

# P-Delta and Minimum Base Shear

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# Min. Base Shear

- $V = (0.8ZN_v I/R)W$  for drift limitation?
- Is it for ground motion uncertainty or “modeling” uncertainty or both?
- Let’s say explicitly what it is for!
- Should be the same “enforcement” as for code-conforming structures
- If for modeling uncertainties and alternative design, then it belongs to Level 3 – if for collapse safety?



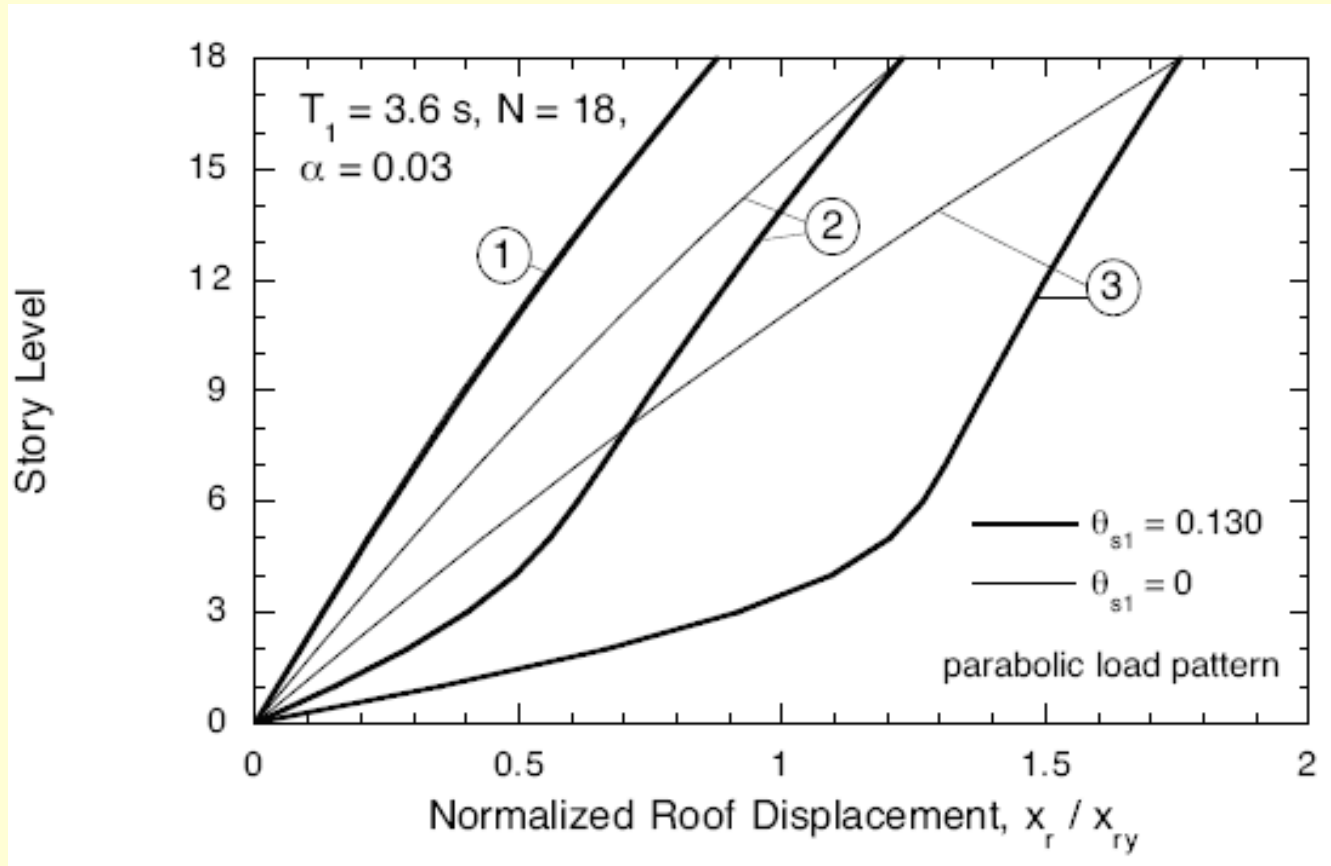
# Collapse Safety + Drift $\equiv$ P-Delta

