



**First South East European
Regional CIGRÉ Conference**

SEERC

Portoroz, Slovenia, 7—8 June 2016

Steel and Concrete Composite Polygonal Towers for Transmission Lines

4-11

C. TORT

Outline

- Introduction about Miteng/Mitas
- Composite Columns
- Design Methods of Composite Columns
- Cyclic Response
- Shear Connection
- Conclusion

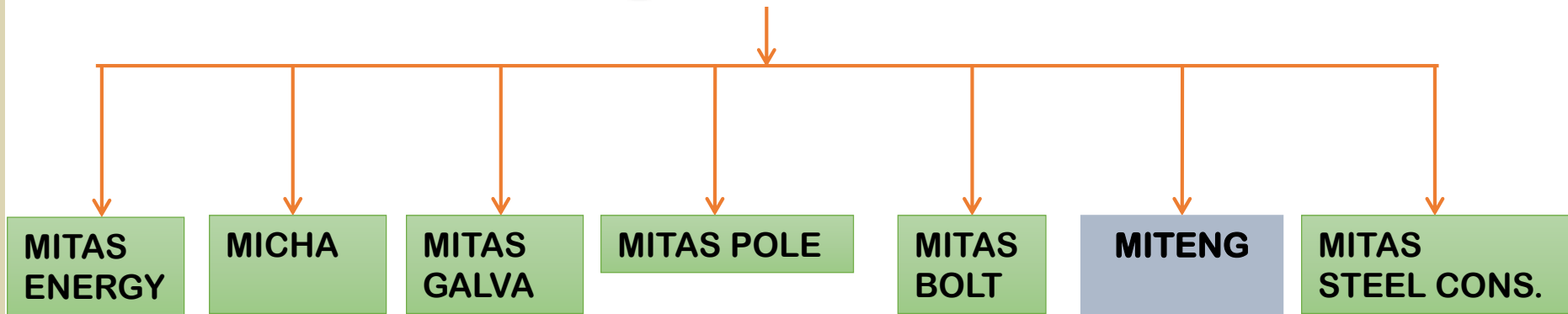
Introduction about Miteng/Mitas



ENGINE

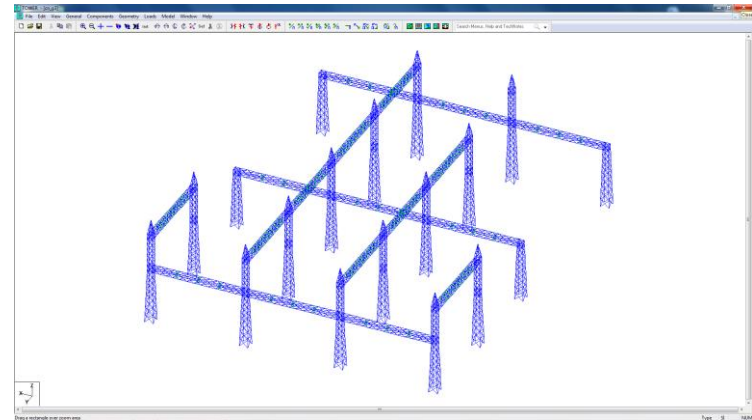
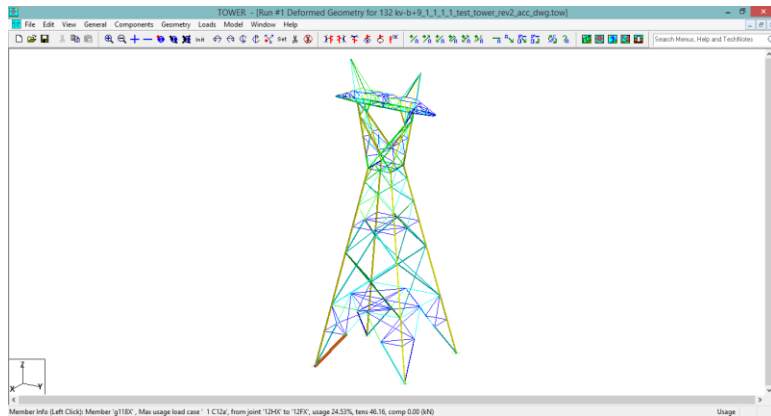
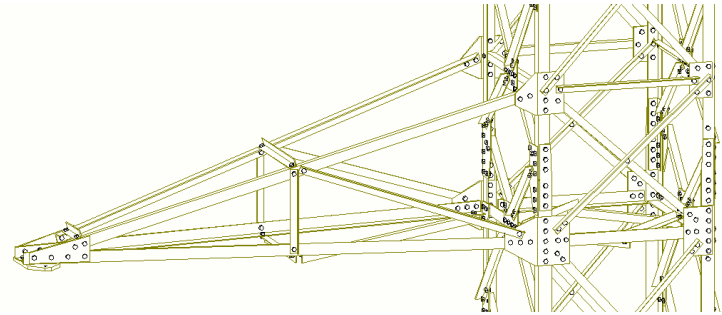


