qquad 1.28X = .8 \times 200$, $X = 125$

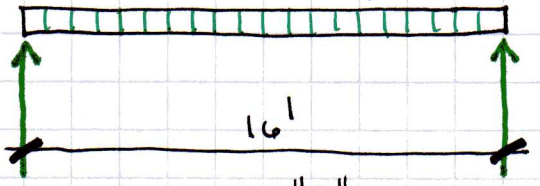
DO THIS → $200 \times \frac{1.28}{0.8} = 320\,in^4$ ✓

- PG 42 BLUE HANDOUT → # 51

  * DEFLECTS .9" → BRING DOWN TO 3/4" OR .75"

- PG 29 #9

BEAM "A" DEFLECTS 1" → $\Delta = 1"$



BEAM "A"

I, E

BEAM "B" DEFLECTS ____ ?



BEAM "B"

I, E

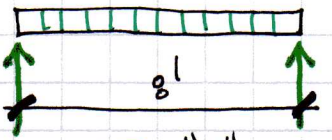
* LARGER SPANS = MORE DEFLECTIONS

$= 1" \times \left(\frac{20}{16}\right)^3$

USE $\frac{20}{16}$ OR $\frac{16}{20}$

$= 1" \times \left(\frac{20 \times 12"}{16}\right)^3$

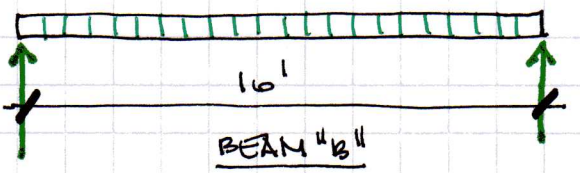
BEAM "A" DEFLECTS 1" $\Delta = 1$



BEAM "A"

I, E

BEAM "B" DEFLECTS 1" $\Delta = 1$



BEAM "B"

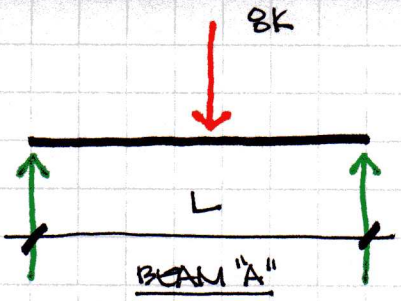
I, E

$= 1" \times \left(\frac{16}{8}\right)^3 = 8"$

$\left(\frac{16 \times 12"}{8}\right)^3 = 8"$

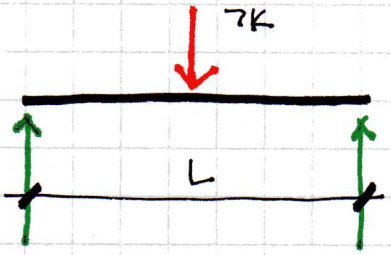
* DOUBLE THE SPAN = 8 X MORE DEFLECTION!

- BEAM "A" DEFLECTS 1" $\Delta = 1"$



- BEAM "B" DEFLECTS ? $\Delta = ?$

$= 1" \times \frac{7}{8} = .875"$

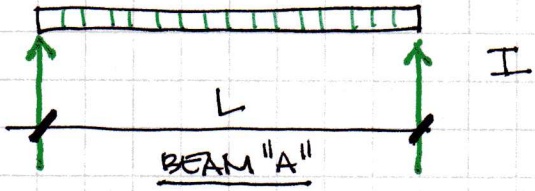


* A SPAN IS NOT CUBED ( )^3

- BEAM "A" DEFLECTS 1" $\Delta = 1"$

· SOUTHERN YELLOW PINE (SYP)

E SYP #2 = 1,600,000 psi



- BEAM "B" DEFLECTS 1" $\Delta = 1"$

E SYP #3 = 1,400,000 psi



Q. WHICH DEFLECTS MORE "A" OR "B"?

$1" \times \frac{1.6}{1.4} = 1.14"$ LIMIT IS 1" ← 1.14"

- BEAM "A" DEFLECTS 1" $\Delta = 1"$
  E SYP 2 = 1,600,000 psi
- BEAM "B" = ?
  E GLUELAM = 2,000,000 psi

* GLUELAM DEFLECTS LESS!

$1" \times \frac{1.6}{2} = .8"$

- BEAM "A" DEFLECTS 1" $\Delta = 1"$

  2" x 8"

  $I = \frac{bd^3}{12} = \frac{1.5 \times 7.25^3}{12} = 47.63\ in^4$

- BEAM "B" DEFLECTS ? $\Delta = ?$

  2" x 10"

  $I = \frac{bd^3}{12} = \frac{1.5 \times 9.25^3}{12} = 98.93\ in^4$

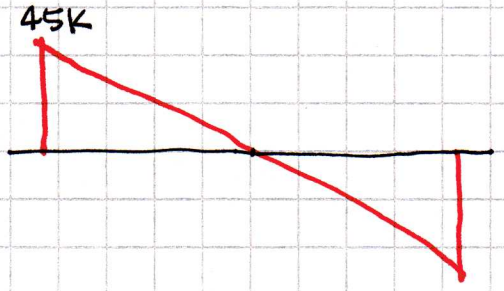
$$\Delta = 1" \times \frac{47.63\ in^4}{98.93\ in^4} = .48" \text{ or } 1/2" \text{ (APPROX)}$$

* END OF DAY 2

DAY 3 1/21/06

ARE

- LOADING PERPENDICULAR TO AXIS
- U = THE ULTIMATE STRENGTH METHOD
  "FOR CONCRETE ONLY"
- L.R.F.D = LOAD RESISTANCE FACTOR DESIGN
  "FOR WOOD & STEEL"
- SHEAR = AREA
- BENDING = SECTION MODULUS
- DEFLECTION = MOMENT OF INERTIA
- SHEAR DIAGRAM — CONCRETE



CONCRETE DOESN'T NEED STIRRUPS

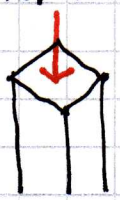
- DETERMINE DIRECTION OF LOAD & AXIS OF LOAD
- E = STIFFNESS OF MATERIAL
- I = STIFFNESS OF SECTION

WOOD / STEEL / CONCRETE

CONCEPT QUESTION

WOOD

- REVIEW CHING BOOK
- ALS — MATERIALS & METHODS
- GRAIN = CHANNELS WATER PARALLEL
- PERPENDICULAR TO GRAIN = PORES (SQUISH)
  WHEN IT DRIES — IT SHRINKS
- STRENGTH IN COMPRESSION



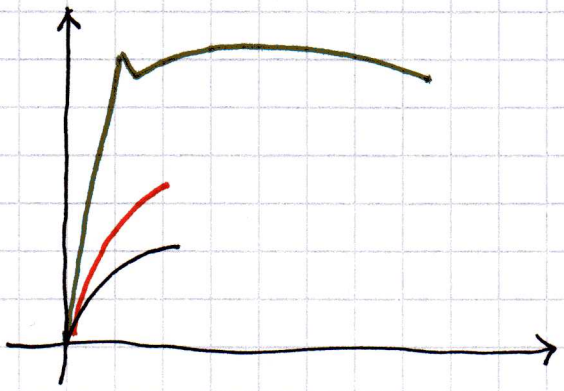
- <u>BOARD FOOT</u> = VOLUME OF WOOD, STANDARDISES

1. 100 PIECES 2 X 6 X 10'
2. 60 PIECES 2 X 8 X 12'
3. 80 PIECES 2 X 4 X 8'

- BD FT = $\left(\frac{b \times d}{12}\right) \times L \times$ # PIECES

1. $\frac{2 \times 6}{12} \times 10' \times 100$ PIECES = 1,000 BF
2. $\frac{2 \times 8}{12} \times 12' \times 60$ PIECES = 960 BF
3. $\frac{2 \times 4}{12} \times 8' \times 80$ PIECES = 427 BF

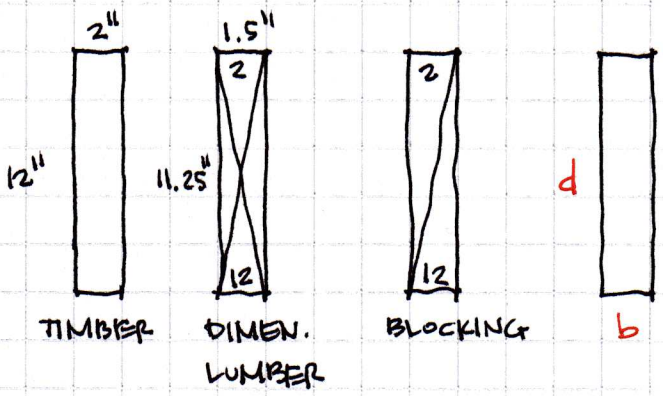
- <u>SAW MILLS</u> : <u>CUT</u> DIMENSIONAL LUMBER OR TIMBER

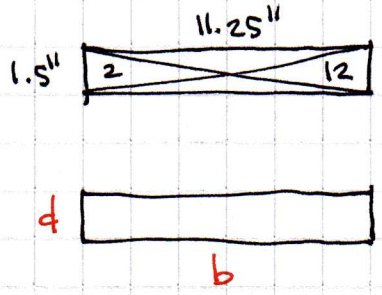


SLOPE = E

STRAIN =

Wood





2 X 12

$A = bd = 1.5'' \times 11.25'' = 16.875\ in^2$

$S = \frac{bd^2}{6} = \frac{1.5'' \times 11.25''^2}{6} = 31.64\ in^3$

$I = \frac{bd^3}{12} = \frac{1.5'' \times 11.25^3}{12} = 177.9\ in^4$

12 X 2

$A = bd = 11.25'' \times 1.5'' = 16.875\ in^2$

$S = \frac{bd^2}{6} = \frac{11.25'' \times 1.5''^2}{6} = 4.22\ in^3$

$I = \frac{bd^3}{12} = \frac{11.25'' \times 1.5''^3}{12} = 3.16\ in^4$

$A = bd$ = SHEAR

$S = \frac{bd^2}{6}$ = BENDING, STRENGTH, FLEXURE

$I = \frac{bd^3}{12}$ = DEFLECTION

A = AREA

S = SECTION MODULUS

I = MOMENT OF INERTIA

PG 96 : GREEN BOOK — SEE TABLE

WATER = 62.4 #/FT³
CONC = 100 #/FT³
WOOD = 35 - 40 #/FT³

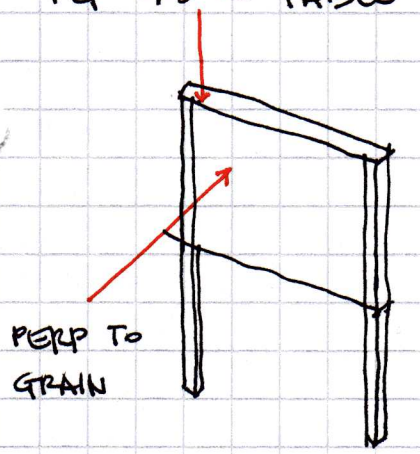
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2 X 12		12 X 2
16.875 in^2	A: SHEAR	16.875 in^2
31.64 in^3	S: BENDING	4.22 in^3
177.9 in^4	I: DEFLECTION	3.16 in^4

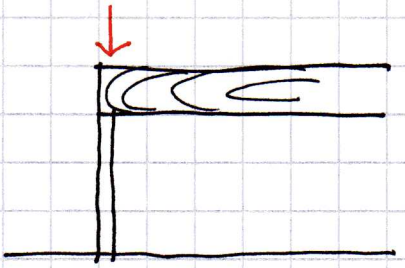
"SAME"

- 2X12 STRONGER (ALMOST 8 TIMES)
- 2X12 ALMOST (60 TIMES MORE)

PG 95 – TABLE

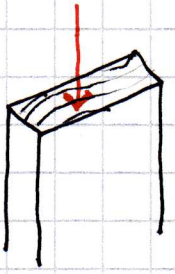


SIGN



LOAD IS PERPENDICULAR TO GRAIN

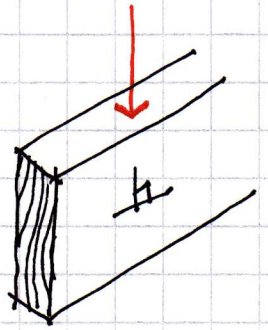
JOISTS & PLANKS



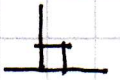
4x10

IN COMPRESSION
PARALLEL · AXIAL

$F_c = 1{,}250$



4X10



PERPENDICULAR
TO GRAIN

BENDING/
SHEAR

$F_b = 1{,}750$ OR $1{,}500$
$F_v = 95$

FOLLOW STEPS / PROBLEM → SEE YELLOW HANDOUT.

Wood
$F_v = 90$ psi

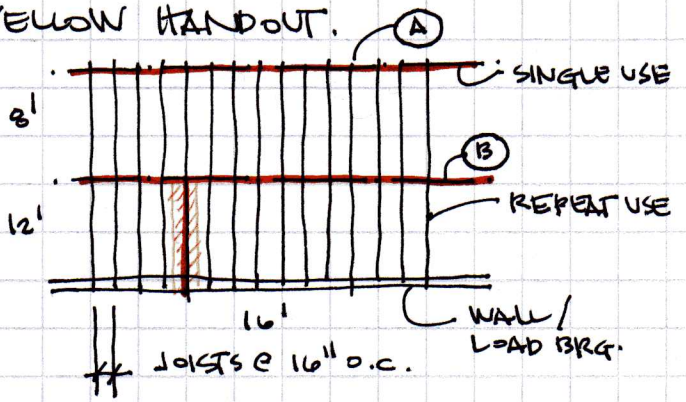
$F_b = 1{,}600$ psi – SINGLE JOIST
$= 1{,}800$ psi – REPEATATIVE USE

* LOOK AT MOISTURE CONTENT

STRENGTH $E = 1{,}800{,}000$ psi
(IN STIFFNESS)

A LOAD = DEAD LOAD DL = 20 PSF
LIVE LOAD LL = 30 PSF
TOTAL LOAD = 50 PSF

CODE SAYS .. $\Delta_{ALLOW} = \frac{L}{360}$

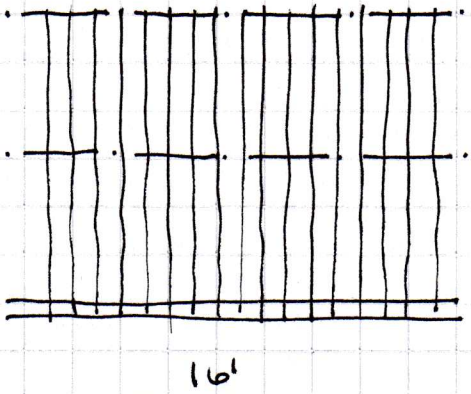


JOIST AREA = 16 OR $1.33' \times 12' = 15.96$ FT²

TRIBUTAIRY AREA = $1.33' \times 12' = 15.96 \times 50\#/FT^2$
$= 800\#$

PG 79
MAX SHEAR V $V_{MAX} = \frac{W}{2} = \frac{800\#}{2} = 400\#$

MAX MOMENT $M_{MAX} = \frac{WL}{8} = \frac{800 \times 12}{8} = 1{,}200\#$

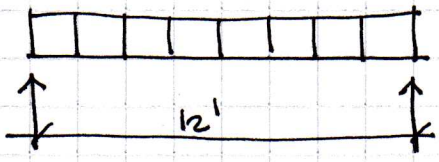


JOISTS

$$\text{SHEAR} = F_V = \frac{3 V_{MAX}}{2 A\,(IN^2)} \quad \#\text{ OR K}$$

JOISTS $w = 50\#/FT^2$

$W = 800\#$



JOISTS

* $\text{SHEAR} = F_V = \frac{3 V_{MAX}}{2 A}$

IN A WOOD BEAM =

A = AREA $\quad A = \frac{3 V_{MAX}}{2 F_V} = \frac{(3)(400\#)}{(2)(90\#/IN^2)} = 6.66\ IN^2$

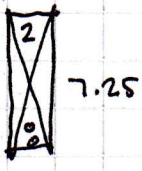
* $\text{BENDING} = F_b = \frac{M}{S} \qquad S = \frac{M_{MAX}}{F_b} = \frac{1200\#FT}{1800\#IN^2} \times 12 = 8\ IN^3$ (SECTION MODULUS)

(CONVERSION)

$A_{MIN.} = 6.67$ (SHEAR)

$S_{MIN.} = 8\ IN^3$ (BENDING)

SELECT A 2X8 $\quad A = bd = 1.5 \times 7.25 = 10.88\ IN^2$



$S = \frac{bd^2}{6} = \frac{1.5 \times 7.25^2}{6} = 13.14\ IN^3$

$I = \frac{bd^3}{12} = \frac{1.5 \times 7.25^3}{12} = 47.63\ IN^4$

THEREFORE A 2X8 IS GOOD IN SHEAR & BENDING MOMENT

VERIFY ACTUAL DEFLECTION D_{ACTUAL}

GIVEN ALLOWABLE $D_{ALLOW} = \frac{L}{360} = \frac{12' \times 12}{360} = 8.4$ IN DEFLECTION (CONVERSION)

$\Delta_{2x8} = \frac{5 \times WL^3}{384\ EI} =$ [illegible]

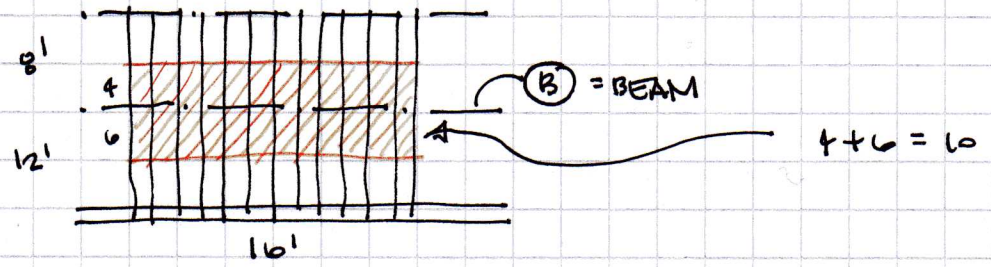
START HERE

$$\Delta_{2\times8} = \frac{5}{384} \times \frac{WL^3}{EI} = \frac{5 \times 800\# \times (12' \times 12)^3}{384 \times 1{,}800{,}000\#/in^2 \times 47.63\,in^4}$$

$= .36''$ < LESS THAN .4 ✓ OK

PG 82A → READ THESE 82A, B, C, E

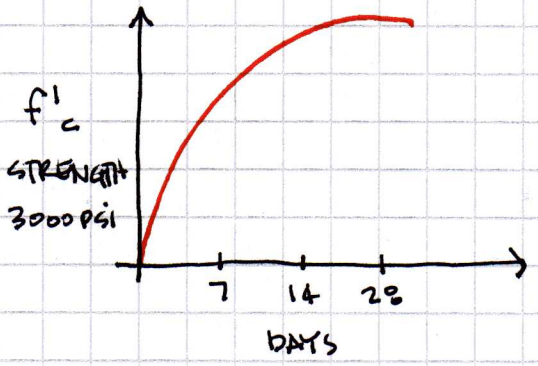
* OR DO THIS SHORTCUT METHOD !



TAKE THE SPAN & SUBTRACT 4 FROM SPAN JOIST ONLY

$= 14 - 4 = 10$ OR → 2X10

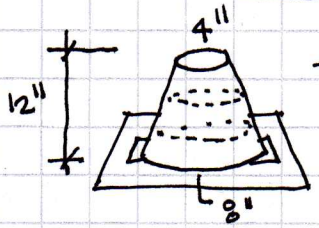
CONCRETE : NORMAL, AIR ENTRAINING, HIGH EARLY (3 DAYS) STRENGTH LIGHT WEIGHT



CYLINDER TEST
- 6-7 BAG MIX
- MORE MIX = STRONGER CONCRETE
- MORE WATER = WEAKER CONCRETE

* 150 #/FT³ WEIGHT OF CONCRETE

① TEST : SLUMP — WORKABILITY, CONSISTENCY — FOR EVERY TRUCK

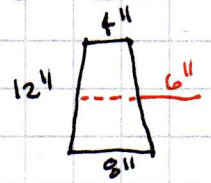


— PACK CONCRETE IN 1/3RDS
TAKE CONE OFF



1" SLUMP = STIFF
3-4" = GOOD
6" = SIDEWALK
— TOO MUCH WATER OR CHEMICALS ADD MIXTURES - SUPERPLASTIZERS

② TEST CYLINDER : SAME VOLUME AS CONE



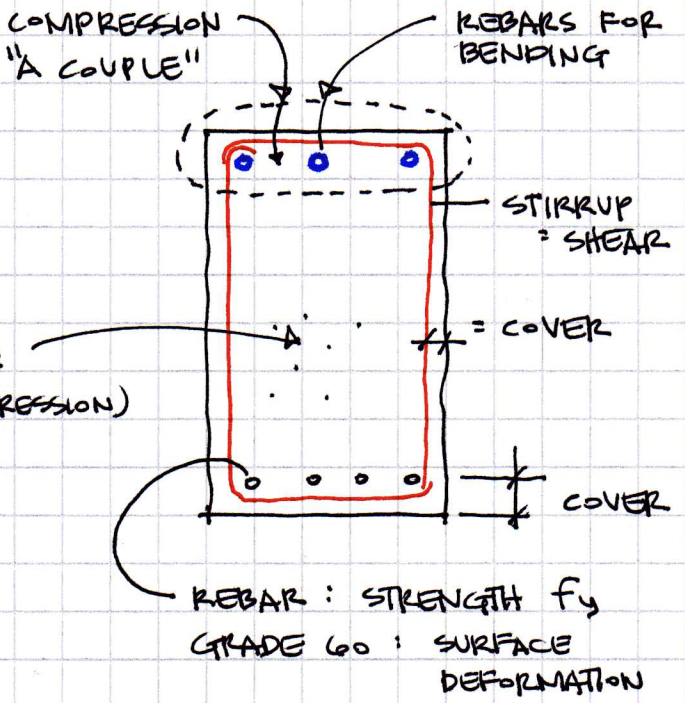
A "TRAPEZOID" — TEST EVERY 50 YDS : 9-12 YDS / TRUCK

BAG OF CEMENT = 90#

READ MATERIALS !