P-Delta is controlled by

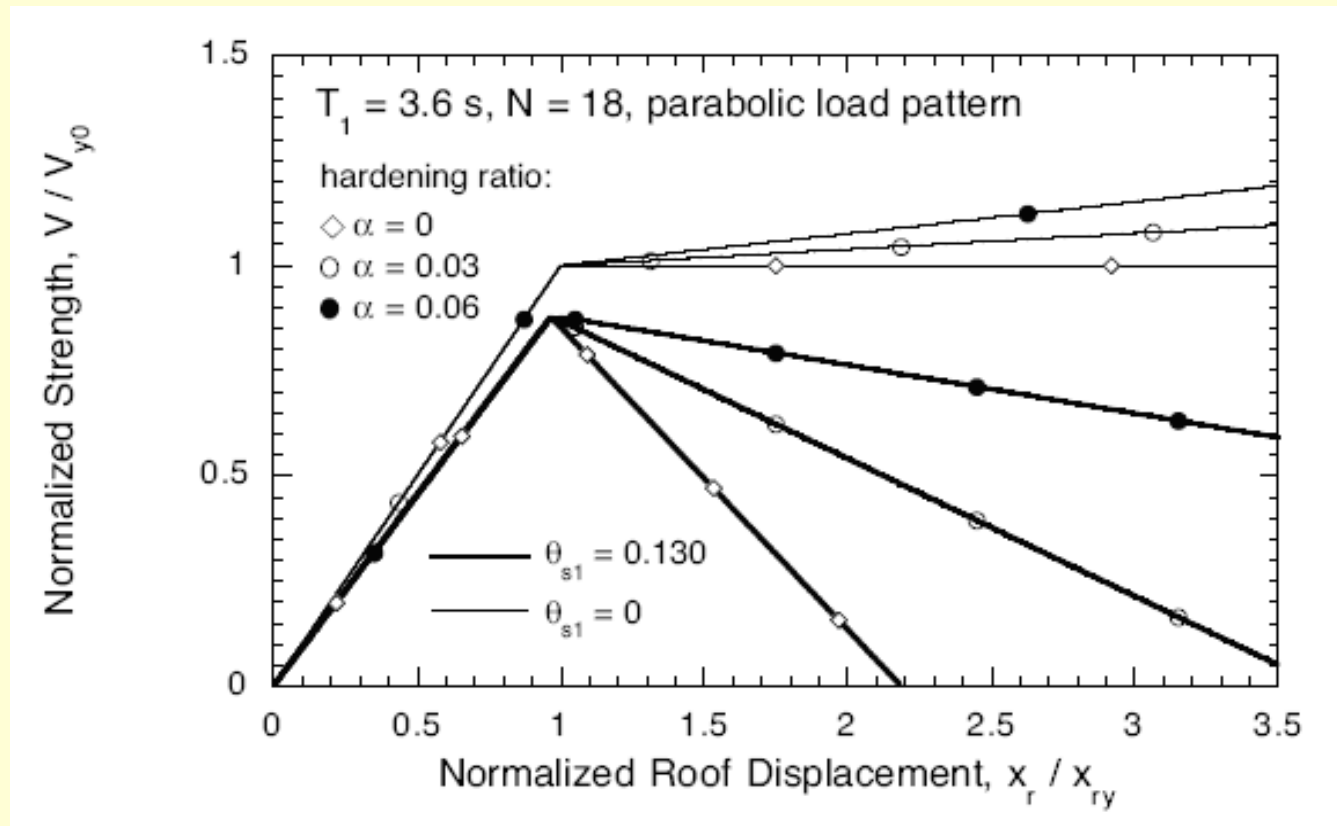
- P (large in lower stories)
- Delta - but inelastic  $\delta$
- Collapse mechanism
- Length of post-yield “plateau”
- Effective post yield stiffness
- Deterioration
- Frame problem very diff. from wall problem