Introduction about Miteng/Mitas



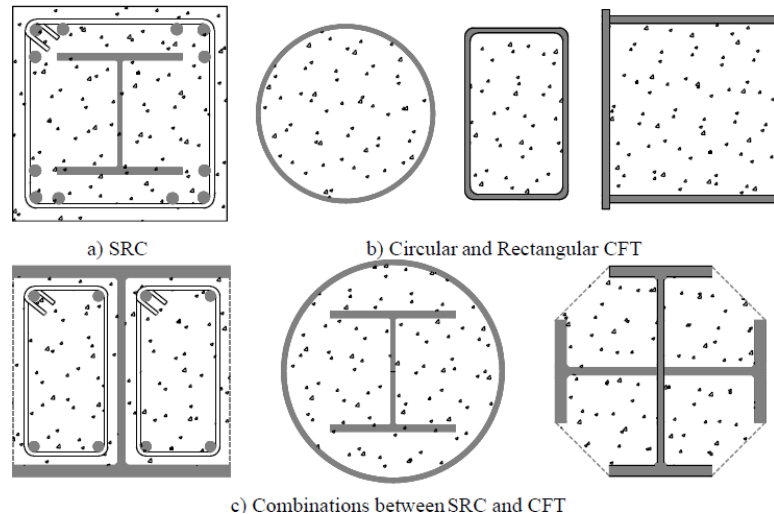
Introduction about Miteng/Mitas

- Located in Ankara/Turkey
- Design, manufacture and construction of transmission lines and substations



Composite Columns

- Economy
- High strength and stiffness
- Inherent damping
