DEVELOPMENTS IN COMPOSITE COLUMN DESIGN

Tiziano Perea (GT)
Roberto T. Leon (GT)
Jerome F. Hajjar (UIUC)
Mark Denavit (UIUC)

AISC NASSC – Nashville

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OVERVIEW

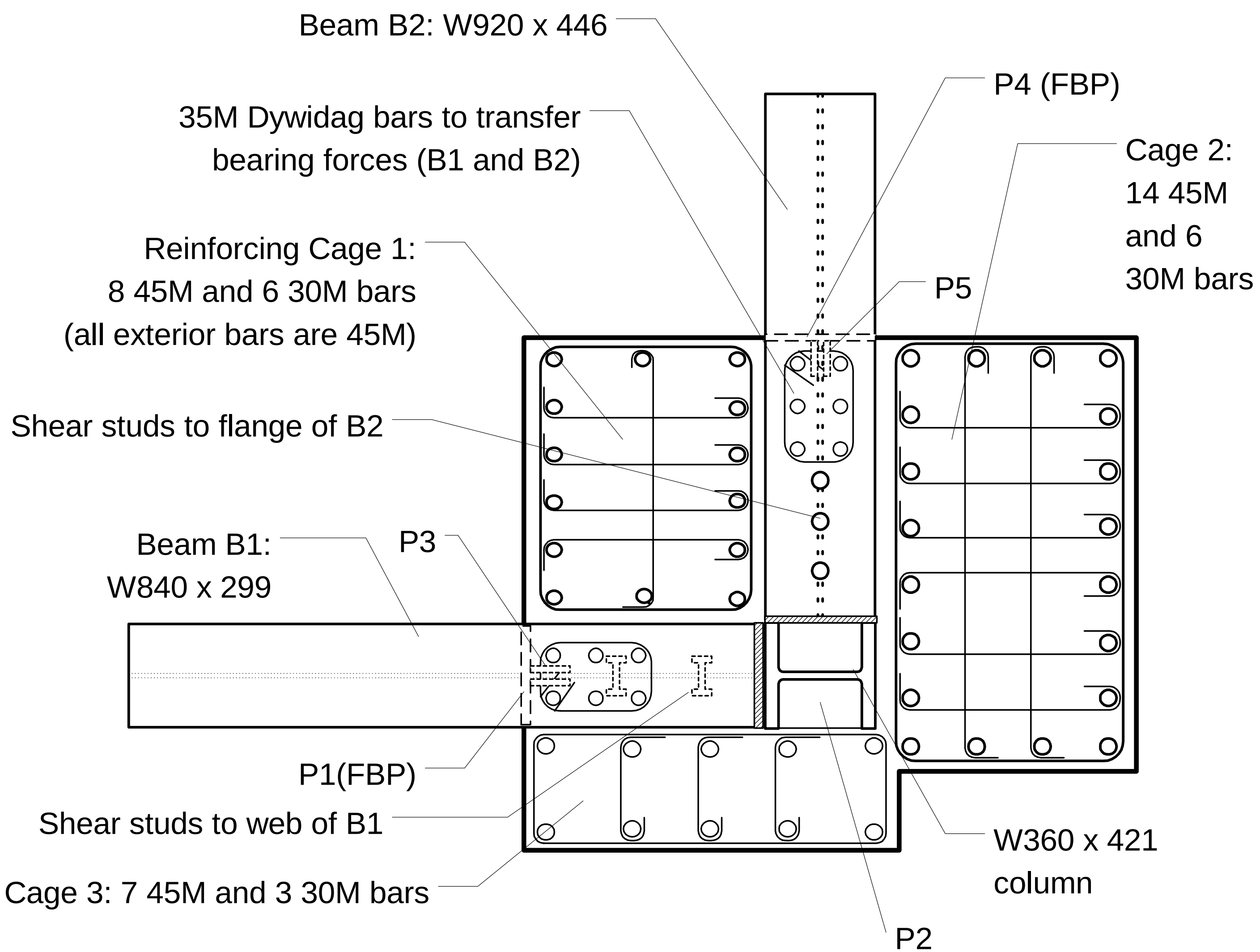
- Introduction
  - Advantages of composite columns
  - Applications in high-rise buildings
- Background to 2005AISC Specification
  - Reason for changes
  - Reduction of conflicts with ACI 318
  - Issues for future work
- Experimental program

Composite Columns in Tall Buildings

- Four super-columns tied by 5-story Virendeel trusses provide all the lateral resistance to the Norwest Center in Minneapolis
- Speed of construction = gravity load system followed by lateral load system and building finishes
- Concrete in columns used mostly for stiffness

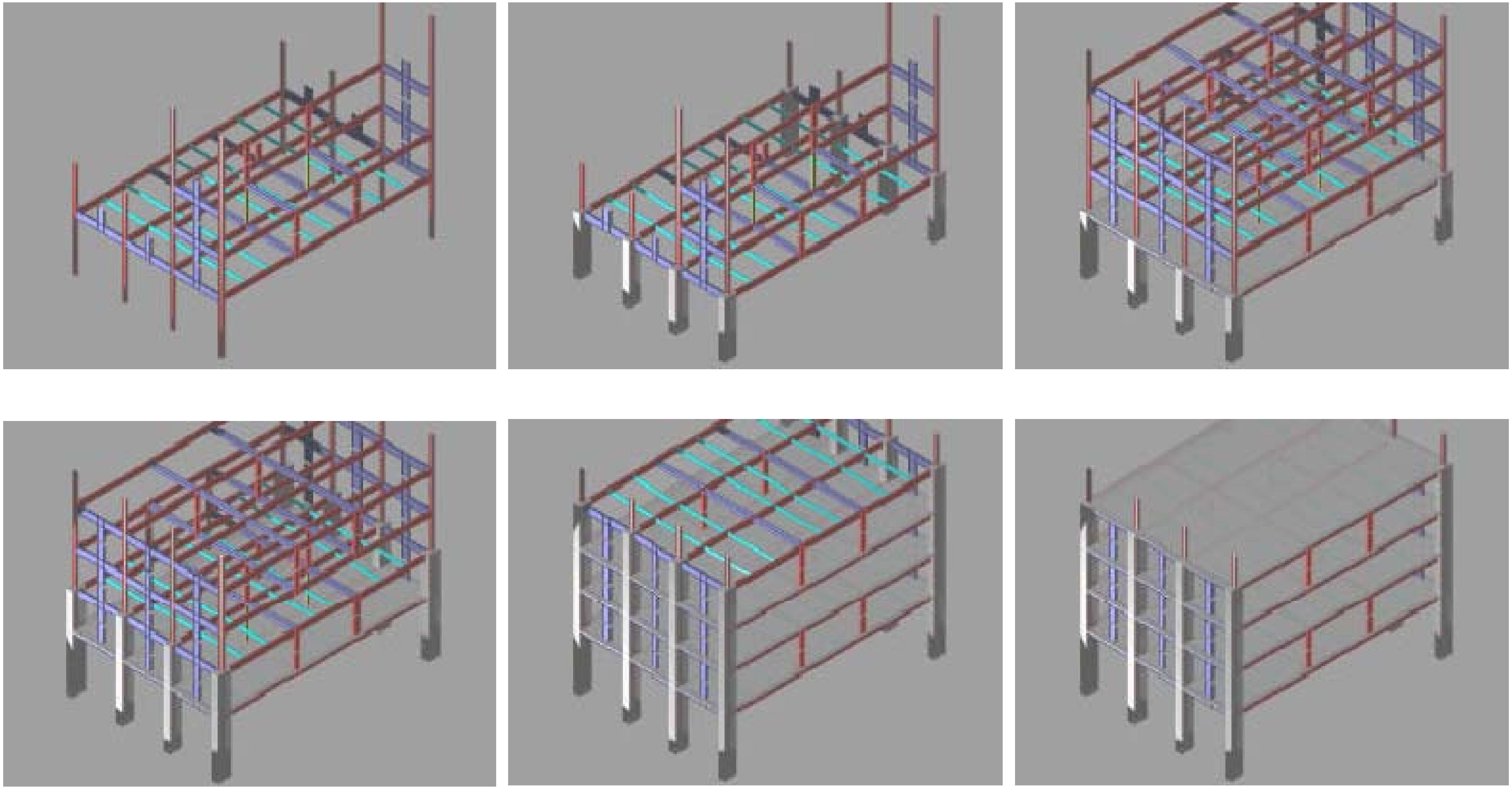
CBM Engineers - Houston

Column Details



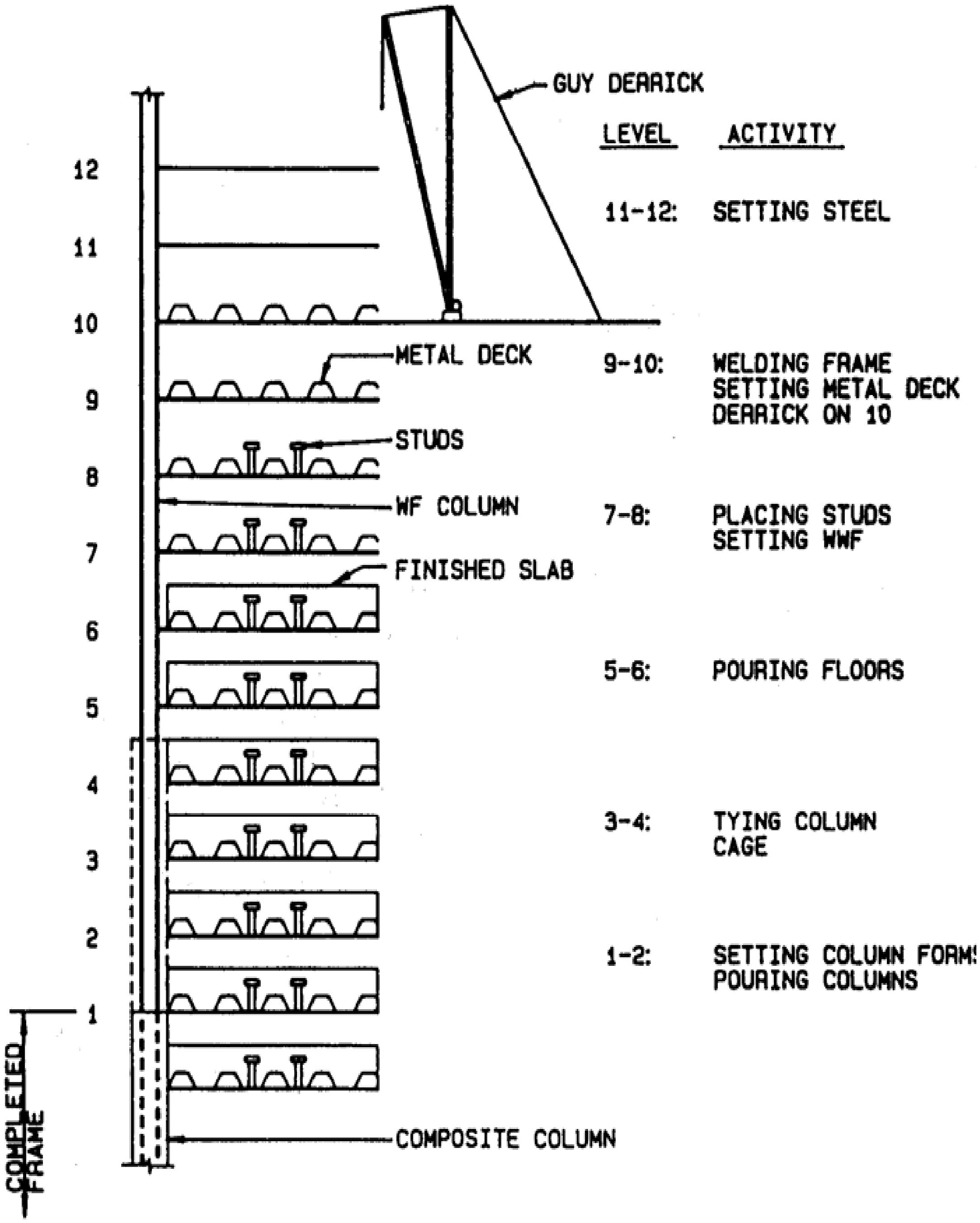
Frames with SRC columns

Phases in erection & construction



Source: Martinez-Romero, 2003

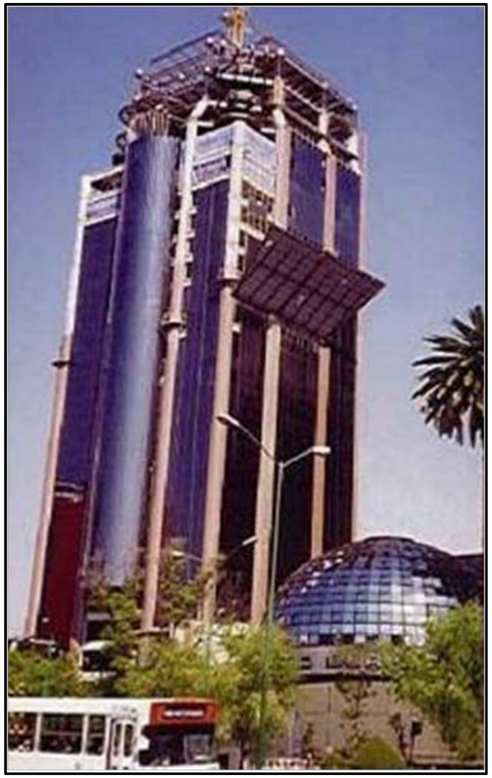
Construction Sequence

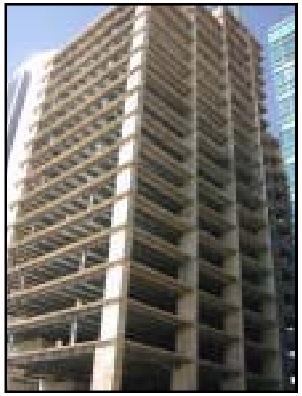


Composite Columns in Tall Buildings

Design for hurricane forces – Houston – Walter P. Moore & Assoc.

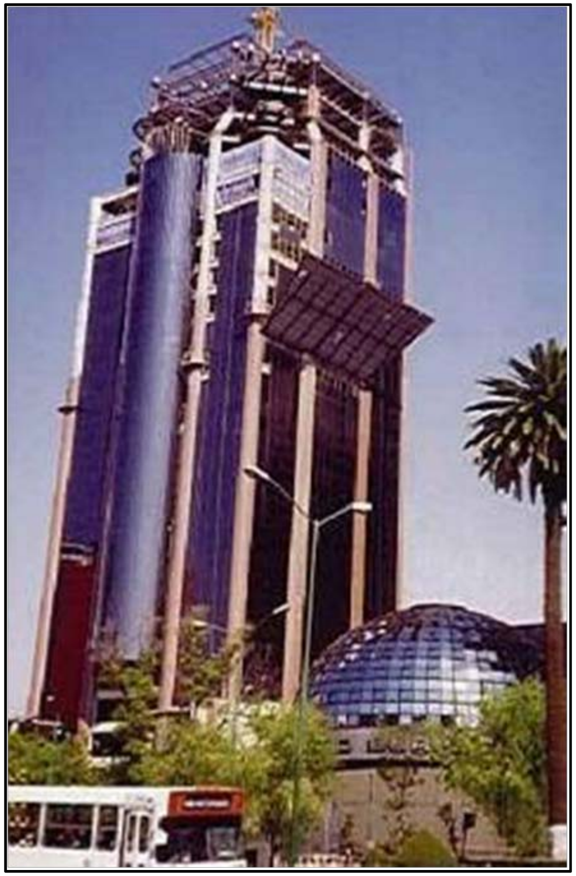
Buildings with SRC Columns *(Martinez-Romero, 1999 & 2003)*





Building: **Avantel** Firm: **EMRSA** Floors: **28**

Use: **Office** Location: **Mexico City** Year: **1995**



Structural steel:
ASTM A-572-50

Concrete:
f_c' = 5.7 ksi

Reinf. steel:
Fy = 60 ksi

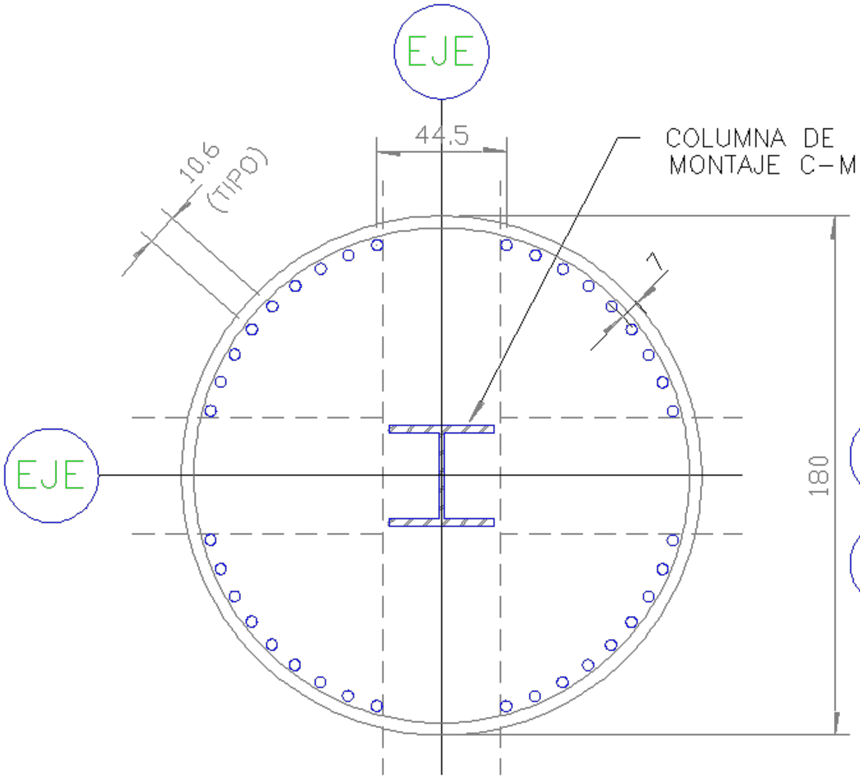
Source: Martinez-Romero, 1999

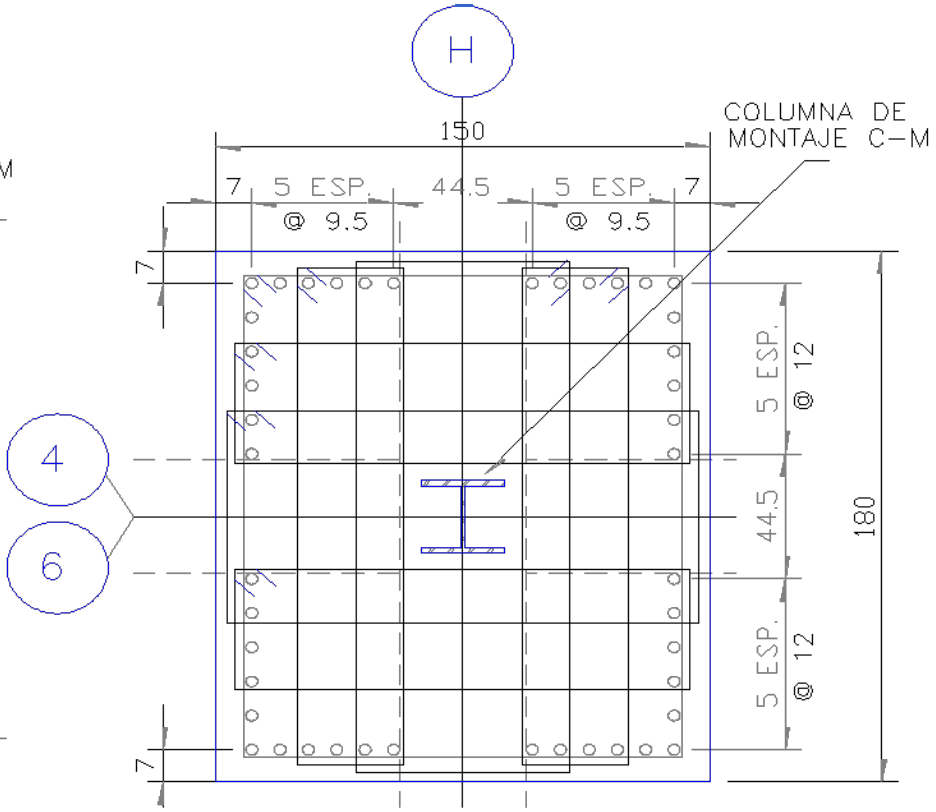
SRC-Section Drawings

Concrete:
f_c'= 6 ksi

Structural steel:
ASTM A-572-50

Reinf. steel:
Fy = 60 ksi





Source: Martinez-Romero, 1999

Uses for Composite Columns

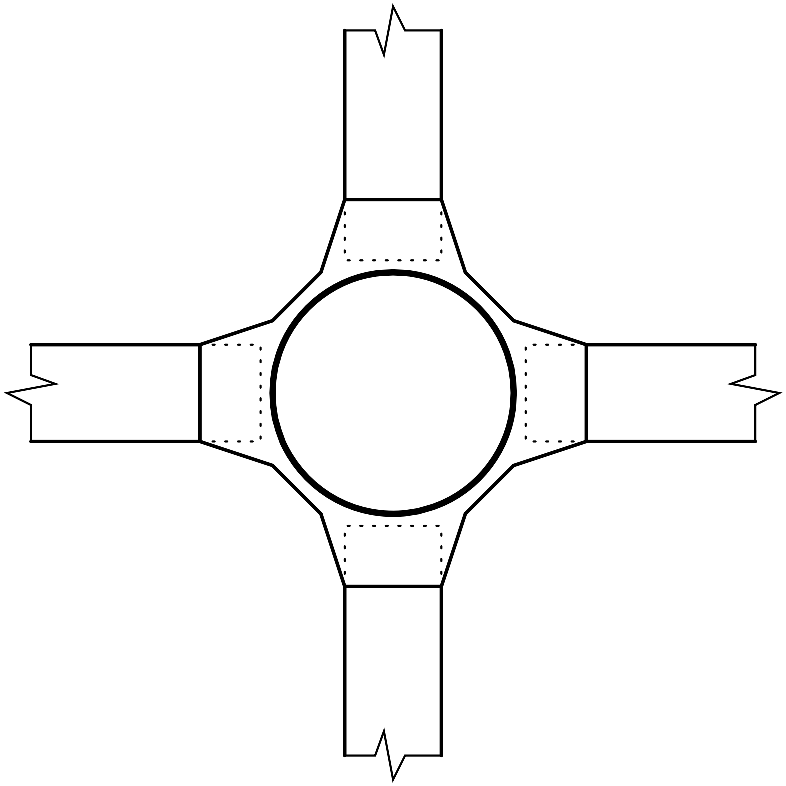
- *Extra capacity in concrete column for no increase in dimension*
- *Large unbraced lengths in tall open spaces*
  - *Lower story in high rise buildings*
  - *Airport terminals, convention centers*
- *Corrosion, fireproof protection in steel buildings*
- *Composite frame – high rise construction*
- *Transition column between steel, concrete systems*
- *Toughness, redundancy as for blast, impact*

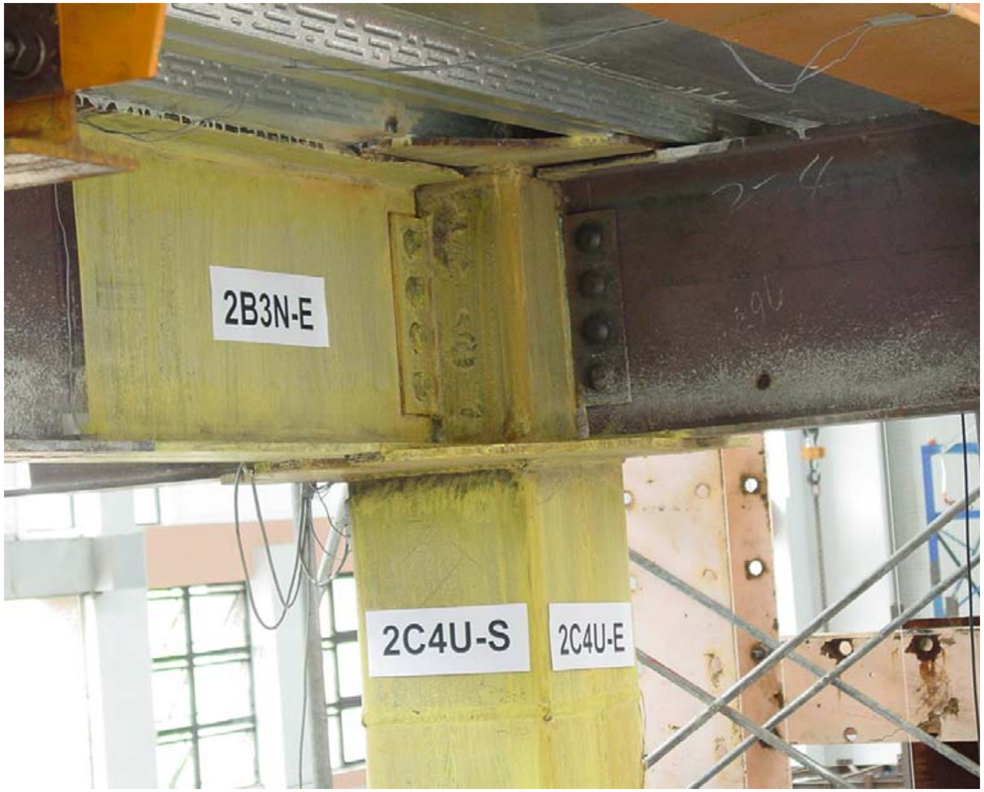
(from Larry Griffis)

Applications around the world

Full-scale 3stor, 3-bay braced frame tested in Taiwan

Applications around the world





Rectangular or circular composite columns with external diaphragms

Transition Floors

From concrete walls and columns to steel columns

S.D. Lindsey & Assoc.