# Pushover Deflection Profiles, without and with P-delta -- N = 18, T = 3.6 -- Frame

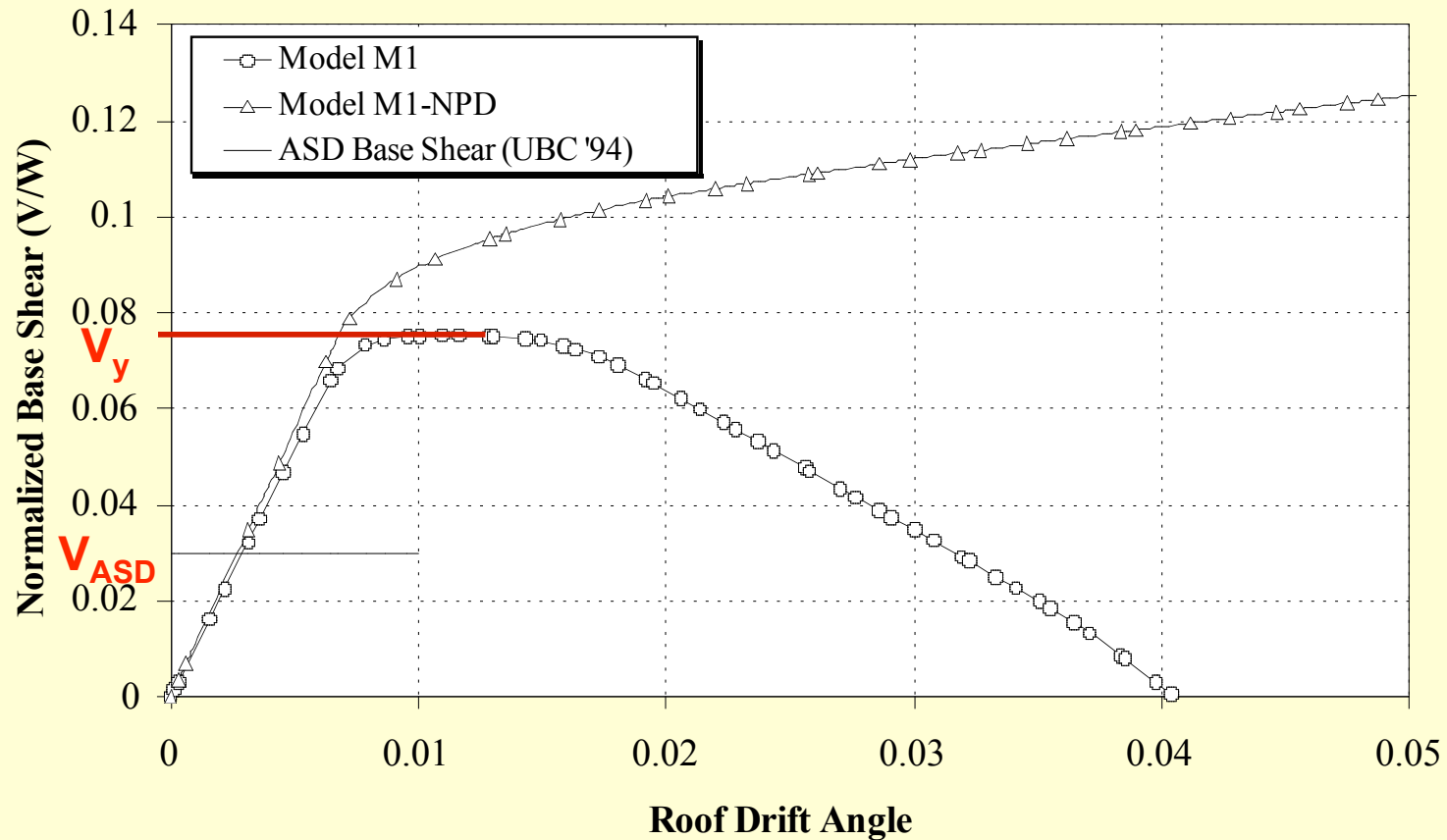


# Global Pushover Curve, without and with P-Delta -- N = 18, T = 3.6 -- Frame



# Global