- Large energy dissipation
- Reduced time dependent effects



c) Combinations between SRC and CFT

Composite Columns

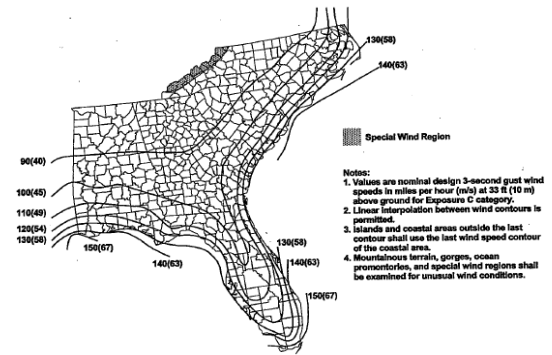
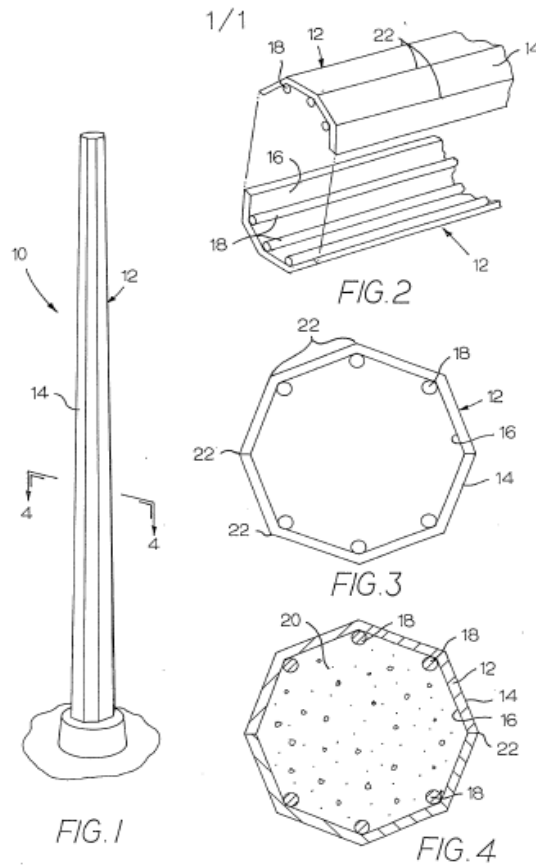
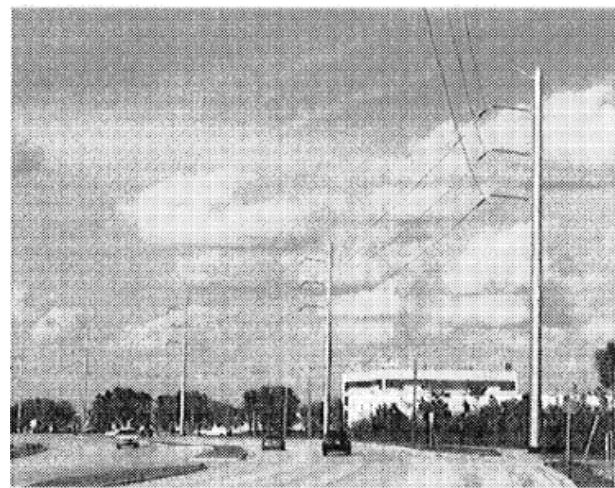
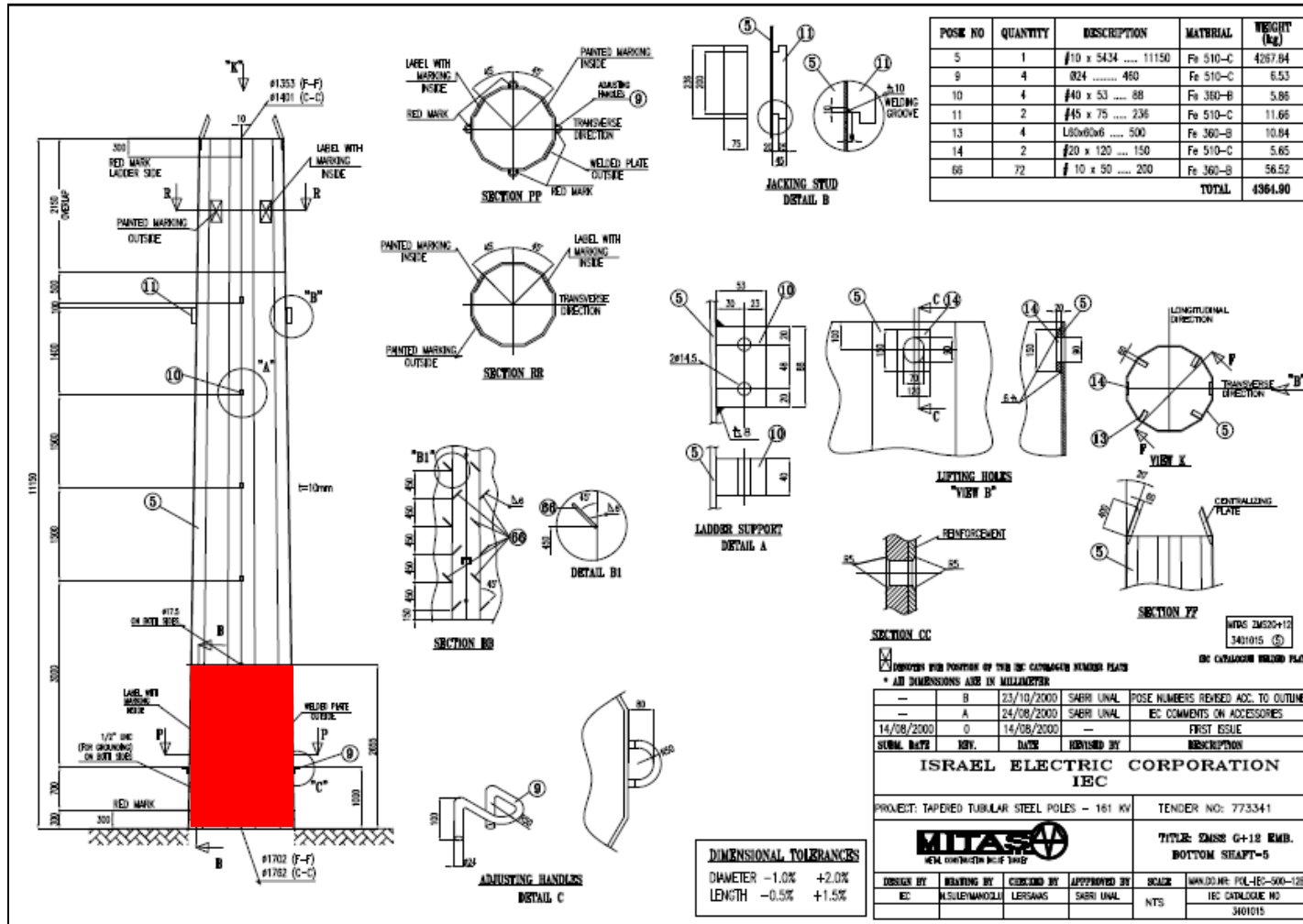


