Louisiana TIMED Managers
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LOUISIANA TRANSPORTATION CONFERENCE

Baton Rouge, 11th January 2011

Dante Lius, P.E.
Deputy Project Manager
JJ Audubon Bridge
Evolution of Cable Stayed Bridges and Various Tower Shapes

Presentation by Dante Lius, P.E.
Evolution of Cable Stayed Bridges
Various Tower Shapes
Summary

- Progress from “First generation” of cable-stayed to the last evolution.
- Factors that affect the choice of the towers:
  - Design, location and environment constraints.
  - Geotechnical, seismic, wind, structural factors.
  - Constructability.
  - Aesthetic factors.
- Why the tower shape?: some specific cases.
First generation Cable-stayed bridges

- Static scheme: continuous beam on multiple supports
- Limited number of cables (piers repl.)
- Largely spaced cables
- Strong cables
- Strong anchorages
- Rigid deck
Donzère Bridge (1951) 81m, 266’
Strömsund Bridge (1956) 103 m, 337’
Lake Maracaibo Bridge (1962) 235m, 771’
Chaco Corrientes (1973) 245 m, 804’
“Second generation” Cable-stayed bridges

- Static scheme: continuous beam on elastic supports
- Multiple cables spaced few meters
- Moderate flexural rigidity deck
- Deck supported on pylons
Brotonne Bridge (1977) 320m, 1050’
Sunshine Skyway (1987) 366 m, 1200’
New Panama Canal Bridge (Centenario) (2004) 320 m, 1050’
“Third generation”
Cable-stayed bridges

- Deck completely supported by cables
- Static scheme: space truss
- Multiple cables narrowly spaced
- Low flexural rigidity (slender) deck
- Behavior under wind/seismic
- Behavior under service load
Pasco-Kennewick (1978) 229 m, 752'
Barrios De Luna (1983) 440m, 1443’
Alex Fraser (1986) 465 m, 1526’
Cooper River Bridge (2005) 1546’, 471 m
Fourth generation Cable-stayed bridges

- Hybrid between 2nd and 3rd type
- Deck lightly supported at towers
- Not completely suspended
- Cables starting at the towers, evenly spaced, semi-fan configuration
- P.T.I. cable loss requirement
J.J. Audubon Bridge  (under construction: 1583’, 482 m)
Sidney Lanier (2003) 381 m, 1250’
Factors that influence the shape

- Environment-design constraints
- Wind design constraints
- Seismic design constraints
- Constructability
- Aesthetic
Environment-design constraints

- Distance to span between the towers
- Deck width (number of traffic lanes)
- Geological-geotechnical constraints
- Scour, stream current or tidal action
- High or low deck clearance above water
- Proximity of airport (reduced height of pylons)
Wind design constraints

- ‘H’ or ‘Ψ’ shape:
  - Twist effect (legs oscillating in opposite phase)
  - Possibility of torsional loads
  - Up/downwind conditions on the tower legs
  - Cantilevering structure
  - Vortex shedding during construction
  - Large sectional area subject to static force
Wind design constraints

- ‘A’ or ‘Λ’ or (inverted Υ) or ‘Diamond’ shape: all of the above, but:
  - Improved resistance to transverse forces due to wind

- ‘I’ shape (single mast):
  - Better aerodynamic
  - Reduced static force on the pylon
  - No twist effect
  - No upwind-downwind issues
  - Cantilevering structure during construction
  - Possibility of vortex shedding
Seismic design constraints

- Rigidity decreases with height
- Foundations are connected and monolithic
- In extreme cases, foundations are sliding
- Plastic hinge formation for extreme earthquakes
- Importance of Deck-Tower connection
- Energy dissipation/absorption devices
Constructability

Factors:
- Formwork complexity
- Time required for construction
- Geometry

Shapes:
- I, H, Π less problems with f/work and geometry
- A, Y, Λ, inverted Y: longer construction time
- X, Diamond: most complex, high requirement on geometry (camber) control.
Aesthetic

- Cable stayed bridges are intrinsically elegant and beautiful structures.
- They easily become a landmark.
- Balance of proportions of the bridge in general.
- Visual compatibility of the parts and of the whole.
- Integrated design: fit in the environment.
- Aesthetic is not anymore an “extra” but a necessity.
## Summary of considerations

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Why the tower shape?

- Reduced clearance (20m, 60ft)
- Structural reasons (axial forces)
- Lateral triangular suspension (truss)
- Avoid negative moments deck-towers
- Allow vertical/horizontal movements

Puente de Arade (1991) 324 m, 1063’
Arade Bridge
Why the tower shape?

- Deep water (65m, 213 ft)
- Tectonic movements
- Seismic activity
- Probability of tsunamis
- Loose sediment seabed
- Multi-span

Rion Antirion Bridge
Rion Antirion (2004) 560 m, 1837’

- Footing on leveled gravel bed
- Double “A” shape (space frame)
- Connection pier-deck
- Monitoring devices
Cooper River Bridge (2005) 1546', 471 m
Vasco da Gama (1998) 420m, 1378’
Vasco da Gama
Juscelino Kubitschek Br. (2002) 720m, 2362’
Langkawi Sky Br. (Malaysia) 125m, 410’
Langkawi Bridge
Sutong Bridge 1088m, 3570 ft Towers: 306m, 1004 ft
Questions?