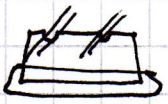
REASONS FOR COVER

1. CORROSION PROTECTION
2. FIRE PROTECTION
3. BONDING / EMBEDMENT
4. SAFETY



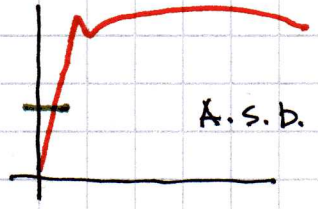
COVER: EXTREME FIBER OF CONC TO THE FIRST FIBER OF REBAR

COVER: 1.5" INTERIOR OF BEAM
2" EXTERIOR OF BEAM
3" FOUNDATIONS
¾" WALLS
* DO THIS WITH CHAIRS



CONCRETE & STEEL

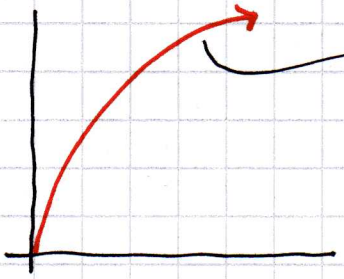
- DIFFERENCES IN COMPRESSION & TENSION
- IF IT FAILS .... **SAFETY FACTOR**
  1.7 × DEAD LOAD
  1.4 × LIVE LOAD



* YOU DON'T WANT CONCRETE TO FAIL FIRST!
  — REBAR MUST FAIL FIRST

IF REBAR BENDS
- A CRACK SHOWS UP IN THE COVER
- IT'S A WARNING! — SPALLING
- CONC EXPLODES → NOT BREAK

ULTIMATE STRENGTH — JACK UP THE LOADS!

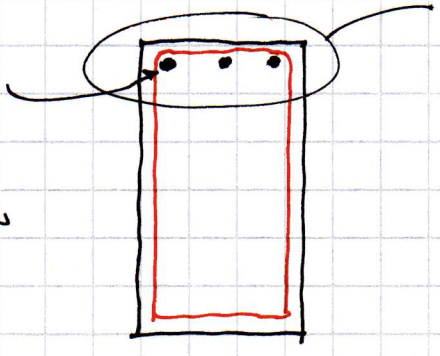


- MAKE SURE REBAR (STEEL) FAILS & GIVES YOU A WARNING!

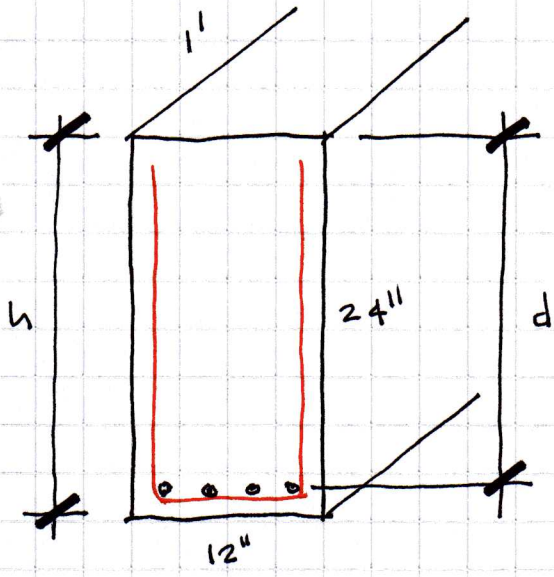
1. REDUCE CONC DEPTH
2. "CREEP" = DEFLECTION OVER TIME

DEPTH = DEFLECTION





COMPRESSION
- HELPS CONCRETE = YOU NEED LESS CONC. = LESS DEPTH

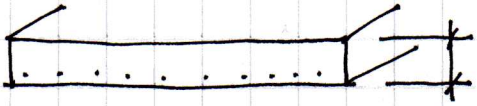


(WT OF CONC)

BEAM WT = #/FT

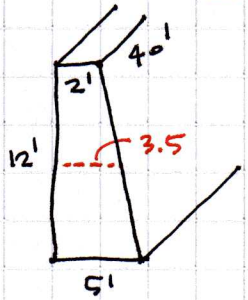
$= \left(\frac{24"}{12}\right) \times \left(\frac{12}{12}\right) = 2' \times 1' \times 150\#/FT^3 = 300\#/FT$

SLAB:



$6" = \frac{6"}{12} \times \frac{150\#}{FT^3} = 75\#/FT^2$

VOLUME OF CONCRETE



AREA = 3.5 X 12

Q. FIND THE VOLUME

V = 3.5 x 12 x 40 = 1,680 FT³ (CUBIC FT)

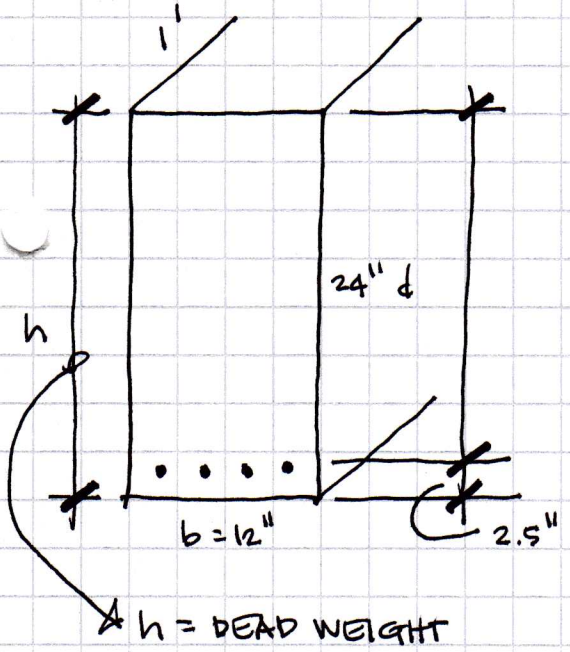
Q. HOW MANY TRUCKS?
= 10 YDS /TRUCK

1 YD = 3 FT
1 YD² = 9 FT²
1 YD³ = 27 FT³

$\frac{1680}{27} = 62.22\ YD^3$

7 X 10 = 70 CU YDS
(7) TRUCKS

- ORDER 10% EXTRA
- $\frac{62.2\ YD^3}{10\ YD/TRUCK} = 6.5 - 7$ TRUCKS
- CONC COST APPROX $100/CUBK YDS



$$A = b \times d$$

$$S = \frac{bd^2}{6}$$

$$I = \frac{bd^3}{12}$$

REBARS

- #3 & #4 = STIRRUPS, COLUMN TIES, TEMPERATURE STEEL (SLAB ON GRADE)
  - GRADE 40 KSI (SMOOTH)
  - GRADE 60 KSI (HIGH STRENGTH)
- #5, 6, 7, 8, 9 & 10 REBARS ⟶ #3 USES STIRRUP
- #11, 14, 18 BIG REBARS → HWY. CONSTRUCT, HIGH RISES
  - ↳ USE #5 STIRRUPS

1/8TH #7 = 7/8

P = % OF STEEL → $P = \frac{A_{STEEL}}{A_{CONC}}$

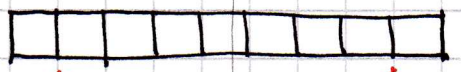
- REBAR MUST BREAK / FAIL BEFORE CONCRETE
- CONCRETE & REBAR FAIL AT THE SAME TIME → $P_{BALANCE}$ → $P_{MAX} = .75\ P_b$

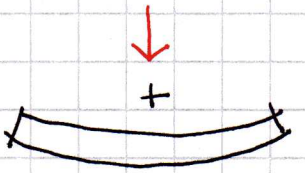
DON'T EXCEED 75%

- THE % CAN'T BE 0
- CODE REQUIRES 11, 14, 18 BARS ⟶ USE # 4 STIRRUPS

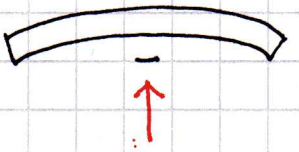
PG. ____

F.B.D.



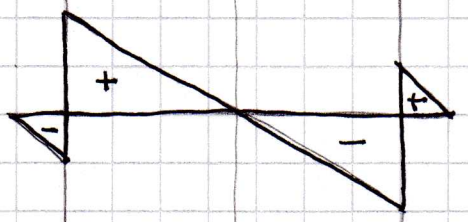


POSITIVE MOMENT



NEGATIVE MOMENT

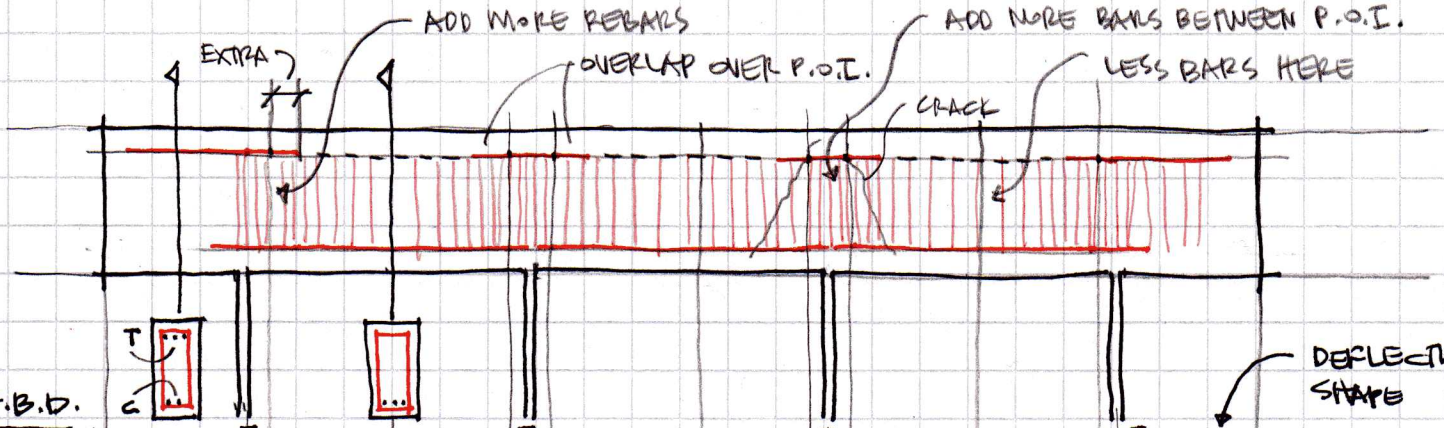
SHEAR



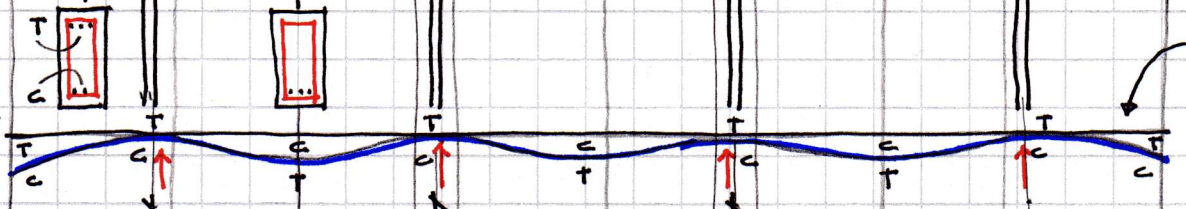
MOMENT



0 MOMENT = P.O.I (POINT OF INFLECTION)



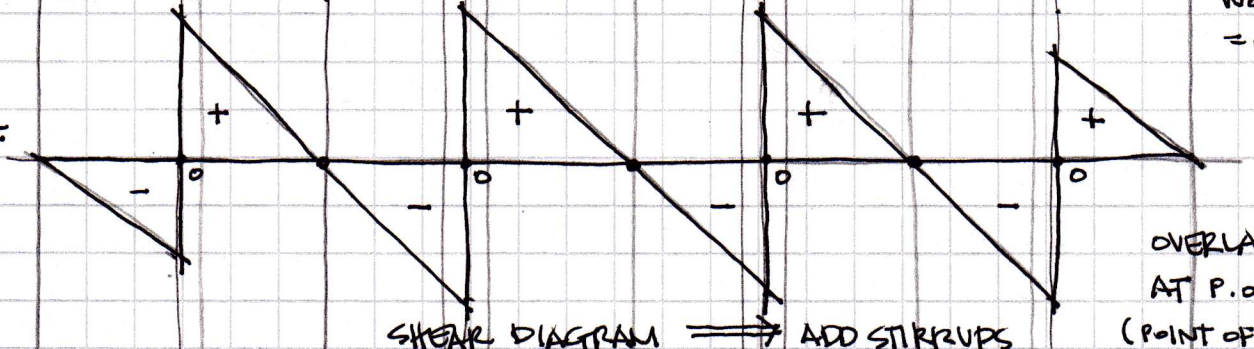
F.B.D.



DEFLECTION SHAPE

WORST SHEAR = MORE STIRRUPS

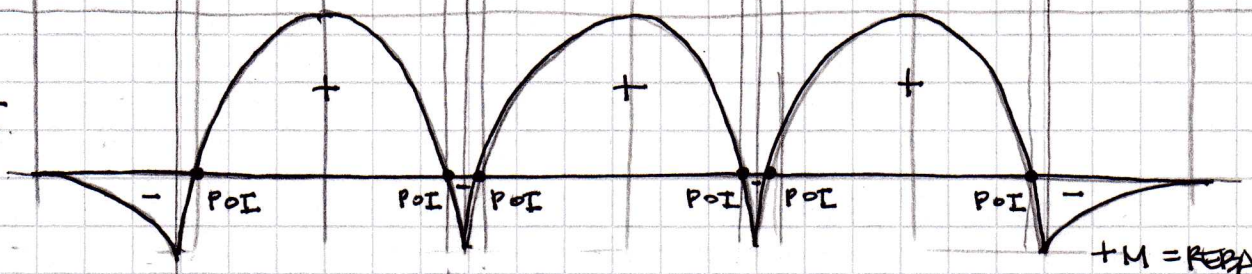
SHEAR



OVERLAP BARS AT P.O.I (POINT OF INFLECTION)

SHEAR DIAGRAM ⟹ ADD STIRRUPS

MOMENT



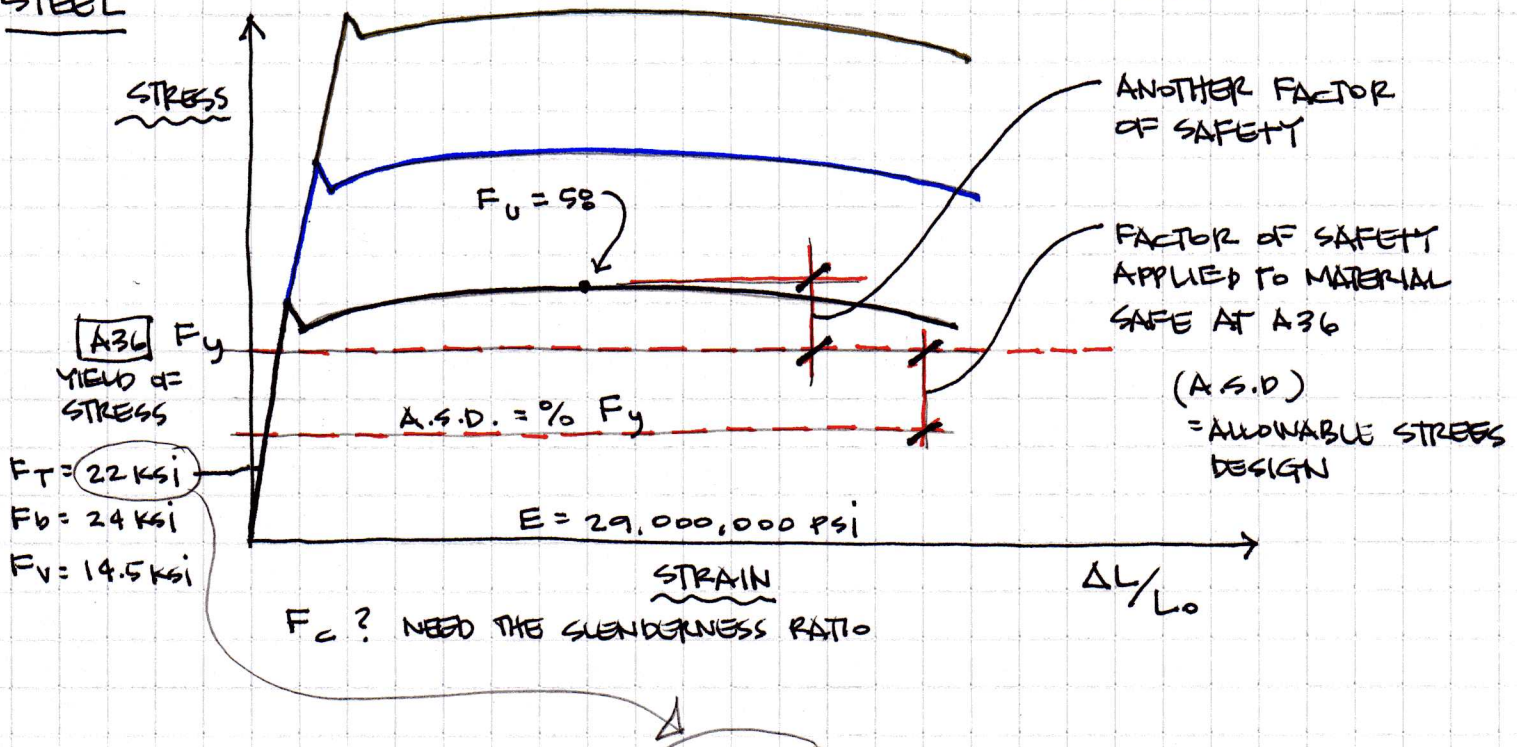
+M = REBAR @ BOT.
−M = REBAR @ TOP

BENDING MOMENT ⟹ ADD REBAR

DIAGONAL TENSION = ADD HORIZONTAL REBAR

STEEL

U = ULTIMATE



F_c ? NEED THE SLENDERNESS RATIO

A36 STEEL → BENDING 22 ksi

28 ksi = VIOLATES CODE
30 ksi = ON BRINK OF DEFORMATION
40 ksi = DEFORMATION (NO LIVES LOST)
50 ksi =
60 ksi = COLLAPSE

36 ksi → 58 ksi = HASN'T BROKEN

- PG 102 GREEN
  - A36 STEEL — .60Fy = 60% of A36
  - A50 STEEL — .60Fy = 60% of A50

ALLOWABLE STRESS DESIGN IN STEEL (A.S.D.)