Figure 250-2(d)—Eastern Gulf of Mexico and southeastern US hurricane coastline



230 kV Line 24m Above Ground West Palm Beach, FL

Composite Columns



Design of Composite Columns

- Design Criteria
 - Deflection
 - 5.5% of total pole height
 - Strength (AISC-LRFD 2005 Chapter I, Eurocode 4)
 - Concrete crushing
 - Steel Yielding
 - Global and Local Buckling

Design of Composite Column



WIND LOAD & TEMPERATURES

GENERAL CONDITIONS ;

Design Specification	:	IEC 60826
Return Period	:	500 Years
Reliability Level	:	3
The Load Factor for wind speed	:	1.20 (Table 2 of IEC 60826)
Terrain type	:	A
Height above Sea Level	:	0 m.
Basic Span	:	350 m.
Minimum Ambient Temperature	:	-5 °C
Maximum Ambient Temperature	:	40 °C
Everyday Temperature	:	15 °C
Maximum Conductor Temperature	:	75 °C
Maximum Design Wind speed (V _R)	:	29 m/s at 10 m. Height, in +15 °C
Radial ice thickness;	:	0 mm.

High Wind ; at 15 °C 29.0 m/sec ; 104 km/h at 10 m. Height

WIND PRESSURE ;

According to standard IEC 60826

$$Q_0 : \text{Dynamic wind pressure; } Q_0 = 0.5 \cdot \rho \cdot v^2$$

$$K_R = 1.08 ; \mu = 1.225 \text{ Kg/m}^3$$

Dynamic Wind Pressure for Design ; $Q_0 = 865.2$

Minimum Wind : $Q_{0m} = 311.5$

Wind Loads on Conductors ;

$$A_c = Q_0 \cdot C_{xd} \cdot G_c \cdot G_L \cdot d \cdot L \cdot \sin^2 \Omega \cdot a$$

Where ;

C_{xd} : is the drag coefficient of conductor taken equal to

G_c : is the combined wind factor for the conductors given

G_L : is the span factor given in figures 4.

d : is the diameter of conductor (m)

L : is the wind span of support

Ω : is the angle between the wind direction and the c

Average Height of Conductors above ground level ; Height of attachment point of
Ha = 20.73

Average Height of Shieldwires above ground level ; Height of attachment point - ;
Ha = 26.64

Combined wind Factor ; G_c

for the Terrain Category "A", from Figure-3 of IEC 60826 ;

$$G_c = 0.2914 \cdot \ln (H_a) + 1.0468$$

For Shieldwire ; $G_c = 0.2914 \cdot \ln (H_a) + 1.0468 = 1.94$ and

$$\text{Minimum Wind } q_h = 1611.0 \text{ Pa}$$

For Conductor ; $G_c = 0.2914 \cdot \ln (H_a) + 1.0468 = 1.83$

$$\text{Minimum Wind } q_h = 1522.0 \text{ Pa}$$

$$\text{Minimum Wind } q_{hm} = 548.0 \text{ Pa}$$

Span Factor, G_L : $G_L = 4E-10 \cdot L^2 - 5E-7 \cdot L^2 - E-4 \cdot L + 1.0403 = 0.96$

Reduction factor due to long series of suspension spans in line section ; $a = 1.00$
(from clause 6.2.6.2 of IEC 60826)

Wind Loads on insulator Strings ;

$$A_i = Q_0 \cdot C_{xi} \cdot G_t \cdot S_i$$

Where ;

Q_0 : Dynamic Wind Pressure for Design

C_{xi} : is the drag coefficient of insulators, considered equal to 1.20

G_t : is the combined wind factor for the insulators given in figure 5.

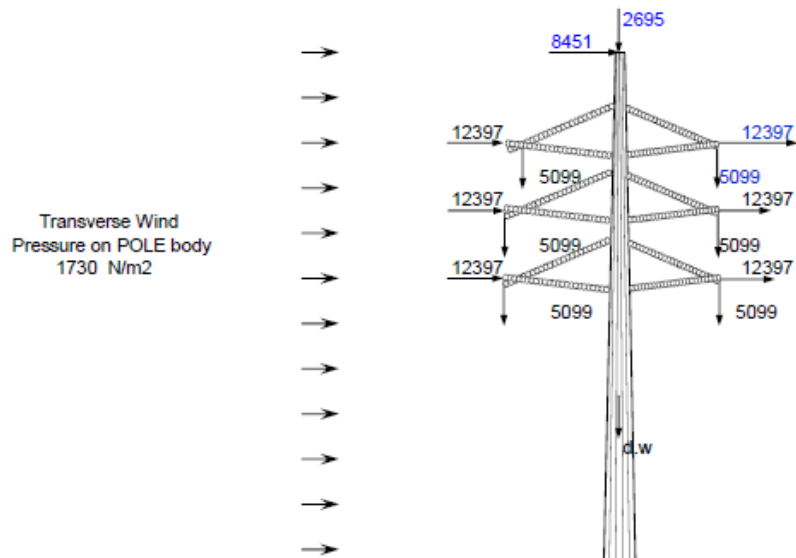
S_i : is the area of insulator string (m²)

$$A_i = 1887 \cdot S_i \cdot N$$

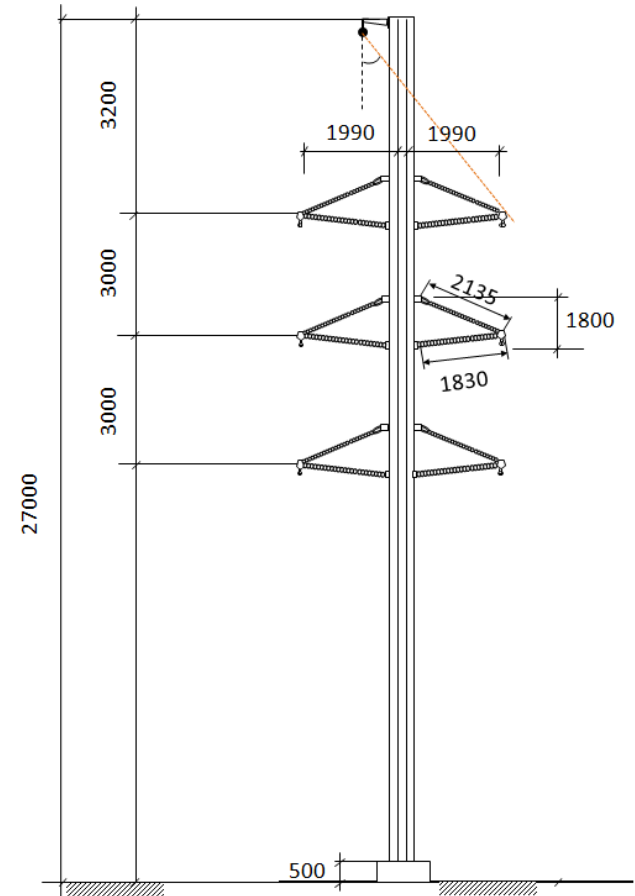
Design of Composite Column



LOADING TREE FOR STEEL POLE
DOUBLE CIRCUITS OPERATION) ("P122A-CF"