Composite or hybrid system (concrete & steel)

System which combines the advantages of concrete and structural steel

Concrete

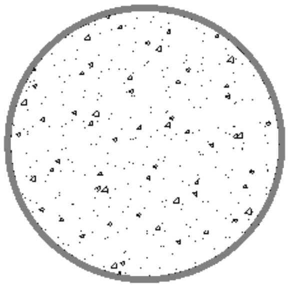
* Rigid
* Economic
* Fire resistant
* Durable

Structural steel

* High strength
* Ductile
* Easy to assemble
* Fast to erect

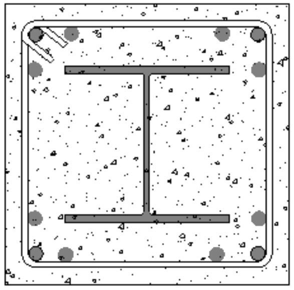
Frames with CFT columns

- Steel tube **confines** concrete
- Concrete restricts the **local buckling** of the steel tube
- Increase in strength & **deformation** of the concrete
- Delay in the **global buckling** of the steel tube

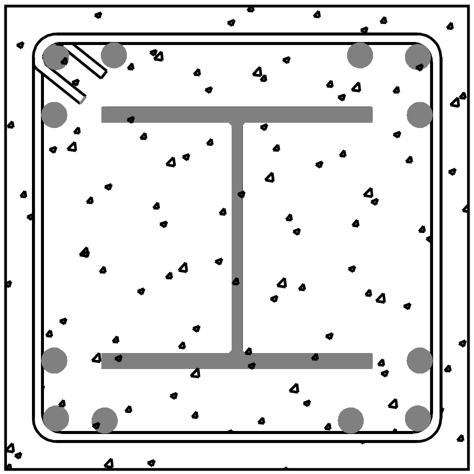


Frames with SRC columns

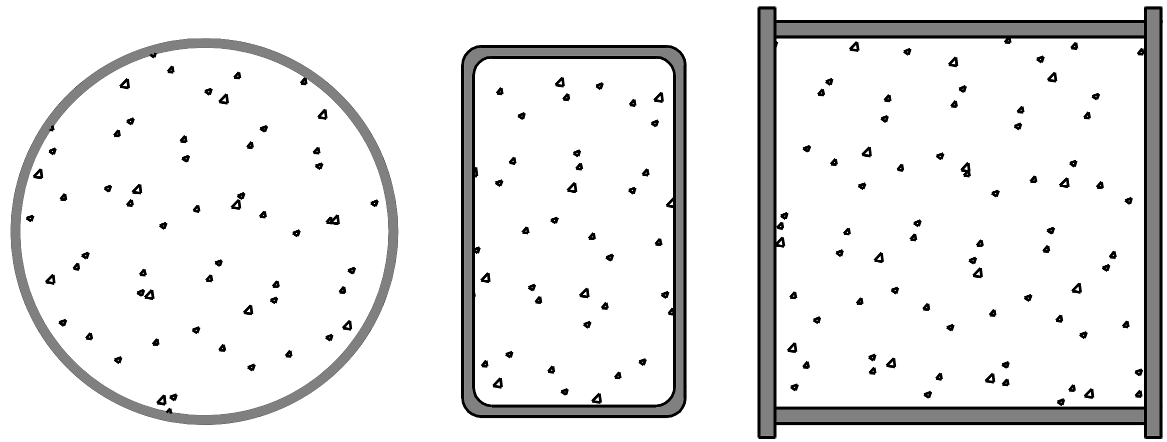
- Steel element supports the **construction loads**
- The concrete gives final **stiffness** and **fire resistant**
- Shear connections become **FR** once concrete is cast
- System **fast** to erect & build
- Redundancy & robustness



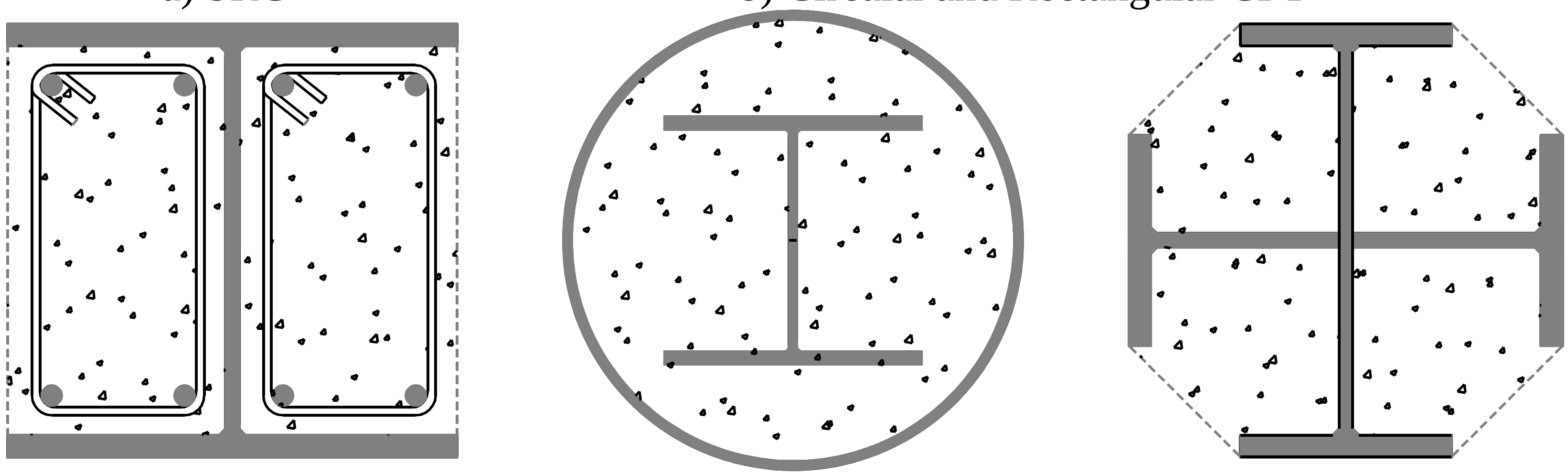
Configurations for Composite Columns



a) SRC



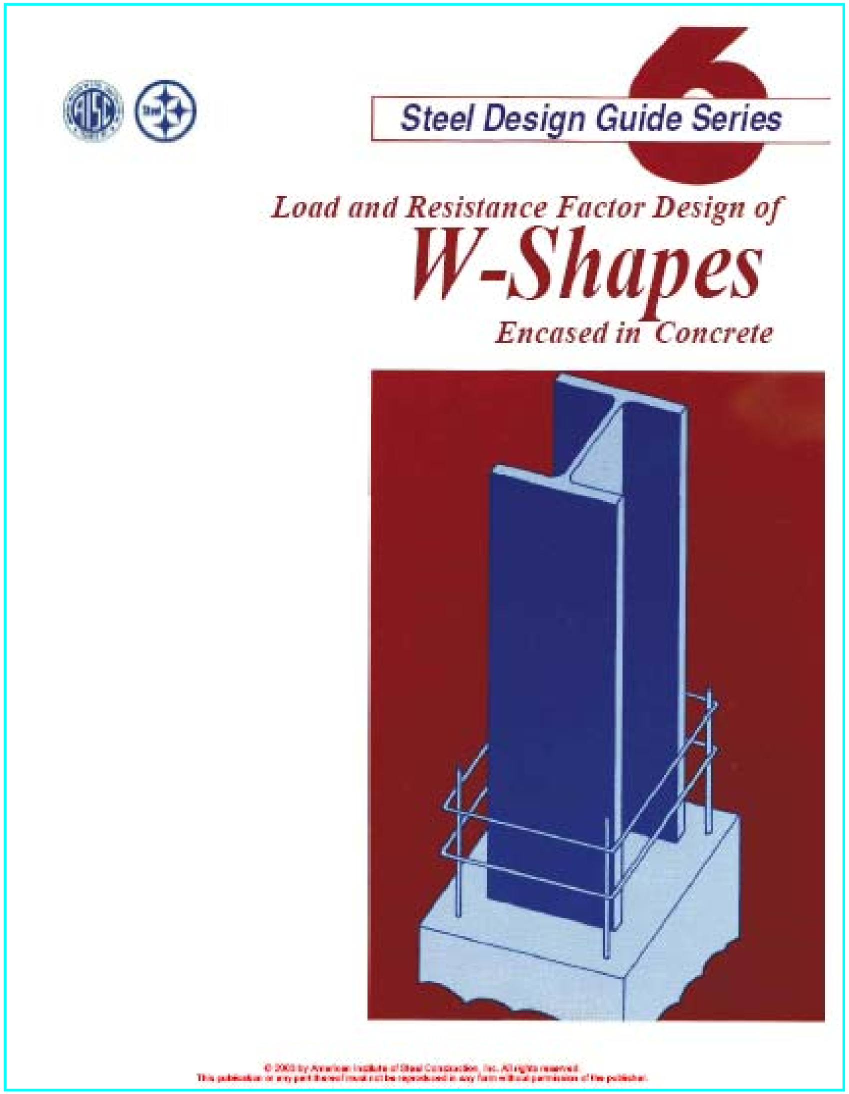
b) Circular and Rectangular CFT



c) Combinations between SRC and CFT

Design Guide 6

- *Concrete encased WF shapes*
- *Based on 1986 LRFD Spec*
- *5, 8 KSI NW concrete*
- *A36, A572 Gr 50 WF*
- *1%-4% Rebar patterns*



Design Guide 6

Adjust φ_c factor 0.85 to 0.75 ; φ_b=0.9 same

M_{ui}(AISC05) = M_{ui}(Design Guide) x 0.75/0.85

COMPOSITE BEAM-COLUMN DESIGN CAPACITY - LRFD

ϕc = 0.85 f'c : 8.0 ksi NW
ϕb = 0.90 Fyr : 60 ksi

Axial Load Capacity (kips), Uniaxial Moment Capacity (ft-kips) Column Size(b x h): 28 x 28

Designation		W 14 x120								W 14 x109							
Fy (ksi)		36				50				36				50			
Reinf.	KL	ϕcPn	Pu/(ϕcPn)	Mux	Muy	ϕcPn	Pu/(ϕcPn)	Mux	Muy	ϕcPn	Pu/(ϕcPn)	Mux	Muy	ϕcPn	Pu/(ϕcPn)	Mux	Muy
.51 %	0	4260	0.0	1180	1190	4680	0.0	1430	1420	4170	0.0	1110	1130	4550	0.0	1350	1350
Ar(in²)	11	4140	0.2	1060	1070	4530	0.2	1290	1280	4050	0.2	1000	1010	4400	0.2	1210	1210
= 4.00	13	4090	0.3	926	936	4470	0.3	1130	1120	4000	0.3	876	886	4350	0.3	1060	1060
	17	3970	0.4	794	802	4330	0.4	967	957	3880	0.4	751	760	4200	0.4	908	908
4-# 9	21	3820	0.5	661	668	4150	0.5	806	798	3730	0.5	626	633	4030	0.5	757	757
2x-2y	25	3650	0.7	397	401	3950	0.7	483	478	3560	0.7	375	380	3830	0.7	454	454
	40	2870	0.9	132	133	3030	0.9	161	159	2780	0.9	125	126	2920	0.9	151	151
#3 Ties		Cex	Cey	rmx	rmy	Cex	Cey	rmx	rmy	Cex	Cey	rmx	rmy	Cex	Cey	rmx	rmy
@ 15 in		850	850	8.40	8.40	850	850	8.40	8.40	806	806	8.40	8.40	806	806	8.40	8.40

AISC Spec. (2005)
New Composite Column Provisions

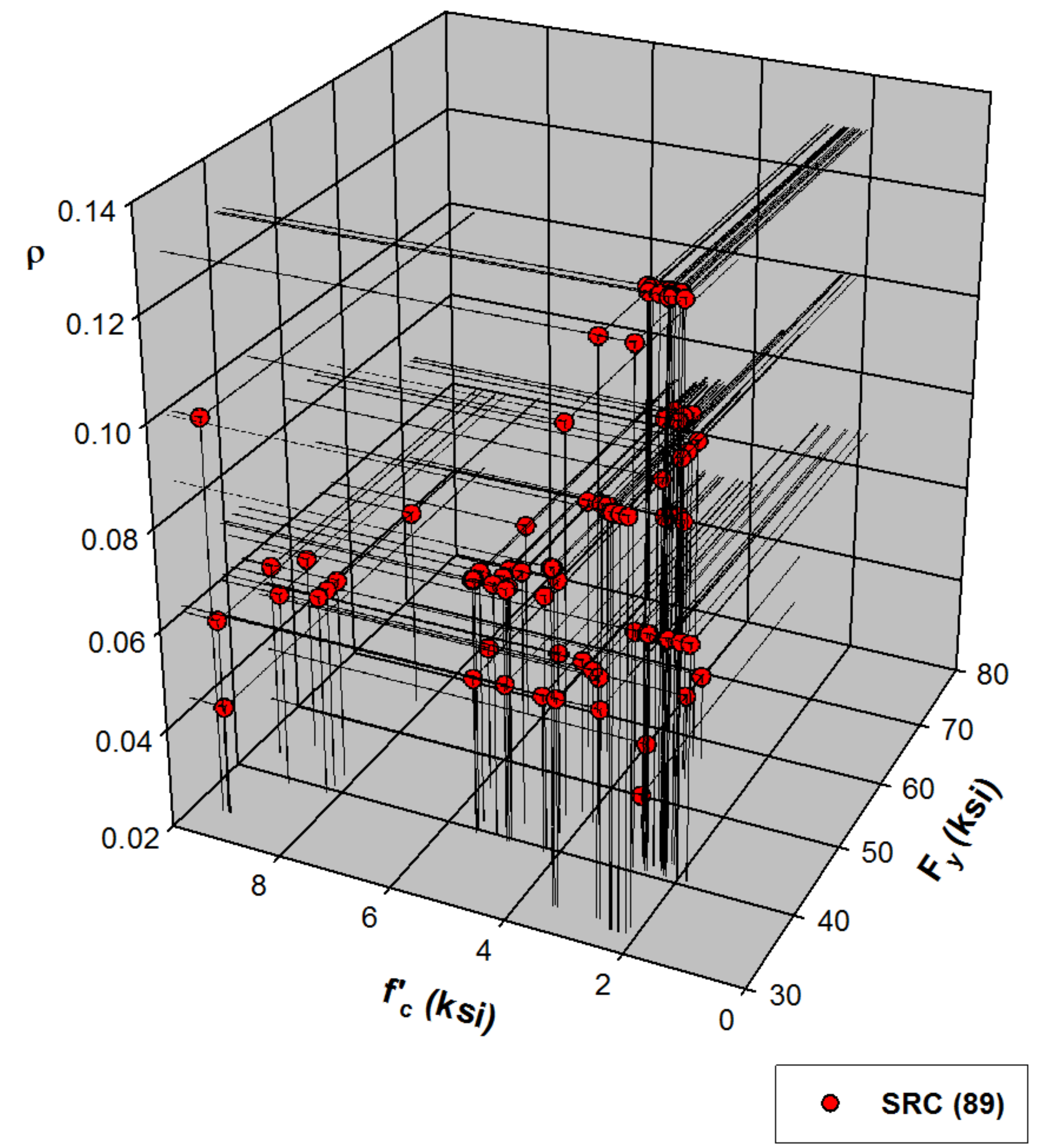
- Changes in materials permitted
- Relaxation of slenderness limits
- New strength provisions for encased columns
- New strength provisions for CFT columns
- New provisions for force transfer
- New expressions for flexural stiffness

Φc = 0.75 (LRFD) (Change from 0.85)
Ωc = 2.00 (ASD)

Composite Column Database

- Determine range of sizes and materials tested
- Assess robustness of data
- Extract useful information
- Determine types of tests needed

Leon and Aho, 2000

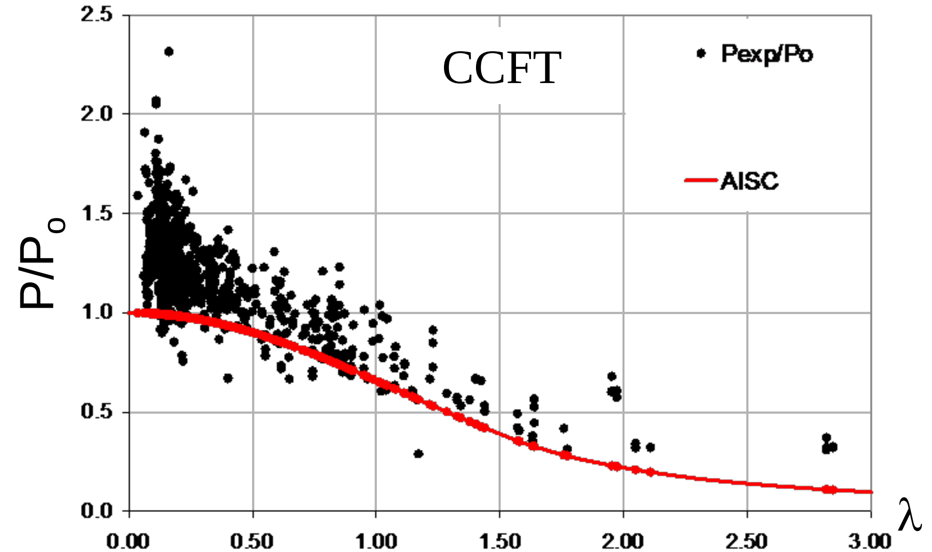


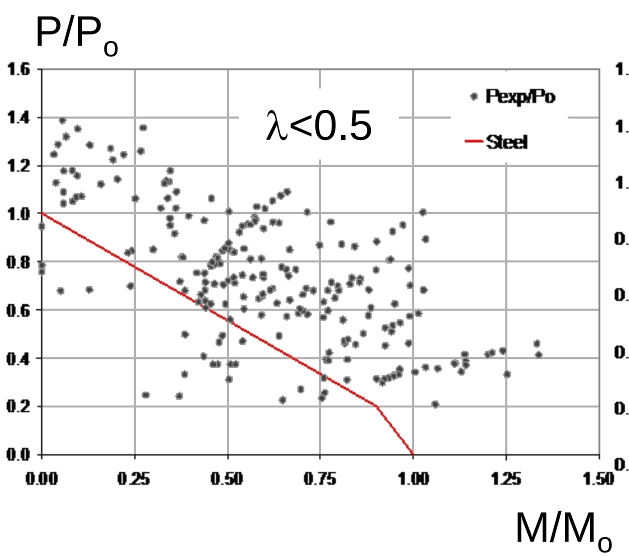
Databases in CCFT composite columns (Leon and Aho, 1996) (now: Goode *et al.*, 2007 + Leon *et al.*, 2005)

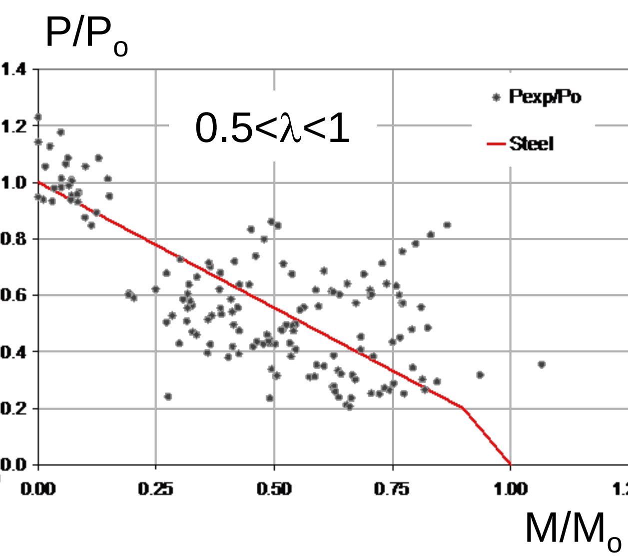
1375 Circular CFT
- 912 columns
- 463 beam-columns