- PG 103 GREEN
  - ROLLED SHAPES
  - A.E.S.S. = ARCHITECTURAL EXPOSED STRUCTURAL STEEL
    * ADD INTUMESCENT PAINT — PAINT BECOMES FOAM = 2 HR RATING
  - H.S.S. = HOLLOW STRUCTURAL STEEL

· PG 20 – GREEN HANDOUT

PLAN – FRAMING PLAN

FULL LATERAL $F_b = 24$ ksi

B1, B2, (B3), B4

G2, G3 (BAR JOIST), G4 (DECK)

G5, G6, G7

PARTIAL LATERAL $F_b < 24$ ksi

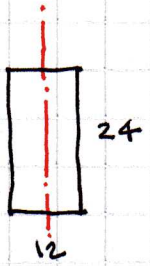
G1 (L = UNBRACED LENGTH) = 12'

G8 (L = UNBRACED LENGTH) = 20'

G9 (L = UNBRACED LENGTH) = 10'

· DESIGN A MEMBER

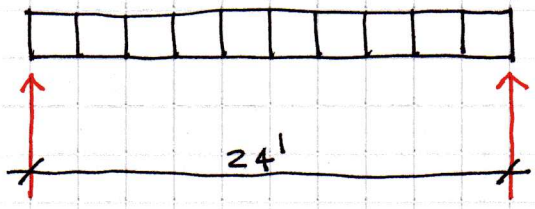
B3



$A = 12 \times 24 = 288$ K

$w = 100$ #/FT

$W = 12 \times 24 \times 100 = 28.8$ K



· DON'T CARE ABOUT SHEAR!

$$M_{MAX} = \frac{WL}{8} = \frac{28.8\text{K} \times 24'}{8} = 86.4 \text{ K FT}$$

M MAX (MAX MOMENT)

$F_b = 24$ ksi (FULL LATERAL)

$$F_b = \frac{M_{MAX}}{S} = \frac{86.4 \text{ K FT} \times 12''/\text{FT}}{S} = \frac{86.4 \text{ K/FT} \times 12''/\text{FT}}{24 \text{ K/in}^2}$$

· CONVERT TO INCHES

$$S = \frac{M_{MAX}}{F_b}$$

1. FIND SECTION MODULUS TO SATISFY BENDING. $S = 43.2 \text{ in}^3$
   · AT LEAST 43.2 in^3

2. SIZE A WIDEFLANGE TO SATISFY BENDING.
   · NEED TABLE W16X31

PG 104 → W12X35 = 45.6 ksi (IS O.K) BUT LOOK FOR "BOLD" NUMBERS.
BOLD = MORE ECONOMICAL SHAPES ⇒ W16X31 = LESS COST

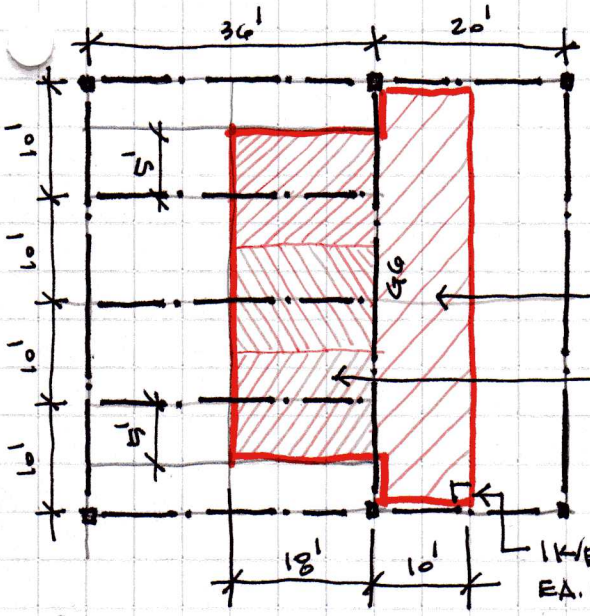
3. $$\Delta = \frac{5 \cdot WL^3}{384\ EI}$$

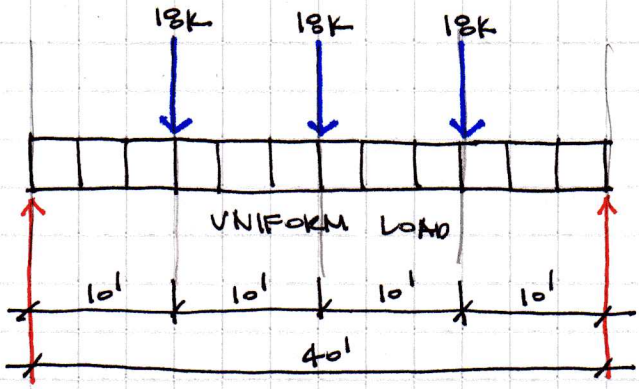
$W = 28.8$ K
$L = 24' \times 12''/\text{FT}$
$E = 29{,}000{,}000$
$I = ?$ LOOK IT UP. · SEE PG 109

Δ = DEFLECTION
I = MOMENT OF INERTIA

PG 20 – GREEN HANDOUT

G6 – GIRDER





$w = 1\ K/FT$

$W = 940\ K$

AREA = $10' \times 40' = 400\ FT^2 \times 1\ K/FT = 400K$

AREA = $18' \times 30' = 540\ FT^2 \times 1\ K/FT = 540K$

$540 + 400 = 940\ K$

MAX. MOMENT = $M_{MAX} = \frac{WL}{8} + \frac{PL}{2}$ (PG 79)

$= \frac{40K \times 40'}{8} + \frac{18K \times 40'}{2}$

$= 200 + 360$

$M_{MAX} = 560\ K/FT$ Q. FULL OR PARTIAL LOAD?

- $F_b = 24\ ksi$ → S_x TABLES IN BOOK

FIND SECTION MODULUS $F_b = \frac{M}{S}$ OR $S = \frac{M}{F_b}$

PG 105 : WAIT, YOU DON'T NEED "S"

W30 x 108 = M = 592 K/FT BUT IT'S THE MOST ECONOMICAL!

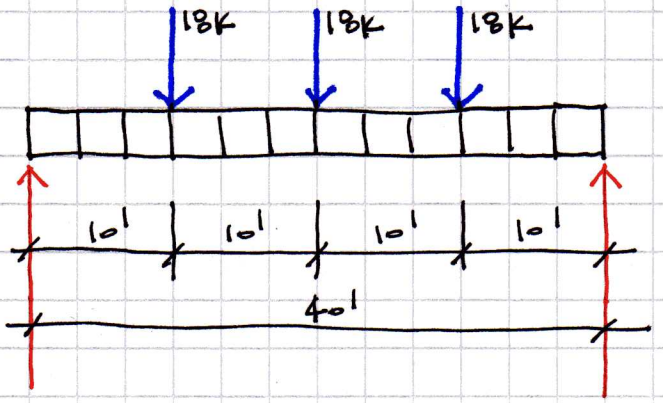
↖ IT'S IN "BOLD" IN TABLE

GIRDERS G1, G8, G9

w = 1K/FT

W =

G9



18x10 = 180 x 100 = 18K

P.79 $M = \frac{PL}{2}$ $M = \frac{18 \times 40'}{2} = 360\ K/FT$

PARTIAL LATERAL SUPPORT

~~Fb = 24 psi~~ = UNBRACED

* THIS IS NOT FULLY SUPPORTED !

- CAN'T USE THE S_x TABLE
- GET M_{MAX}
- UNBRACED LENGTH = 10'

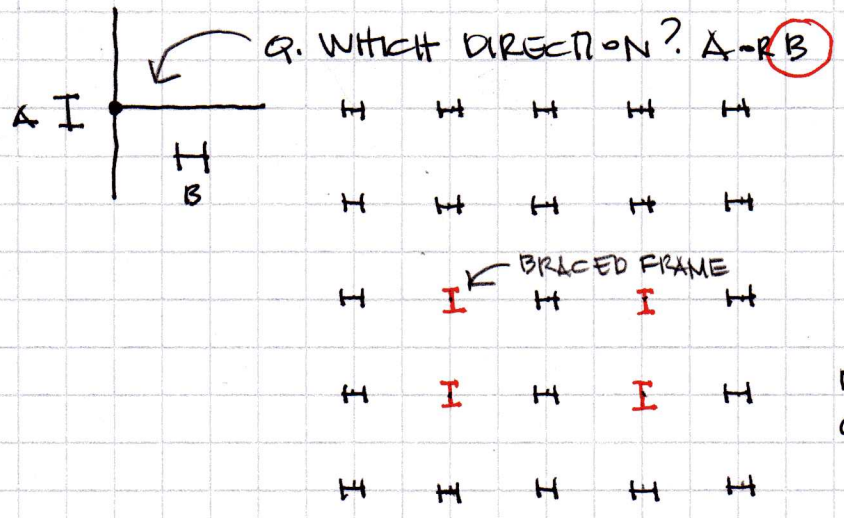
Go To:
PG. 108

- MUST HIT A SOLID ! SOLID = MOST ECONOMICAL.
- = W27 x 84 - NOT A DASHED

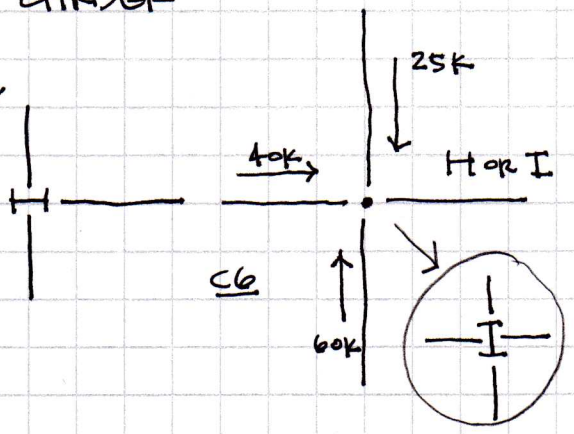
→ FOR UNBRACED LENGTH !

STEEL COLUMN

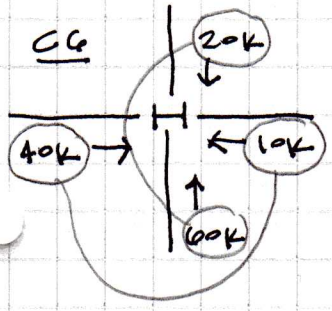
C6 COLUMN

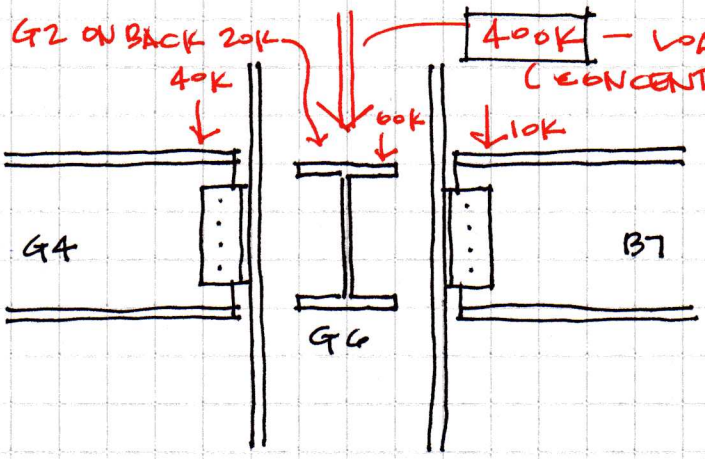


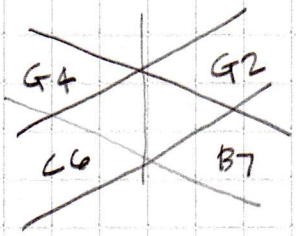
- STRONG DIRECTION OF COLUMN TO GO TO THE GIRDER



BEAMS = NS
GIRDERS = EW







400K = CONCENTRIC LOAD - DOWN THE MIDDLE OF COLUMN C6

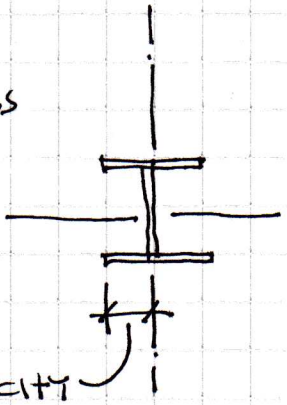
10K (40 x 10) x DEPTH / 2

40K

20K = LITTLE MOMENT 40K x 1/2 WEB THICKNESS

60K

530K ON COLUMN C6



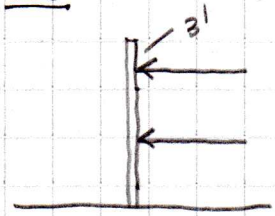
* SAFETY FACTOR ALREADY INCLUDED.

COMBINED LOADING = AXIAL + BENDING

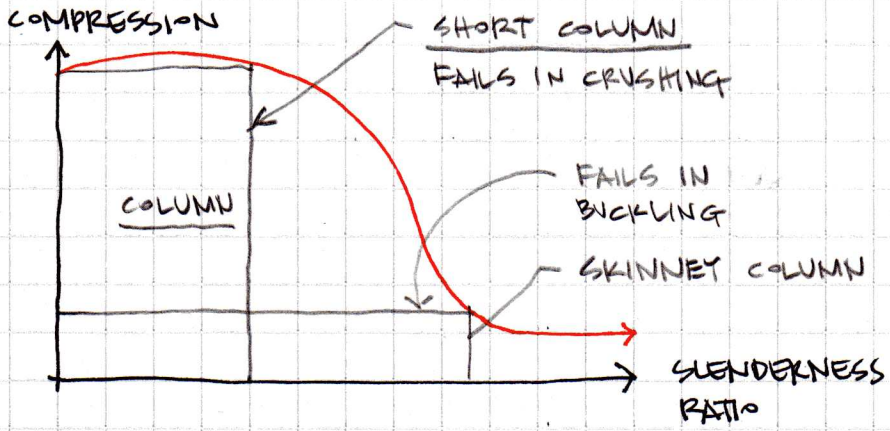
$F = \frac{P}{A}$ $F_b = \frac{M}{S}$

* DESIGN FOR 600K NOT 530K

IF L = 30'



· SLENDERNESS RATIO

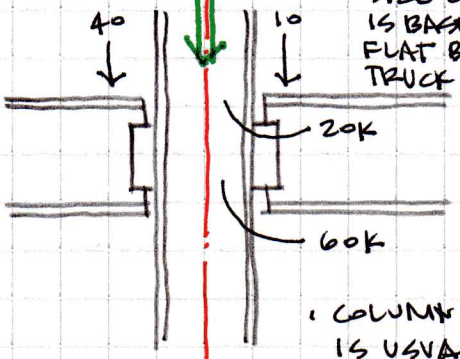


AXIAL LOAD

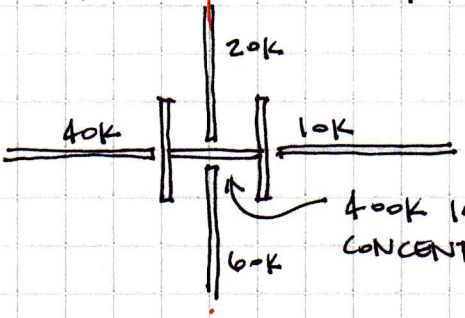
400K

MULTISTORY

· SIZE OF COL. IS BASED ON FLAT BED TRUCK.



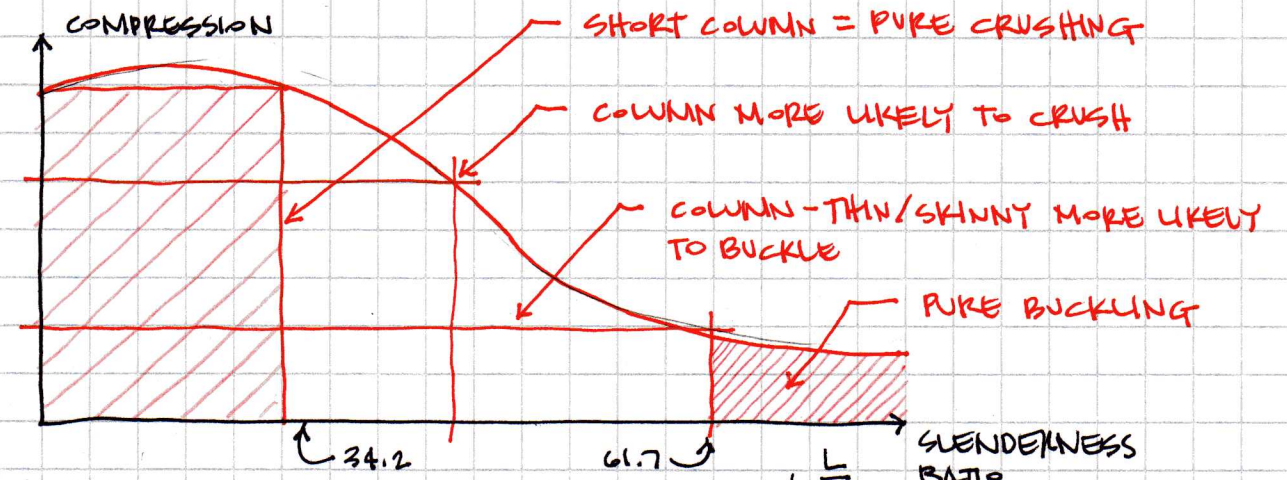
· COLUMN HT IS USUALLY 3' ABOVE 2ND FLOOR.

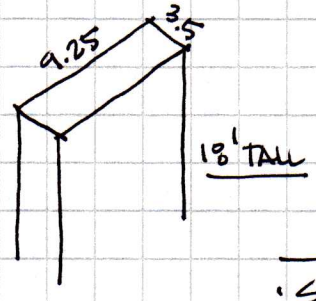


AXIAL $\frac{P}{A}$ + BENDING $\frac{M}{S}$

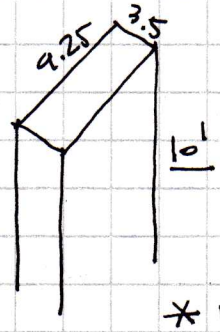
EULER'S EQUATION

$$F_c = \frac{P}{A}$$





$$\frac{L}{d_{LEAST}} = \frac{18'(x12)}{3.5} = 61.7 \text{ RATIO}$$



$$\frac{L}{d} = \frac{10'(x12)}{3.5''} = 34.2 \text{ RATIO}$$

LEAST OR SMALLER DIMENSION

COLUMNS

- SHORT & FAT = CRUSHES
- SKINNEY & THIN = BUCKLING

4 X 10

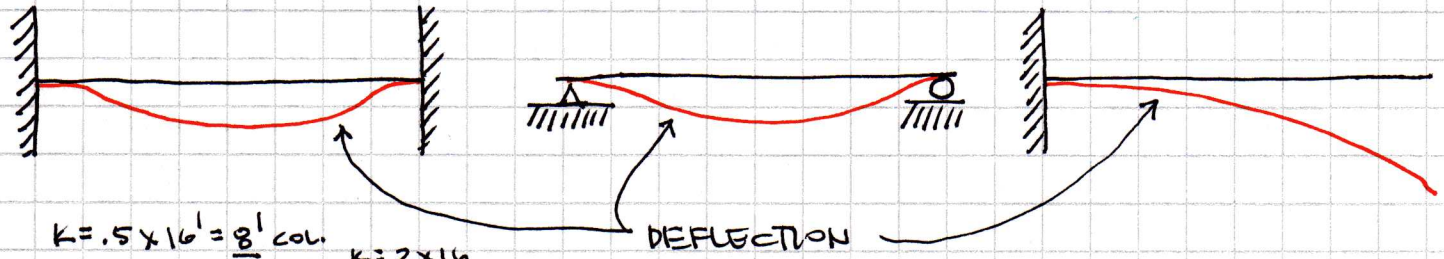
* BETWEEN 11 – 50

$$\text{STEEL} = \frac{KL}{r}$$

K = WAY COLUMN IS CONNECTED

L = UNBRACED LENGTH

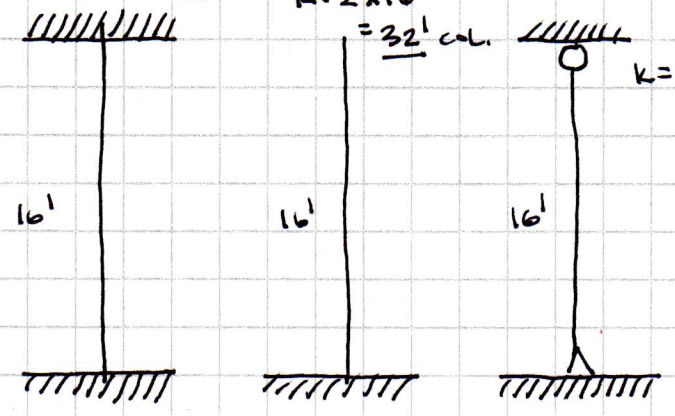
r = RADIUS OF GYRATION $\quad r = \sqrt{I/A}$



K = .5 x 16' = 8' COL.

K = 2 x 16 = 32' COL.