NORMAL LOADING - 1a : at +15 °C, Max Wind 0° to the Bisector, Max Weight Span
Case : N1a
Strength Factor : 0.90
Notes : All loads are in (N)



Design of Composite Column

-2 types of analysis:

- Beam finite element to determine deflections, member forces and foundation reactions

-Cross-section analysis to evaluate strength limit states



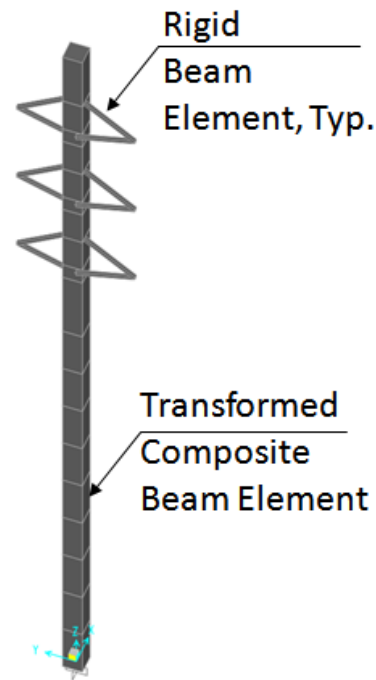
Beam Finite Elements



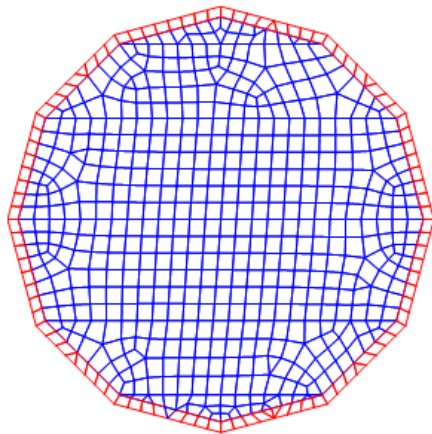
Cross-Section Analysis

Design of Composite Column

- FEM Model using SAP2000 to determine deflections and foundation reactions
- Equivalent material properties for composite section
- Materially linear, geometrically nonlinear analysis