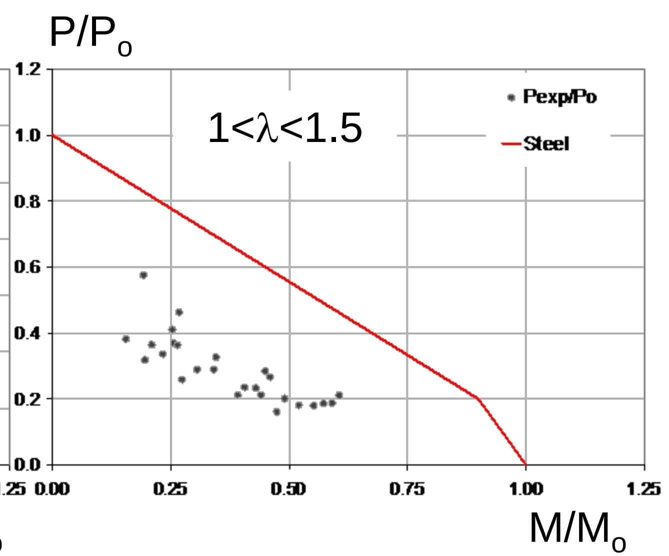
798 Rectangular CFT
- 524 columns
- 274 beam-columns

267 Encased SRC
- 119 columns
- 148 beam-column

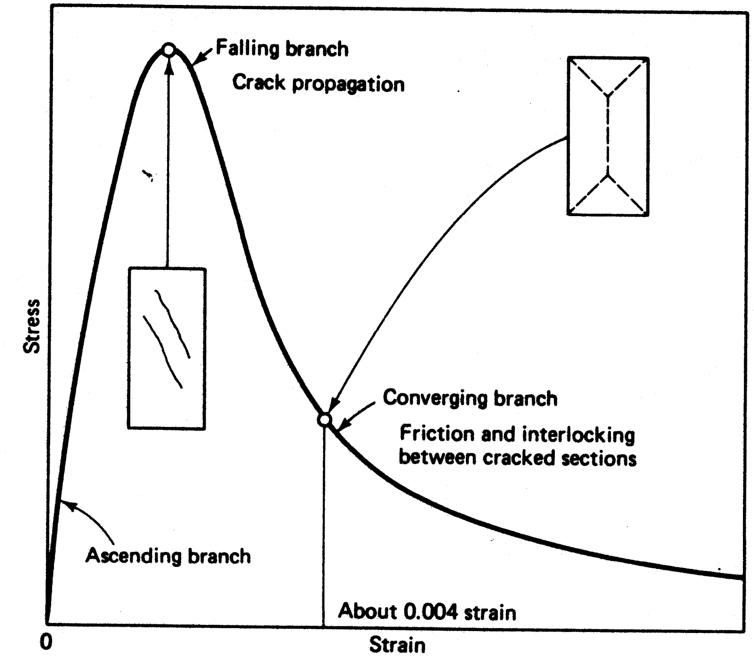






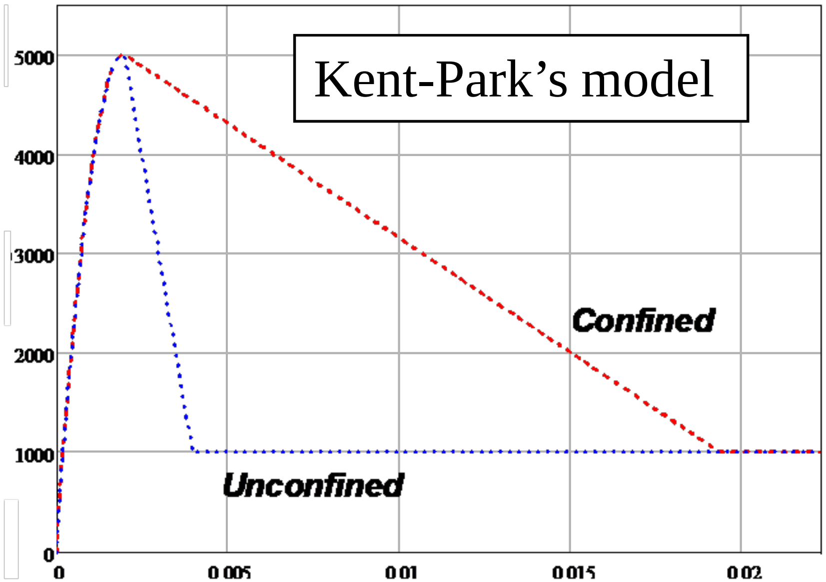


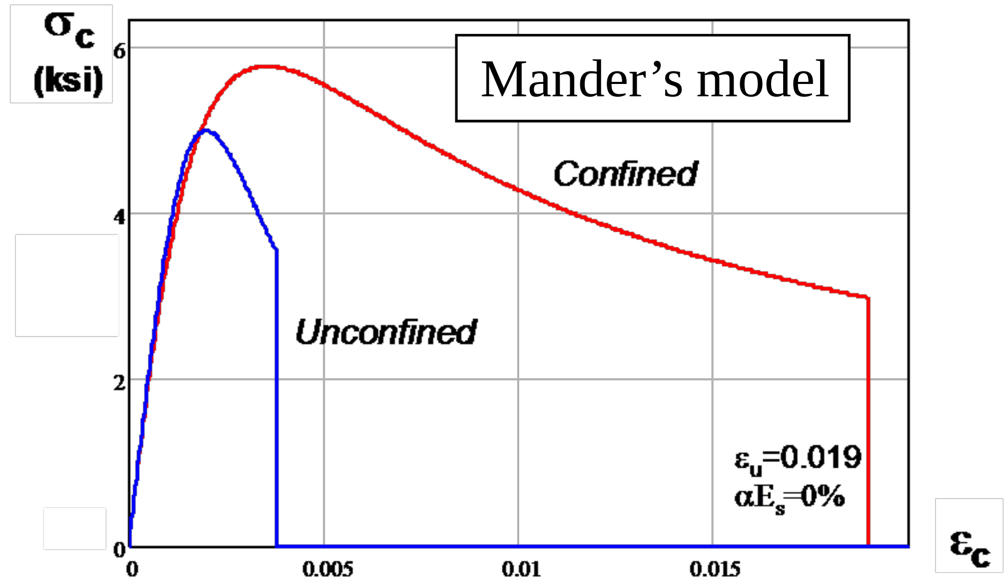
Material Limitations

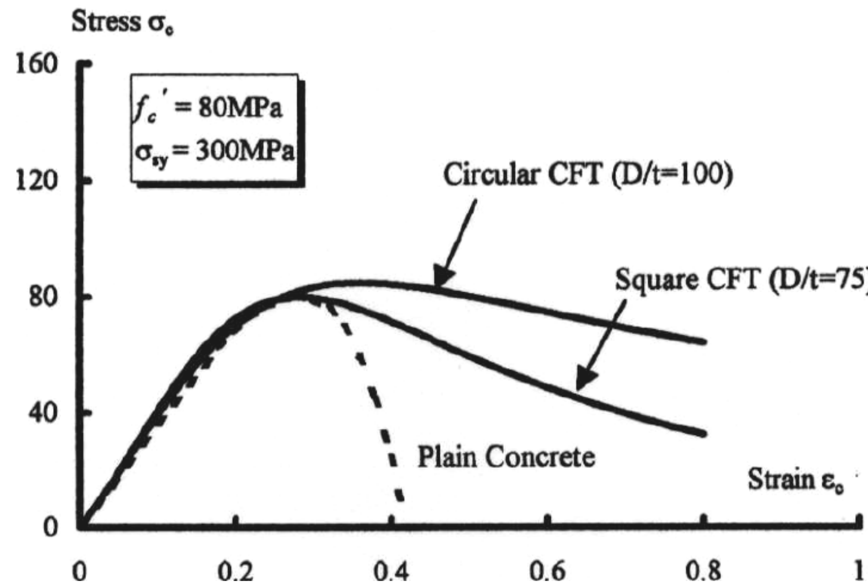


- *Concrete Strength f'_c*
  - *NW: 3 – 10 ksi*
  - *LW: 3 – 6 ksi*
  - *Higher values usable for stiffness*
- *Structural Steel, Rebar*
  - *F_y = 75 ksi max*
- *Higher strength materials by testing or analysis*

Confinement Effects







$0.95f'_c$ for CCFT only for simplicity

Sakino-Sun's model

Encased Composite Columns
New Limitations

- *Steel core = 0.01 x* A_g *min*
- *4 longitudinal continuous bars w/ ties or spirals*
- *Min transverse reinf* ≥ 0.009 in^2 / in tie spacing
- *Min reinforcement* $A_{sr} / A_g = 0.004$

Filled Composite Columns
New Limits

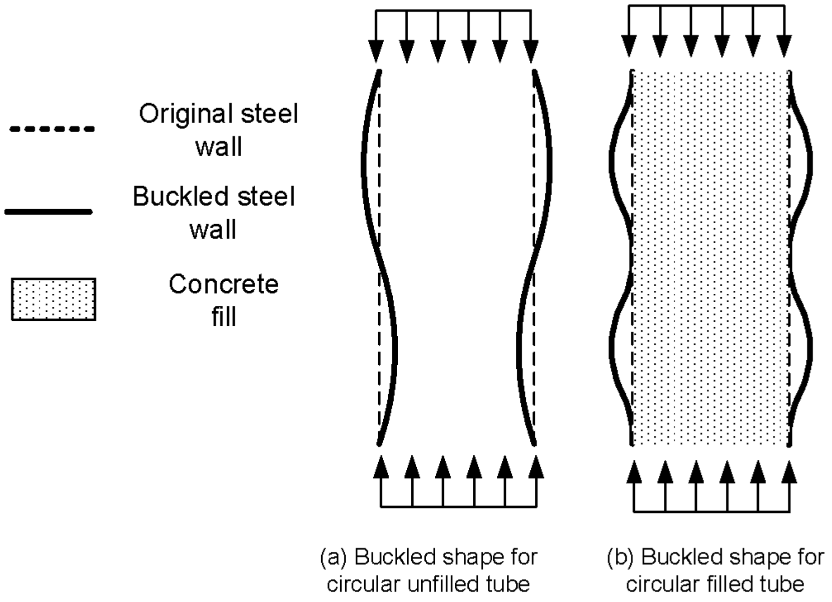
- *HSS area = 0.01* A_g *min (down from 0.04 in 1999)*
- *Rectangular HSS:*

  $b/t \leq 2.26\,[E/Fy]^{0.5}$

  $= 54.4$ *for 50 ksi (+20%)*
- *Round HSS:*

  $D/t \leq 0.15\,E/Fy$

  $= 87$ *for 50 ksi (+50%)*



Slenderness

For $P_e \geq 0.44\, P_o$:

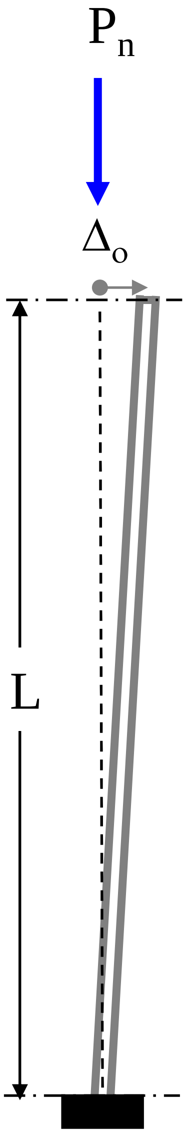
$$P_n = P_o\,[\,0.658^{\,Po/Pe}]$$

For $P_e < 0.44\, P_o$:

$$P_n = 0.877\, P_e$$

$$P_o = A_s F_y + A_{sr} F_{yr} + 0.85\, f'_c A_c$$

$$P_e = \pi^2 (EI_{eff}) / (KL)^2$$



> *Note similar format to all steel column*

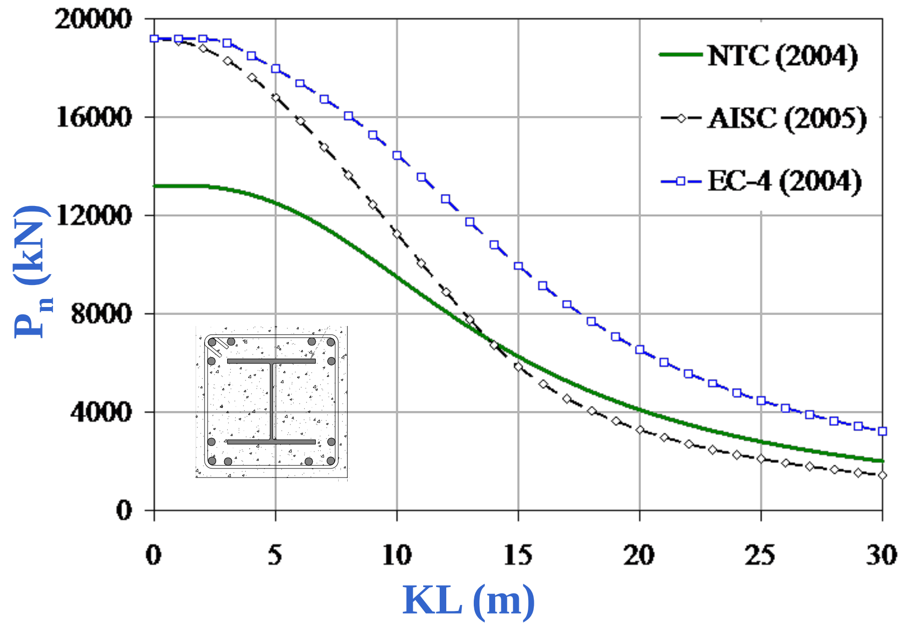
Moments of Inertia - Composite Columns

SRC new effective stiffness:

$E\,I_{eff} = E_s I_s + 0.5\,E_s I_{sr} + C_1 E_c I_c$

$C_1 = 0.1 + 2\,[A_s / (A_c + A_s)] \leq 0.3$

(concrete effectiveness factor)



CFT new effective stiffness:

$E\,I_{eff} = E_s I_s + E_s I_{sr} + C_3 E_c I_c$

$C_3 = 0.6 + 2\,[A_s / (A_c + A_s)] \leq 0.9$

(concrete effectiveness factor)

Effective stiffness (EI_{eff})

Mirza and Tikka (1999)

$$EI_{eff} = \left(0.313 + 0.00334\frac{L}{h} - 0.203\frac{e}{h}\right)E_c\left(I_g - I_{ss}\right) + 0.729E_sI_s + 0.788E_sI_{sr}$$

EC-4 (2004)

$$EI_{eff} = 0.9\left(E_sI_s + E_sI_{sr} + 0.5E_cI_c\right)$$

AISC (2011?)

$$EI_{eff} = E_sI_s + 0.5E_sI_{sr} + \beta \cdot C_iE_cI_c$$

β = f (creep & shrinkage) = f (ρ,KL/r) ≤ 0.6-0.9 (RFT-CFT), 0.3 (SRC)

Alternatives:

Concrete-only or a **steel-only** (not unusual in practice, too conservative!)

Fiber element analysis: Nonlinearity (σ–ε, P-Δ, P–δ), buckling, confinement (contact enforcement)

Finite element analysis: Local buckling, effective confinement, cracking.

Steel-concrete contact (friction, bond stress, slip, adhesion, interference).

Design Methods
Encased Composite Beam Columns

- *Method 1: AISC Interaction Equations*
- *Method 2: Plastic Stress Distribution Method*
- *Method 3: Strain Compatibility Method (like ACI Column Design)*

Encased Composite Beam Columns Method 1 (Interaction Eq's)

- *Uses AISC Beam Column Interaction Eq's*
- *Strong and Weak Axis Bending*
- *Requires only pure axial, pure moment capacities (P_o, M_n)*
- *Conservative designs*
- *Can use existing Design Guide 6 (conservative answers)*

AISC Interaction Equations

- For $P_r / P_c \geq 0.2$,
  - $P_r/P_c + 8/9\,(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$

- For $P_r / P_c < 0.2$,
  - $P_r/(2P_c) + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$

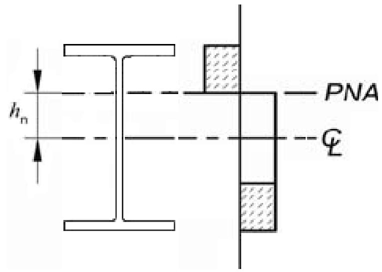
    - P_r = required axial compressive strength
    - P_c = available axial compressive strength ($\phi_c P_n$ or P_n/Ω_c)
    - M_r = required flexural strength
    - M_c = available flexural strength ($\phi_b M_n$ or M_n/Ω_b)
    - $\phi_c = \phi_b = 0.9$

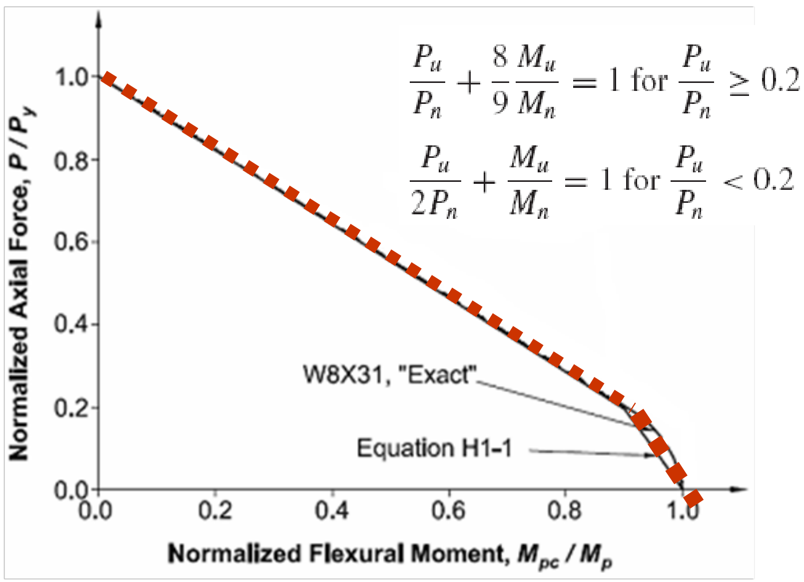
Encased Composite Beam Columns
Method 2 (Plastic Stress Distr)

- *Plastic Capacity Equations*
  - *Points A,B,C,D (plus E weak axis only)*
  - *Defined on the Example CD (w/ manual)*
- *Strong and weak axis bending*
- *Bar placement must conform to equations*
- *Apply slenderness effects to P,M values*
- *More capacity than Method 1*

Rigid-plastic & strain-compatibility methods

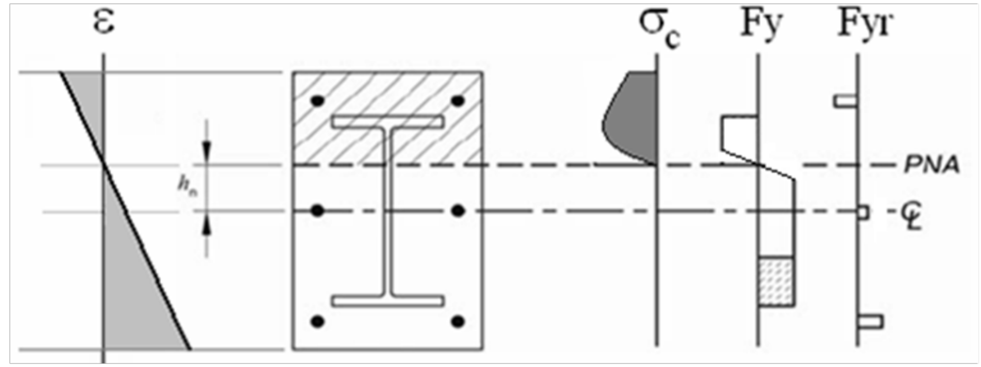
STEEL

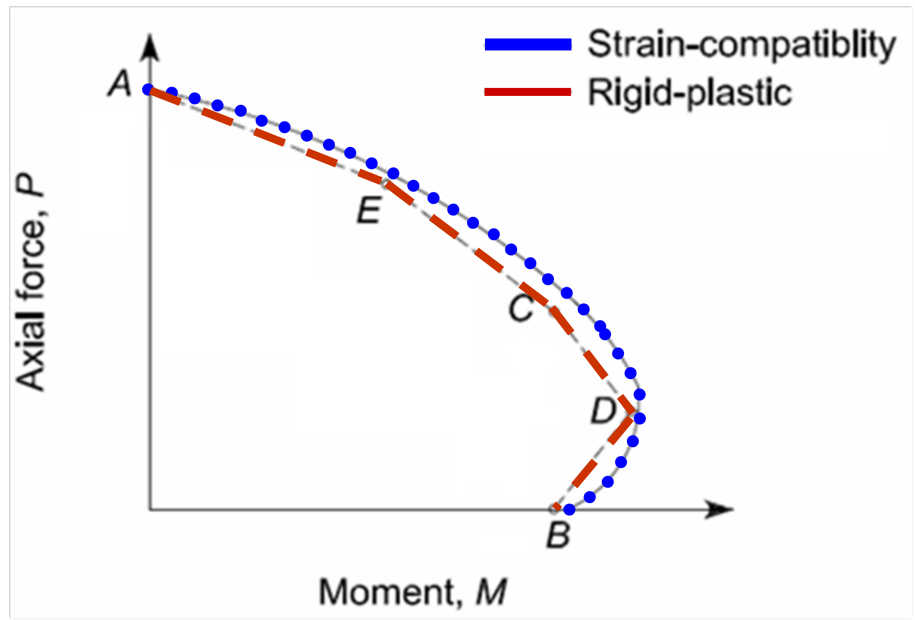




Interaction diagram: W8×31
F_y=50ksi. (*AISC Commentary, 2005*)