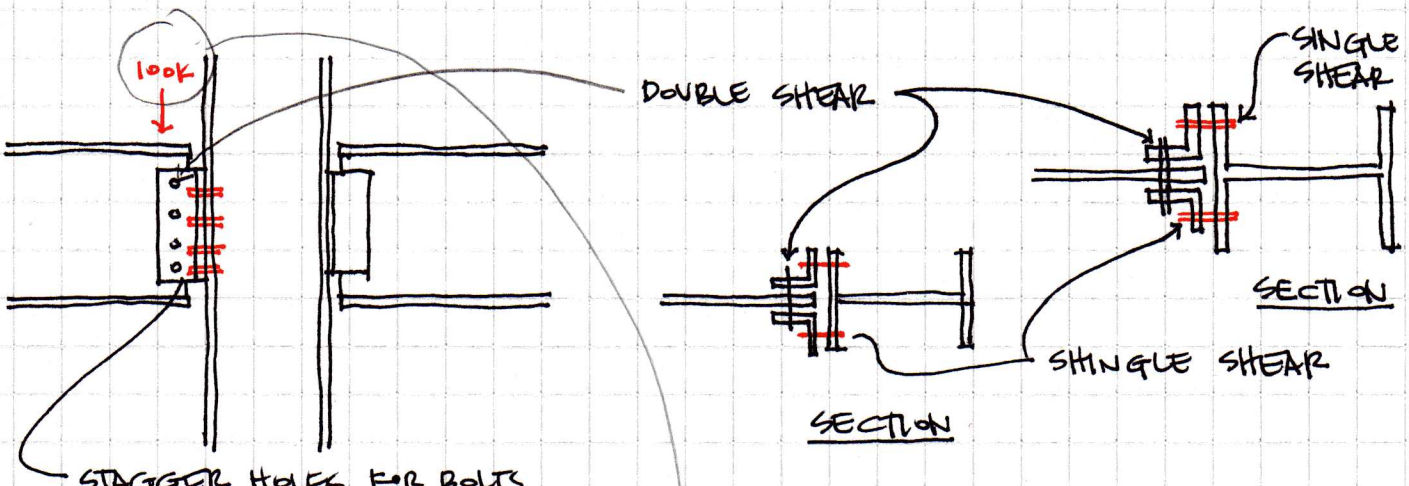
K = 16' COL.



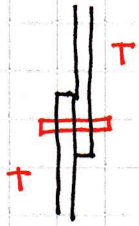
* STRENGTH OF CONNECTION DETERMINES HT OF COLUMN.

BOLTS

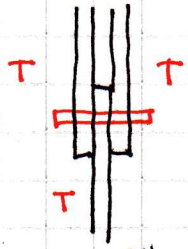
PG 115 BOLT TABLE — ALWAYS ON EXAM!



STAGGER HOLES FOR BOLTS
'MAKES EASIER TO WRENCH BOLTS



SINGLE SHEAR



DOUBLE SHEAR

* F = TIGHTEN TO FRICTION (NOT ALLOWED TO SLIP)

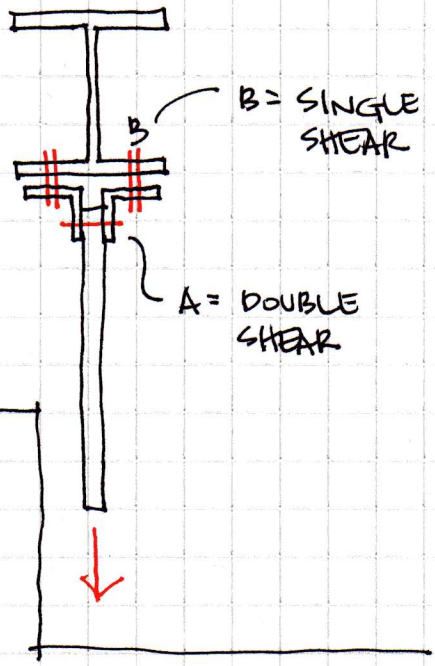
IN = THREADS INCLUDED



EX = ~~PRO~~ THREADS EXCLUDED



· BOLTS ARE IN OR OUT OF SHEAR



EX: 100K A325 BOLTS TYPE N 1" ϕ

Q. * HOW MANY BOLTS?

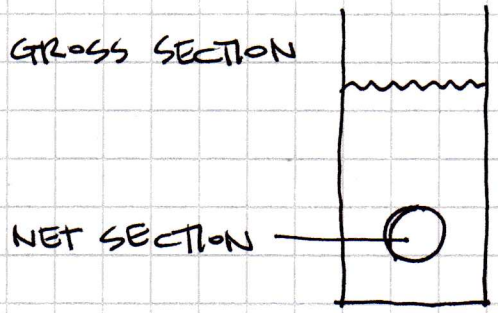
· DBL SHEAR IT CAN HANDLE 33K
YOU NEED (4) BOLTS — NOT 3

· SINGLE SHEAR
IT SPLIT



A325 BOLT TYPE N 1" ϕ
= 16.5 · NEEDS TO HANDLE 50K
3.5 OR 4 BOLTS ON EA. SIDE

· SPLIT 100K TO EA. SIDE OF BEAM

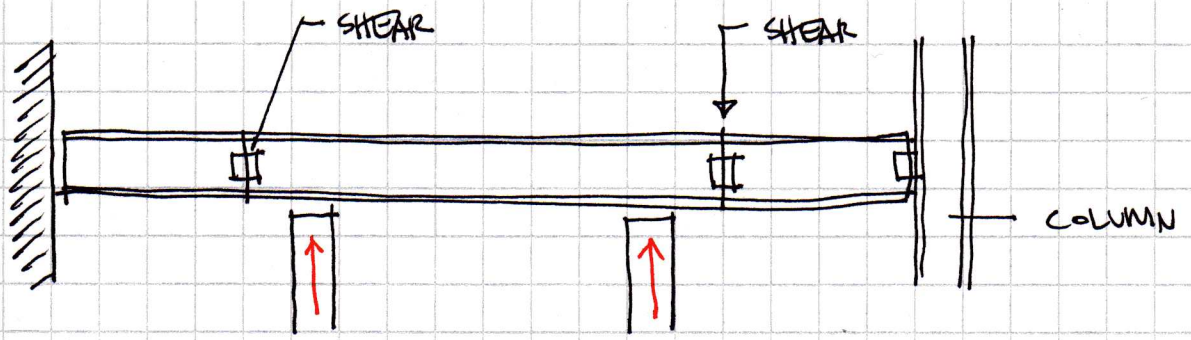


* HOLE IS 1/16" BIGGER THAN BOLT

* 1/8" BIGGER HOLE = OVERSIZED HOLE

MOCK EXAMS — SEE BLUE BOOKLET

- IMMEDIATELY WRITE DOWN FORMULAS ON PROVIDED PAPER
- REMOVE KEYBOARD TO MAKE ROOM
- CLOCK HASN'T STARTED
- WRITE DOWN 1 PAGE CHEAT SHEAT



* THIS IS STATICALLY DETERMINATE = (3) BEAMS

CHEAT SHEET

AXIAL

- TENSION
- COMPRESSION

- COLUMN
- CABLE
- TRUSS
- BRACE

$$F = \frac{P}{A}$$

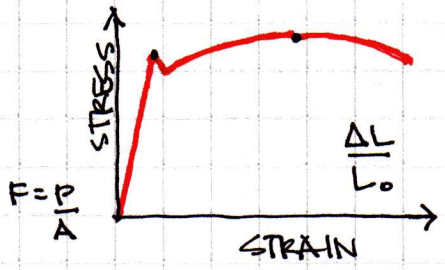
F = STRESS
P = LOAD (#ORK)
A = CROSS SECT. AREA (IN^2 OR FT^2)

UNIT STRAIN - $$E = \frac{\Delta L}{L_o}$$

E = MODULUS OF ELASTICITY

$$E = \frac{RISE}{RUN} = SLOPE$$

$$E = \frac{STRESS}{STRAIN}$$



$$\Delta L = \frac{PL_o}{AE}$$

Δ =
L =
P = LOAD
L_o = ORIG. LENGTH
A = AREA
E = MOD. OF ELAST.

TEMP $$\Delta L = \alpha(\Delta T)L_o$$

α STEEL = .0000065

PERPENDICULAR

- SHEAR
- BENDING

- DECK
- FLOOR
- JOIST
- BEAM
- ROOF

WOOD $$F_v = \frac{3V}{2A}$$: SHEAR

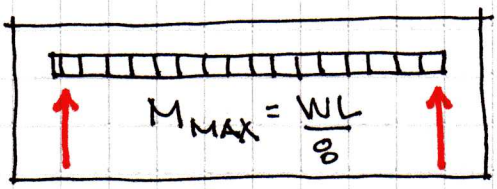
$$A = b \times d$$

- WOOD
- STEEL
- CONC

$$F_B = \frac{M}{S}$$: BENDING

STRENGTH, FLEXURE

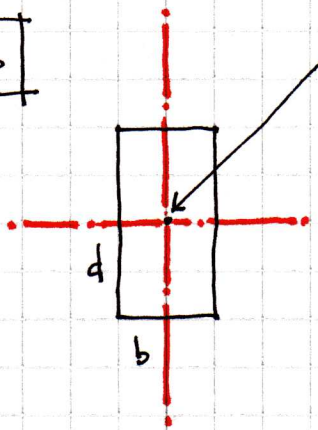
$$S = \frac{bd^2}{6}$$



$$\Delta = \frac{\text{CONST}\ \frac{W}{P} L^3}{EI}$$ (STIFFNESS)

$$I = \frac{bd^3}{12}$$

$\Delta_{ALLOW} = \frac{L}{240}, \frac{L}{360}$
- IS CODE SPECIFIED



CENTER OF GRAVITY

$A = b \times d$ ⟶ SHEAR

$S = \frac{bd^2}{6}$ ⟶ MOMENT

$I = \frac{bd^3}{12}$ ⟶ DEFLECTION

DAY 4 1/22/06

ARE

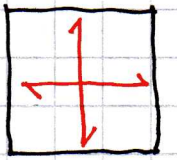
- HOW TO SELECT STRUCTURAL SYSTEMS

* LONG SPAN STRUCTURES
- GENERAL EXAM
- DON'T SPEND TOO MUCH TIME ON LONG SPAN !

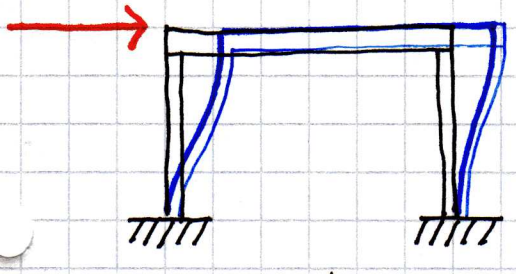
PG 53A



1 WAY SLAB



2 WAY SLAB



POST & BEAM

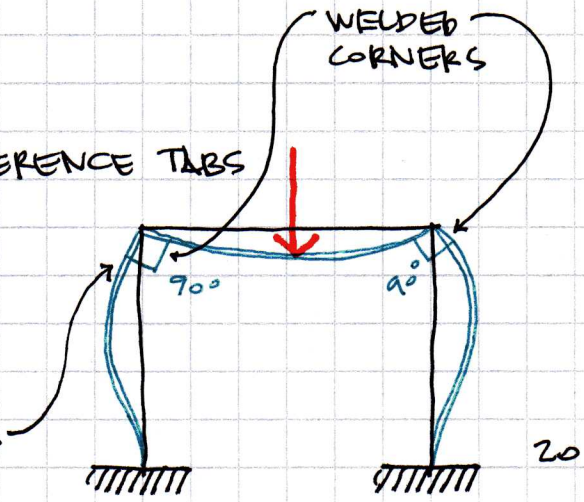
- MUST MAKE RIGID JOINTS
- BRACE / SHEAR WALL
- DUAL SYSTEM — WELD JOINTS & BRACE
- SHEAR & BENDING

- SIMPLE TRUSSES
  - SHEAR AT END
  - BENDING
  - ACTS LIKE A BEAM
  - MEMBERS ARE IN TENSION & COMPRESSION
  - SHEAR & BENDING

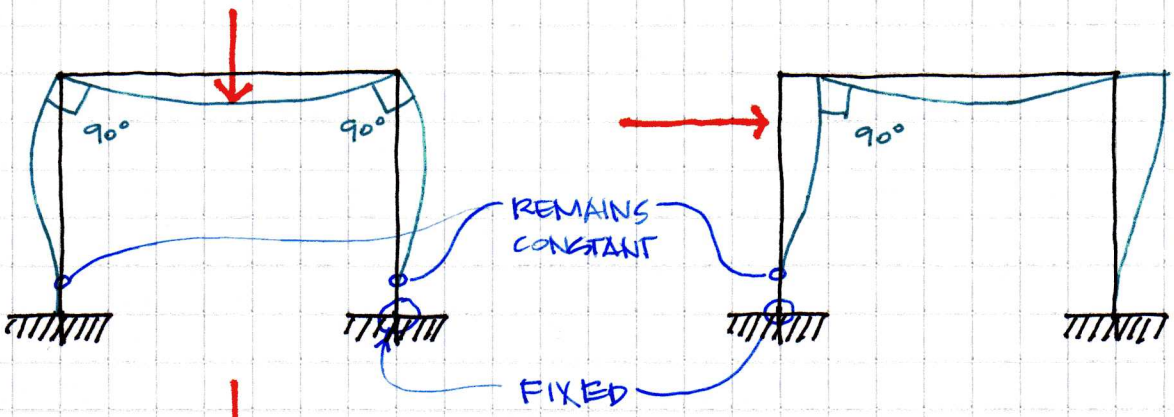
- LOAD BEARING WALLS
  - GOOD IN PLANE
  - BAD OUT OF PLANE

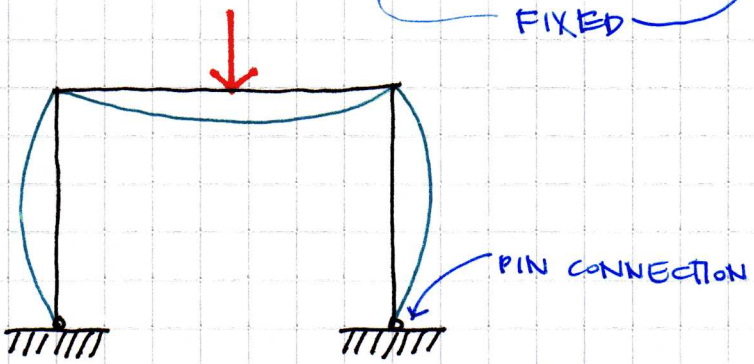
LATERAL FORCE EXAM ⟶ NO REFERENCE TABS

* WELDED CONNECTIONS = A FRAME



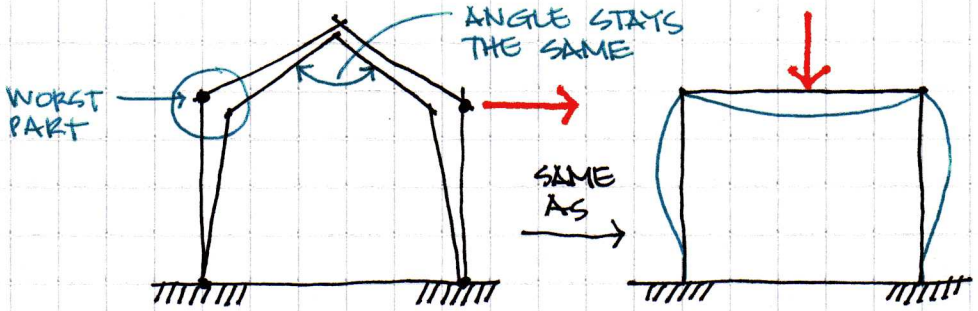
- DEFLECTION IS LESS
- MUST KEEP 90° AT CORNERS





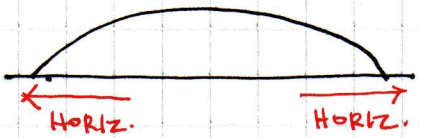
POINT OF INFLECTION

- RIGID FRAMES = IMPORTANT!

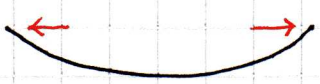


* PIN JOINT — ALLOWS EXPANSION & CONTRACTION

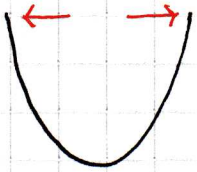
- **ARCHES** : STEEP = REACTION IS VERTICAL
  SHALLOW = REACTION IS HORIZONTAL



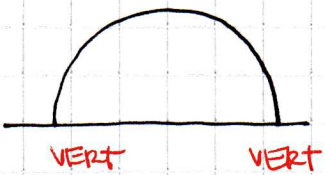
- **CABLES** :



· HORIZ. REACTION
· LITTLE VERTICAL



· VERTICAL REACTION
· LITTLE HORIZ



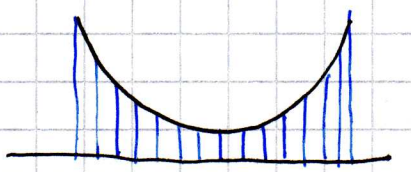
- **FUNICULAR** : NATURAL SHAPE CABLE MAKES UNDER A LOAD.



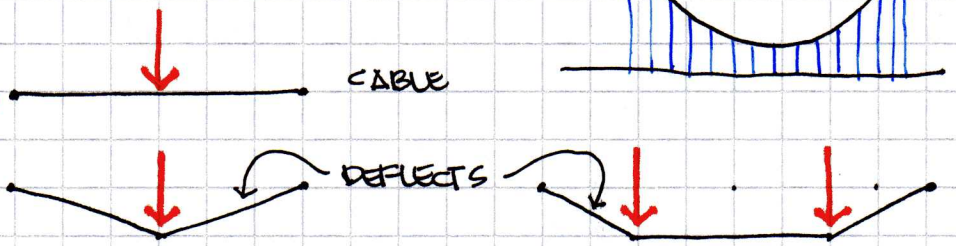
- **CATENARY** : DEFLECTS UNDER ITS OWN WEIGHT



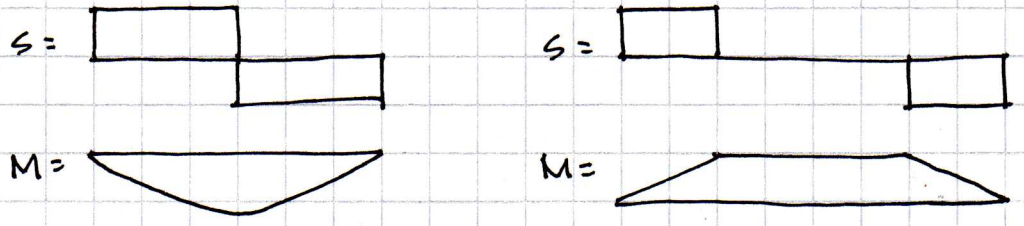
- **PARABOLA**



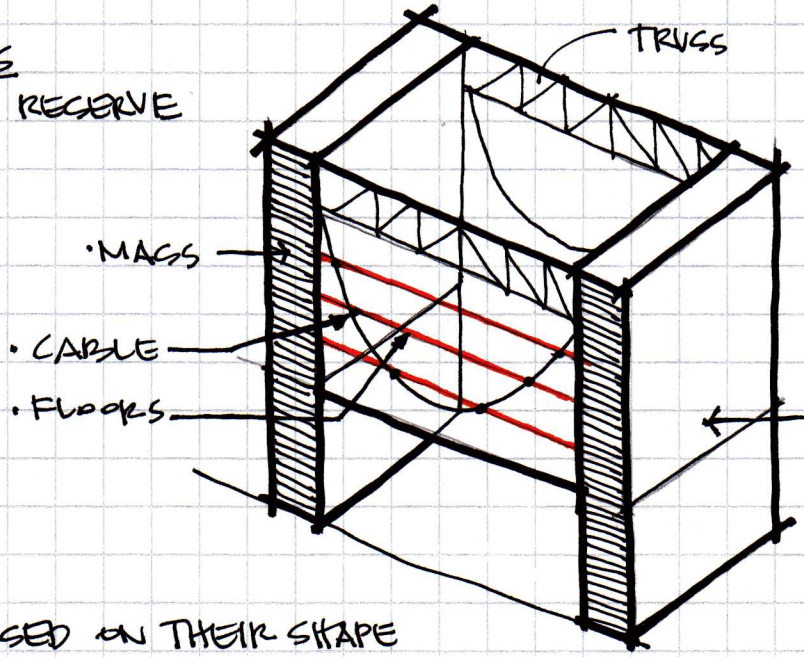
- ADD WEIGHT ON CABLE



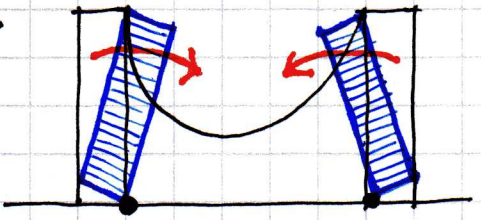
- GAUDI



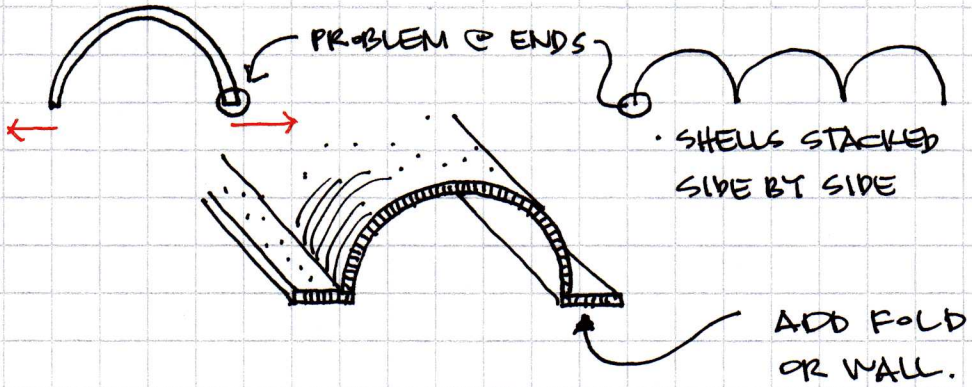
BERKERTS FEDERAL RESERVE



- FLOORS TIED TO CABLES
- MASS WANTS TO PULL IN = ADDED TRUSS ON TOP IN COMPRESSION



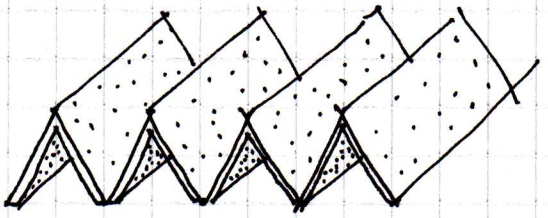
- **SHELL** : BASED ON THEIR SHAPE GET STRENGTH FROM SHAPE



- CABLE PULLS MASS INWARDS = ADD TRUSS BETWEEN MASS

- SPAN SHELL IN LONG DIRECTION.