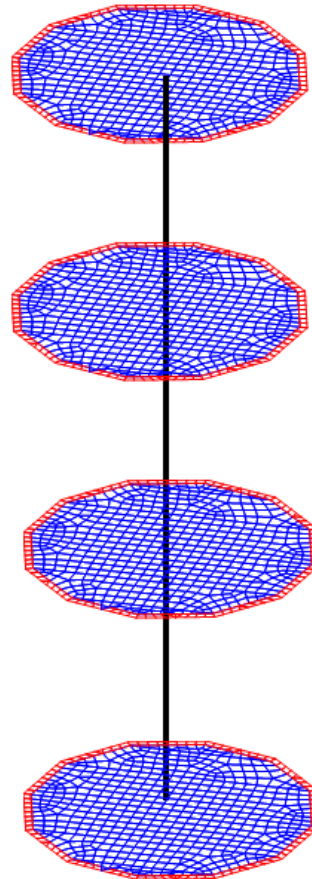
Design of Composite Column



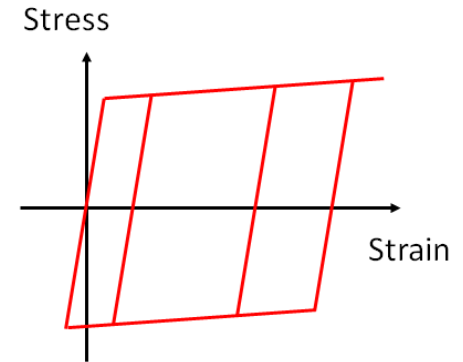
Steel and Concrete
Fibers



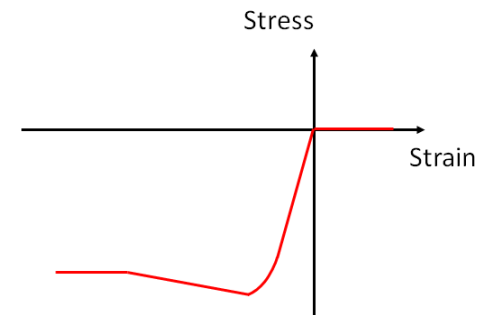
Composite
Pole



Fiber Beam
Element



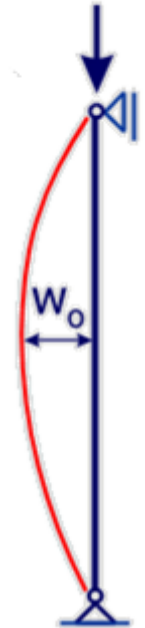
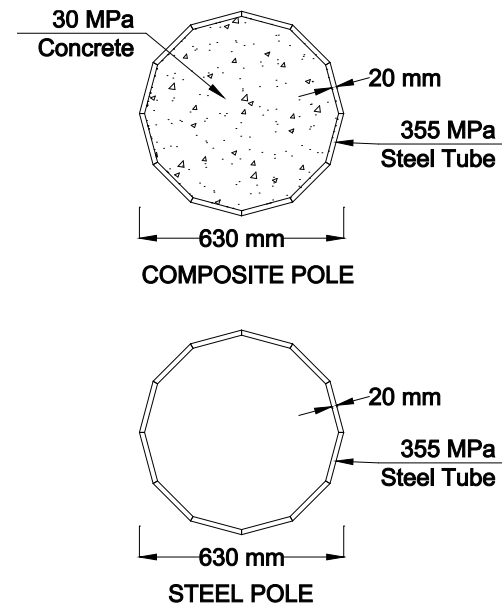
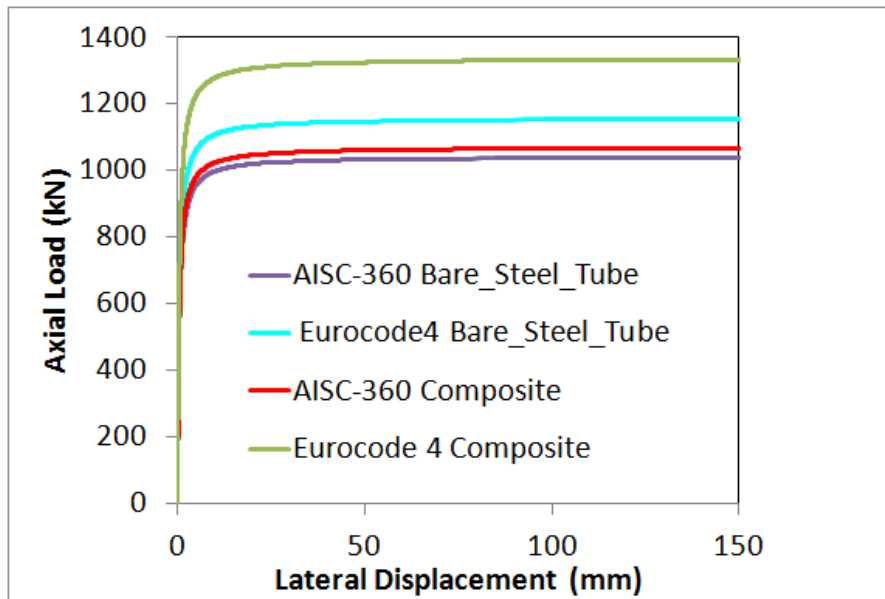
Steel01