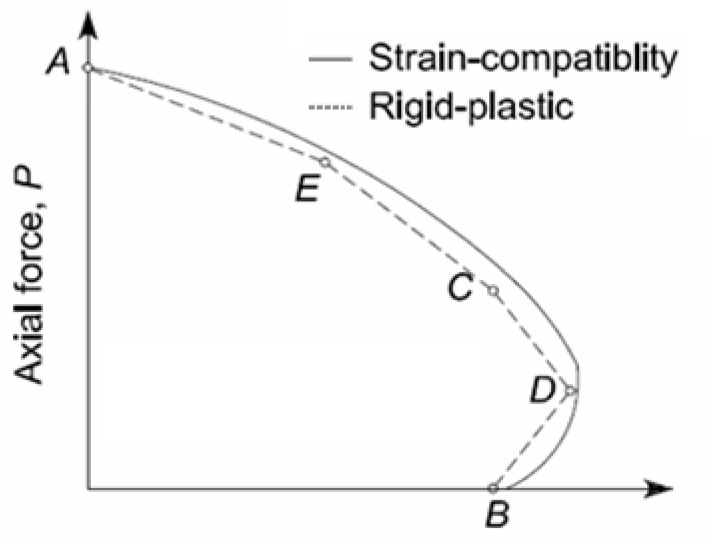
COMPOSITE

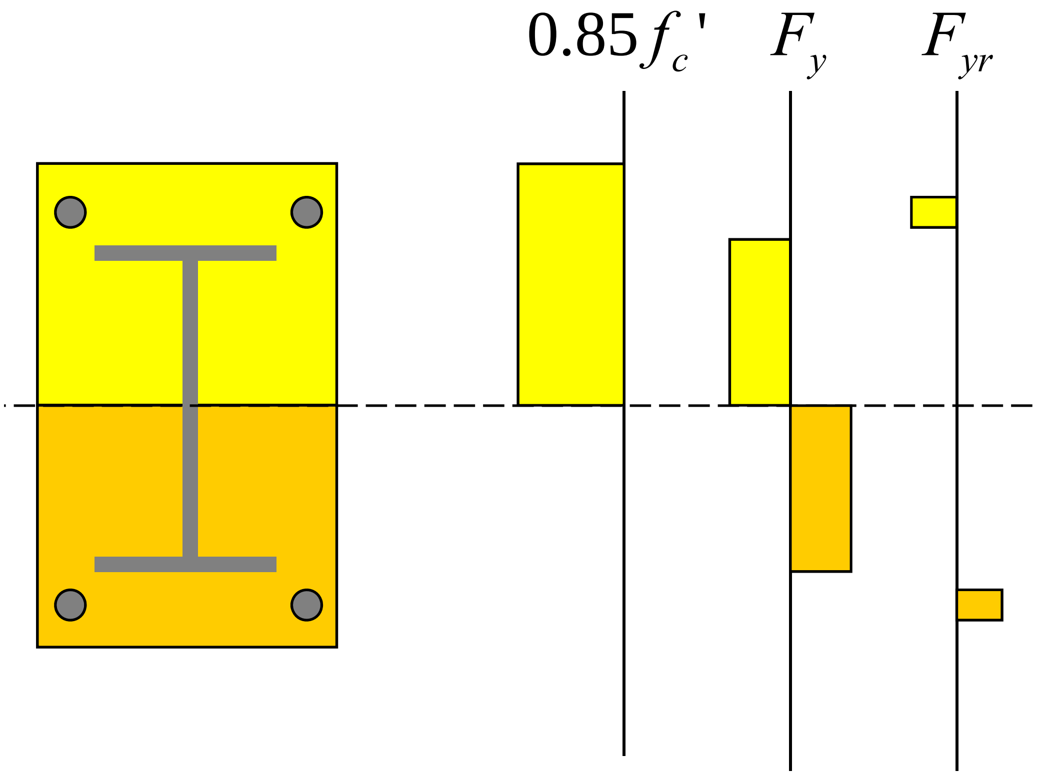




Interaction diagram
(*AISC Commentary, 2005*)

Plastic stress distribution or rigid-plastic method



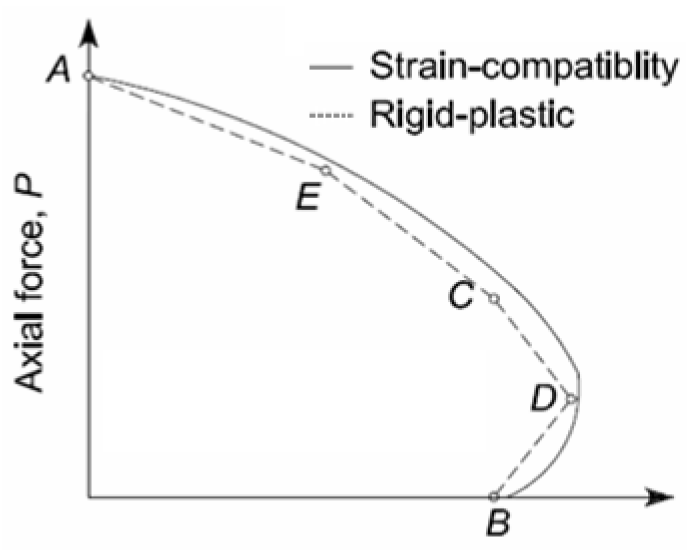


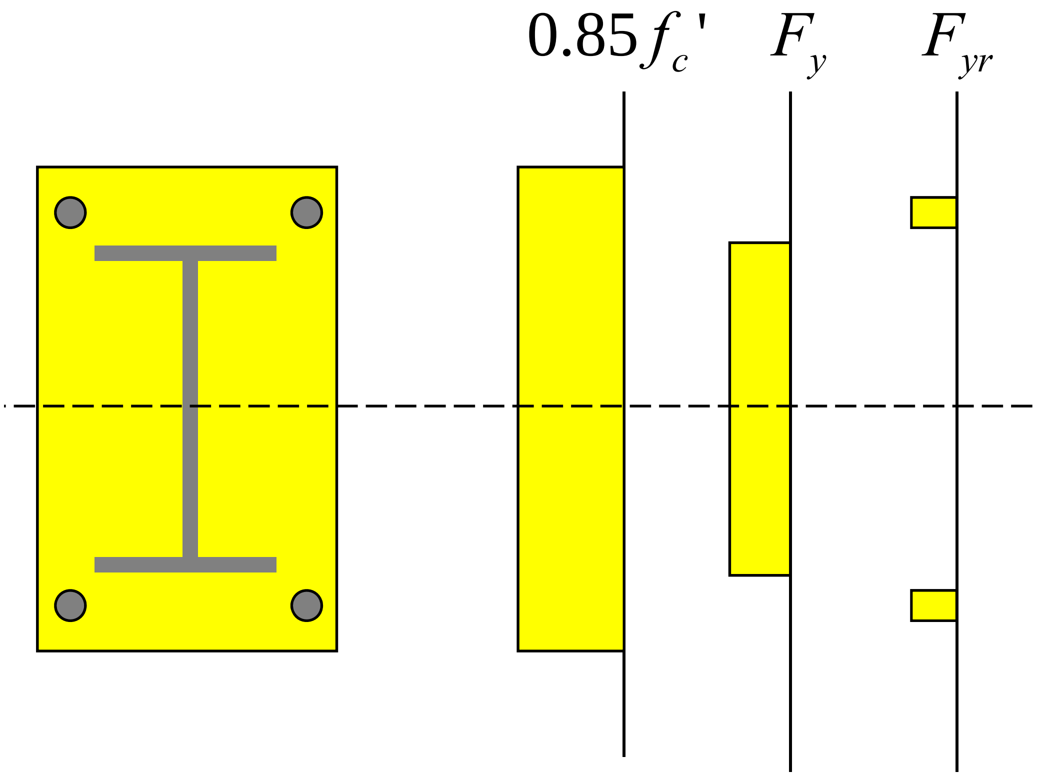
$$P_D = 0 + \frac{0.85 A_c f_c'}{2}$$

$$M_D = Z_s F_y + \left[A_{sr} \left(\frac{h}{2} - c \right) \right] F_{yr} + \left(\frac{bh}{2} \cdot \frac{h}{4} \right) 0.85 f_c$$

$$M_D = Z_s F_y + Z_r F_{yr} + \frac{Z_c}{2} (0.85 f_c')$$

Plastic stress distribution or rigid-plastic method

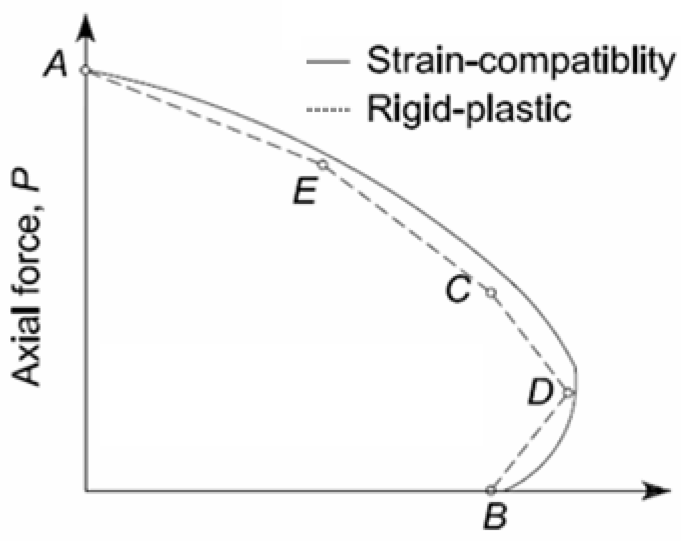




$$P_A = 0.85 A_c f_c' + A_s F_y + A_r F_{yr}$$

$$M_A = 0$$

Plastic stress distribution method

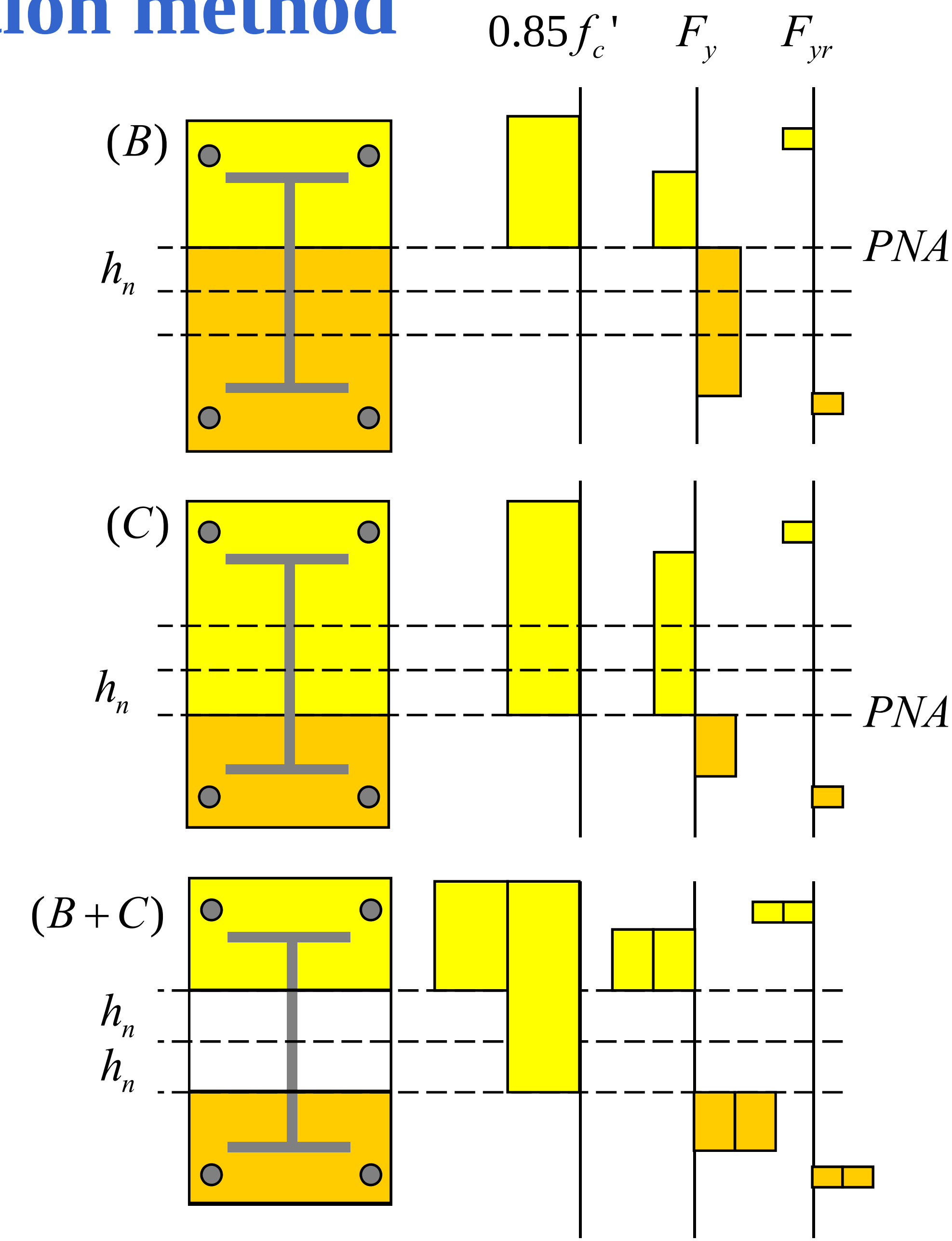


$$P_B = \sum P_i = 0$$

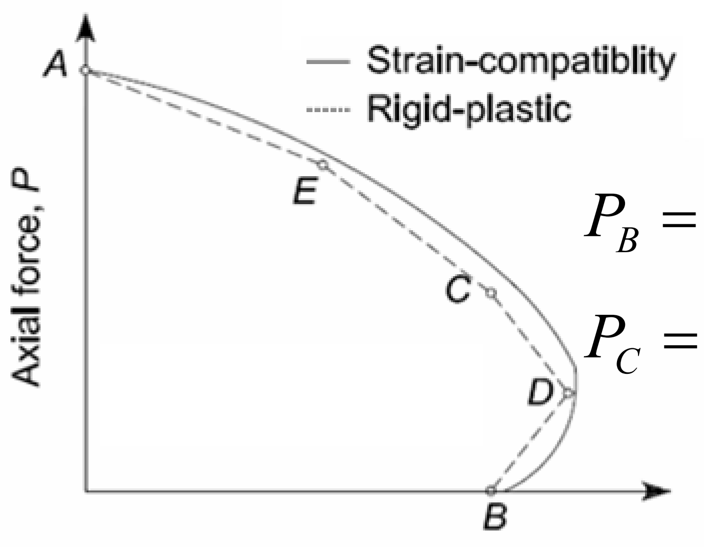
$$P_C = \sum P_i \neq 0$$

$$P_C + P_B = P_C$$

$$P_C = 0.85 f_c' A_c$$



Plastic stress distribution method



$$P_B = \sum P_i = 0$$

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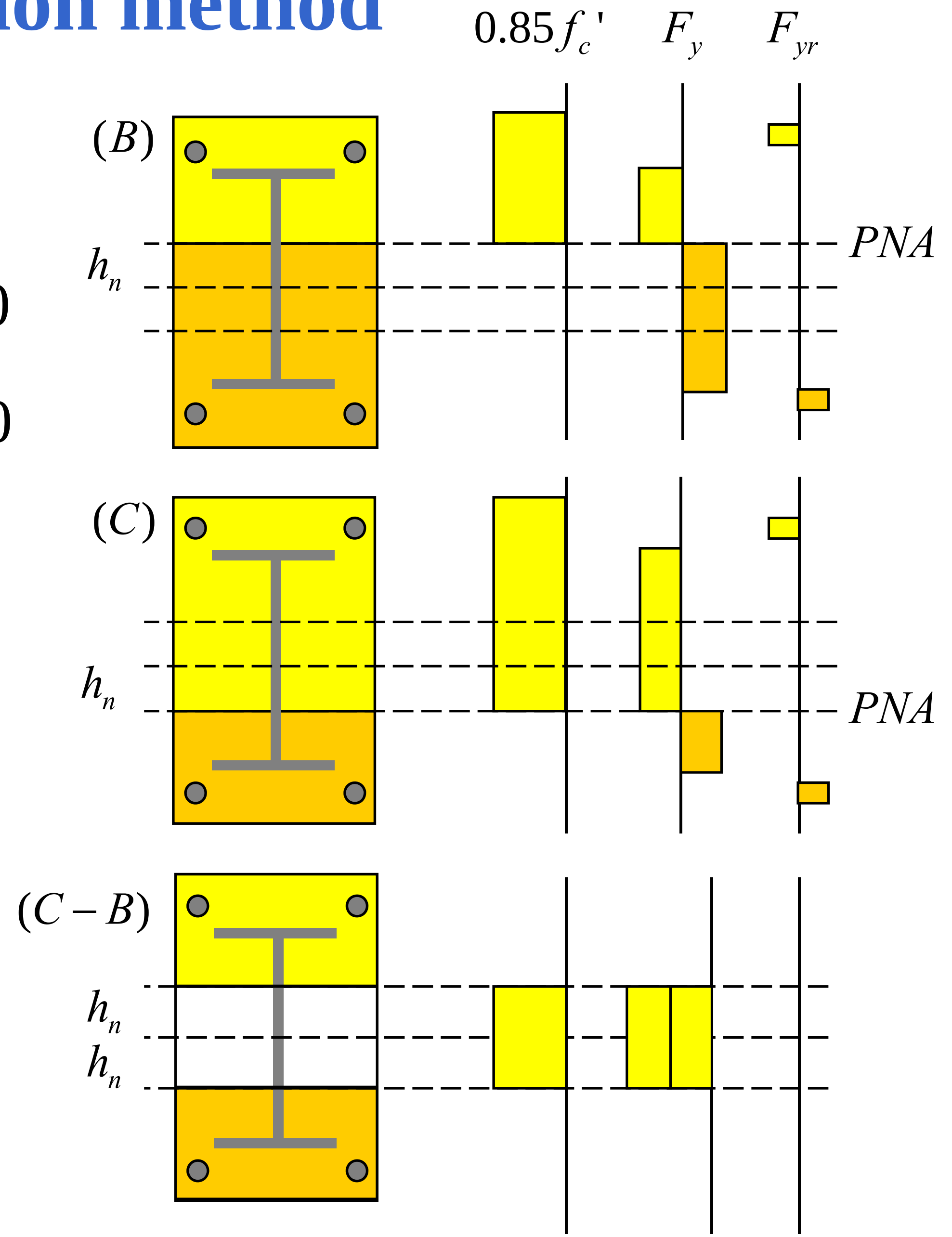
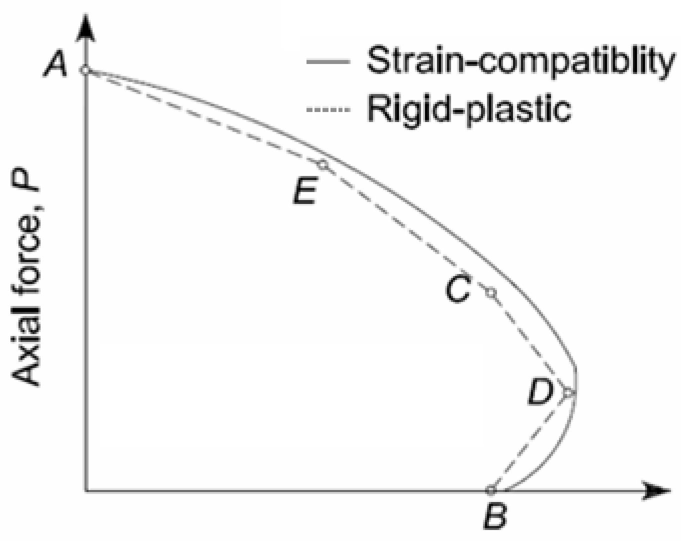


$$P_C - P_B = P_C$$

$$P_C = 2h_n\left(0.85 f_c' b + F_y\right)$$

$$h_n = \frac{0.85 f_c' A}{2\left(0.85 f_c' b + F_y\right)}$$

Plastic stress distribution method

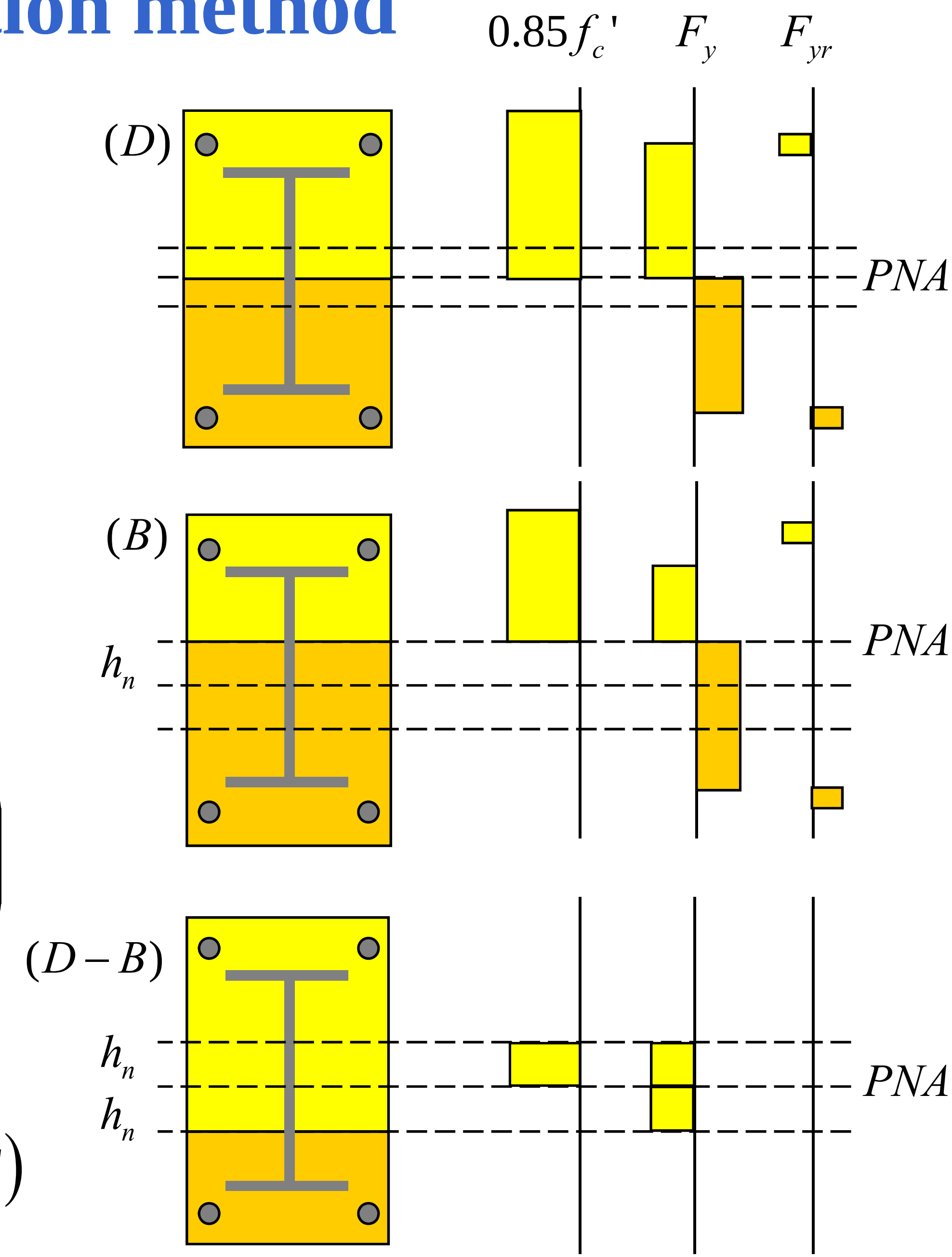


$$M_B = M_C = M_D - \Delta M_{D-B}$$

$$\Delta M_{D-B} = F_y\left(t_w h_n^{\ 2}\right) + 0.85 f_c'\left(\frac{b h_n^{\ 2}}{2}\right)$$

