BASE SHEAR

$$V = \frac{ZIC}{Rw} W$$

$$C = \frac{1.25\ S}{T^{2/3}}$$

$$T = Ct \times hn^{3/4}$$

V = base shear
Z = site
I = importance factor
Essential:
1.15 = wind
1.25 = seismic
1.50 = seismic elements
W = dead load
Rw = method of construction/lateral load resisting system
Rw high = ductile
Rw low = stiff
C = seismic factor = soil; fundamental period of vibration
S = soil
T = fundamental period of vibration
Ct = material stiffness
hn = height of bldg.

Ct = .035 steel, moment resisting frame MRF
.030 concrete, reinforced concrete moment resisting frame RF; eccentric braced frames EBF MRF
.020 other

S1 = rock,stiff = 1.0
S2 = stiff clay, med. = 1.2
S3 = soft to med. Stiff clays & sand, soft = 1.5
** if no soil factor given – then 1.5*
** if no soil factor given – then 2.75*

notes
- product of C + S not to exceed .14
- Cmax = 2.75
- min $\frac{C}{Rw} = .075$
- greater Rw = greater ductility
- value of C not to exceed .12

Total horizontal seismic force
Z I K C S W
K = type of structural system
C = flexibility – fundamental period of vibration, height & plan dimensions

Distribution of Base Shear

$$Fx = \frac{(V-Ft)\ wx \times hx}{\mathcal{E}\ wh}$$

wx = dead load @ level x *(distributed weight)*
hx = height in ft above base level *(height above floor)*
$\mathcal{E}$ wh = summation of wh for each level *(*multiply)*
Fx = distributed force @ each level
V = base shear
Ft = whiplash factor (T > .7 sec.)
Ft = .07TV
Ft = lateral load
T = fundamental period of vibration
* if T is less than .7, then Ft = 0
* T = greater than .7 seconds, additional force must be added to top of bldg.

DESIGN WIND PRESSURE

(psf)
P = Ce Cq qs I

Ce = bldg. **height**, exposure, gust factor
Cq = pressure/bldg. part : Method 1 = normal force method (perp. + gable), Method 2 – projected area
qs = wind stagnation pressure
I = importance factor

Design Wind Pressure Distribution
Ce = differs per height !!! @ each height
windward - inward
leeward – outward
roof

Part of Structure
Fp = Z I Cp Wp (*ZIC – part of structure = greater value than* $\frac{ZIC}{R_w}$ *whole bldg.*)

Fp = lateral seismic Force
Z = zone
I = importance factor
Cp = horizontal force factor – either .75 or 2.0 *(cantilevered)*
Wp = weight (per ft of length = w *(load)* x height

* Moment on part of structure = F x h/2

Wind Pressure

*wind pressure P = wind velocity^2
*if wind velocity doubles – pressure increases x 4
*no reduction in wind pressure is allowed with model bldg. codes.
*wind forces have NOTHING to do with MASS of bldg.
*period of vibration = $\frac{\text{height}}{\text{stiffness}}$

*p = .00256V^2 (fastest mile velocity in miles per hr.) (stagnation – direct wind pressure)

$P = kv^2$

P = wind pressure -psf
k = constant
v^2 = wind velocity - mph

Force in Member

1. $\Sigma H = 0$
2. $\frac{av}{ah} =$
3. $av = \frac{y}{x} ah$ *(solve for other)*

$\sqrt{(ah)^2 + (av)^2}$

Drift

btwn. stories	*maximum*
(.0025 x story height)	(1/500 of height)

* IBC = bldgs. over 160’-0” high MUST have MRSF (resisting not less than 25% of req. seismic force)\
*max. allowable drift:
.0025 = wind - of story height)
.005 = earthquake (1/2%) - of story height

unit stress (force) $f = \frac{P}{A}$ (weight/load) / (area)
internal force per unit area

unit strain $\mathcal{E} = \frac{/\backslash}{L}$ (total change) / (original length)

modulus of elasticity $\mathcal{E}$ $\mathcal{E} = \frac{P/A}{/\backslash / L}$
*stiffness of material
*brings together unit stress & unit strain
*ability to resist deformat

Newton's Law

F = Ma (force = mass x acceleration)

$A = \frac{F}{M}$ & $F = \frac{a}{g} W$

mass = weight / g
g = acceleration of gravity
g = 32 feet per second

Active Lateral Soil Pressure
Retaining Wall Earth Pressure

$P = 15h^2$ *OR* $P = \frac{ph^2}{2}$

p = fluid pressure = 30 pcf
P = horizontal force = equivalent fluid pressure
h^2 = ½ square of retained height
OTM = $15h^2$ x 1/3 height (horizontal force x height)
** can use 1.5 of soil weight to resist*

Moment = F x d (force x distance)

Dead Load Resisting Moment - * vertical DL x distance

MR = DL soil x DL wall = (DL total) x (1/2 length) = MR
1.5 MO = MR (1.5 overturning moment = resisting moment)
(1.5 overturning moment < resisting moment = OKAY)
*DL moment must be equal to or more than 1.5 overturning moment (OTM)

Overturning Moment
1. (horiz. force x height) + (horz. force x height) = * for BLDG. (force x distance)
2. horiz. force x ½ height (part of structure)

Uplift
$\frac{\text{OTM}}{\text{horiz. distance}}$ = only 85% of DL may be used to resist uplift (DL x .85)

Saftey Factor
DL resisting moment / OTM
*must be = or < 1.5 OTM

load transfer

* VERTICAL – continuous connections – follow thru
* LATERAL support - positive + direct
  * *anchorage
  * *metal straps
  * *min. force = 200 lbs/lin. ft.

Max Moment = $M = \frac{wl^2}{8}$

Reaction magnitude + direction (horizontal force x height = plf) (force x distance)

$= \frac{wL}{2}$

Total Shear = $Vs = \frac{FL}{2}$ (force or load per lineal ft. x length of wall)

(V = total shear)

Unit Shear Stress = $v = \frac{Vs}{d}$ *(total shear)* *(depth)*

Max Chord Force $C = \frac{\frac{wl^2}{8}}{d}$ *(maximum moment)* *(diaphragm depth)*

Max Diaphragm Shear Stress

$$\frac{\frac{wl}{2}}{\text{diaphragm depth}}$$

(reaction & shear force)

Torsional moment

TM = force x (distance btwn. center of mass + center of rigidity)

Multi-story overturning moment

OTM = $\mathcal{E}$ (Fx x hx)

((OTM = (F1 x h1) + (F2 x h2) + (F3 x h3) **x** (height to floor level))

Minimum Nail Spacing

1. # of nails required = $\frac{\text{total load}}{\text{allowable load per nail}}$

2. spacing = $\frac{\text{length in inches}}{\text{\# of nails}}$ *(*multiply by 12 to get inches)*

Bolt Spacing – based on capacity

1.spacing = $\frac{\text{allowable bolt shear \# per bolt}}{\text{diaphragm \# per ft.}}$ = x ft/bolt x 12 (for inches)

2. # of bolts = $\frac{\text{lbs uplift}}{\text{resist lbs each bolt}}$

fundamental period of vibration

* dependent on <u>mass</u> (weight) + <u>stiffness</u> (rigidity)
* **L**ong perios = **L**ow seismic force + **L**ow acceleration
* short period = high seismic force + high acceleration
* does NOT vary directly with height but <u>3/4 power of height</u>

P – delta

<u>/ \</u> = story drift

P = vertical load in column

* bending is increased by P x A (or P-delta)