Pushover Curve, LA-20, without and with P- $\Delta$

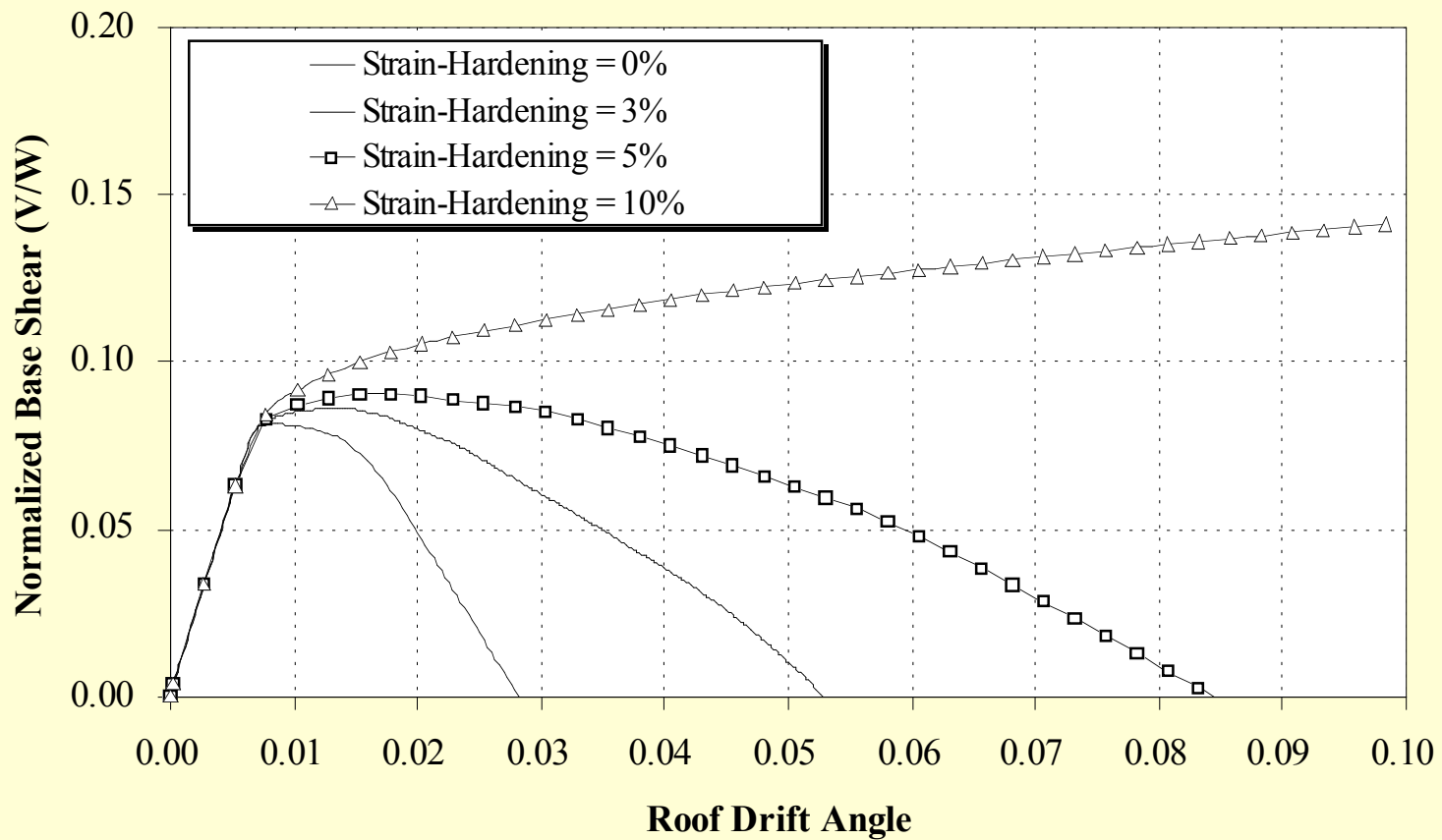
**ROOF DRIFT ANGLE vs. NORMALIZED BASE SHEAR**  
Pushover (NEHRP '94 k=2 pattern): LA 20-Story, Pre-Northridge, M1, M1-NPD