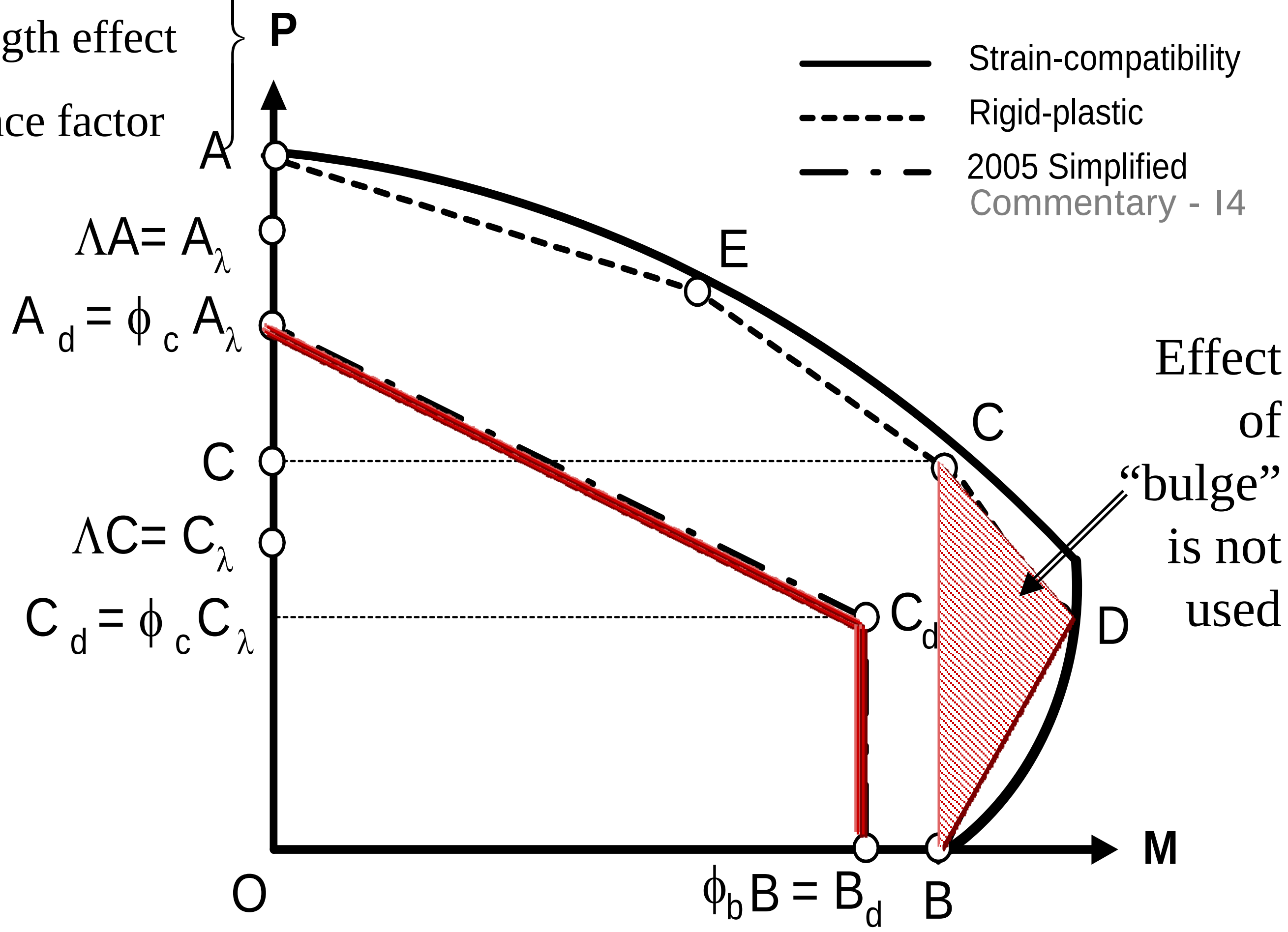
$$M_D = Z_s F_y + Z_r F_{yr} + \frac{Z_c}{2}\left(0.85 f_c'\right)$$

$$M_B = Z_{sB} F_y + Z_{rB} F_{yr} + \frac{Z_{cB}}{2}\left(0.85 f_c'\right)$$



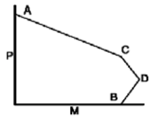
Composite Column Models

Calculate section strength
Reduce by length effect
Apply resistance factor

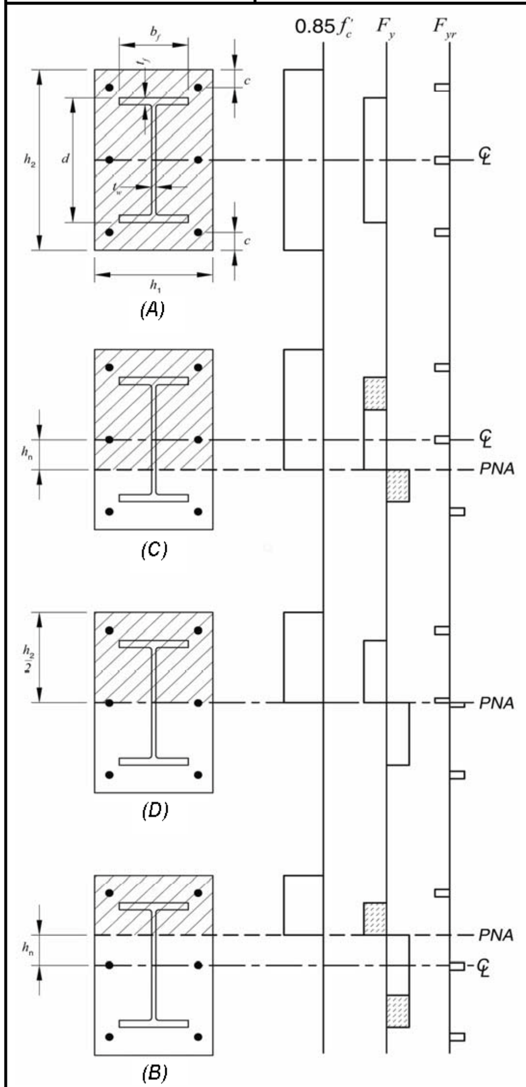


P-M Interaction anchor points *(AISC Examples, 2005)*

PLASTIC CAPACITIES FOR RECTANGULAR, ENCASED W-SHAPES BENT ABOUT THE X-X AXIS

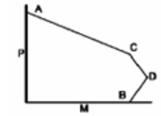


Section | Stress Distribution

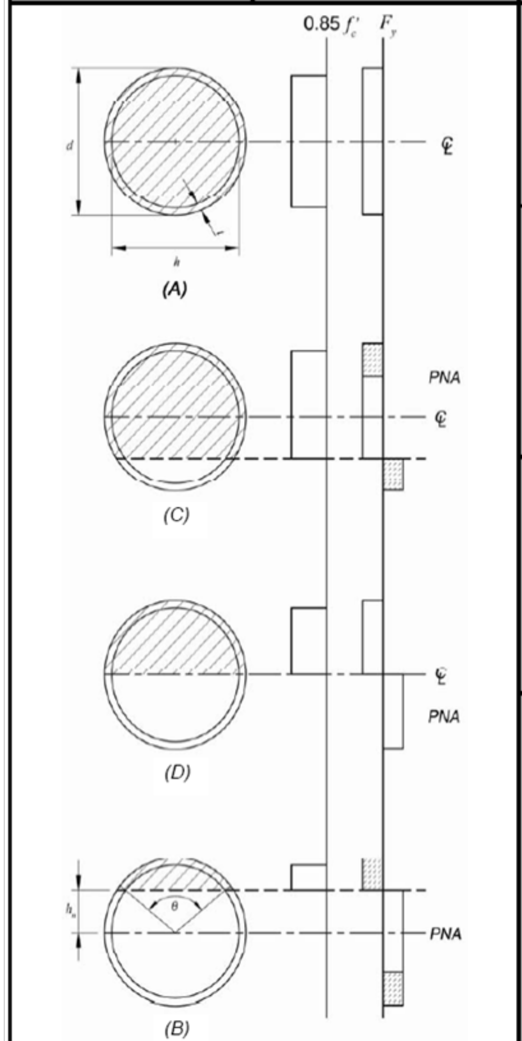


Point	Defining Equations
A	$P_A = A_s F_y + A_{sr} F_{yr} + 0.85 f'_c A_c$ $M_A = 0$ A_s = area of steel shape A_{sr} = area of all continuous reinforcing bars $A_c = h_1 h_2 - A_s - A_{sr}$
C	$P_C = 0.85 f'_c A_c$ $M_C = M_B$
D	$P_D = \frac{0.85 f'_c A_c}{2}$ $M_D = Z_s F_y + Z_r F_{yr} + \frac{1}{2} Z_c (0.85 f'_c)$ Z_s = full x-axis plastic section modulus of steel shape A_{srs} = area of continuous reinforcing bars at the centerline $Z_r = (A_{sr} - A_{srs})\left(\frac{h_2}{2} - c\right)$ $Z_c = \frac{h_1 h_2^2}{4} - Z_s - Z_r$
B	$P_B = 0$ $M_B = M_D - Z_{sn} F_y - \frac{1}{2} Z_{cn} (0.85 f'_c)$ $Z_{cn} = h_1 h_n^2 - Z_{sn}$ For h_n below the flange $\left(h_n \le \frac{d}{2} - t_f\right)$ $h_n = \frac{0.85 f'_c (A_c + A_{srs}) - 2 F_{yr} A_{srs}}{2[0.85 f'_c (h_1 - t_w) + 2 F_y t_w]}$ $Z_{sn} = t_w h_n^2$ For h_n within the flange $\left(\frac{d}{2} - t_f < h_n \le \frac{d}{2}\right)$ $h_n = \frac{0.85 f'_c (A_c + A_s - d b_f + A_{srs}) - 2 F_y (A_s - d b_f) - 2 F_{yr} A_{srs}}{2[0.85 f'_c (h_1 - b_f) + 2 F_y b_f]}$ $Z_{sn} = Z_s - b_f \left(\frac{d}{2} - h_n\right)\left(\frac{d}{2} + h_n\right)$ For h_n above the flange $\left(h_n > \frac{d}{2}\right)$ $h_n = \frac{0.85 f'_c (A_c + A_s + A_{srs}) - 2 F_y A_s - 2 F_{yr} A_{srs}}{2(0.85 f'_c h_1)}$ $Z_{sn} = Z_{sx}$ = full x-axis plastic section modulus of steel shape

PLASTIC CAPACITIES FOR COMPOSITE, FILLED ROUND HSS BENT ABOUT ANY AXIS



Section | Stress Distribution



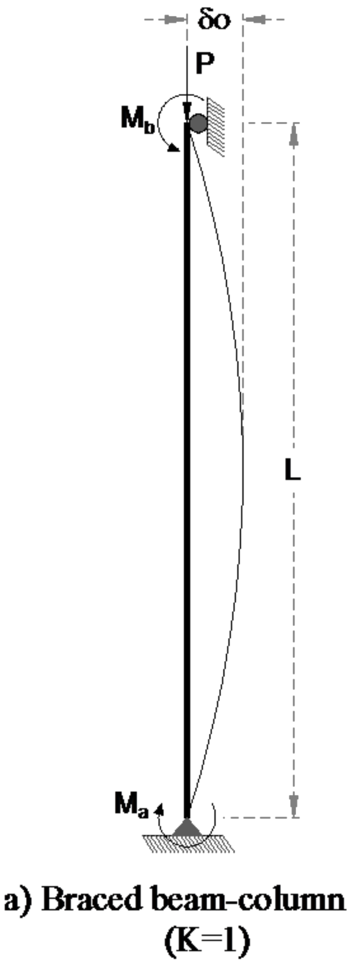
Point	Defining Equations
A	$P_A = A_s F_y + 0.85 f'_c A_c$ * $M_A = 0$ $A_s = \pi(dt - t^2)$ $A_c = \frac{\pi h^2}{4}$
C	$P_C = 0.85 f'_c A_c$ $M_C = M_B$
D	$P_D = \frac{0.85 f'_c A_c}{2}$ $M_D = Z_s F_y + \frac{1}{2} Z_c (0.85 f'_c)$ Z_s = plastic section modulus of steel shape $= \frac{d^3}{6} - Z_c$ $Z_c = \frac{h^3}{6}$
B	$P_B = 0$ $M_B = Z_{sB} F_y - \frac{1}{2} Z_{cB} (0.85 f'_c)$ $Z_{sB} = \frac{d^3 \sin^3(\theta/2)}{6} - Z_{cB}$ $Z_{cB} = \frac{h^3 \sin^3(\theta/2)}{6}$ $\theta = \frac{0.0260 K_c - 2 K_s}{0.0848 K_c} + \frac{\sqrt{(0.0260 K_c + 2 K_s)^2 + 0.857 K_c K_s f'_c A_c}}{0.0848 K_c}$ (in rads) $K_c = f'_c h^2$ $K_s = F_y \left(\frac{d - t}{2}\right) t$ ("thin" HSS wall assumed) $h_n = \frac{h}{2} \sin\left(\frac{\pi - \theta}{2}\right) \le \frac{h}{2}$ (not used, for reference only)

* $P_A = A_s F_y + 0.95 f'_c A_c$ is permitted to be used when the composite column is loaded only in axial compression.

Encased Composite Beam Columns Method 3 (ACI Strain comp)

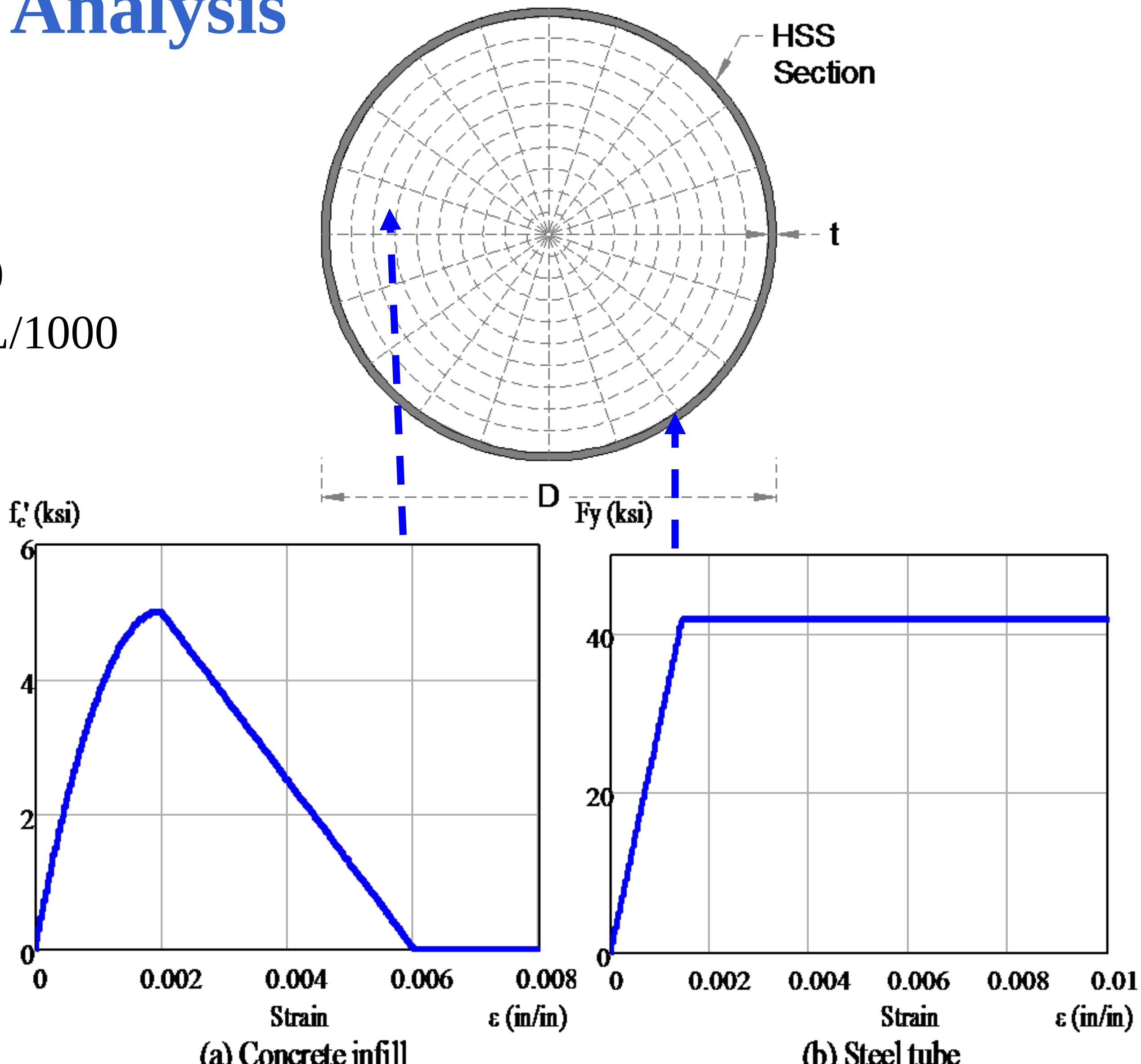
- *Strain compatibility approach*
- *Linear strain diagram with 0.003*
- *Same as ACI Beam Column design*
- *Use AISC φ factors (φ_c=0.85, φ_b=0.9)*
- *Can convert WF to equivalent bars*
- *Yields smaller values than Method 2*

Fiber Element Analysis



$\delta_o = 0$

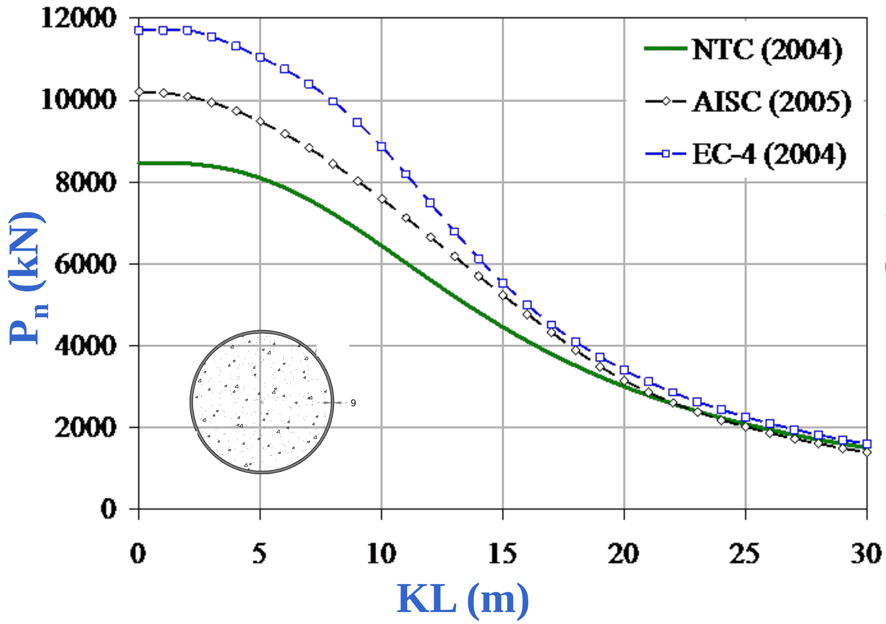
$\delta_o = L/1000$

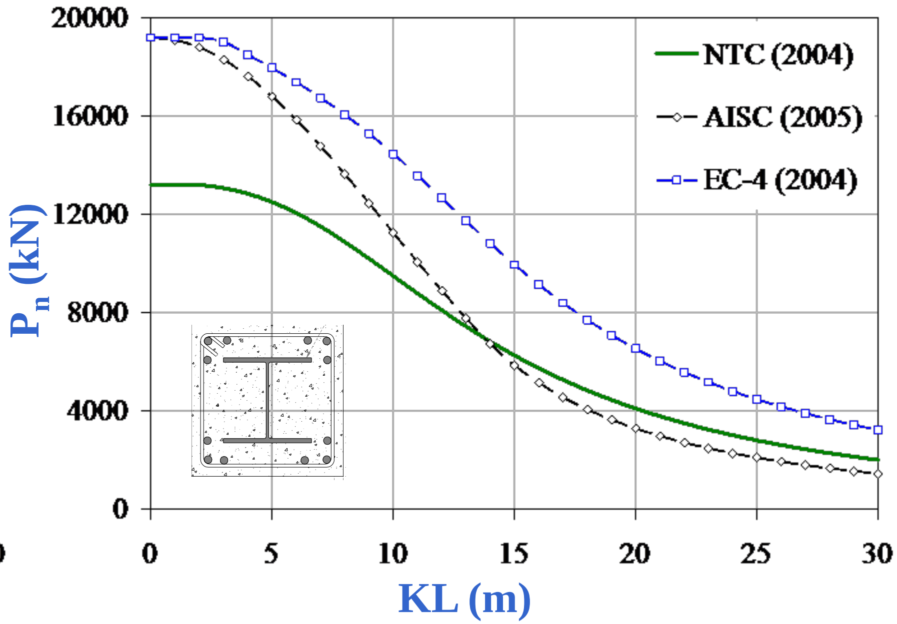


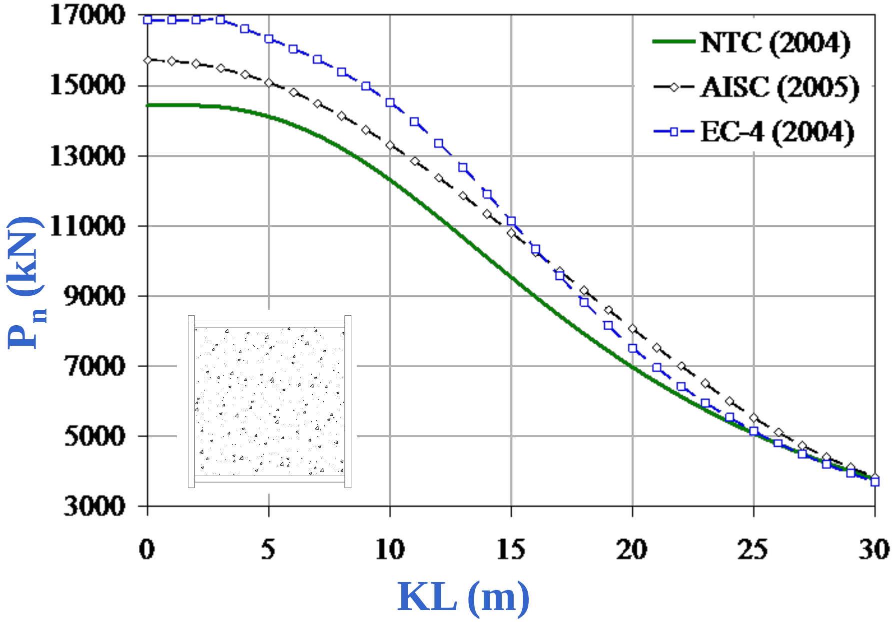
Kent-Scott-Park model

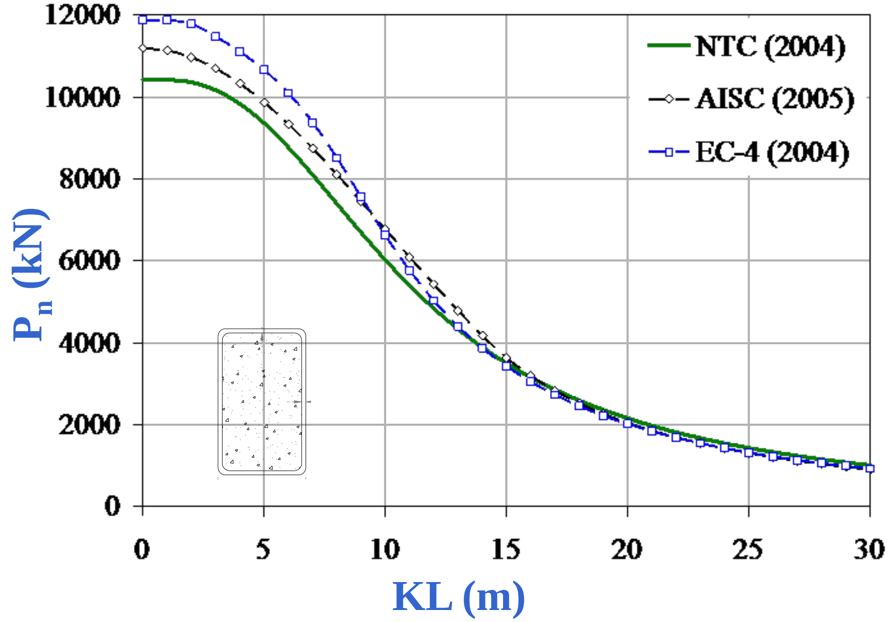
Elastic-perfectly-plastic model

Pure-compression (flexural buckling limit state)