Concrete01

Design of Composite Column

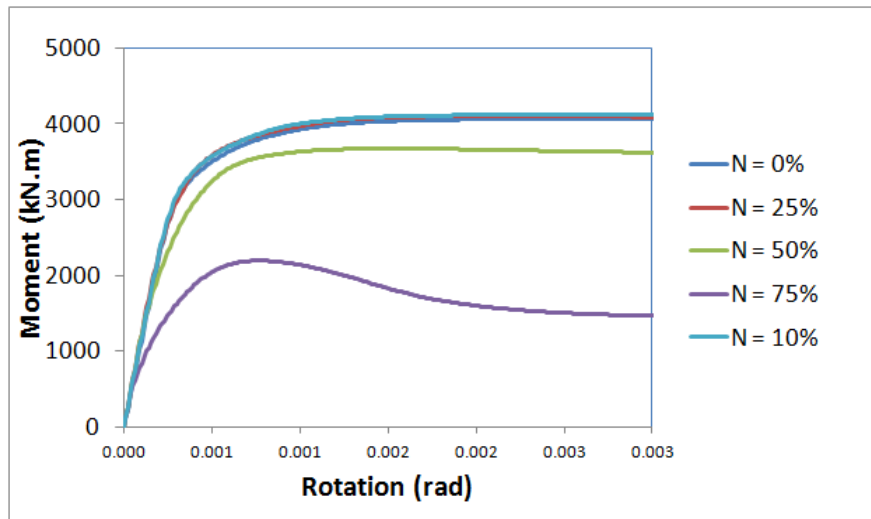
Buckling Response



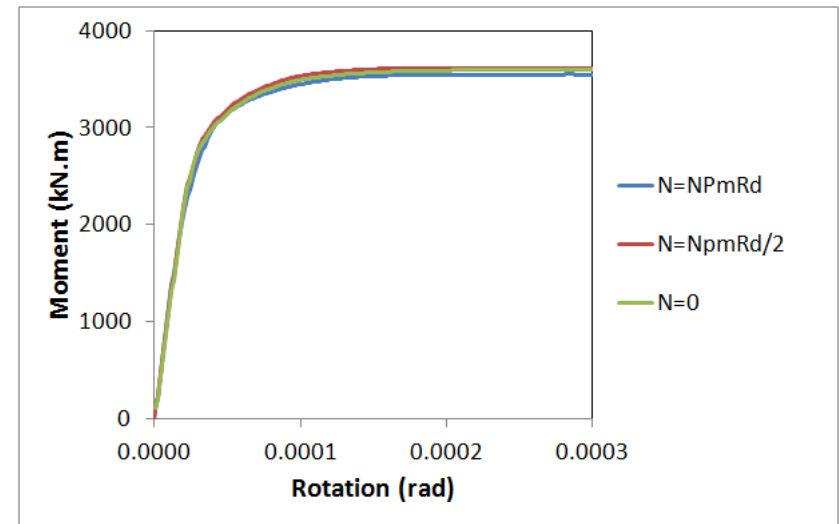
Design of Composite Column

Constant Axial Load Increasing Bending Moment

AISC 360

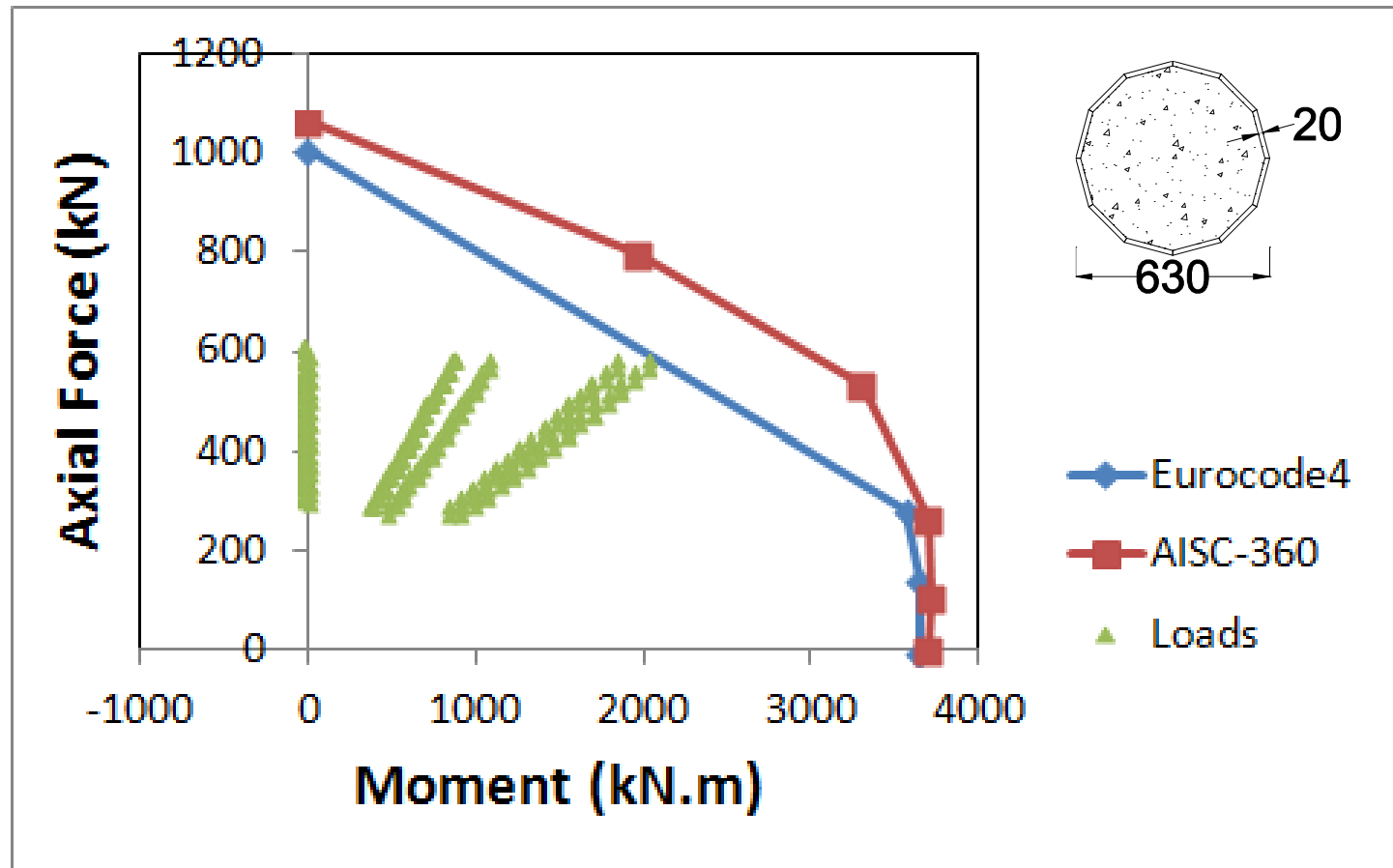


Eurocode

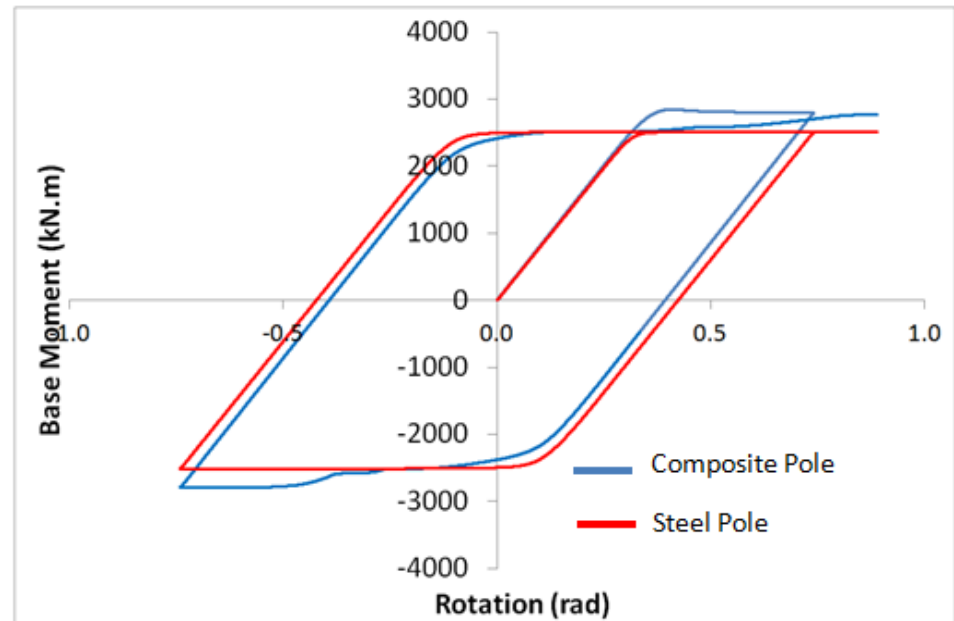


Design of Composite Column

Bending and Axial Load Interaction