- FOLDED PLATE



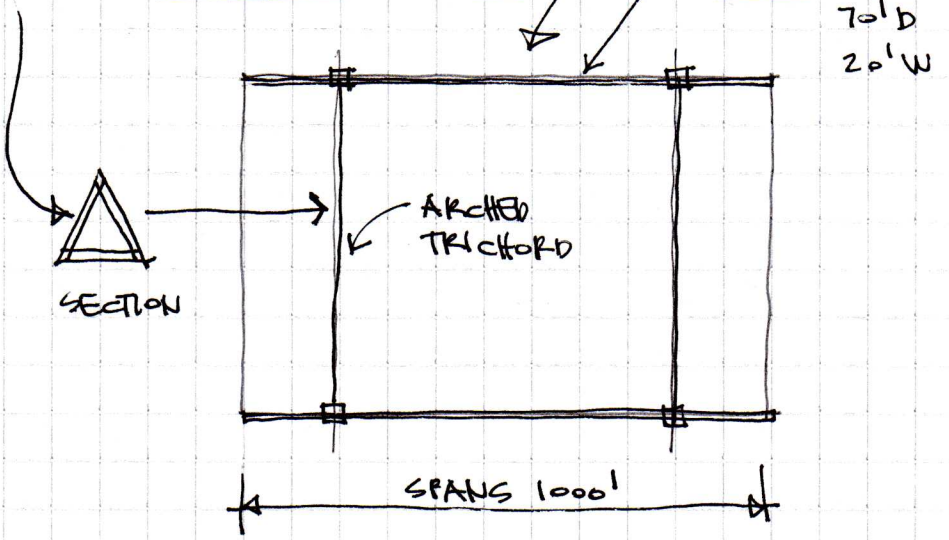
- GOOD IN CONCRETE
- BAD - NOT EFFECTIVE IN WOOD.

- SPAN IN LONG DIRECTION

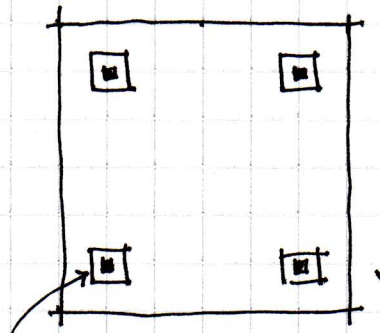
- BOOKS - ARCHITECT'S STUDIO COMPANION
  - SELECTION OF STRUCTURAL SYSTEMS

- PG 54 ⟶ REPLACED W/ PG 53B
- PG 53 TABLE
- PG 55 TABLE
- PG 56
- PG 57

- PG 60 STEEL - TRICHORD - RELIANT STADIUM

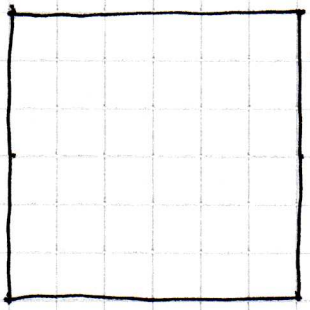


- SPACE FRAME



SUPPORT AT COLUMNS

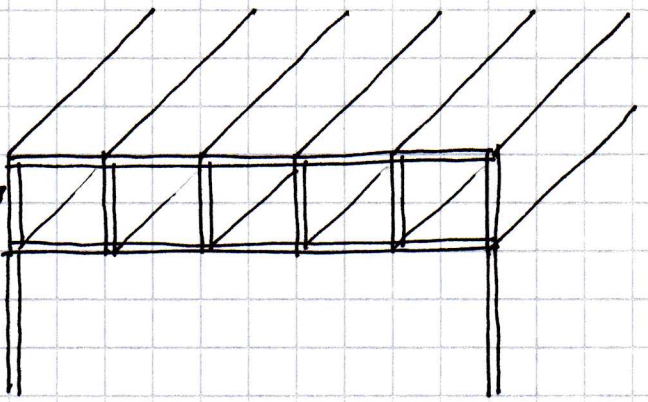
"SQUARE BAY" - BEST FORM



- PROVIDE SUPPORT AROUND PERIMETER OF FRAME WITH WALLS OR COLUMN
  = SHALLOW SPACE FRAME

"SHALLOW STRUCTURE"

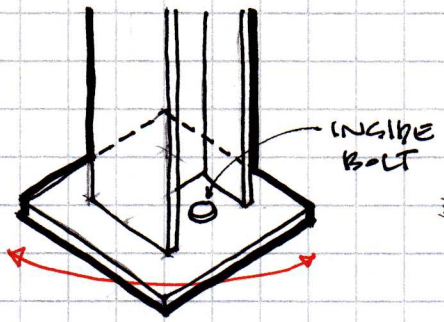
PG 61 STEEL FRAME SYSTEM



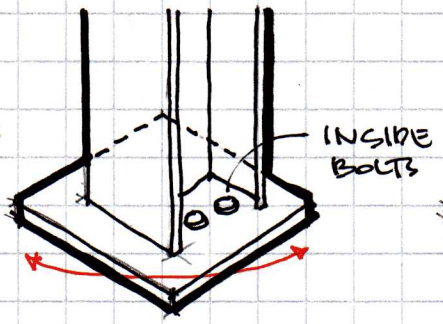
- VERENDEEL TRUSS
  - FULLY WELDED
  - ACTS AS A BEAM
  - BIG
  - NO DIAGONALS
  - ALL WELDED CONNECTIONS

- GUSSET PLATES

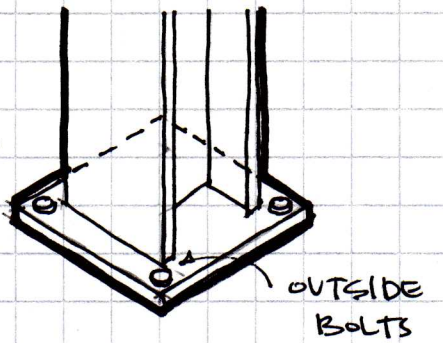
- GIRT = HORIZONTAL BETWEEN FRAMES



PINNED CONNECTION



PINNED CONNECTION



FIXED/RIGID CONNECTION

PG 58 CONCRETE

PG 59 ONE WAY SLAB IS EASIER TO PUNCTURE THAN 2 WAY.

(d) TWO WAY FLAT PLATE — SPANS 20' — NOTHING DROPS DOWN.

(e) PUNCHING SHEAR — REINFORCED LOCALLY @ COLUMN CAP.

FOUNDATIONS

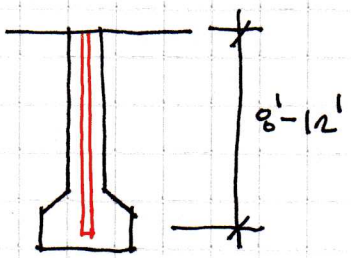
PG 1 - ORANGE
PG 2 - WHAT HAPPENS IN A FOUNDATION

EX: P = LOAD ON COLUMN
P = 100K

* $F = \frac{P}{A}$ $A = \frac{P}{F} = \frac{100K}{3K/FT^2} = 33.33\ FT^2$ (6'x6") AREA OF PAD

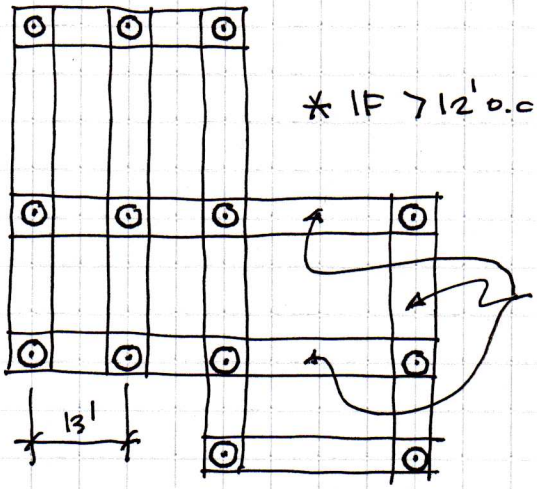
* DEPTH OF PAD $\sqrt{6 \times 6} = 36"$ ⌀

PG 2



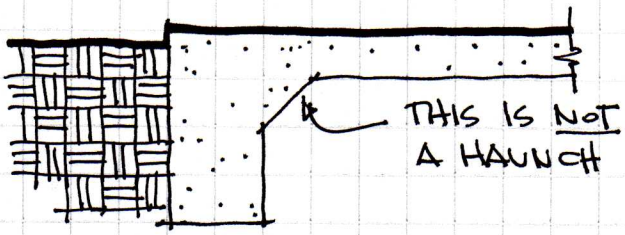
HOUSTON, TX
- RESIDENTIAL FOUNDATION
- NO BASEMENTS
- BAD SOIL

- PIER CODE @ 12' O.C. MAX



* IF > 12' O.C. = ADD PIER

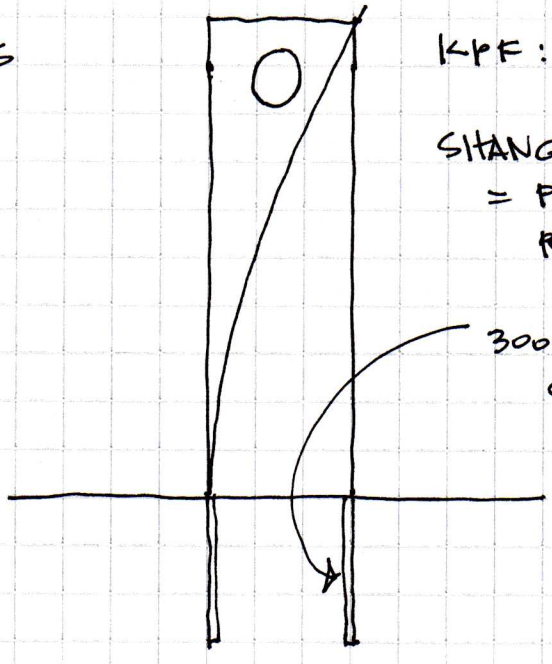
PLAN



PG 7 - ORANGE READ THIS

$F = \frac{P}{A}$

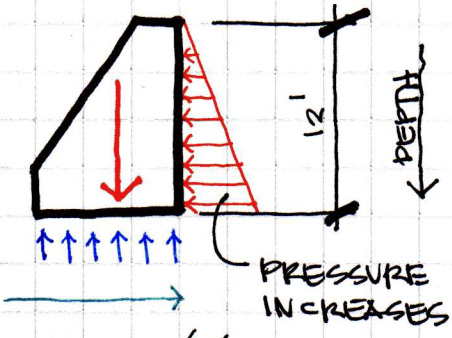




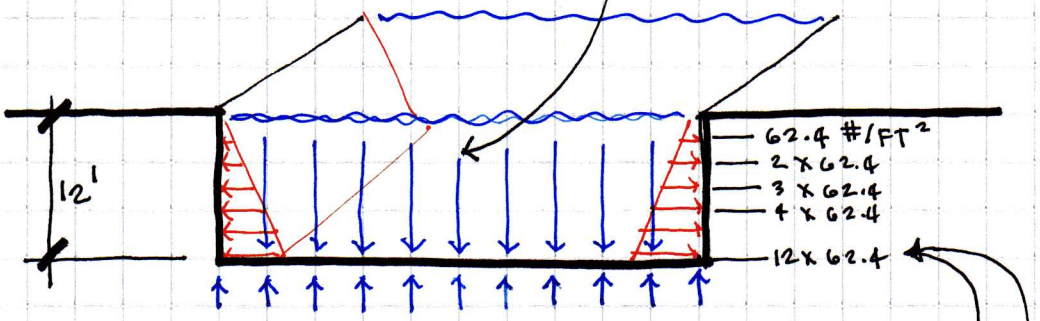
PG 6 - ORANGE (AT THE END OF THE SECTION) BEFORE DEFINITIONS

- RETAINING WALLS
  - IF WALL IS TOO HEAVY = SETTLEMENT
  - IF UNEVEN SETTLEMENT = PROBLEM

Q. WHAT DOES THE DIRT DO ON WALL
- INCREASES (PRESSURE) WITH DEPTH.

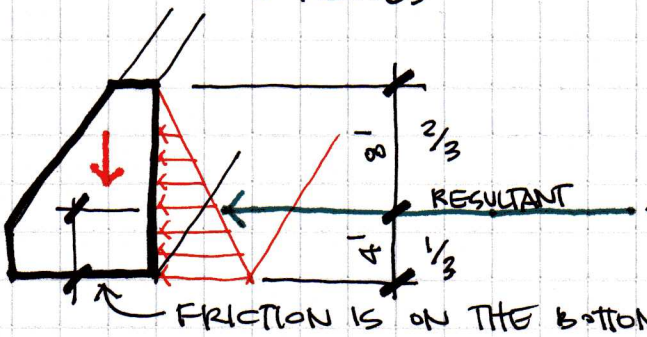


WATER HAS WT = 62.4 #/FT³

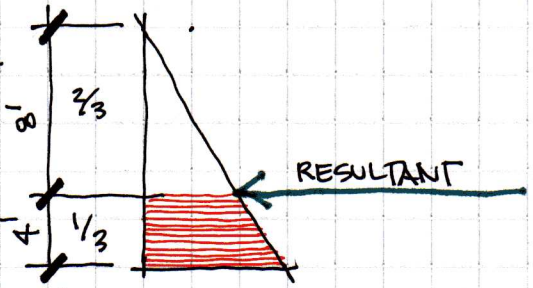


POOL

- PRESSURE WORST AT 12'
- RESULTANT = 12' X 62.4 #/FT² = 748.8 #/FT

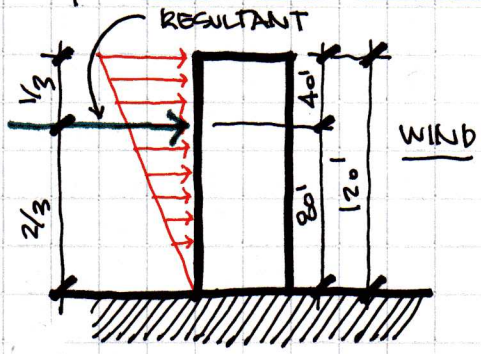


- RESULTANT = AREA CLOSER TO BOTTOM



- IF YOU DON'T KNOW SOIL — ASSUME 1/2 LOAD OF WATER = 30 #/CUBIC FT.

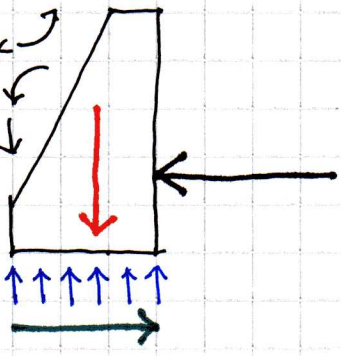
- TRIANGULAR LOAD = WATER, WIND, SOIL OR RETAIN WALL



- RESULTANT IS NOT IN THE MIDDLE

- 3 CONDITIONS
  - SETTLEMENT
  - SLIDING
  - OVERTURNING

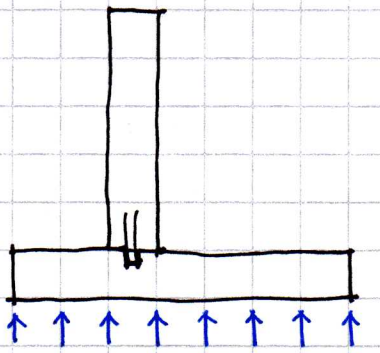
IF... GREEN IS > BLACK →
BLACK IS > GREEN ←
RED IS > BLUE = ↓



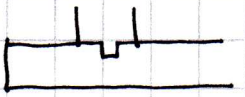
PG 6 - ORANGE

C = COMPRESSION
T = TENSION

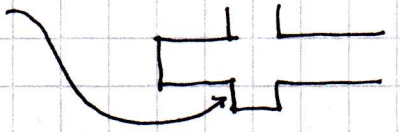
- CANTILEVER WALL



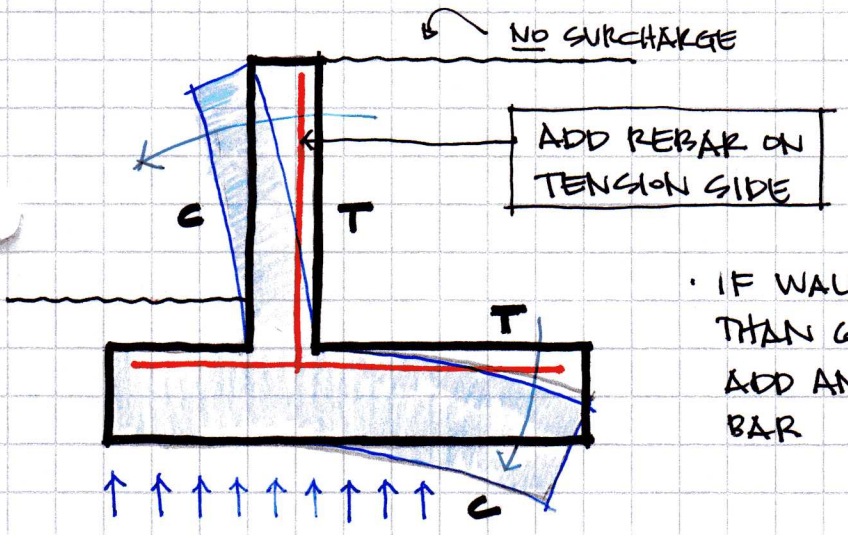
- ONE PIECE = MONOLITHIC
- KEY = 2 PIECES