Composite Sections (short columns)

$f_c' = 5$ ksi

34.5 MPa

$E_s = 29000$ ksi

200 GPa

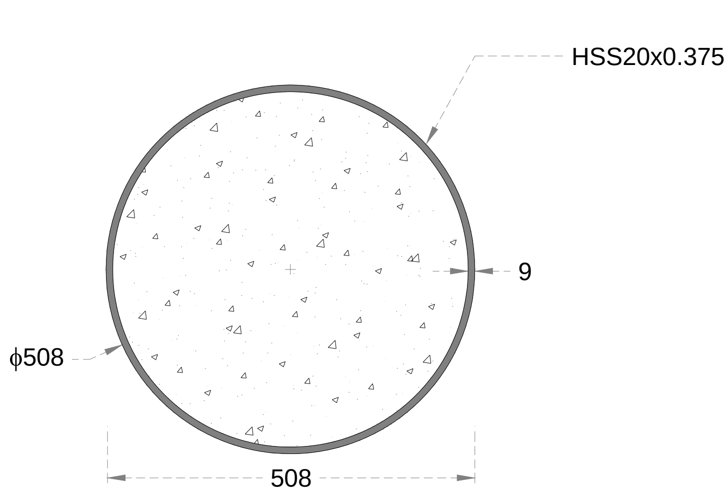
E_c = From Code

NTC (2004)

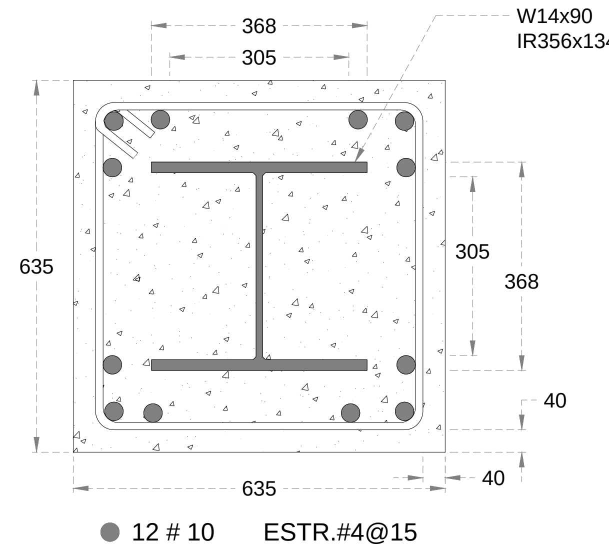
AISC (2005)

EC-4 (2004)

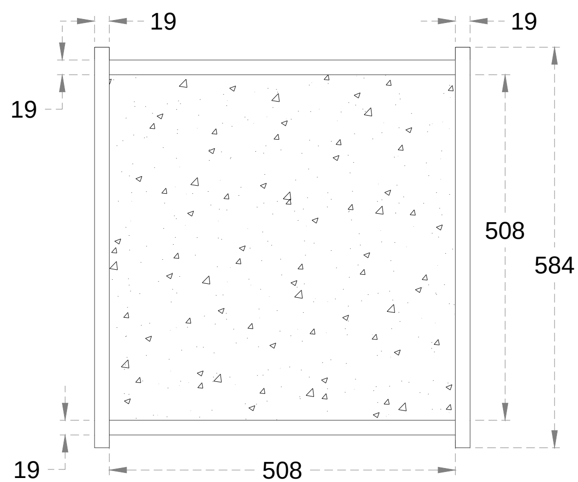
AIJ (2004)



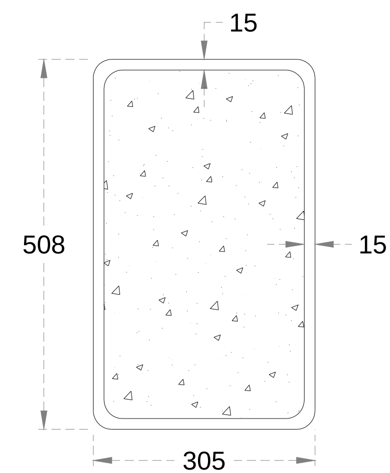
a) CCFT20x0.375



b) 25x25SRC14x90



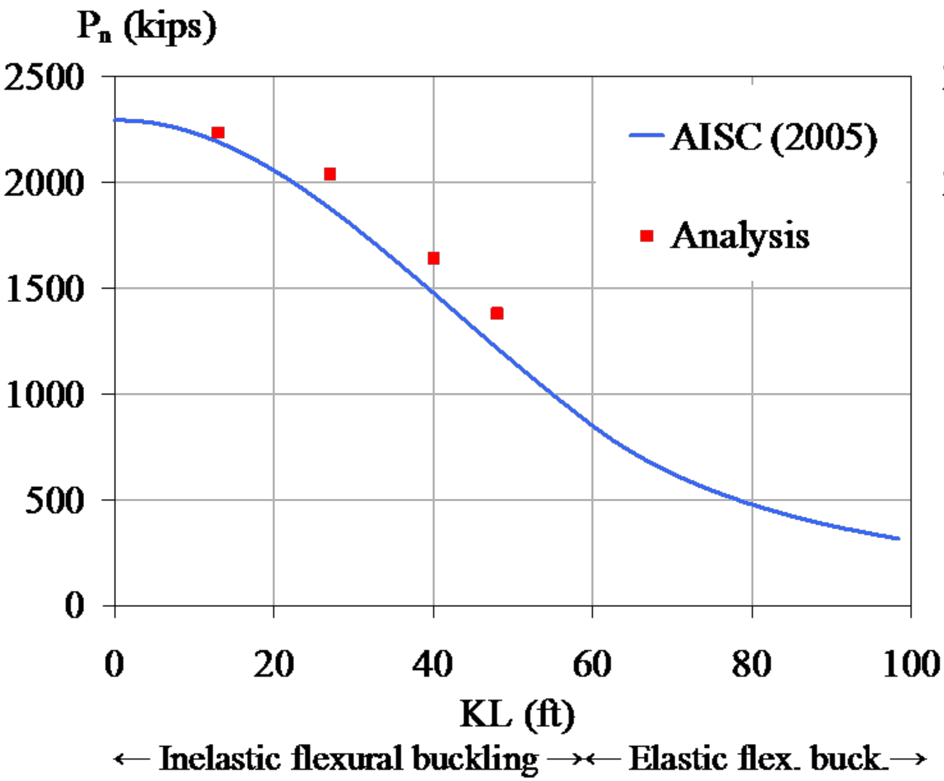
c) RCFT20x20x3/4



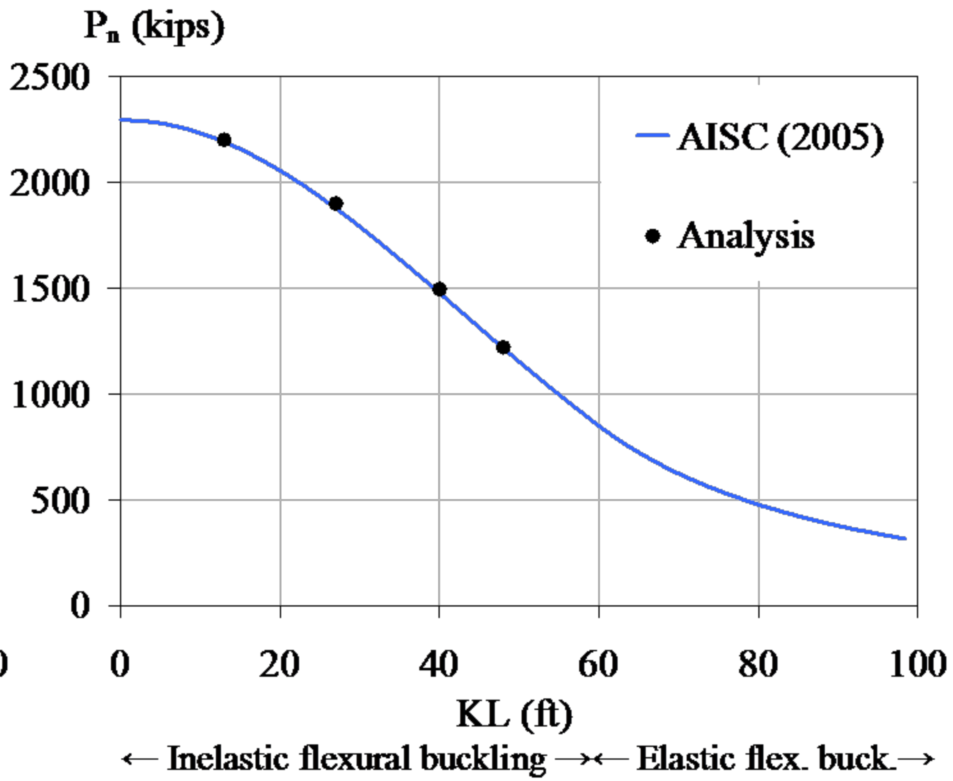
d) RCFT20x12x5/8

Pure-compression-strength

AISC curve vs. **fiber analysis** results

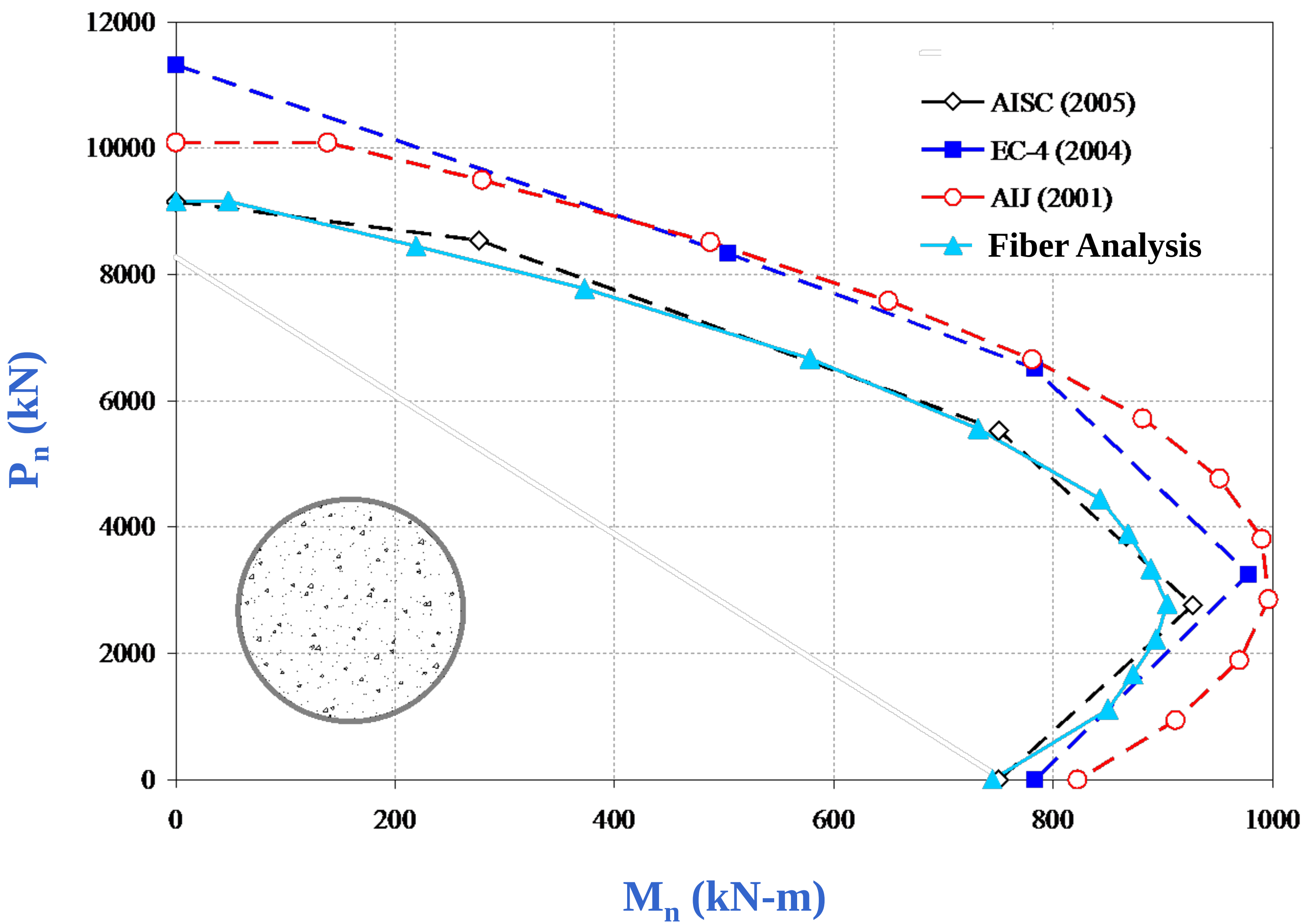


a) Analysis without initial imperfection

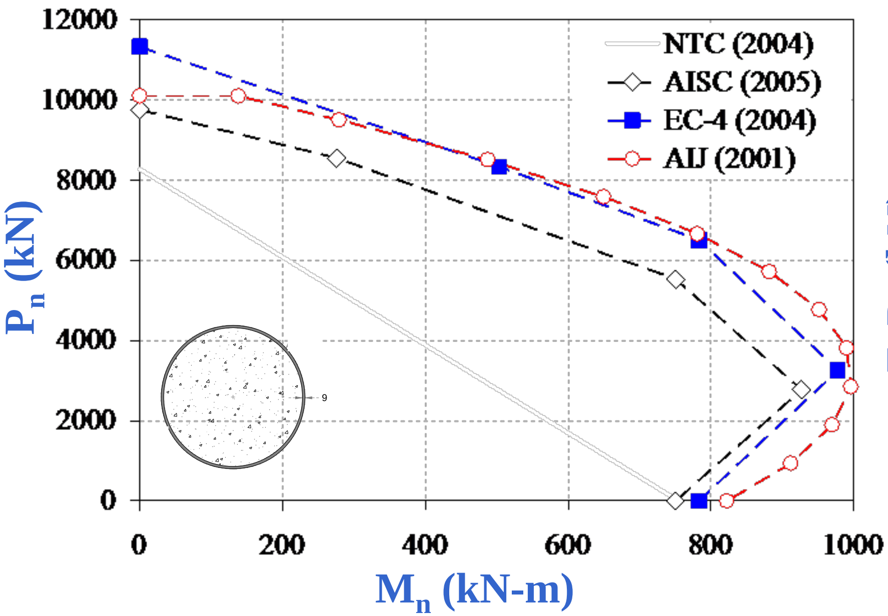


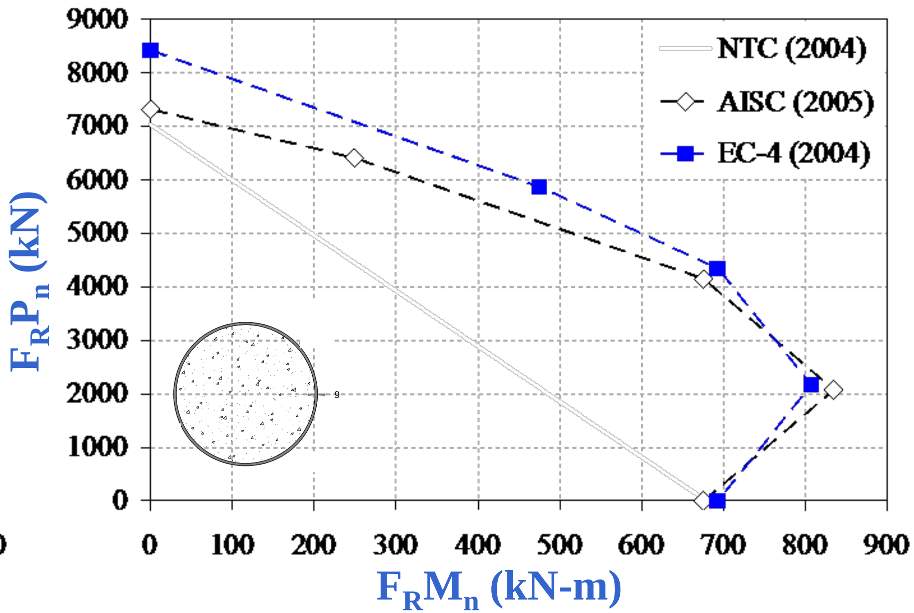
b) Analysis with initial imperfection

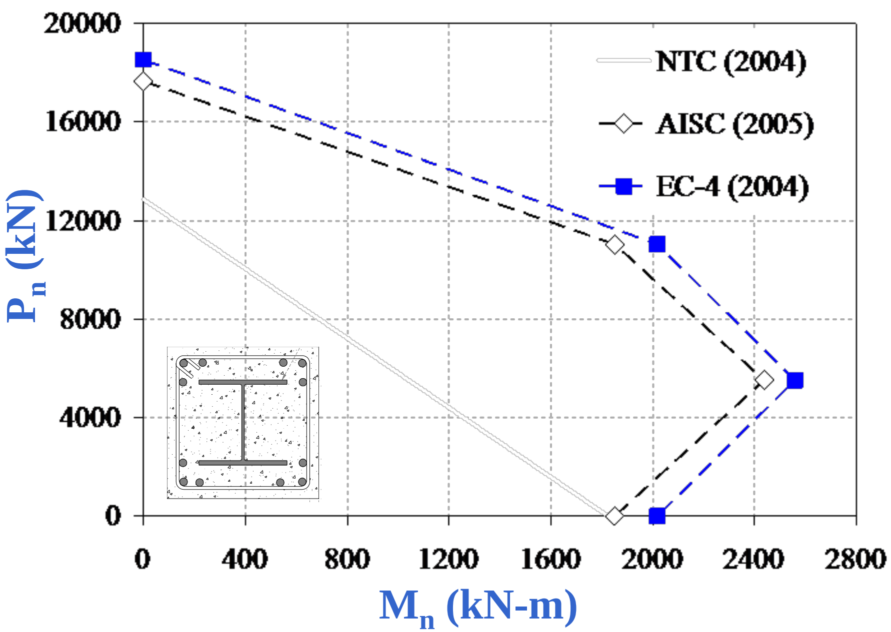
P-M Interaction Diagram for CCFT20x0.375