# Sensitivity to Strain Hardening, Pushover, LA-20

## ROOF DRIFT ANGLE vs. NORMALIZED BASE SHEAR

Pushover: LA 20-Story, Pre-Northridge, Model M2,  $\alpha = 0\%, 3\%, 5\%, 10\%$

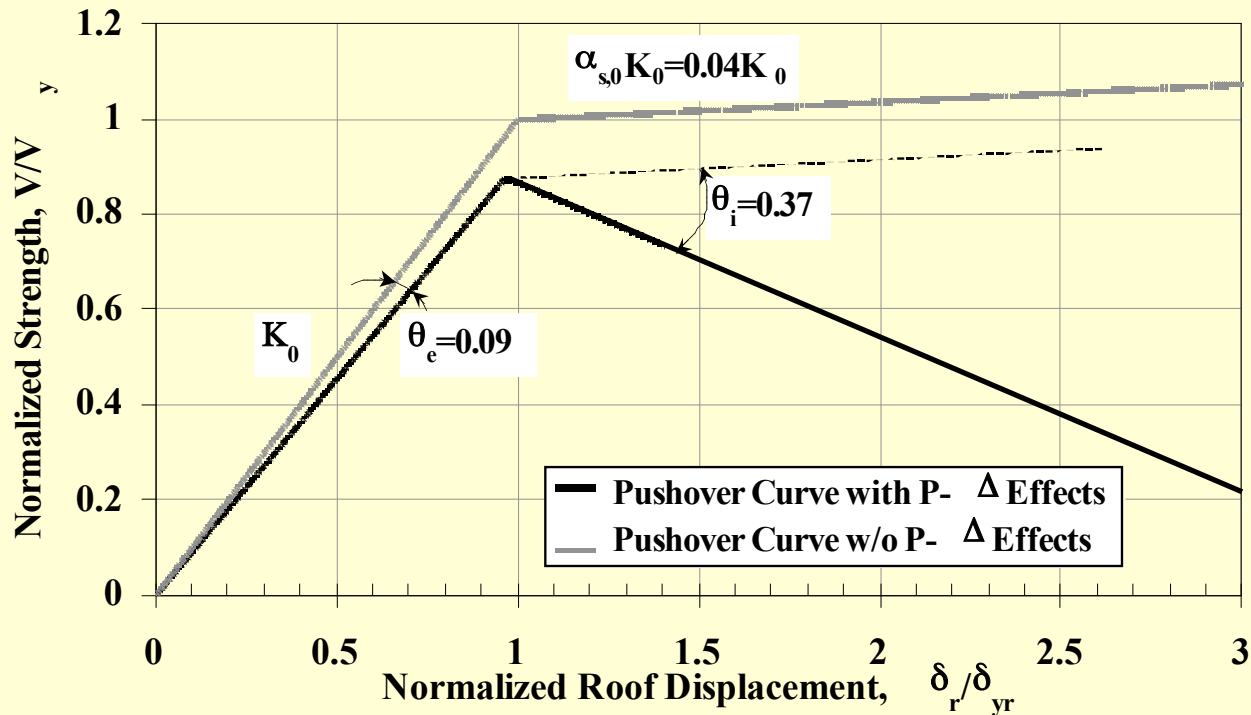


# Elastic and Inelastic Stability Coefficient