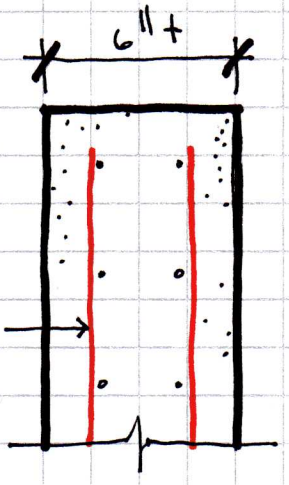


- KEY = PREVENTS SLIDING

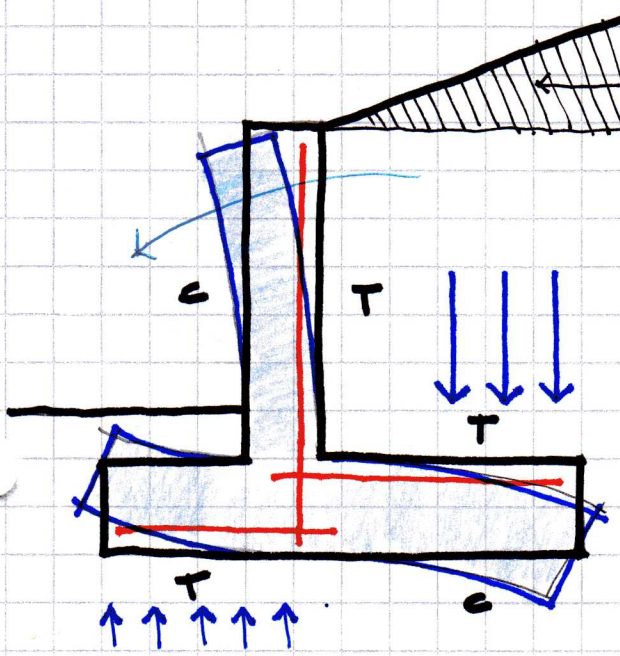


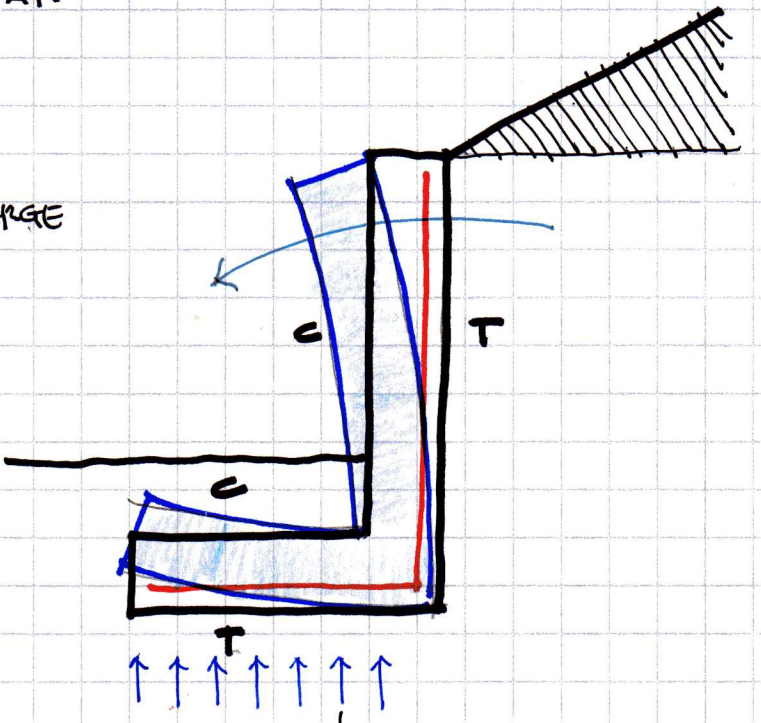
- ADD REBAR - DRAW DEFORMED SHAPE





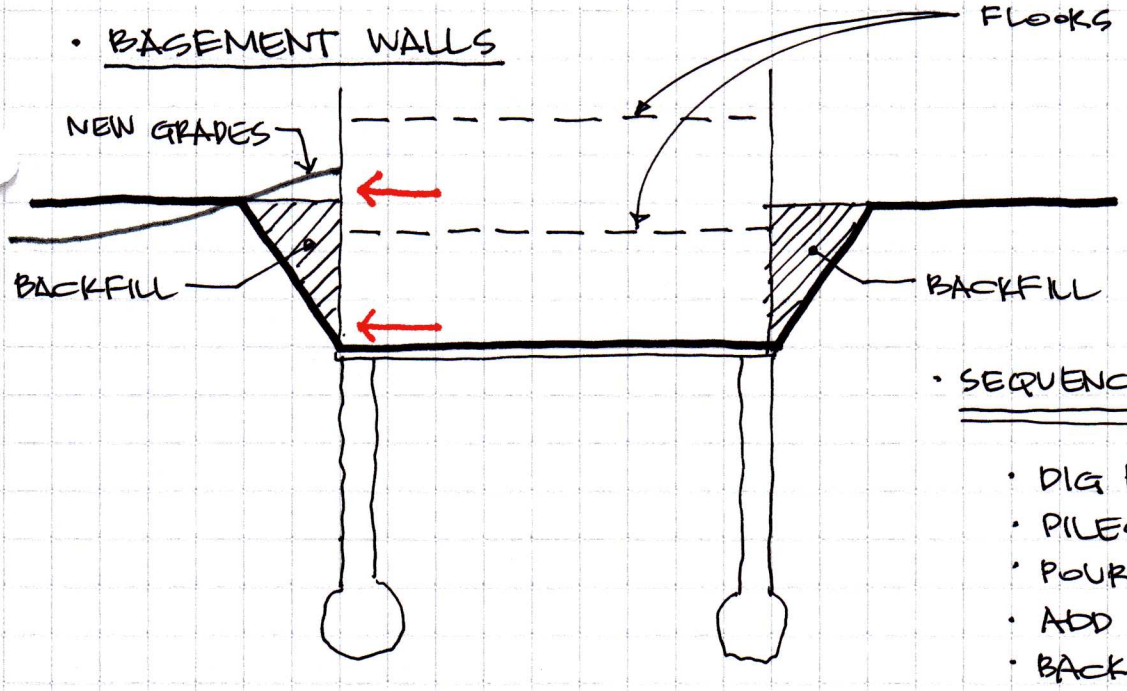
- IF WALL IS WIDER THAN 6" - THEN ADD ANOTHER BAR



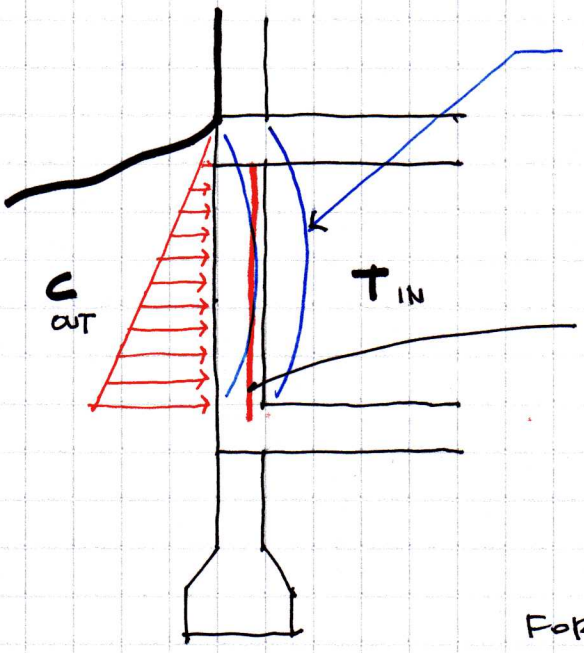


= REBAR

- **BASEMENT WALLS**



- **SEQUENCE OF CONSTRUCTION**
  - DIG HOLE
  - PILES
  - POUR WALLS
  - ADD FLOORS
  - BACK FILL



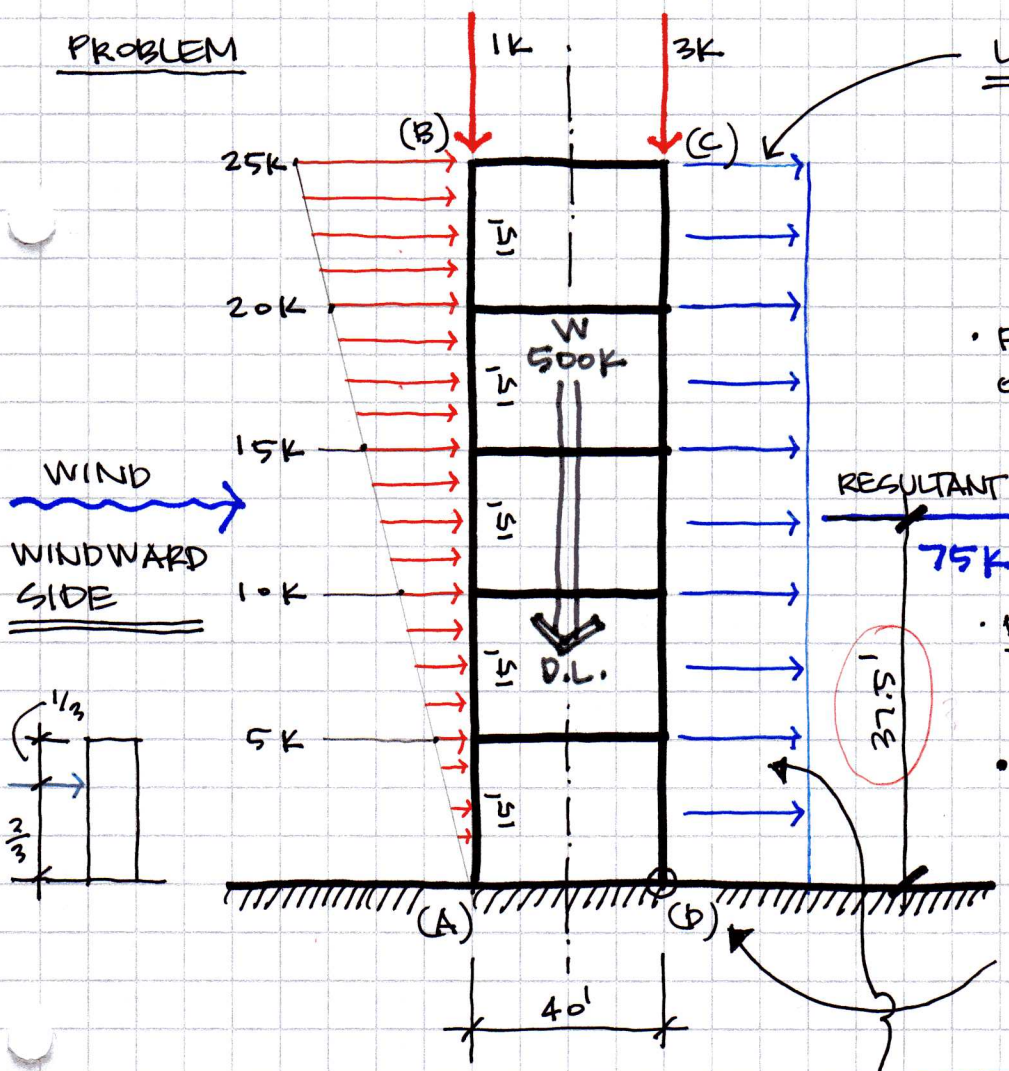
WALL BOWS TOWARD THE INTERIOR

* THIS IS NOT A CANTILEVER!

ADD REBAR ON TENSION SIDE

FORCE / MOMENTS / STRESS

PROBLEM



LEEWARD SIDE

= A UNIFORM LOAD

WIND = 1K/FT

- FORCE INCREASES W/HEIGHT ON WINDWARD SIDE.

RESULTANT

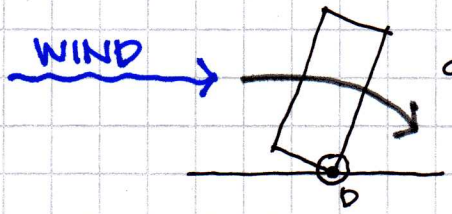
1K/FT : 15' x 5 FLOORS = 75K

- D.L. = DEAD LOAD = THE BUILDING ITSELF
- W = 500K ↓

OVERTURNING POINT IS AT POINT "D"

LEEWARD SIDE IS HOLDING THE OVERTURNING.

Q. WHAT'S WIND DOING TO BUILDING?



OVERTURNING MOMENT = O.M.

- 5K x 15' = 75 K/FT
- 10K x 30' = 300
- 15K x 45' = 675
- 20K x 60' = 1200
- 25K x 75' = 1875

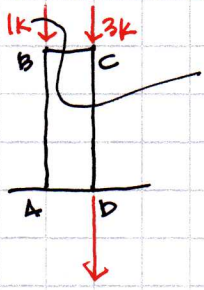
75K x 37.5' IN BLUE

4,125 K/FT 2812.5 K/FT

* TOTAL OVERTURNING MOMENT = 6,937.5 K/FT

- DEAD WT KEEPS BUILDING FROM OVERTURNING
- STABILIZING MOMENT (SM)
- COUNTERCLOCKWISE (CCW)

- 1/2 OF 40' → 500K x 20' = 10,000 K-FT



1K x 40' = 40 K-FT

NET STAB. MOMENT

10,000 K-FT
+ 40 K-FT
10,040 K-FT (S.M.)

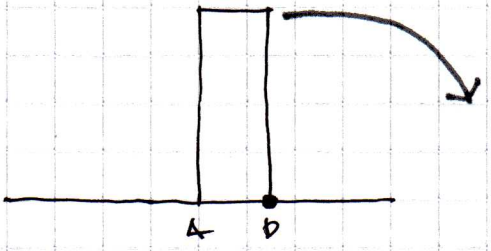
4,125 K/FT
+ 2,812.5
O.M. = 6,937.5 K/FT

O.M. = 6,937.5 K/FT * IF 7,200 = SAFE ... THE CODE REQUIRES

S.M. = 10,000 K/FT S.M. BE 1/2 x O.M = 10,500 K-FT

* THEREFORE: MUST ADD WT... LIKE HVAC EQUIP

METAL STUDS



O.M. = 7,000 K/FT

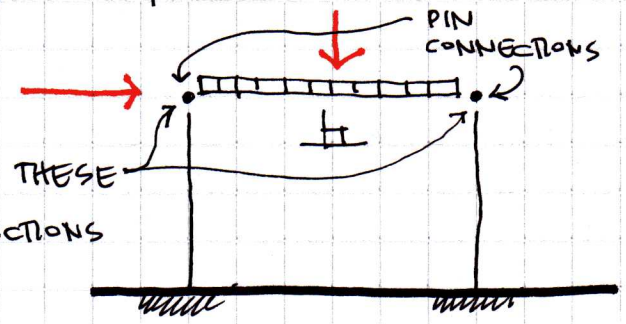
S.M. = 6,000 K/FT — MUST ADD TIE DOWN TO BUILDING. (HOLD DOWN) AT POINTS A & D (BOTH POINTS)

6,000 K/FT IS NOT ENOUGH

· MAYBE ADD ATUNED MASS DAMPER OR COUNTERWEIGHT

Q. HOW DO WE GET LATERAL STABILITY W/ POST & BEAM?

1. MOMENT FRAME (MF)



POST & BEAM

(RIGID FRAME)

- HAS RIGID CONNECTIONS
- ARCHITECT'S BEST FRIEND
  - NO OBTRUSIONS / FLEXIBLE
- FLEXIBILITY IN SPACE PLANNING
  - UNOBSTRUCTED
- ENGINEERS NIGHTMARE (STRUCTURALLY INEFFICIENT)
- HIGH DRIFT (SWAY) DRIFT = HORIZONTAL DEFLECTION OR SWAY
  - HOW MUCH SWAY IS ALLOWED — CHECK THE CODE.
- VERY DUCTILE — GOOD IN EARTHQUAKE
- EXPENSIVE - LABOR INTENSIVE
  - LABOR CERTIFICATION REQUIRED } FOR STEEL
  - MUST INSPECT WELDS
- STEEL, CONCRETE, ~~WOOD~~

L/500	· FLOOR TO FLOOR (SWAY) · OVERALL (SWAY)

MOMENT TRANSFER FROM HORIZ. TO VERT.

(GOOD FOR)
- LOW, BROAD BUILDINGS - NOT TALL.
- GREATEST STRESS ON INDIVIDUAL MEMBERS
  ⇒ LARGEST CROSS SECTIONAL FOR BEAM & COLUMN.
- SMALLER COLUMN GRID (25' OR LESS)

MIES = MOMENT FRAMES

- SWIMMING POOLS

PG. SEE BOOKS

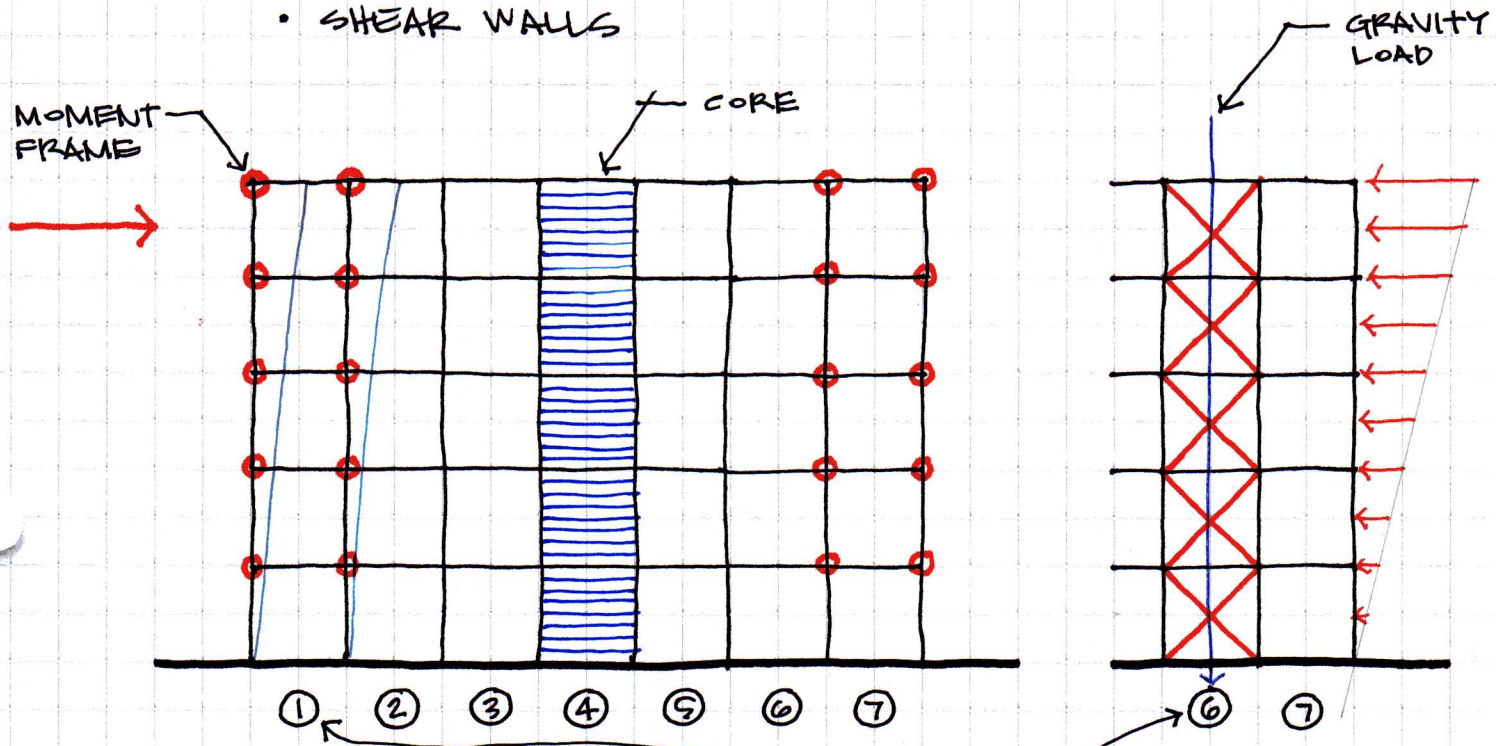
MOMENT FRAME CONTINUED .... WORKSHEET

1. MOMENT FRAME = RIGID FRAME.

LATERAL ABILITY

LATERAL OR GRAVITATIONAL

- MOMENT CONNECTIONS
- RIGID CONNECTIONS
- BRACED BAYS
- SHEAR WALLS



ELEVATION

· BAYS ① & ⑦ STOP LATERAL MOVEMENT

PARTIAL ELEV.

· BAY ⑥ STOPS LAT. MOVEMENT

Q. WHICH BAYS WOULD WORK FOR BRACING ?

① ⑦ ③ ⑤ OR ① ⑦ ④

B A

B = MORE RIGID WITH MORE BAYS

* BAYS ① OR ⑥ IS CALLED: A BENT

OR A RIGID BENT (ENABLED W/ LATERAL)

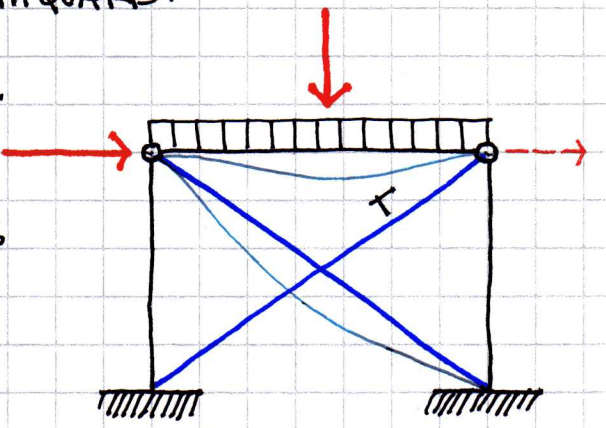
· ON LATERAL EXAM : YOU WANT SYMMETRY OF LATERAL DESIGN SYSTEM .... IT MUST BE SYMMETRICAL! IF NOT = TORSION

2 BRACED FRAME (BF)

* ON PREVIOUS PAGE 31 ... BRACE BAYS 1, 4 & 7
IF YOU LEAVE JOINTS ALONE = SAVE MONEY.