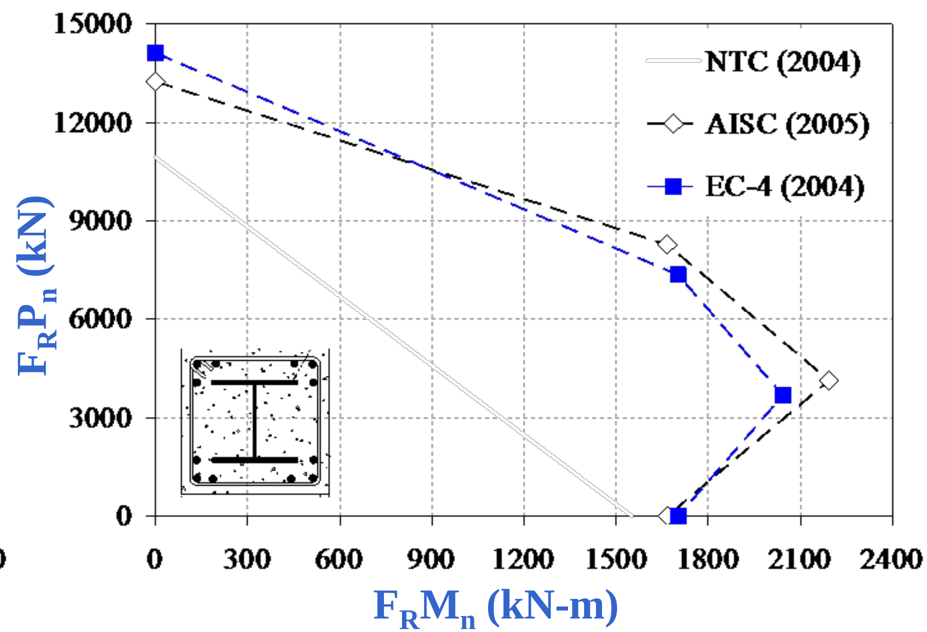


P-M Interaction Diagrams

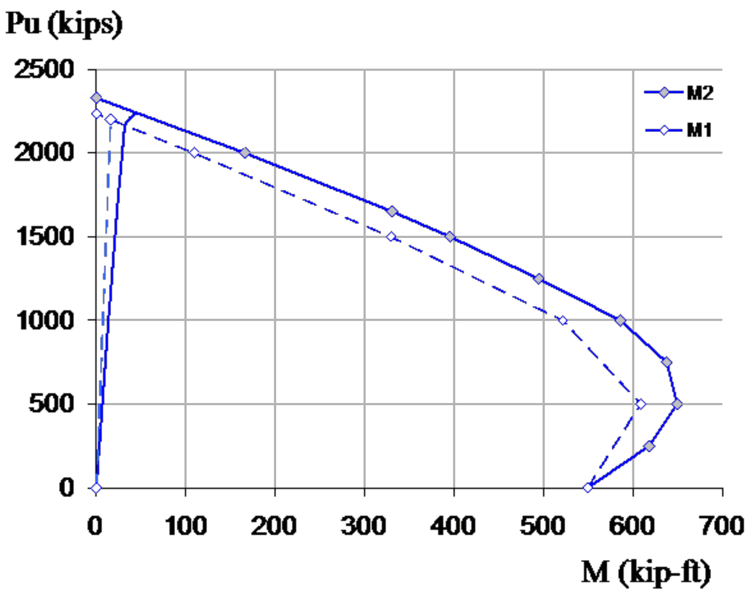




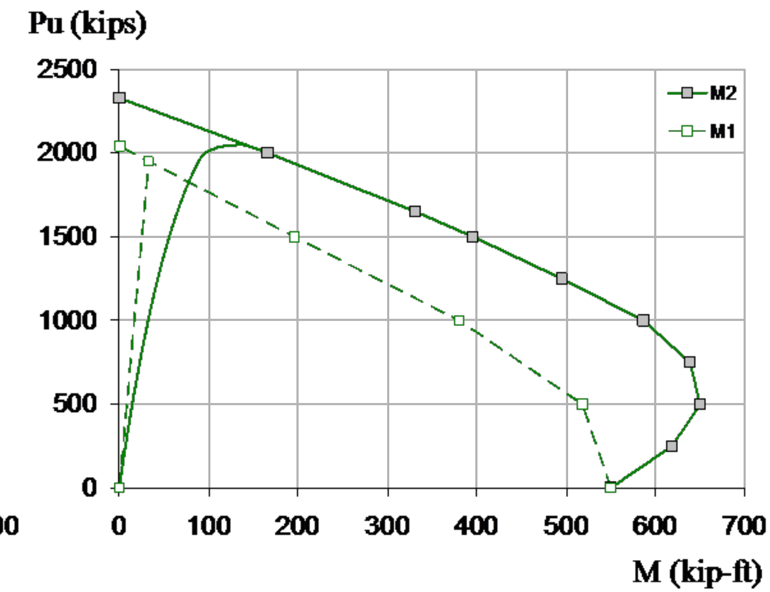




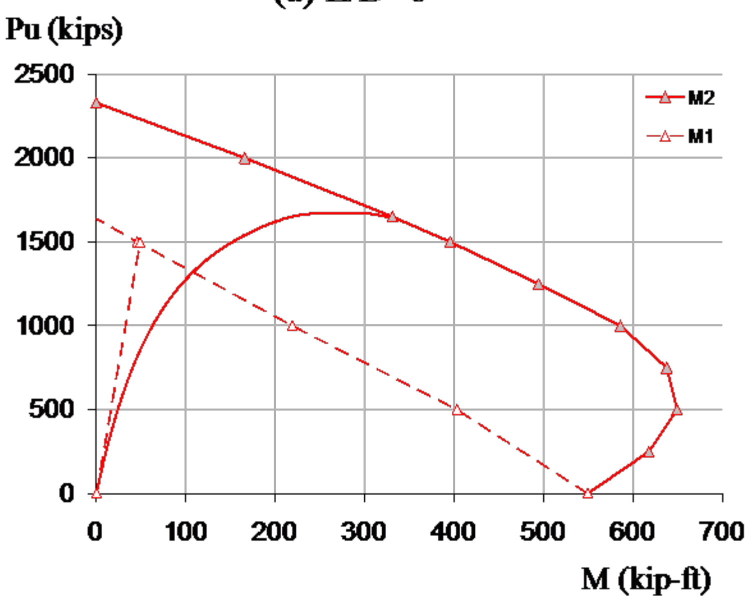
M_1 and M_2 curves



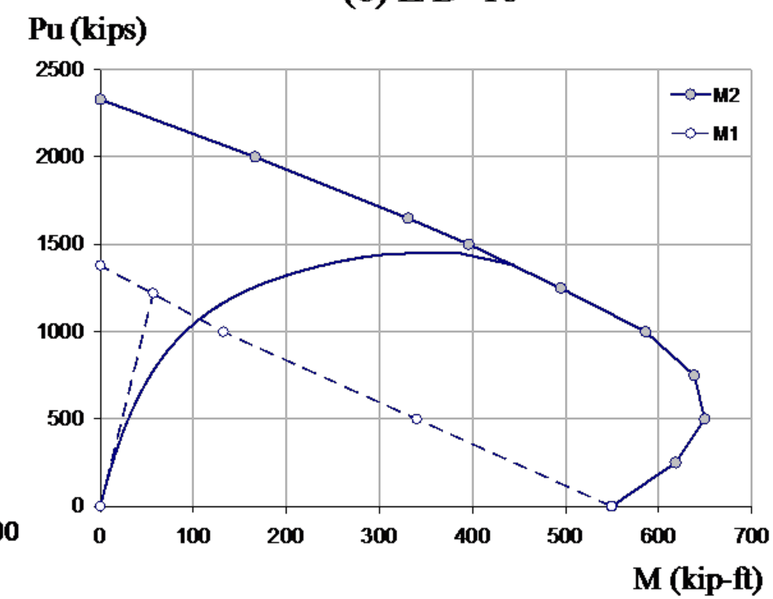
(a) L/D=8



(b) L/D=16

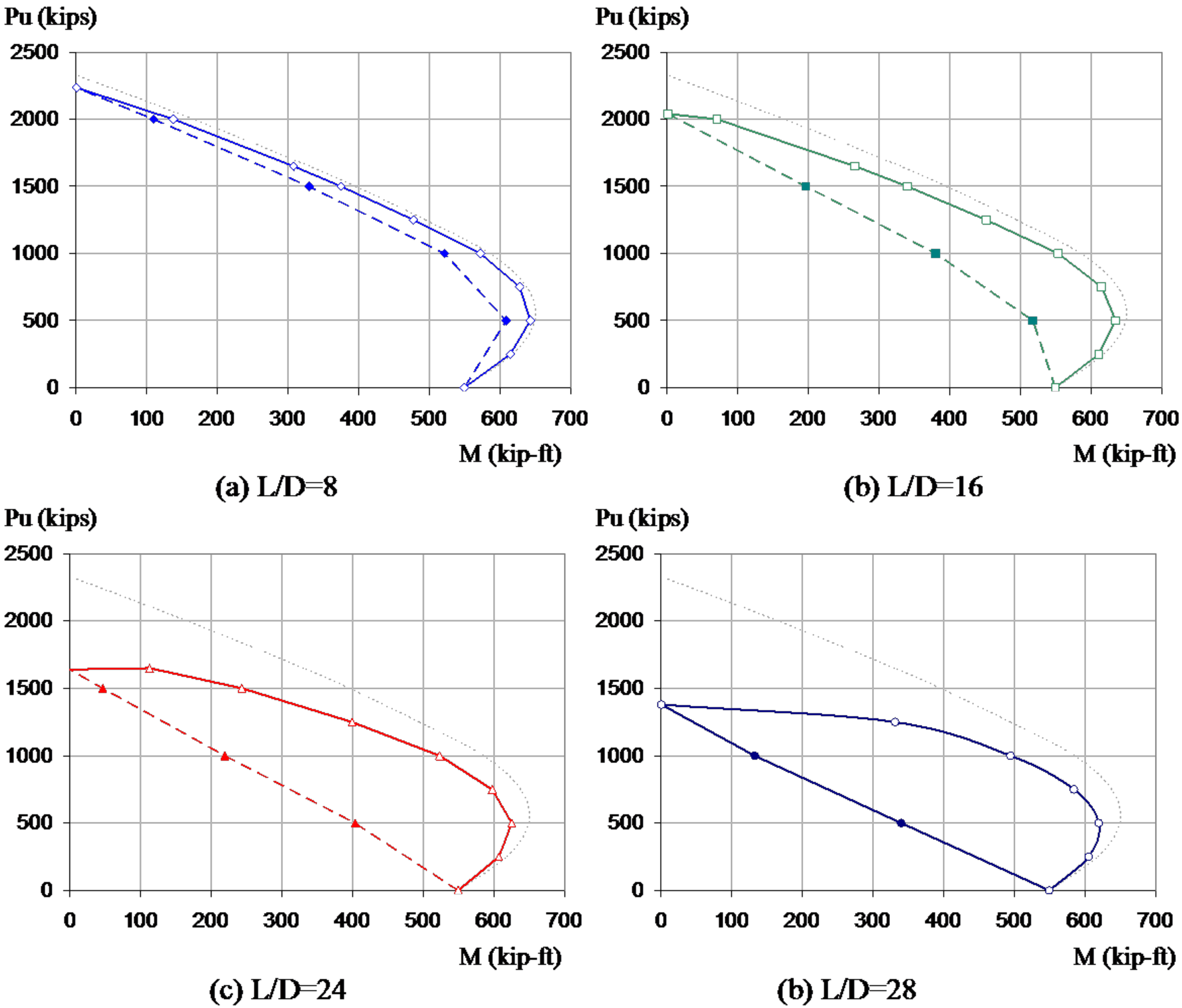


(c) L/D=24



(b) L/D=28

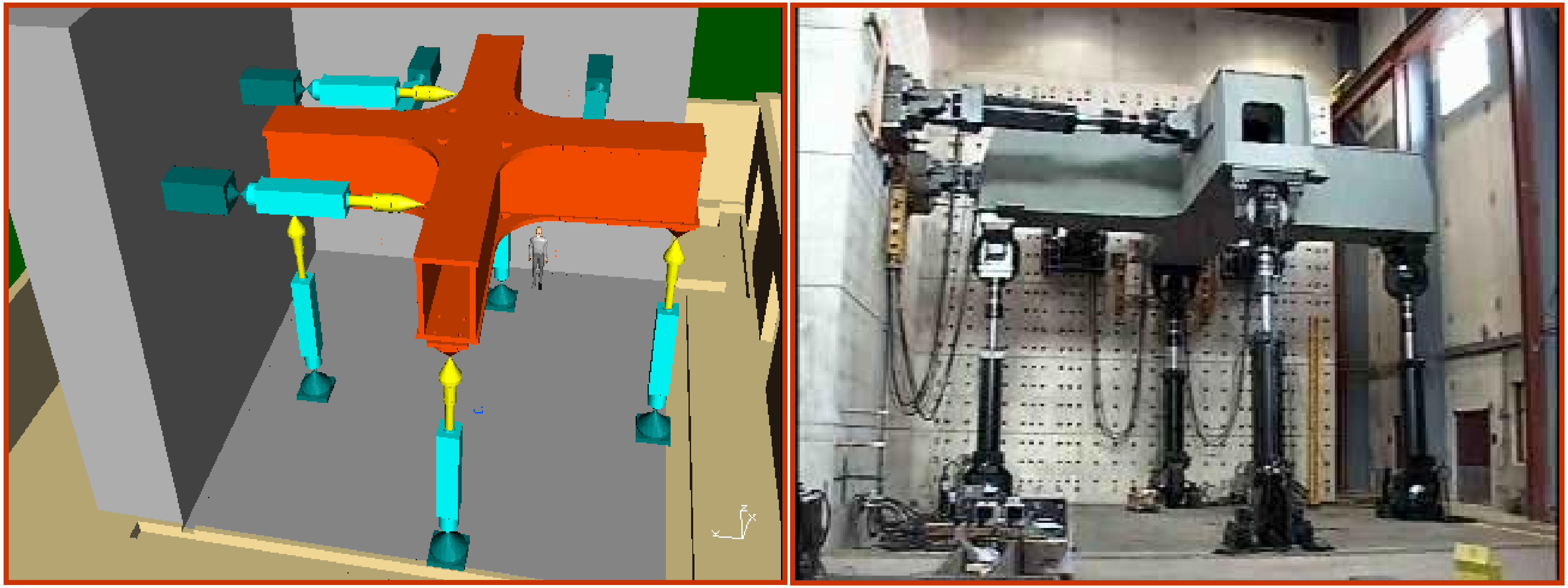
Net M_1 and M_2 curves



Experimental Tests

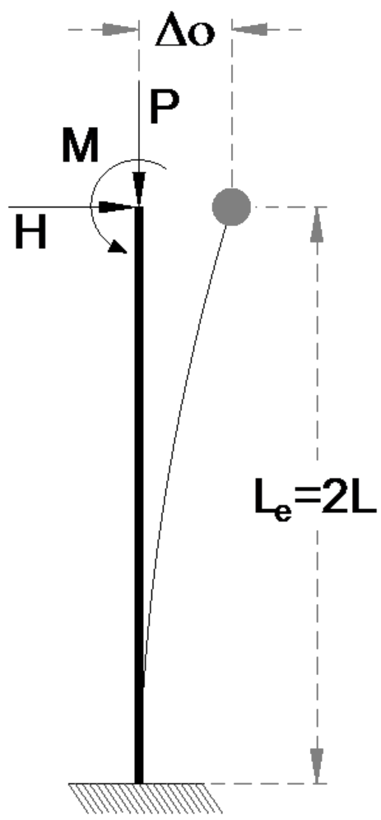
NEES Project: Georgia Tech, U. Illinois, U. Minnesota

- 20 full-scale slender composite beam-columns (8 SRC, 4 CCFT, 4RCFT, 4SCFT)
- Data will fill gaps in U.S. database

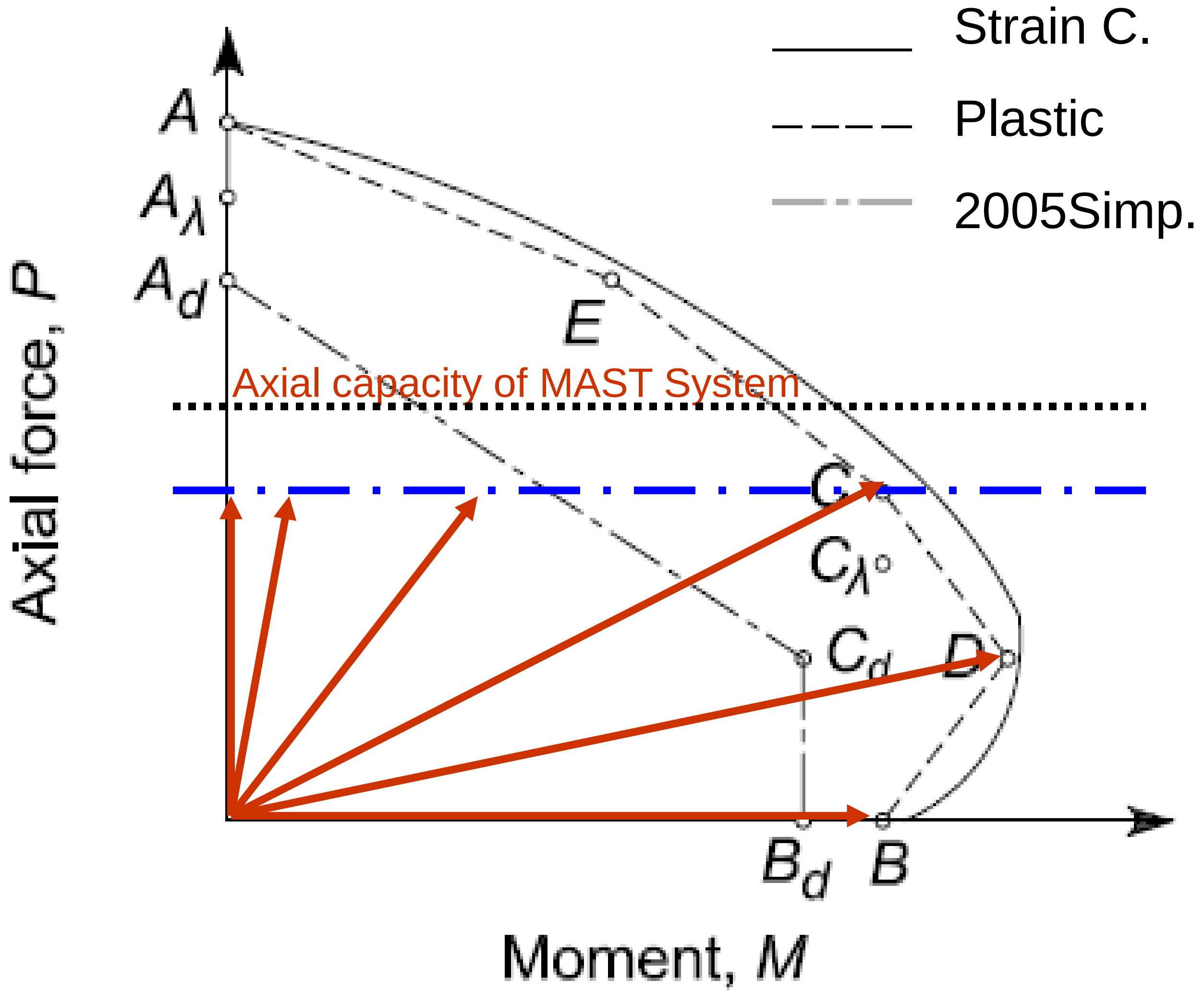


Multi-Axial Sub-assemblage Testing System (MAST-UMN)

Preliminary Test Series



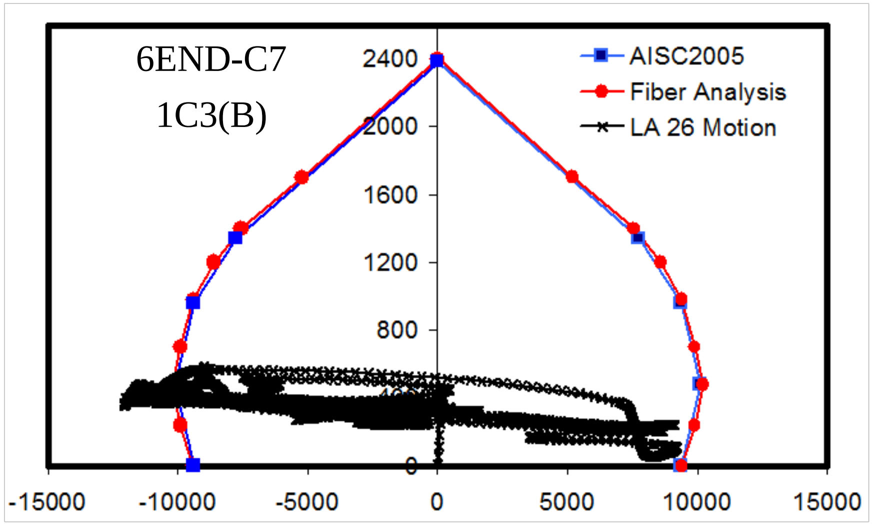
BC's Configuration

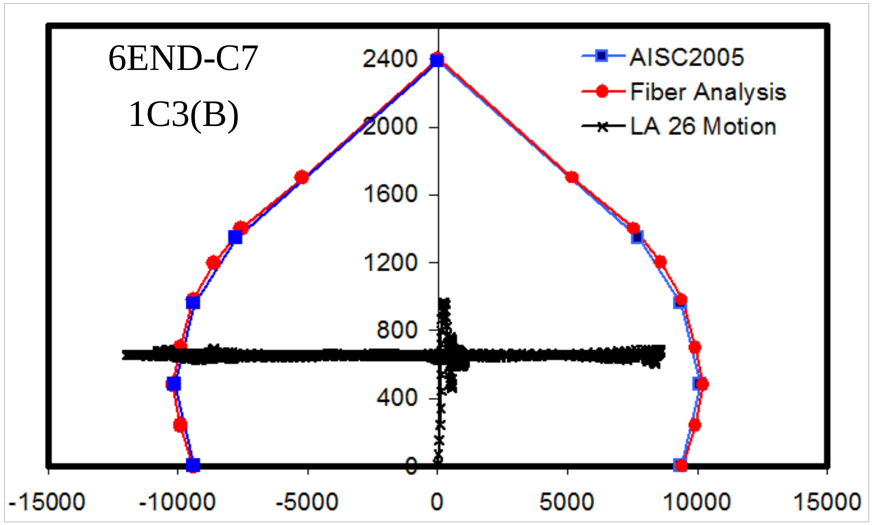


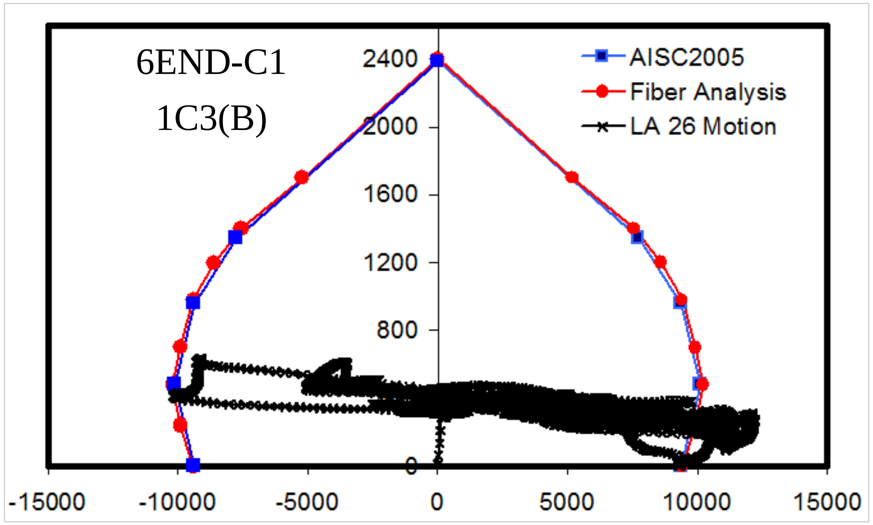
Actual Load Paths

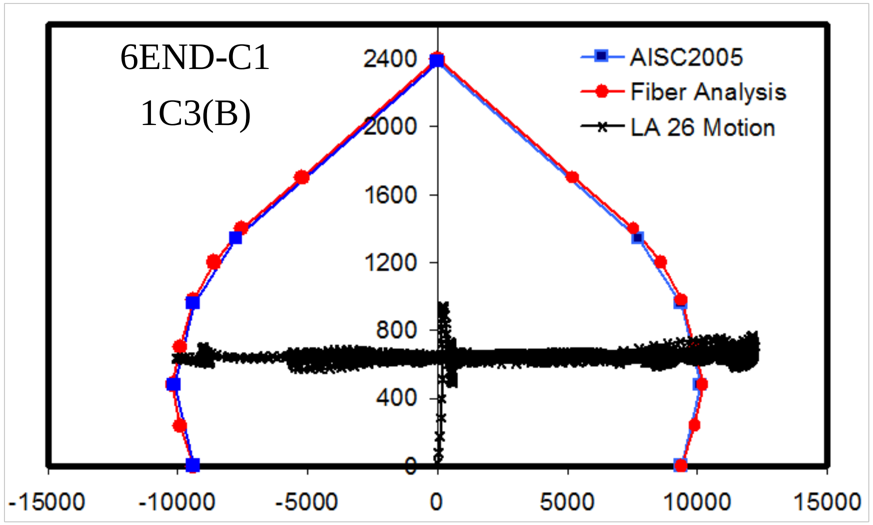
Exterior Columns

Interior Columns

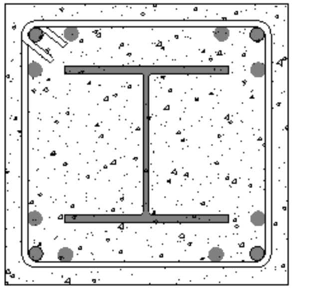






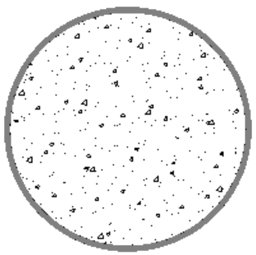


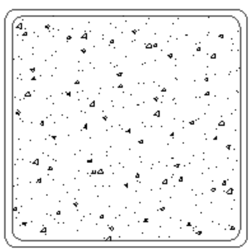
Preliminary SRC Test Series

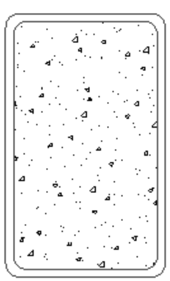


Label	RC Section b (in)	d (in)	Steel Section	Axis	f'_c (ksi)	F_y (ksi)	Long. Reinf.	Trans. Reinf.	ρ (%)	L (ft)	λ $\sqrt{P_e/P_o}$	L/r
SRC1	24	24	W10x49	Strong	5	50	8#8	#4@12	2.3	14	1.00	23.3
SRC2	24	24	W10x49	Strong	5	50	8#8	#4@12	2.3	20	2.00	33.3
SRC3	16	16	W10x100	Strong	5	50	8#6	#4@12	10.3	14	1.25	35.0
SRC4	16	16	W10x100	Strong	5	50	8#6	#4@12	10.3	20	2.50	50.0
SRC5	16	16	W10x100	Weak	5	50	8#6	#4@6	10.3	14	1.25	35.0
SRC6	16	16	W10x100	Biaxial	5	50	8#6	#4@12	10.3	20	2.50	50.0
SRC7	16	16	W10x100	Strong	8	65	8#6	#4@12	10.3	20	2.50	50.0
SRC8	16	16	W10x100	Strong	12	65	8#6	#4@12	10.3	20	2.50	50.0

