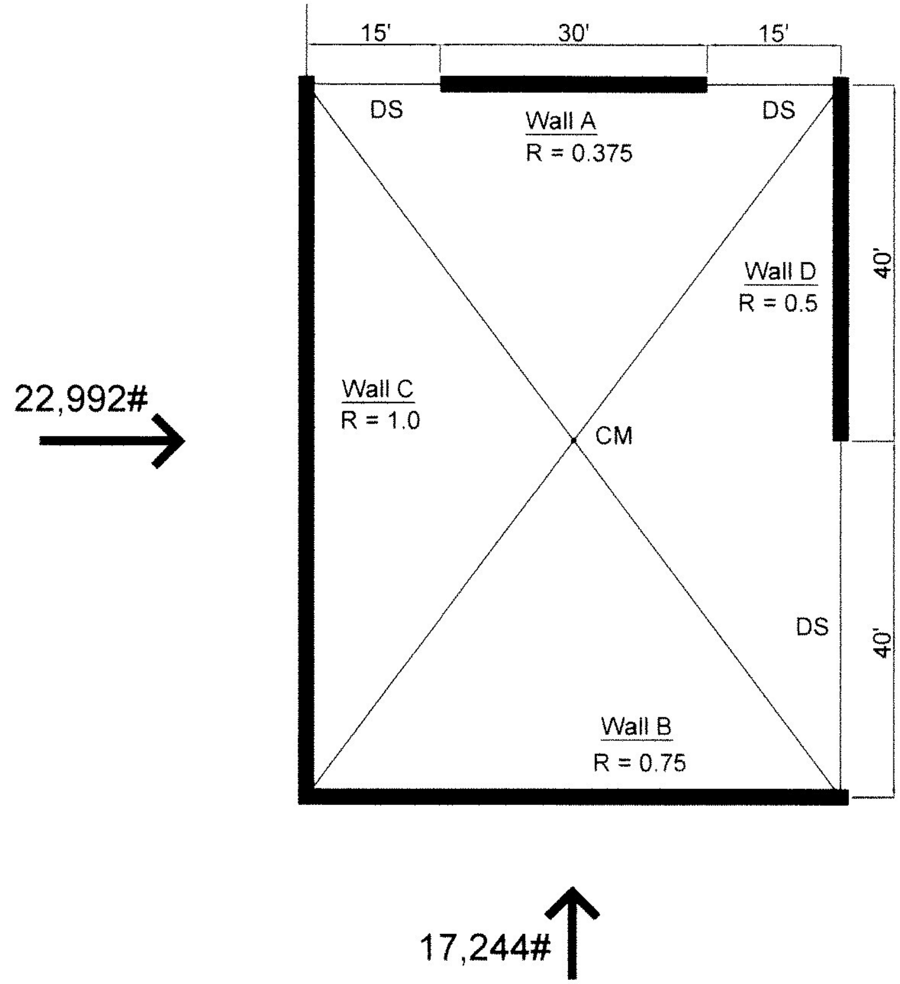
Torsion – The story shear is assumed to act through the center of mass of each level. When the center of mass does not coincide with the center of rigidity a moment or torsion force is induced (Moment or Torque = Force X Distance).

Accidental Torsion - "Where diaphragms are not flexible, the mass at each level shall be assumed to be displaced from the calculated center of mass in each direction a distance equal to 5 % of the building dimension at that level perpendicular to the direction of the force under consideration. The effect of this displacement on the store shear distribution shall be considered." The accidental torsion is a value to either be added or subtracted from the calculated eccentricity. The term "design eccentricity" is used to represent the algebraic sum of the actual and accidental (5%) eccentricities ($e_x + e_a$).

Negative Torsional Shear – The base shear causes a shear stress that acts in the same direction in all vertical base members. The torsional shear stresses, however, have different signs on either side of the center of rigidity. On one side the torsion increases the stress from the base shear; on the other side the stress is decreased. The amount of decrease is known as *negative torsional shear.* Negative torsional shear should be neglected; that is, it should not be considered to decrease the design capacity of a lateral resisting element.

Example: Assume that the diaphragm is rigid. Calculate the center or rigidity. Calculate the Torsional Moment for the North - South Wind and the East - West Wind. (Assume that the Center of Mass conicides with the geometric center or the building.)



Calculate the Center of Rigidity

Similar to calculation to find the centroid of a shape.

$$CR\ \bar{x} = \frac{\sum (Ry)(x)}{\sum Ry} \qquad CR\ \bar{y} = \frac{\sum (Rx)(y)}{\sum Rx}$$

Calculate CR $\bar{x}$ first.

Only consider the walls that resist direct shear in the Y direction (which is the N-S) dirction for this example.

Walls C and D Resist the direct shear for a North - South Lateral Force.

$$CR\ \bar{x} = \frac{\sum (Ry)(x)}{\sum Ry} \qquad CR\ \bar{x} = \frac{(1.0)(0) + (0.5)(60')}{(1.0 + 0.5)} = \underline{20'}$$

Now calculate CR $\bar{y}$.

Only consider the walls that resist direct shear in the X direction (which is the E-W) dirction for this example.