- PIN CONNECTIONS – ALLOWS ROTATION
- ARCHITECT IS O.K. – BUT WORKS AROUND IT.
- MORE RESTRICTED SPACE PLANNING – WITH OPENINGS & WINDOWS
- ENGINEER'S FRIEND.
- LESS DRIFT – SWAYS LESS / OR LESS DANCE.
- LESS DUCTILE – MORE FAILURE IN EARTHQUAKE.
  ↖ = MORE RIGID OR STIFFER
- LESS EXPENSIVE THAN MOMENT FRAME.
- STEEL, WOOD, ~~CONCRETE~~
- TALLER, SKINNEY BUILDINGS.
- LESS STRESS ON INDIVIDUAL MEMBERS
- WIDER COLUMN GRID.

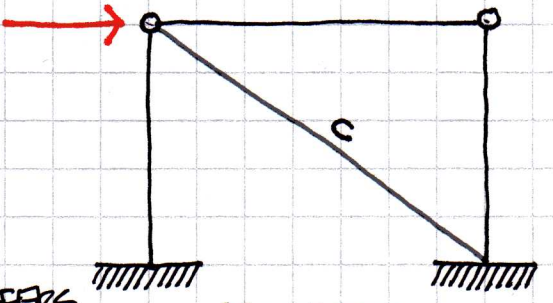
EX: JOHN HANCOCK (CHICAGO) NOT BOSTON!



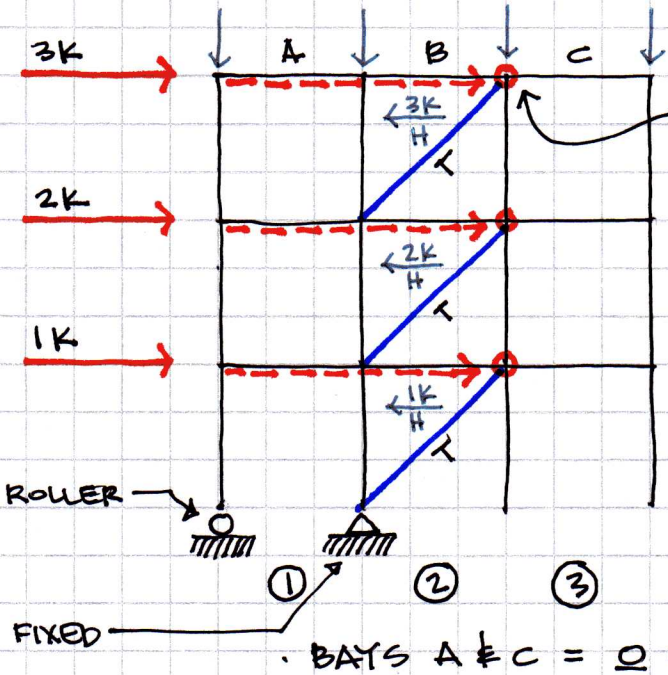
(2) MEMBERS – CABLES

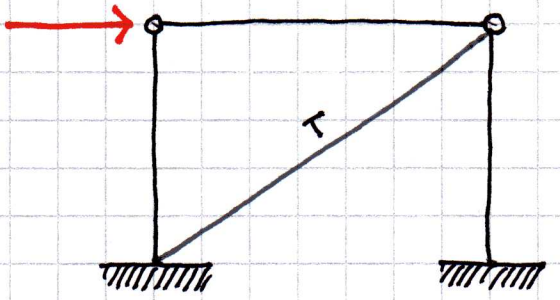
* TRANSFER = AXIAL TRANSFER

- IN COMPRESSION, TENSION OR BY TRUSS ACTION.



(1) MEMBER



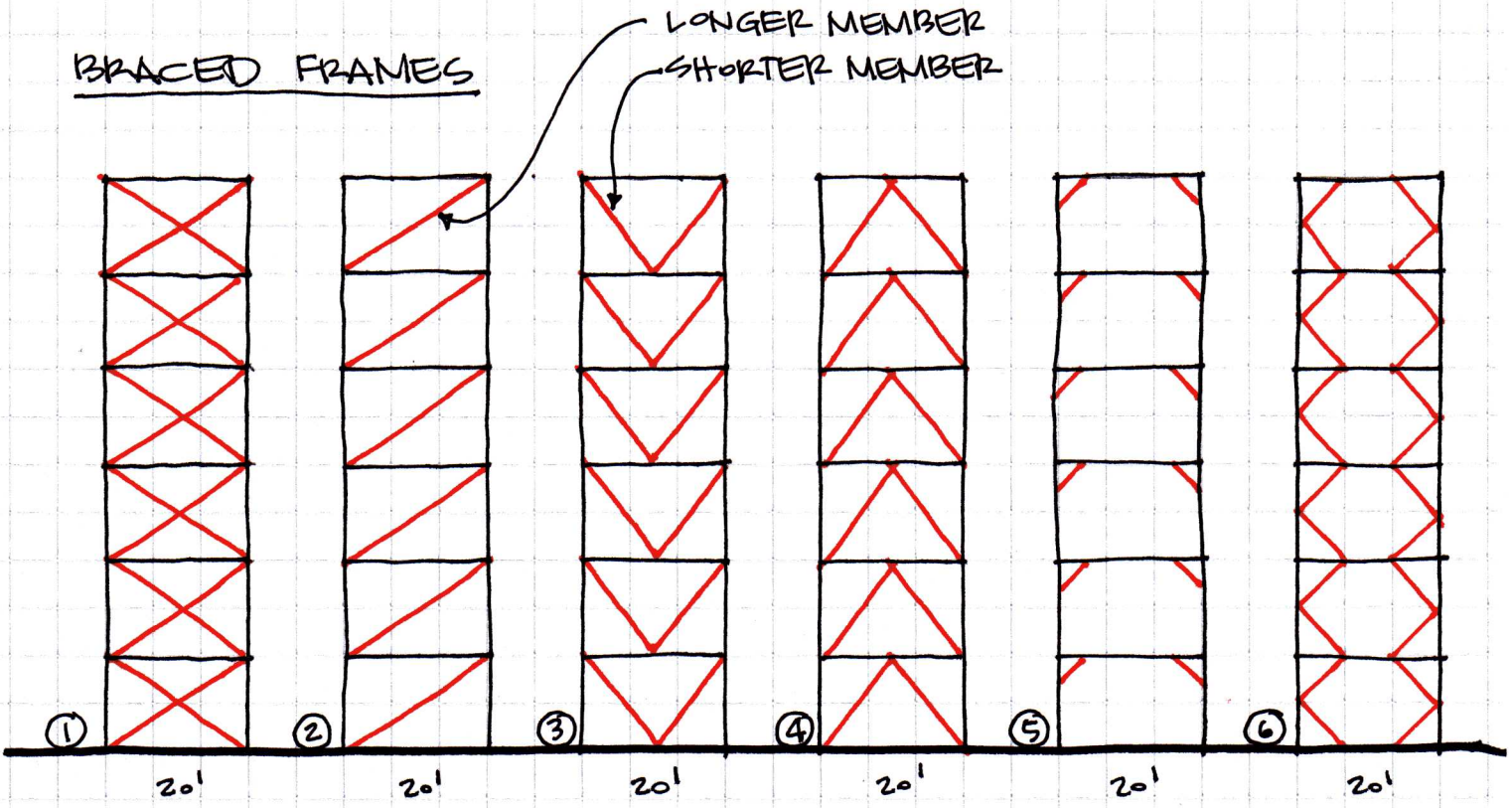


(1) MEMBER

C = COMPRESSION
T = TENSION

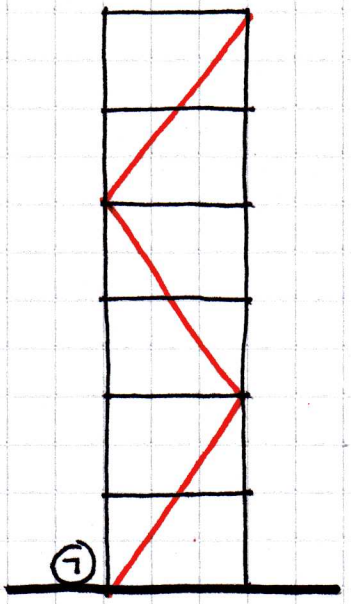
- BAYS A & C = 0 LAT ABILITY
BAY B = 3, 2, 1 K LOADS

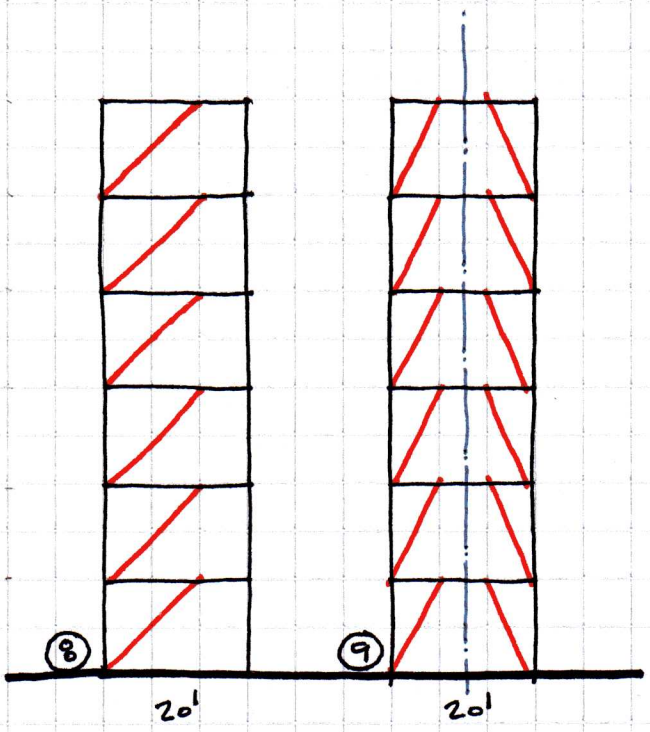
BRACED FRAMES



(1) BAY. CONCENTRIC BRACED FRAMES = NO TORSION!

(1)(2)(3)(4)(5)(6)(7)





(8) & (9)

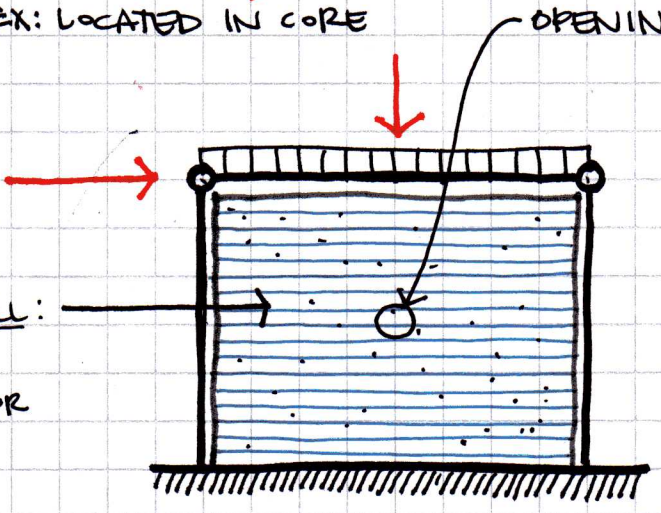
(1) BAY · ECCENTRICALLY BRACED FRAMES

- BETWEEN MOMENT & BRACED FRAME.
- BETTER IN EARTHQUAKE.

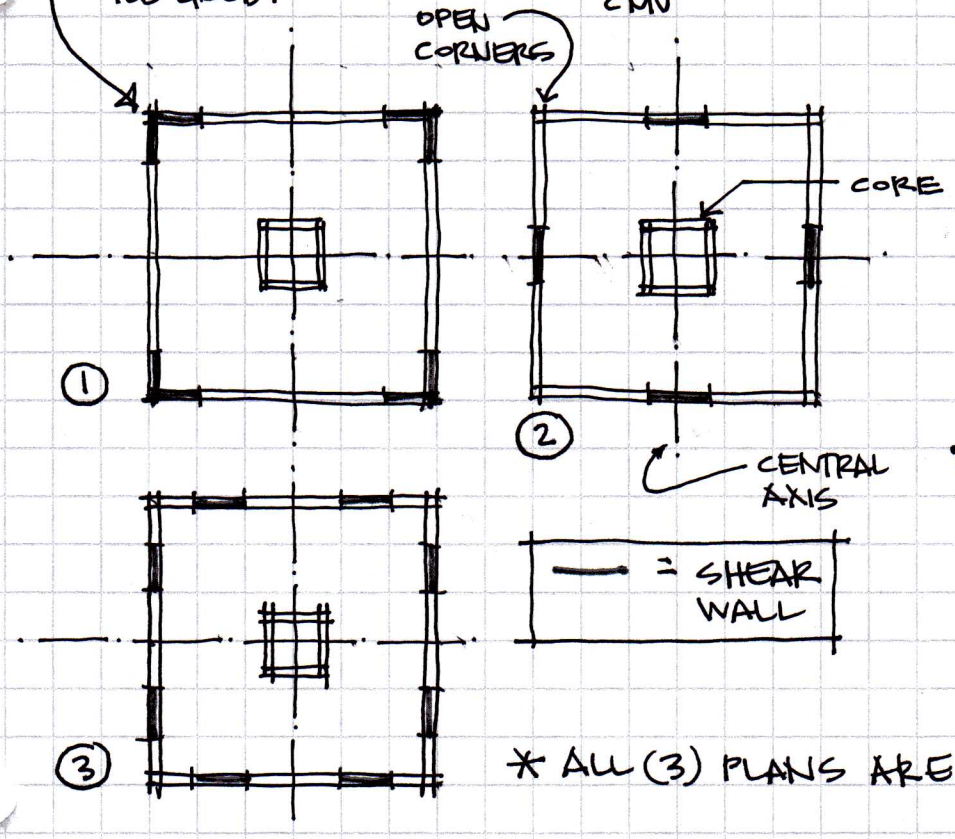
3 SHEAR WALL (SW)

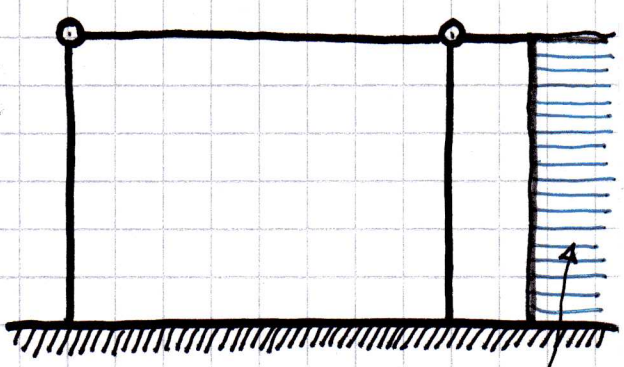
- PIN CONNECTIONS
- ARCHITECT'S NIGHTMARE
- FORGET ANY OPENINGS – UNLESS VERY SMALL & IN THE MIDDLE
- ENGINEER'S BEST FRIEND
- VERY LOW DRIFT
- VERY LOW DUCTILITY – It's A BRITTLE SYSTEM.
- $ = LOW COST – CHEAP
- CONCRETE, MASONRY, WOOD (PLYWOOD), ~~STEEL~~
- VERY TALL BUILDING – EX: LOCATED IN CORE

* SHEAR TRANSFER



* CAN'T GIVE UP CORNERS, THEY'RE TOO GOOD.



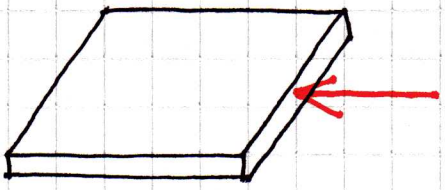


* ALL (3) PLANS ARE SYMMETRICAL!

* PLACE MOST LATERAL RESISTANT SYSTEM FURTHEST FROM THE CENTRAL AXIS.

- SYMMETRICAL.
- FURTHEST FROM CORE.

- **DIAPHRAMS**



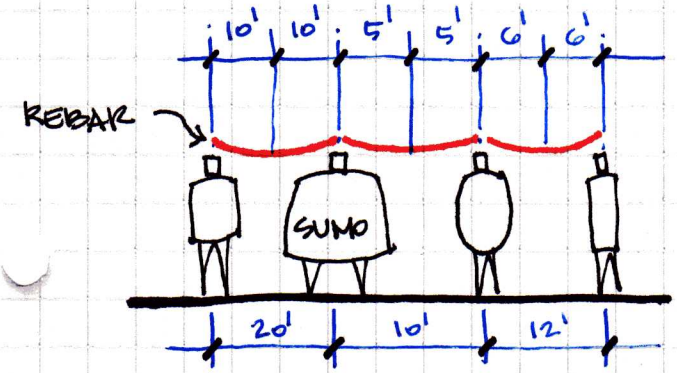
"HORIZONTAL SHEAR WALL"

  - **FLEXIBLE DIAPHRAM**
    - ROOF W/OUT CONCRETE, PLYWOOD ROOF, OR METAL DECK W/OUT CONCRETE

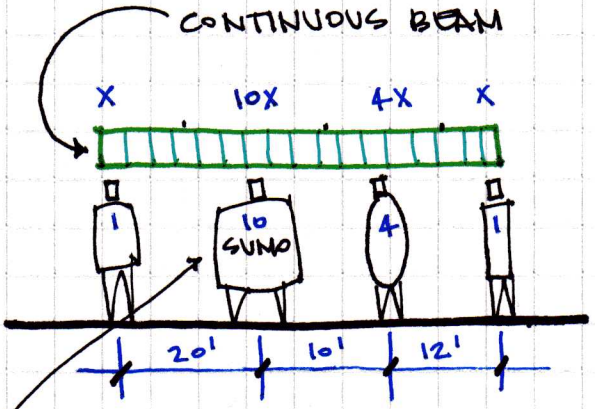
    = PARTS/COMPONENTS ARE IN PIECES
    - TRIBUTARY LOAD
    - LOAD DISTRIBUTION

  - **RIGID DIAPHRAM**
    - FLOOR W/ CONCRETE
    - METAL DECK W/ 2" CONC.
    - HOLLOW CORE SLAB W/ CONC. TOPPING

    = POURED

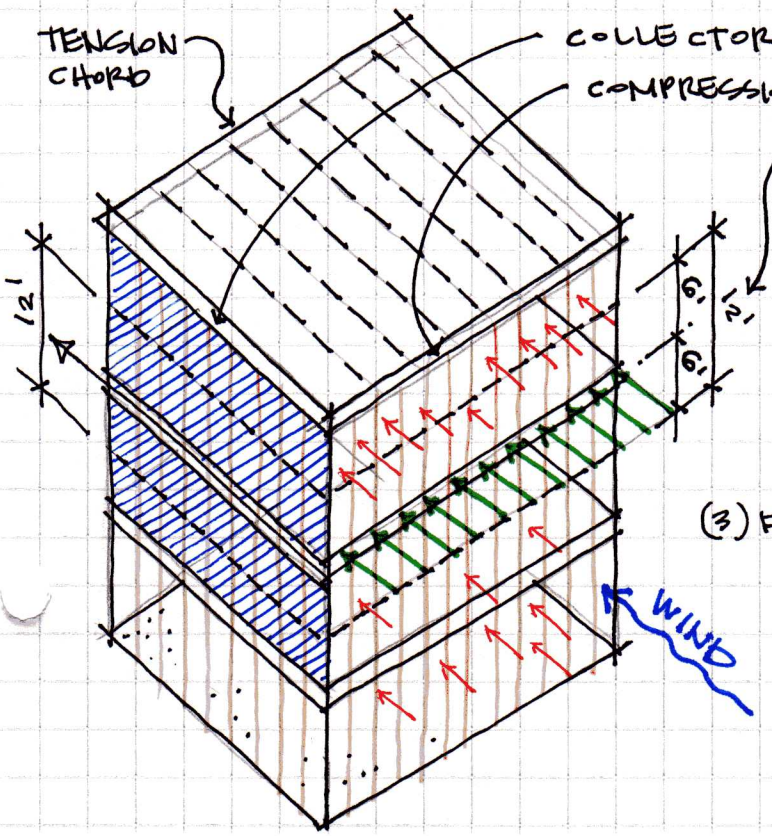


"FLEXIBLE DIAPHRAM"



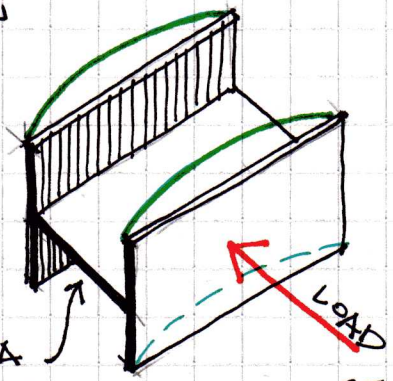
"RIGID DIAPHRAM"

"SUMO MAN" CARRIES 10X LOAD



= CURTAIN WALL
= SHEAR WALL
= WIND HITS CHORD
= WIND ON FACADE

(3) FLOORS @ 12 FT. EA.