## N = 18, T = 3.6 -- Frame

### GLOBAL PUSHOVER CURVES

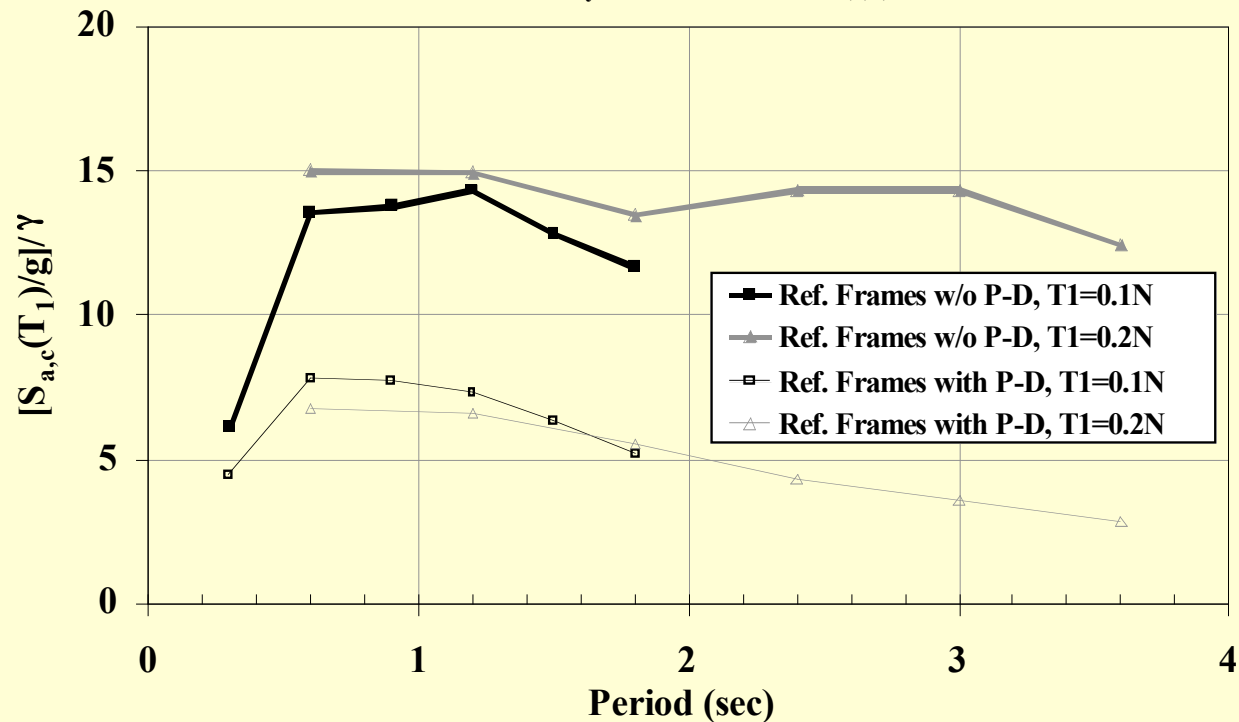
N=18,  $T_1=3.6$ , BH, Peak Oriented Model, LMSR-N,  $\xi=5\%$ ,  
 $\alpha_s=0.03$ ,  $\delta_c/\delta_y=Inf$ ,  $\alpha_c=N.A.$ ,  $\gamma_{s,c,k,a}=Inf$ ,  $\lambda=0$





