Nature and the Tall Building

SEMM Seminar
University of California, Berkeley
18 October 2010

Mark Sarkisian, PE, SE, LEED AP
Director of Structural Engineering
Skidmore, Owings & Merrill LLP
San Francisco
“All-wood” Jesuit Churches
Dowels from the Alerce Tree
Island of Chiloe
Non-linear Analysis

- Perimeter frame of SAC 9-story building
Hysteretic loops definition (From FEMA 356)

- RBS
- Pin Fuse
Results of Pushover Analysis

PUSHOVER CURVE

Base Shear (kips)

Displacement (in)

PIN-FUSE
RBS
Cable Net
90 meters tall
60 meters wide

26 mm diameter vertical cables
34 mm diameter horizontal cables
26 mm diameter vertical cables
#25 Barry Bonds

Age: 39  
Height: 6-2  
Weight: 228 lbs.  
Bats: Left  
Throws: Left  
Pos: LF  

AVG | HR | RBI  
---|----|-----  
.358 | 14  | 29  

Cable Design Force  
40,000 kN
Modernization

220mm diameter high-strength steel cable.

Decoupling “rocker” mechanism

Steel braces for collapse prevention
Final Scheme - Pulley Equivalent at Base of "V"
Background

Modernization

SOM
\[ y = 25.13 + 4.8050 x - 0.0774 x^2 \]
Bamboo Culm Diameter Equations

\[ y = 97.5 - 0.212 x - 0.016 x^2 \] (lower region)
\[ y = 157.6 - 2.868 x + 0.013 x^2 \] (upper region)
\[ y = 101.8 e^{0.022x} \] (entire length)

Where:

- \( y \) = diameter of the culm
- \( x \) = internode number

Bamboo Culm Wall Thickness Equation

\[ y = 35 + 0.0181 (x - 35)^{1.90} \]

Where:

- \( y \) = culm wall thickness
- \( x \) = internode number
BAMBOO CONCEPT FOR AN ULTRA-TALL BUILDING
A ELEVATION - OUTER STRUCTURAL FRAME

STEEL SCHEME
STEEL MEGA-BRACED FRAME LINKED TO INNER DUCTILE STEEL MOMENT RESISTING FRAME (COMPOSITE SCHEME SIMILAR)

B ELEVATION - INNER STRUCTURAL FRAME

STEEL SCHEME
STEEL MEGA-BRACED FRAME LINKED TO INNER DUCTILE STEEL MOMENT RESISTING FRAME
long legs and excel at picking insects off water surfaces.

The wings of the adult dragonfly are one of its most striking physical characteristics. Just as large and just as prominently displayed as those of butterflies and moths, dragonfly wings are at the same time less colorful but more intricate. As we have seen, the wing veins serve important functions both during the final molt and in flight. Since many dragonfly species can be identified from the wings alone, the arrangement of the major veins and cells can also determine family groupings. This means of classification, along with eye placement, became the basis for our pictorial key to the seven North American and

**FIGURE 40**
A collage of the abdomens of several different skimmer species (family Libellulidae) showing differences in terminal appendages. The tails (abdomens) were digitally removed from the scanned images of live dragonflies. Scans provided by authors.
“I discovered that nature was constructed in a wonderful way, and our task is to find out the mathematical structure of the nature itself. It is a kind of faith that has helped me through my whole life.”

Albert Einstein
$\Phi = 1.618$
\[ F_N = \sum_{N=3}^{\infty} F_{N-1} + F_{N-2} \]

\[ F_1 = 0, \quad F_2 = 1 \text{ (binary)} \]

\[ \Phi = \frac{N_2}{N_1} = \frac{13}{8} = 1.6 \]
\[ \frac{\Delta_{CS}}{\Delta_T} = 0.99 \]

(Essentially 100% Efficient)
筒型作用比较研究

Parametric Study of Tubular Behavior

常规的框架筒
Conventional Tube Frame

网状斜杆框架筒
Diagonal Mesh-Tube Frame

$$\frac{\Delta_{CS}}{\Delta_T} = 0.62$$
(62% Efficient)

$$\frac{\Delta_{CS}}{\Delta_T} = 0.99$$
(Essentially 100% Efficient)
Integration of Form & Structure
“One of our strongest human instincts is to try to stand up against what Rudolf Otto called the ‘numinous’ – the unknown and compelling – but also frightening – mysteries of the created and creative forces of the universe. To resist their energies – energies so powerful they can make us feel insignificant in contrast.”

Rev. Dr. Philip Butin
"What if you could develop strong, flexible, responsive, adaptive, sustainable human buildings based on the intrinsic architecture of the hurricane? Buildings that exist in harmony with – instead of trying to resist and stand up against and conquer – the powerful creative forces that might otherwise threaten and endanger us?"

Rev. Dr. Philip Butin
FLOOR AREA = 34,500-25,310 sq. ft.

TYPICAL LOW-RISE OFFICE FLOOR PLAN (L9-24)
FLOOR AREA = 14,018 sq.ft.
RESIDENTIAL L-72 FLOOR PLAN
- 35% Reduction in Concrete
- Flat Slab Construction (no beams)
- Reduced Seismic Mass
- Reduced Weight to Foundations
1 ISOMETRIC VIEW (COMPLETED LINK BEAM JOINT)