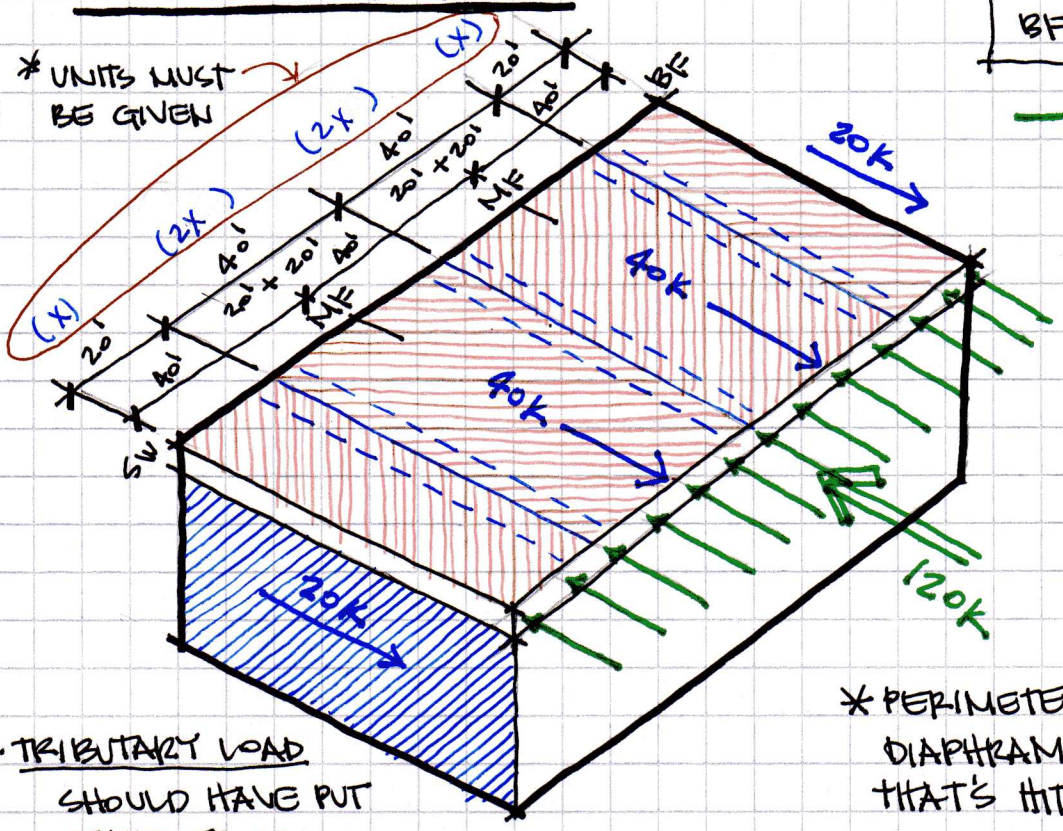
* FLOOR ACTS LIKE A WIDEFLANGE BEAM: BENDING & DEFLECTION

MF = MOMENT FRAME
SW = SHEAR WALL
BF = BRACED FRAME

— = WIND LOAD @ 1 K/FT

= 1 K/FT X 120'
= 120 K/FT

• FLEXIBLE DIAPHRAM



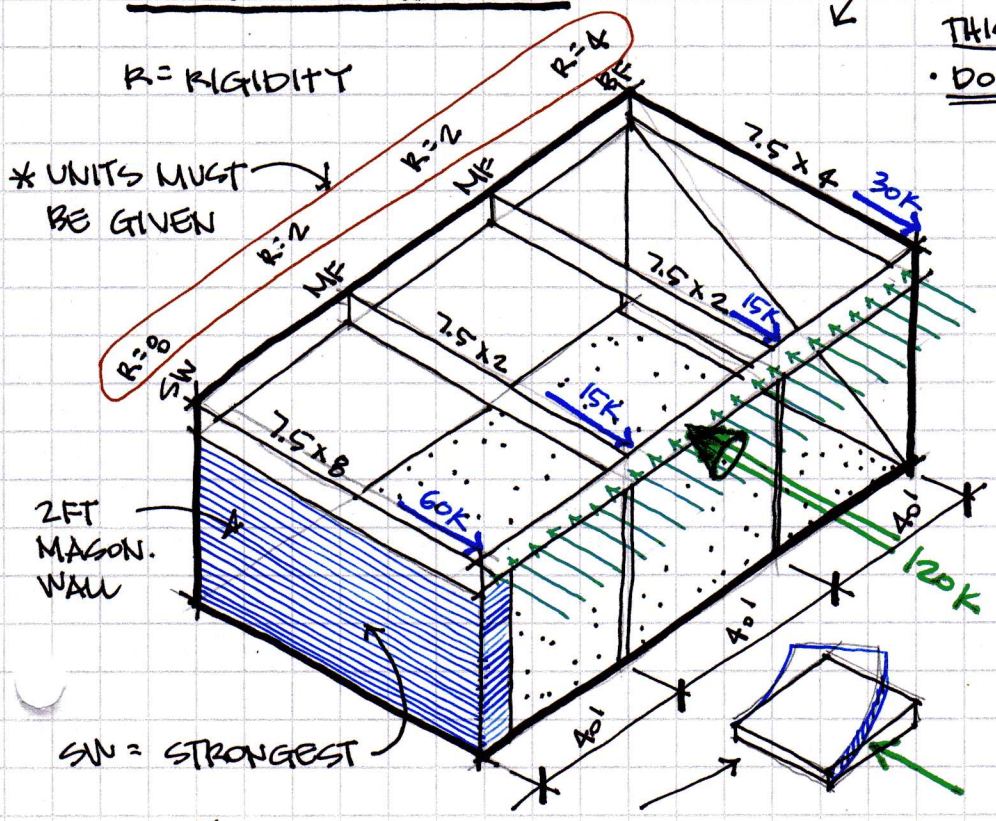
• TRIBUTARY LOAD SHOULD HAVE PUT STIFFNER IN MIDDLE

* PERIMETER MEMBER AT DIAPHRAM = THE CHORD THAT'S HIT FIRST.

$\frac{120K}{6 \text{ UNITS}} = 20K$

• RIGID DIAPHRAM

R = RIGIDITY



• ACTUALLY, YOU WANT "SYMMETRY" THIS IS JUST AN EXAMPLE.
• DON'T MIX SYSTEMS!
= SW ON ONE END & BF ON THE OTHER END.

* SUM R = 8 + 2 + 2 + 4
R = 16 UNITS OF RIGIDITY.

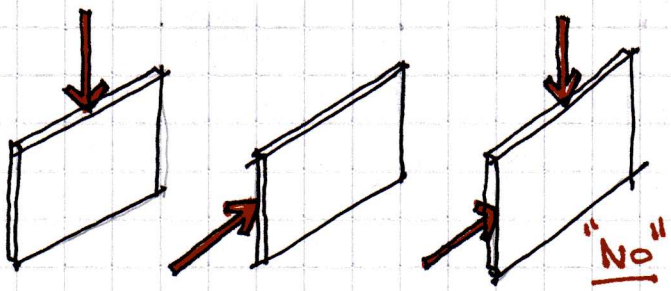
$\frac{120K}{16 \text{ UNITS}} = 7.5$

7.5 = 1 INCREMENT OF RIGIDITY

8 X 7.5 = 60K
2 X 7.5 = 15K
2 X 7.5 = 15K
4 X 7.5 = 30K

* TORSION OCCURS IF SYMMETRY ISN'T THERE. THIS EXAMPLE IS IN TORSION!

- YOU WANT THE WALL DEDICATED TO LATERAL LOADS/FORCES ONLY!
- TRY NOT TO DO BOTH! LATERAL & GRAVATATIONAL



NATURAL

Ce • GUST IBC UBC

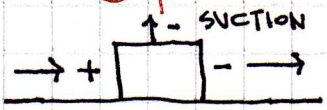
Ce • TERRAIN
- WATER
- SUBURBAN
- URBAN

q_s • WIND SPEED "VELOCITY" (IT'S SQUARE) = MPH → PSF
- 80 MPH = f_s = 16 PSF
- SQUARE OF THE WIND SPEED = #/FT²
- 150 MPH = f_s = 52 PSF

BUILDING

• HEIGHT Ce
• FOOTPRINT
• SLENDERNESS RATIO
• LEEWARD · VS · WINDWARD

Cq



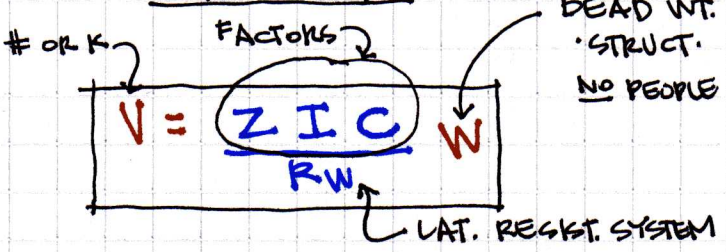
• DEAD LOAD
- STABILIZING MOMENT TO PREVENT OVERTURNING

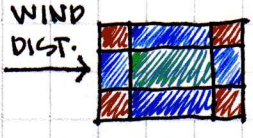
• UPLIFT

$$P = C_e C_q q_s I$$

P = LOAD IN PSF
Ce = EXPOSURE
Cq = BUILDING CONFIGURATION
q_s = HAS UNITS
I = BLDG TIME (PSF)

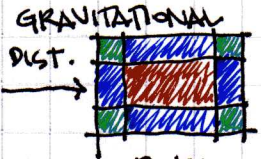
• OCCUPANCY
- IMPORTANCE OF OCCUPANCY
• ASSEMBLIES
• ESSENTIAL FACILITIES
  • POLICE, HOSPITALS, NUKE PLT.
  • OPERATIONS TYPE BLDG.
• OTHER
  • SCHOOL, OFFICES
• AGRICULTURE





PLAN

- MOST WIND/UPLIFT/PRESSURE
- NEXT
- LEAST



PLAN

- MOST GRAVATATIONAL
- NEXT
- LEAST

• CONFIGURATION (SHAPE)

Cq LEEWARD · VS · WINDWARD
- COMPONENTS:
  - PARAPET, CHIMNEY, EAVE RAKE, SIGN, LOUVER, HVAC

• EARTHQUAKE

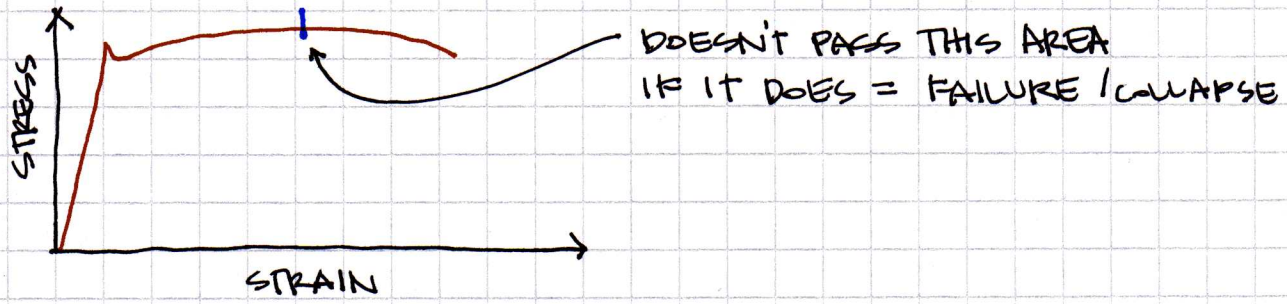
• TERMINOLOGY

• RICHTER SCALE = MEASURES MAGNITUDE.

1 2 3 4 5 6 7 8 9 ← "SCALE FACTORS" 1–9

LOW MED HIGH

- 1 – 4 : MINOR DAMAGE, NO STRUCTURAL DAMAGE
- 5 – 6 : MINOR DAMAGE, SECONDARY SYSTEMS
- 7 – 9 : SIGNIFICANT SECONDARY DAMAGE, SIGNIFICANT STRUCTURAL DAMAGE. HOWEVER... COLLAPSE IS NOT ACCEPTABLE!



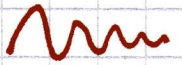
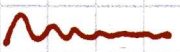
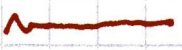
- SEISMIC ZONE
  - CALIFORNIA, NEVADA
- DURATION
- WAVE VALUES
- SITE CLASSIFICATION — SOILS
- SPECTRAL RESPONSE (IBC)
  - HOW BUILDING IS DOING IN THE SOIL

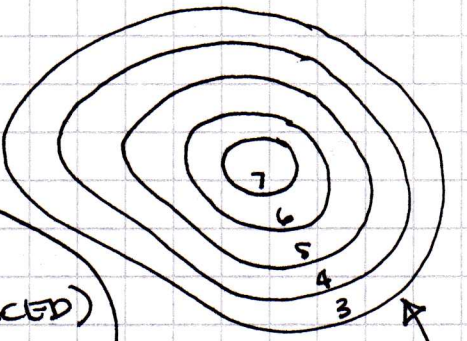
SOIL PERIOD

BUILDING PERIOD

- RESONANCE
- IF SOIL PERIOD & BUILDING PERIOD ARE SIMILAR THAT = A PROBLEM!

EX: STEEL BUILDING ON CLAY SOIL = BAD!

- **BUILDING PERIOD**
  - RESONANCE
  - AMPLIFICATION
- **SOIL PERIOD**
  - LIQUEFACTION (C)
    - WHEN SOIL BECOMES A LIQUID
- **SPECTRAL RESPONSE**
- **INTENSITY**
  - MEASURE OF EARTHQUAKE (DAMAGE DONE & IMPACT PERCEIVED BY PEOPLE)
- **MERCALLI** (12 STEPS) SEE TABLE
  - MEASURES DAMAGE DONE & IMPACT
- **HYPOCENTER** (FOCUS) -VS- **EPICENTER**
  (= CENTERED) (= WHERE IT SURFACED)
- **OSCILLATION** — PERIOD
- **DAMPING**
  - MOMENT FRAME :  LONG TIME TO COME BACK TO REST
  - BRACED FRAME : 
  - SHEAR WALL :  MOVES VERY LITTLE



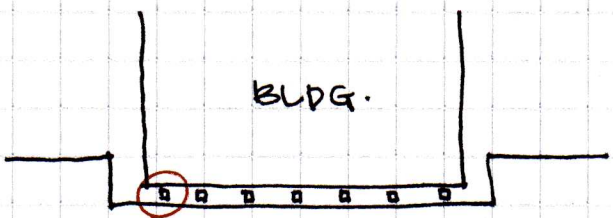
- ACCELOGRAPH
- MAGNITUDE
- RESONANCE
- CONTOURS
- ISOSEISMIC = CONTOURS

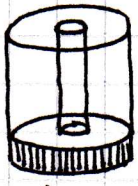
- **AFTERSHOCK**
- **IMPORTANCE FACTOR**
- **BUILDING MASS** ⟶ DEAD WEIGHT
- **CONFIGURATION** — (90% OF ARE QUESTIONS)
  - PLAN
  - ELEVATION
  - MASSING
  - SYMMETRY

  → DISCONTINUITY

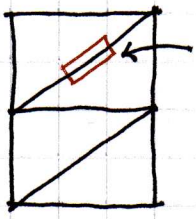
  → = "THE DUCTILITY OF A LATERAL RESISTING SYSTEM"
  MF, EBF, BF, SW EBF = ECCENTRIC BRACED FRAME

- HOW TO RESIST AN EARTHQUAKE
  - TUNED MASS DAMPER
    - IN A TALL BUILDING
  - BASE ISOLATION = $$$
    - ROLLERS IN FOOTINGS
  - VISCOUS DAMPER





- RUBBER PAD W/HOLE IN MIDDLE W/STEEL WASHER - FILLED W/ LEAD
- THE LEAD HEATS UP = ENERGY



DAMPER IN LAT. BRACE

- EARTHQUAKE TRANSMITS ENERGY INTO VISCOUS DAMPER. THE LEAD HEATS UP.

- PG 27 ORANGE

WIND

- HEIGHT, EXPOSURE, GUST FACTORS

$$p = C_e C_q q_s I$$

70 MPH = 12.6 #/FT²
WINDSPEED = PRESSURE

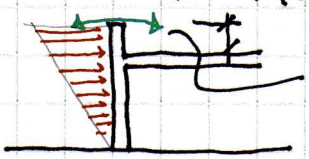
p = LOAD
C_e = EXPOSURE
C_q = LEEWARD OR WINWARD SIDE
q_s = UNITS
I = IMPORTANCE FACTOR

- PG 28 ORANGE

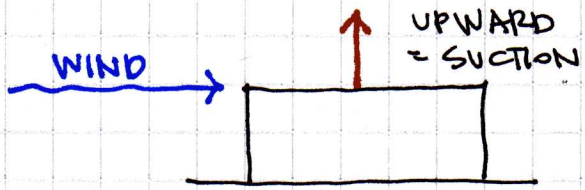
METHOD 1

L = LEEWARD -
W = WINDWARD +

EX: PARAPET



1.3 + OR -



- PG 30 ORANGE

I = IMPORTANCE FACTOR = JACK UP THE %

EARTHQUAKE

- PG 46

$$V = \frac{Z\ I\ C}{R_W} W$$

R_W: BUILDING TYPE FACTOR
Z = ZONE FACTOR (TABLE)
V = BASE SHEAR
W = DEAD LOAD/WT. OF BLDG.
I = IMPORTANCE FACTOR
C = BLDG. PERIOD/SOIL

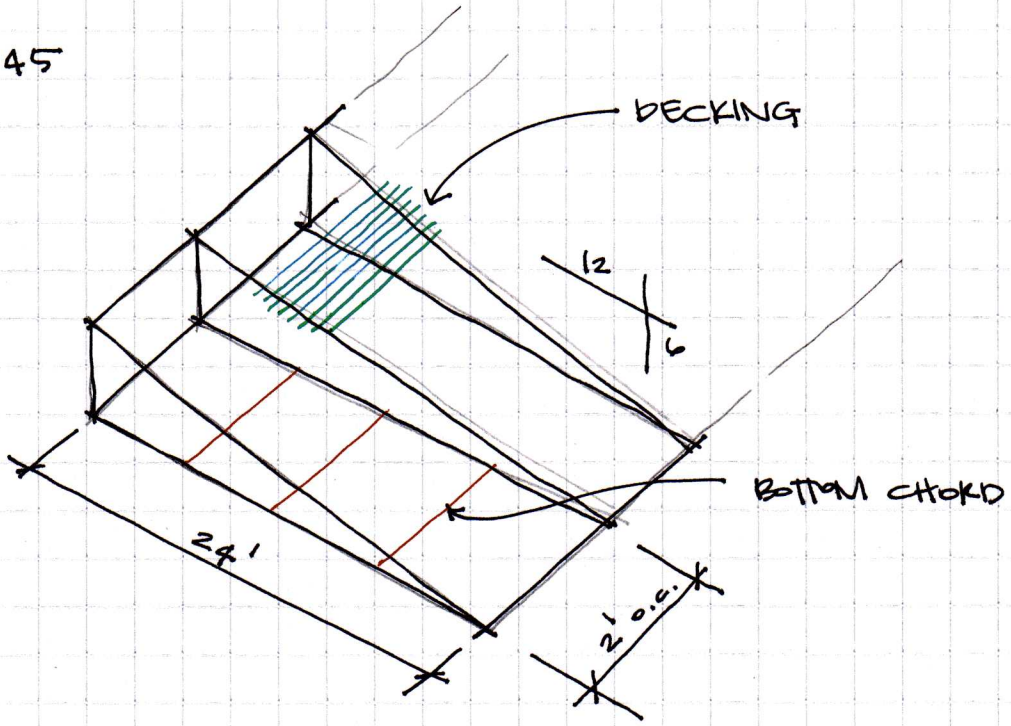
- BIGGER R_W = THE SUMO MAN (P 35 NOTES)
  = THE MORE LOAD YOU CAN CARRY

- DUCTILITY
  - PAY SPECIAL ATTENTION TO DUCTILITY
  - FLEXIBLE & DUCTILE = GET HIGHER #'s (R)

- PG 32 (LOOK AT THIS TABLE)
- PG 42 (LOOK AT THIS TABLE — PERIOD OF BUILDING & SOIL)
- PG 37 (BASIS OF IBC & UBC CODES)
- PG 23 (PAY SERIOUS ATTENTION & TIME TO THIS PAGE)
- PG 24
- PG 25

- MOCK EXAM (BLUE HANDOUT)

PG 45



- PG 34
- PG 49
- PG 35 ALS / BALLAST

- TEMPERATURE QUESTIONS — STUDY KEY

* END OF DAY 4