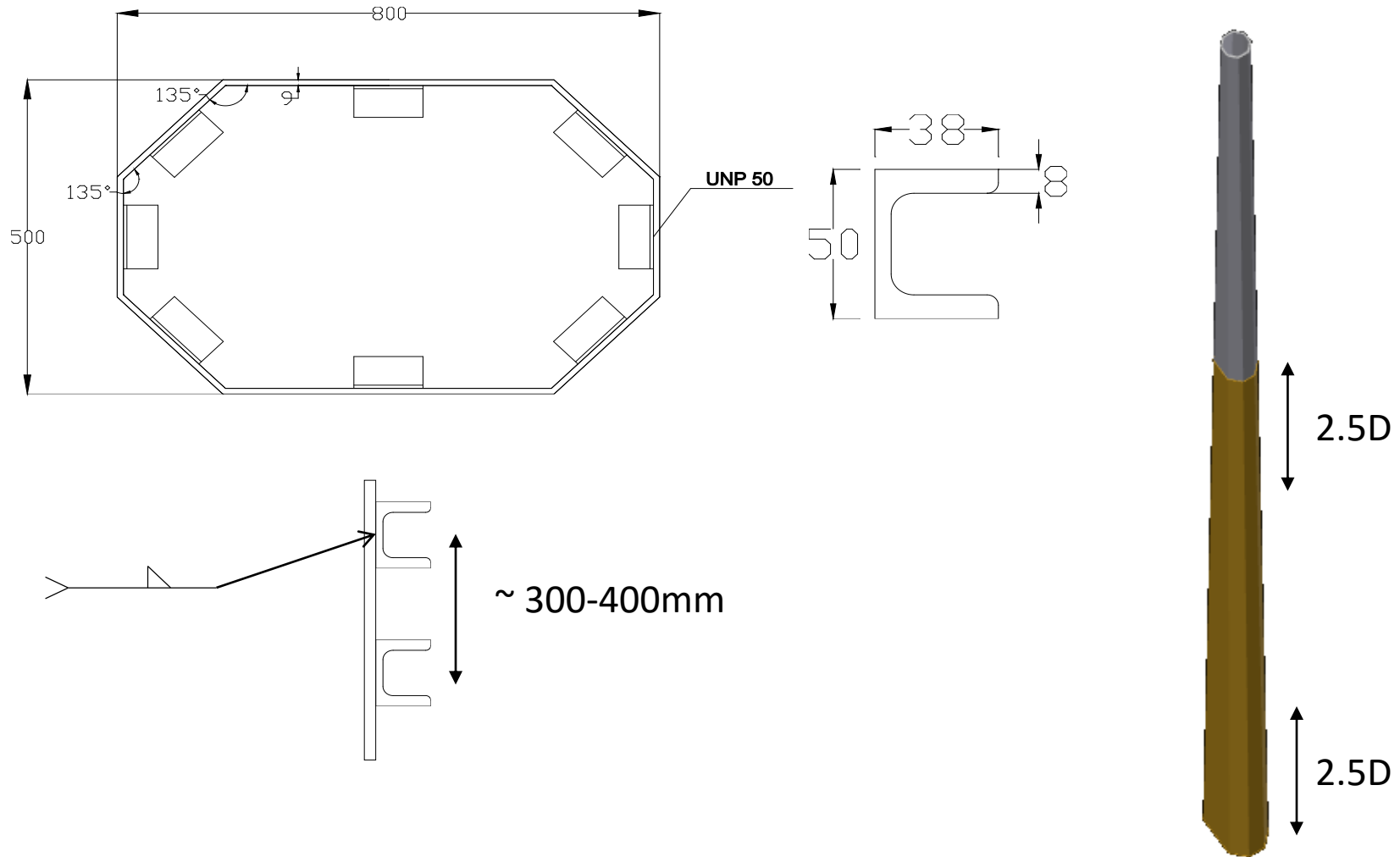
Cyclic Response



Cyclic Response



Shear Connectors



Conclusion

- Both Eurocode and AISC-LRFD do not propose a design method for composite columns
 - Complicated and time consuming design calculations
 - Eurocode and AISC-LRFD resulted in similar bending moment axial load interaction curves
 - 15% less saving in steel weight when filled with concrete