# Effect of P-Delta on Median Collapse Capacity (Deteriorating Frame Systems)

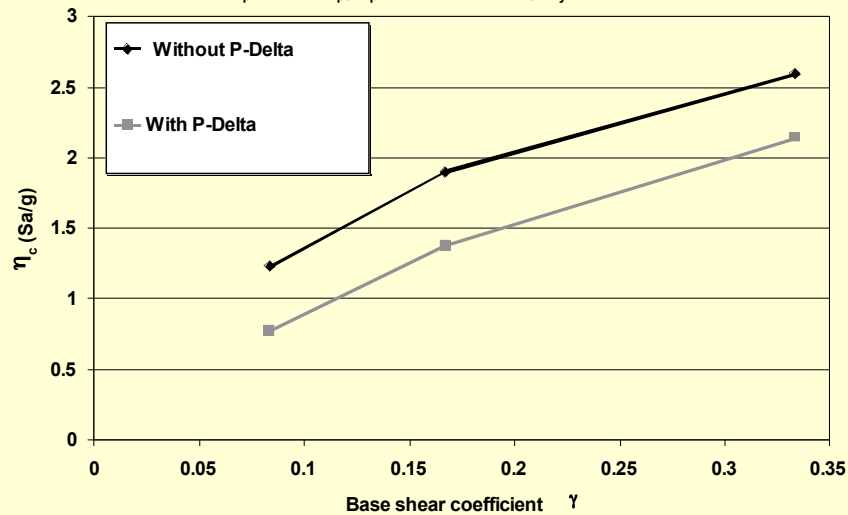
EFFECT OF P- $\Delta$  ON MEDIAN  $[S_{a,c}(T_1)/g]/\gamma$   
 $N=Var, T_1=Var, BH, Peak Oriented Model, LMSR-N,$   
 $\xi=5\%, \alpha_s=0.03, \delta_c/\delta_y=4, \alpha_c=-0.10, \gamma_{s,c,k,a}=Inf, \lambda=0$



# Effect of P-Delta on Median Collapse Capacity (as function of base shear yield coefficient) Frames versus Walls (8-story)

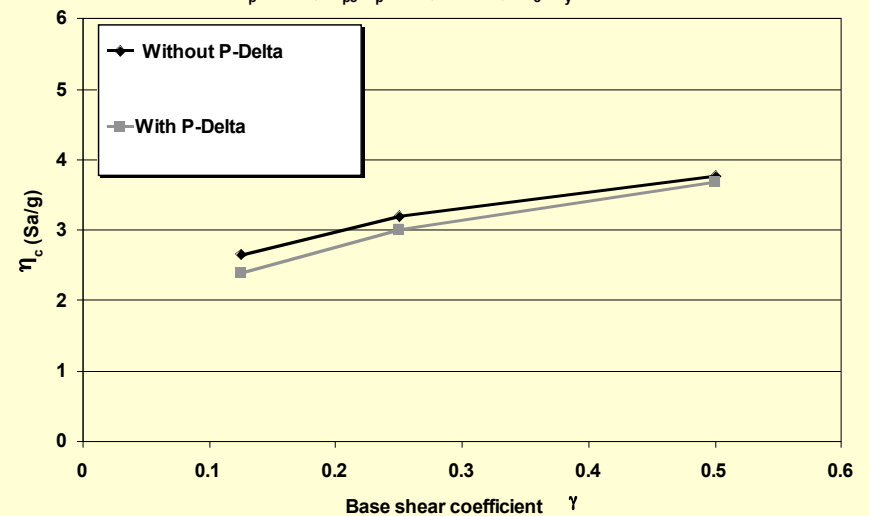
**P-Delta Effect on  $\eta_c$  (MRF)**

N = 8, T<sub>1</sub> = 1.2,  $\gamma$  = var., Stiff.&Str. = Shear, SCB = 2.4-1.2,  $\xi = 0.05$   
 $\theta_p = 0.03$ ,  $\theta_{pc}/\theta_p = 5.0$ ,  $\lambda = 20$ , M<sub>c</sub>/M<sub>y</sub> = 1.1



**P-Delta Effect on  $\eta_c$  (SW)**

N = 8, T<sub>1</sub> = 0.8,  $\gamma$  = var., Str. = var.,  $\xi = 0.05$   
 $\theta_p = 0.02$ ,  $\theta_{pc}/\theta_p = 1.0$ ,  $\lambda = 20$ , M<sub>c</sub>/M<sub>y</sub> = 1.1



# So, what's the point?

- P-Delta, which is amplified by deterioration, causes collapse (not the only source)
- P-Delta effect is very sensitive and not straight forward to predict
- We should safeguard against prediction errors
- But min. base shear does not look like the right vehicle to do so
- In codes: establish a limit on  $P\delta/(V_y h)$ ????