Preliminary CFT Test Series



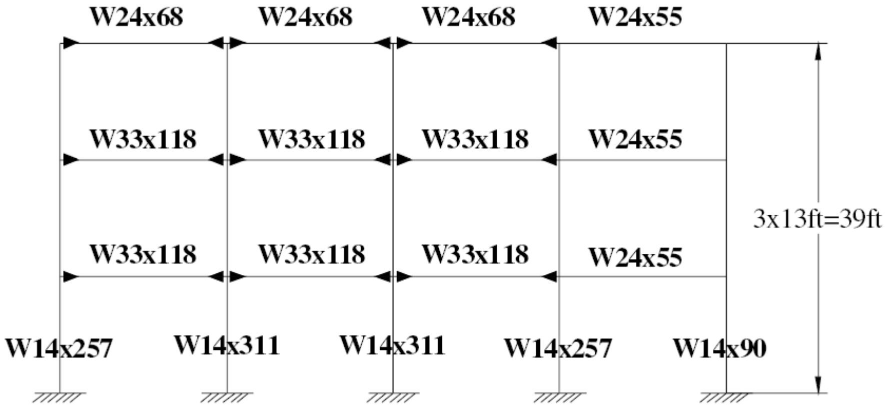




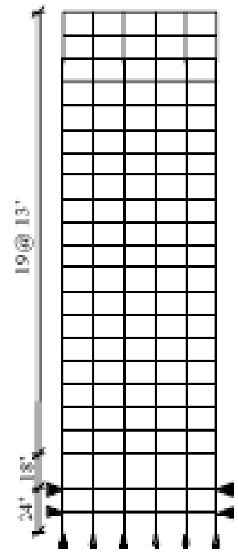
Label	HSS Section	b/t	f'_c (ksi)	F_y (ksi)	L (ft)	P_o (kip)	L/b	L/r
CCFT1	10x0.125	80	5	42	10	472	12	48.00
CCFT2	10x0.125	80	5	42	20	472	24	96.00
CCFT3	10x0.125	80	12	42	10	1040	12	48.00
CCFT4	10x0.125	80	12	42	20	1040	24	96.00
SCFT1	12x12x0.25	48	5	50	10	1030	10	33.33
SCFT2	12x12x0.25	48	5	50	20	1030	20	66.67
SCFT3	12x12x0.25	48	12	50	10	1510	10	33.33
SCFT4	12x12x0.25	48	12	50	20	1510	20	66.67
RCFT1	14x6x1/4	56	5	50	10	900	20	66.67
RCFT2	14x6x1/4	56	5	50	20	900	40	133.33
RCFT3	14x6x1/4	56	12	50	10	1480	20	66.67
RCFT4	14x6x1/4	56	12	50	20	1480	40	133.33

Inelastic Static & Dynamic Analysis

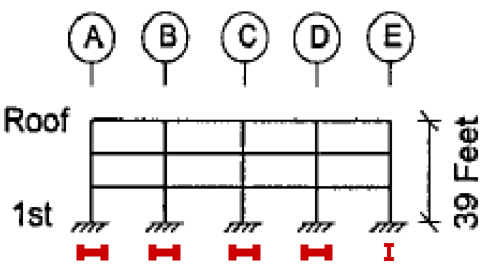
LA 3 & 20 Story SAC frames (FEMA 355C, 2000)

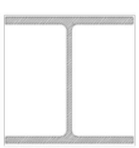


ELEVATION A-A (LA BUILDING)



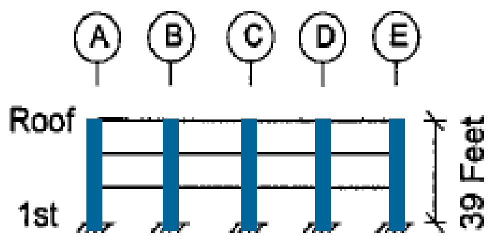
Steel Frame System

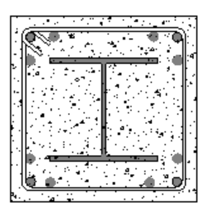




W14x311
W14x257
W14x90

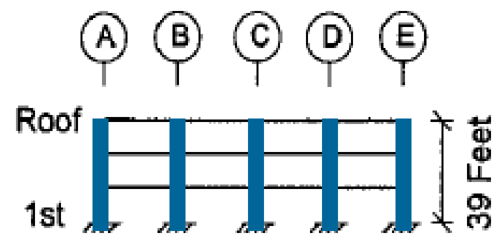
SRC Frame System

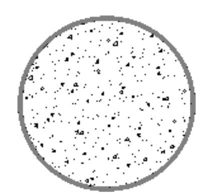




26x26in
12#10 (2.6%)
#4@4in
W14X90

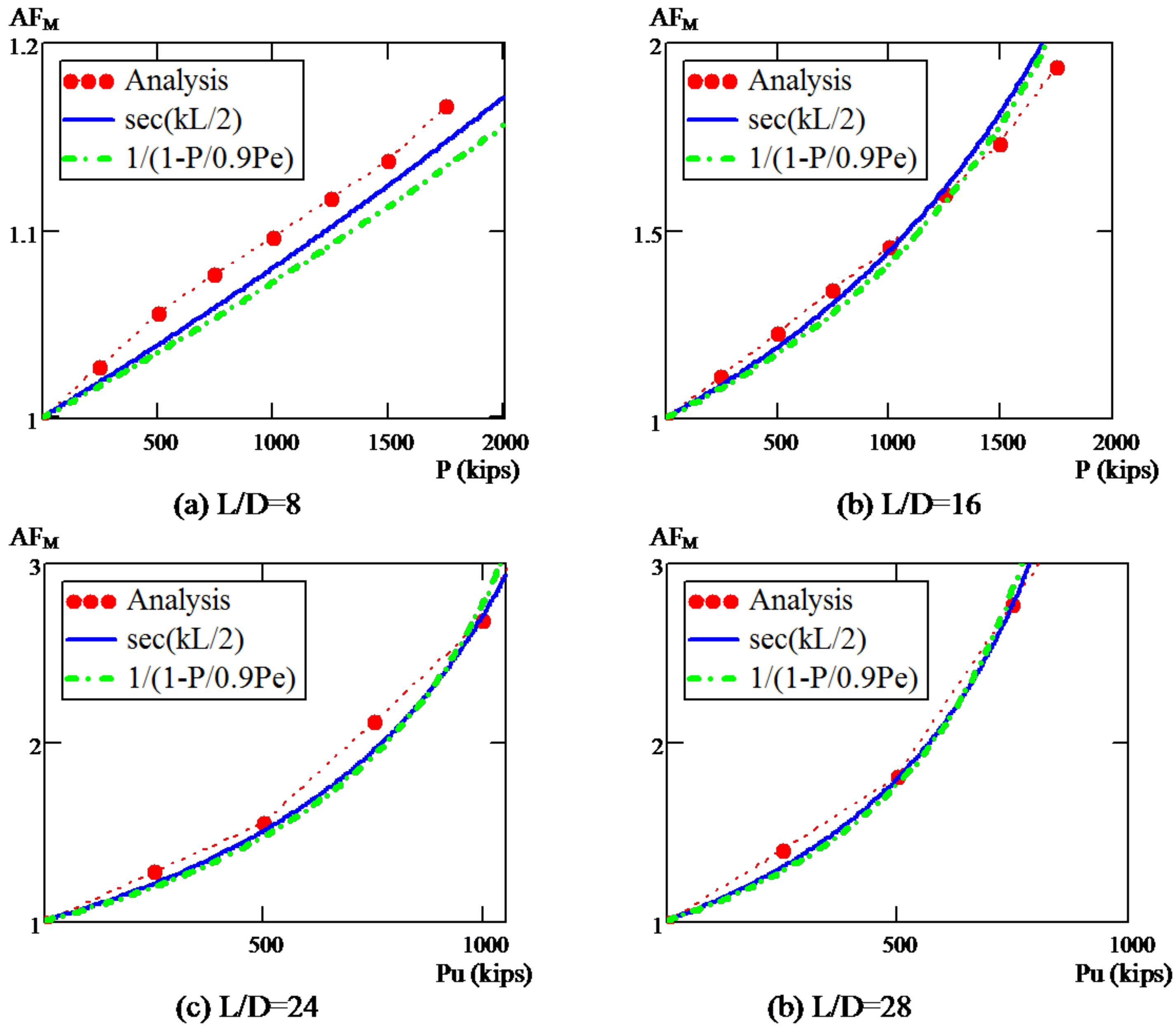
CRC Frame System



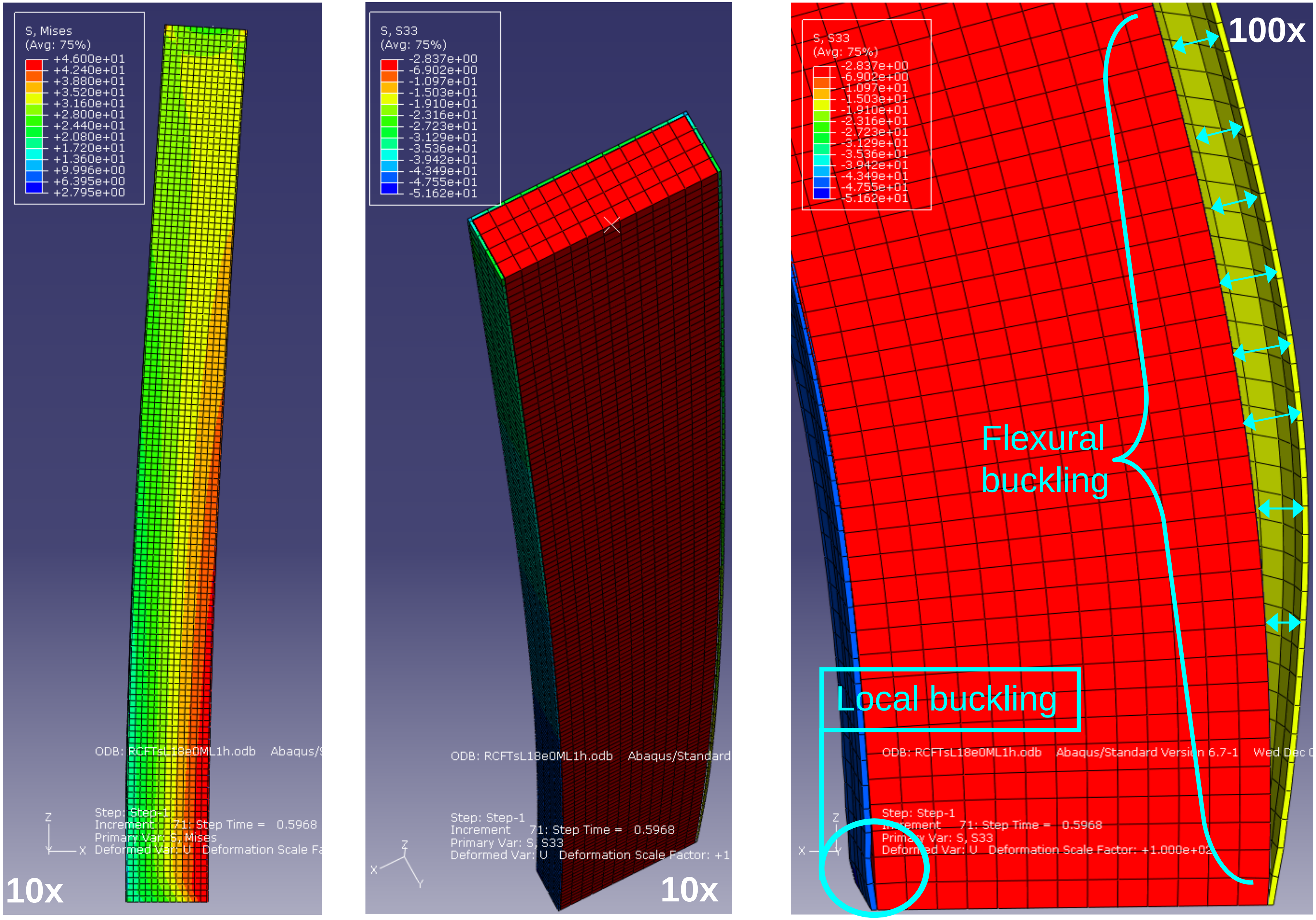


HSS-20x0.375
$f_c' = 5ksi$
$F_y = 42\ ksi$

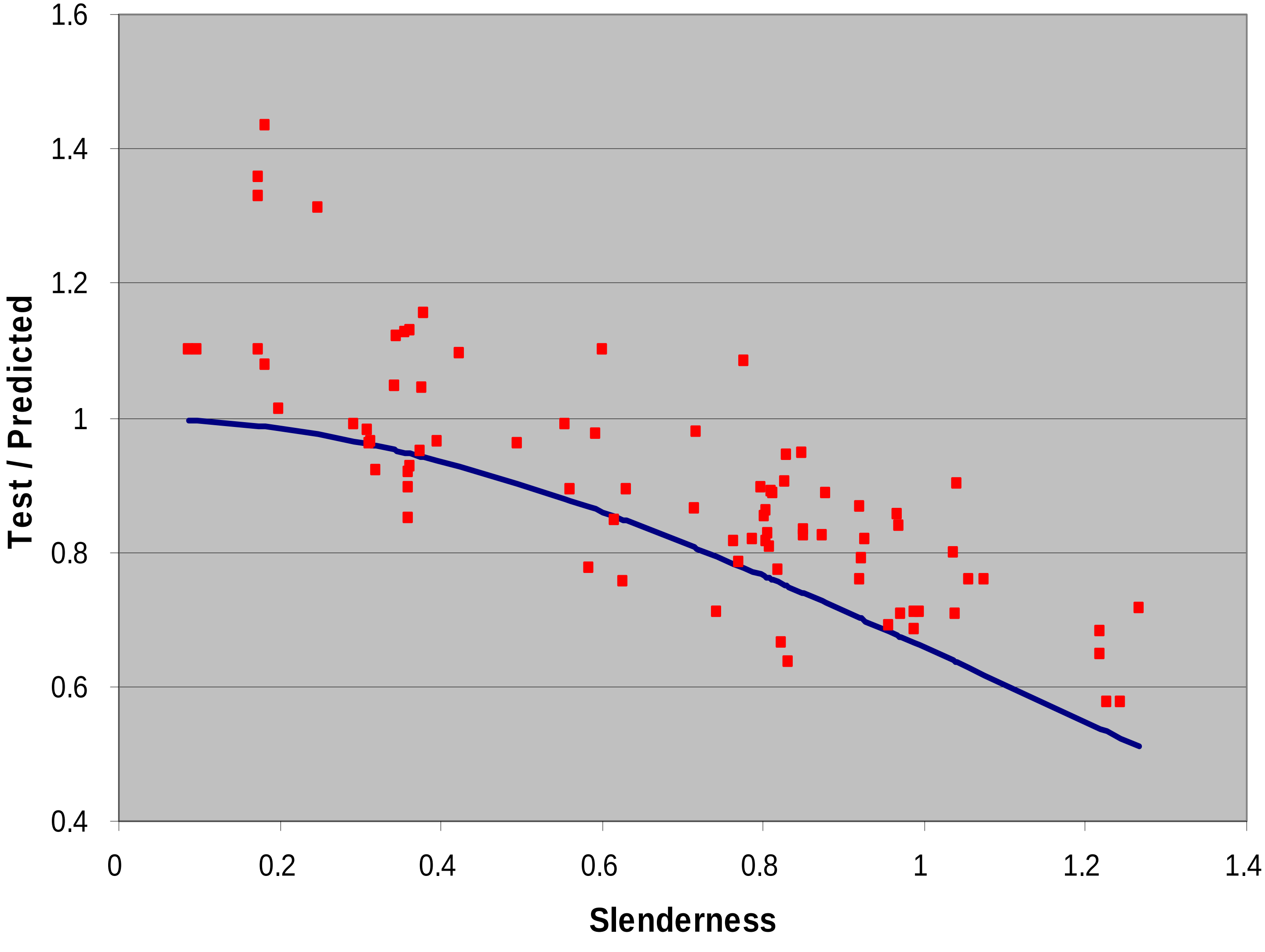
AF_M based on reduced $EI^* = 0.8EI_{eff}$



Beam-column FEA (scaled displacements)



Encased Columns – Improve Reliability

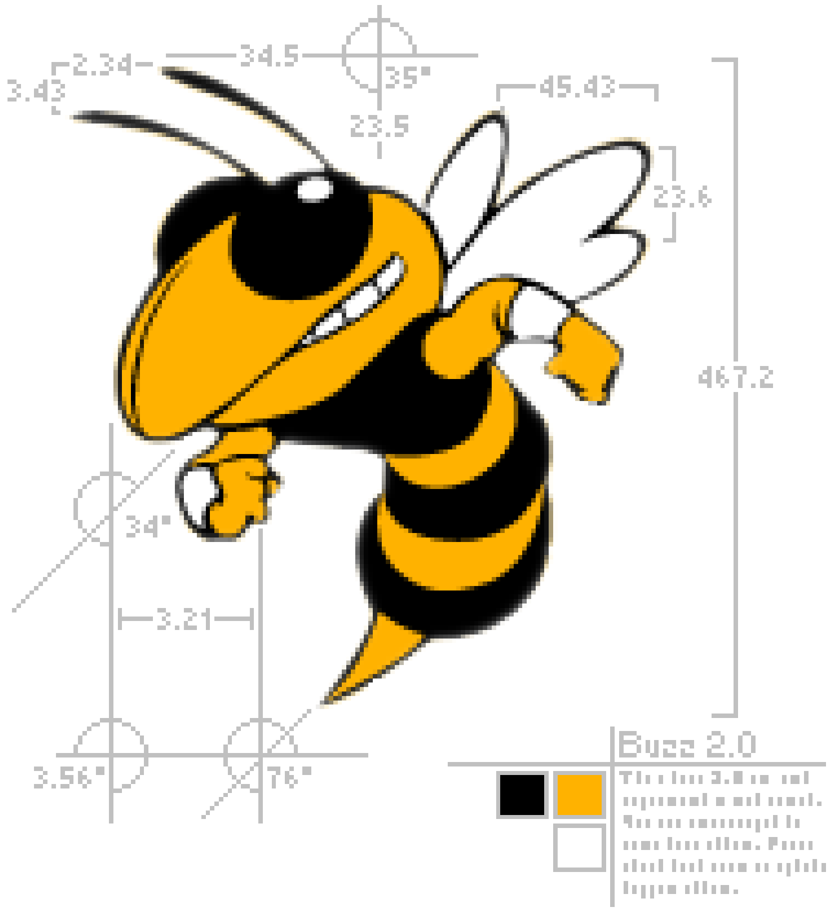


New Composite Column Procedures

- Based on ultimate plastic capacity – simple plastic or strain compatibility (mechanistic approach / EC4)
- Provide transition from a RC to a composite column
- Maintain current length effects approach– adjust EI values
- Improve reliability (from $\beta = 2.4$ to 2.7)
- Relax local buckling - b/t < 56 (+20%); D/t < 121 (+50%)
- Relax concrete material limits = 70 MPa
- Relax steel material limits = 520 Mpa)
- Provide better force transfer guidelines

More Information

- EJ has two papers by Leon, Kim and Hajjar (4th Quarter, 2007) and Leon and Hajjar (1st Quarter, 2008) with all the details of the cahnges to the 2005 Specification


2.34
34.5
3.43
35°
23.5
45.43
23.6
467.2
34°
3.21
3.56°
76°
Buzz 2.0