Walls A and B Resist the direct shear for an East - West Lateral Force.

$$CR\ \bar{y} = \frac{\sum (Rx)(y)}{\sum Rx} \qquad CR\ \bar{y} = \frac{(0.375)(80') + (0.75)(0')}{(0.375 + 0.75)} = \underline{26.67'}$$

Calculate the Offset Center of Mass (5% offset in each direction)

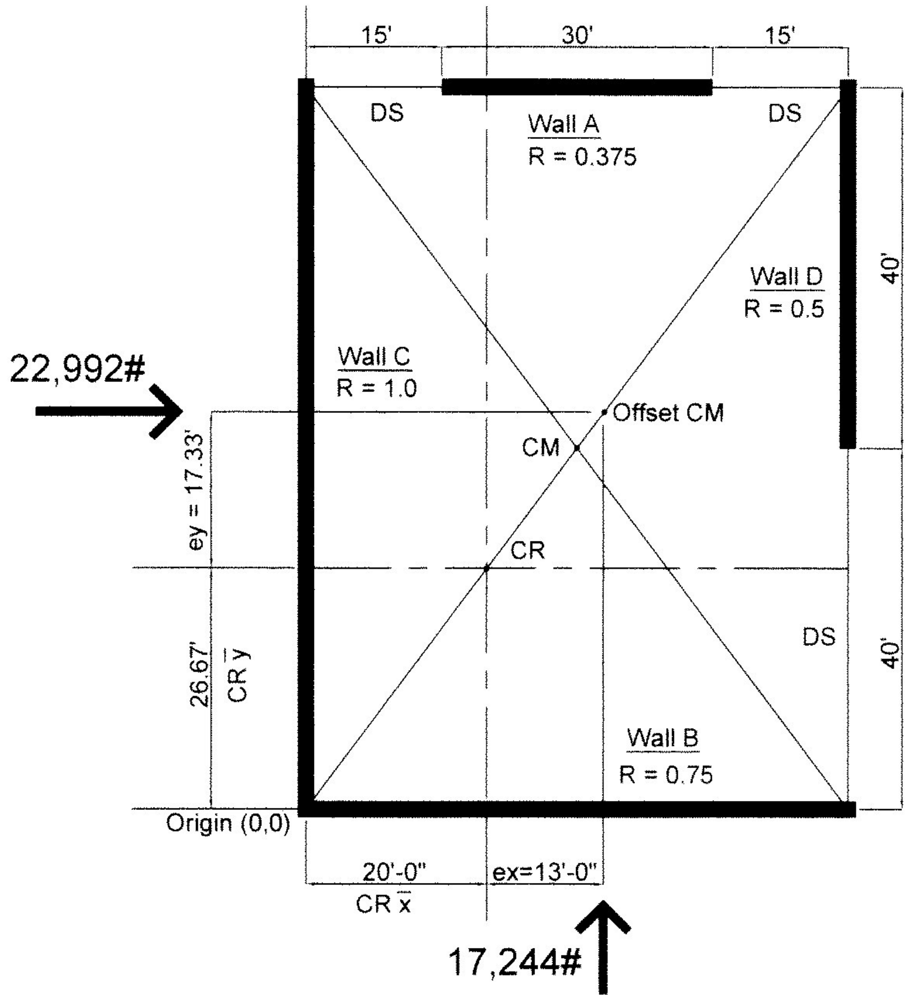
(.05) (60') = 3'

(.05) (80') = 4'

Calculate the eccentricity between the Offset Center of Mass & the Center or Rigidity

ex = (30' - 20') + 3' = 13'

ey = (40' - 26.67') + 4' = 17.33'



North - South Seismic Forces

T = (17,244#)(13') = 224,172 #-ft

East - West Seismic Forces

T = (22,992#)(17.33') = 398,457 #-ft

$$V_v = \frac{(R_c)}{\sum R_c}(V)$$

$$V_T = \frac{(R_c)(d)}{\sum (R_c)(d)^2}(T_{Tot})$$

							North - South V = T =			East - West V = T =		
Wall	Rcx	Rcy	dx	dy	Rcd	Rc(d)^2	Vv	Vt	Vv + Vt	Vv	Vt	Vv + Vt

$$V_v = \frac{(R_c)}{\sum R_c}(V) \qquad V_T = \frac{(R_c)(d)}{\sum (R_c)(d)^2}(T_{Tot})$$

							North - South V = 17,244# T = 224,172 #-ft			East - West V = 22,992 # T = 398,457 #-ft		
Wall	Rcx	Rcy	dx	dy	Rcd	Rc(d)^2	Vv	Vt	Vv + Vt	Vv	Vt	Vv + Vt
A	0.375	--	--	53.33	20	1066.53	--	1,601.23	1,601.23	7,664	2,846.14	10,510
B	0.75	--	--	26.67	20	533.46	--	1,601.23	1,601.23	15,328	(-) 2,846.14	15,328
C	--	1.0	20	--	20	400	11,496	(-) 1,601.23	11,496	--	2,846.14	2,846.14
D	--	0.5	40	--	20	800	5,748	1,601.23	7349.23	--	2,846.14	2,846.14
$\sum$	1.125	1.5				2799.99						