ENCE717 – Bridge Engineering
Long-Span Bridges

BEST Center
Bridge Engineering Software & Technology

Chung C. Fu, Ph.D., P.E.
(http: www.best.umd.edu)

UNIVERSITY OF MARYLAND

Classification Based on Main Span Length

Short Span Bridges (up to 15m)

Medium Span Bridges (up to 50m)

Long Span Bridges (50-150m*)

Extra Long Span Bridges (over 150m*)

* (or 200 m)

Long & Extra Long Span Bridges

Long Span Bridges:

- Composite Steel Plate Girder Bridge
- Cast-in-place Post-Tensioned concrete Box Girder
- Post-Tensioned Concrete Segmental Construction
- Concrete Arch and Steel Arch

Extra Long Span Bridges:

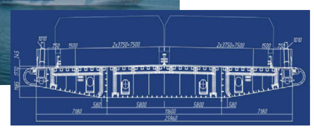
- Cable Stayed Bridge
- Suspension Bridge

Akashi Kaikyō Bridge

Longest Suspension Bridge (Longest span = 1,991 m)

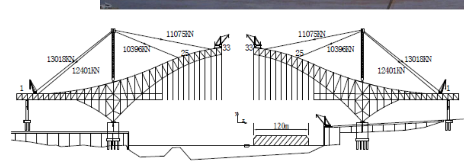
Russian Russky Bridge

Longest Cable-stayed Bridge (Longest span = 1,104 m)



Chaotianmen Bridge

Longest Steel Arch Bridge (Longest span = 552 m)



Canada Pont de Quebec Bridge

Longest Steel Truss Bridge (Longest span = 549 m)

Wanxian Bridge

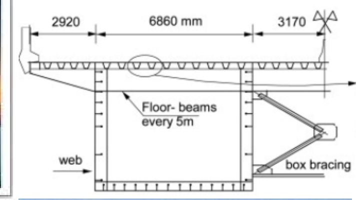
Longest Concrete Arch Bridge (Longest span = 420 m)

Shibanpo Bridge

Longest Prestressed Concrete Bridge (Longest span = 330 m)

Brazil Rio-Niterói Bridge

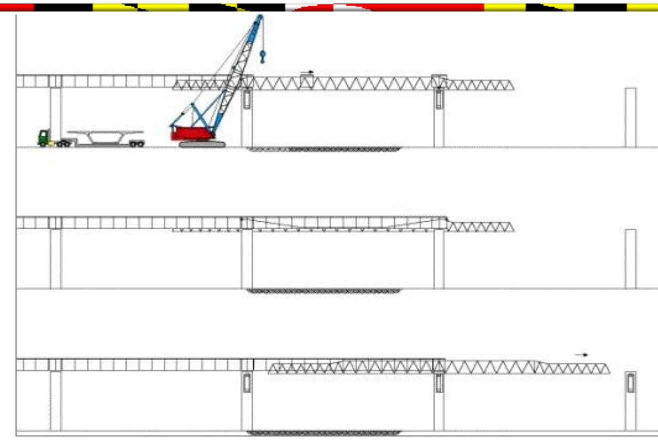
Longest Steel Box/Plate Girder Bridge (Longest span = 300 m)



Economical Span Ranges for Segmental Construction

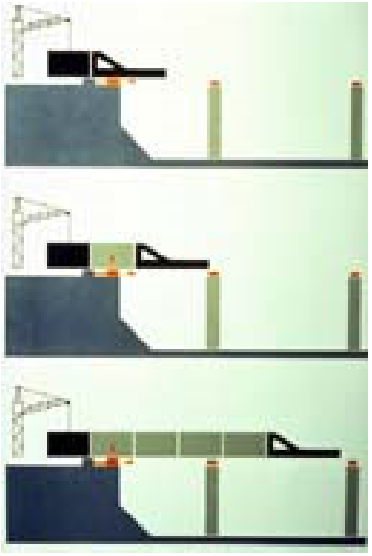
Construction Method		Superstructure Depth – ft (m)	Economical Span Range – ft (m)
Span-by-span	**Precast**	**Constant 6 (1.8)**	**up to 110 (to 33)**
	Precast	**Constant 6 to 8 (1.8 to 2.4)**	**110- 150 (33 - 45)**
	Precast/ Cast-in-place	**Constant 7 to 12 (2.1 to 3.6)**	**120- 160 (36 – 48)**
Incremental Launch	**Cast-in-place**	**Constant 8 to 12 (2.4 to 3.6)**	**up to 240 (to 72)**
Progressive Cantilever	**Precast**	**Constant 8 to 10 (2.4 to 3.0)**	**up to 200 (to 60)**
Balanced Cantilever	**Precast**	**Constant 6 to 12 (1.8 to 3.6)**	**160 – 260 (48 – 78)**
	Precast	**Variable 6 to 20 (1.8 to 6.0)**	**200 - 450* (60 – 135)**
	Cast-in-place	**Variable 6 to 40 (1.8 to 12.0)**	**260 – 750 (78 – 225)**
Cable Stay	**Precast or Cast-in-place by cantilever erection**	**Constant 6 to 15 (1.8 to 4.5)**	**500-1500 (150 – 450)**

Span by Span Segmental Construction



- Disadvantage - the capital investment in the equipment for this type of construction is considerable.
- Advantage – quick, simple erection (2-3 spans/wk); Easy geometry control; savings from less MOT; min. user delays; simple design; durable structures

Incrementally Launched Segmental Construction



- Disadvantage - Inefficient use of materials. Stringent dimensional control is an absolute necessity at the stationary casting site. Straight or constant radius. (not recommended)

Progressive Cantilever Segmental Construction

- Note – Various radius. a movable temporary stay arrangement must be used to limit the cantilever stresses during construction to a reasonable level

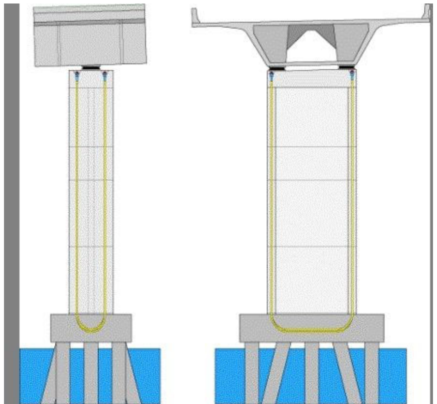
Free Cantilever Segmental Construction

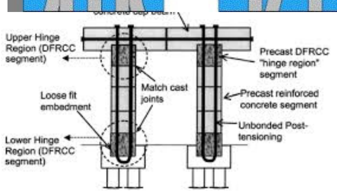
- Note - The form traveler moves forward on rails attached to the deck of the completed structure and is anchored to the deck at rear.
- 4 to 6 segments/day (45 ft)

Cable Stay Segmental Construction

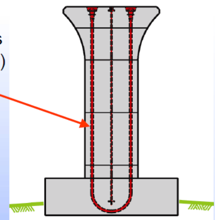
- Viaduct main span 66.5 m

Post-tensioned Precast Piers

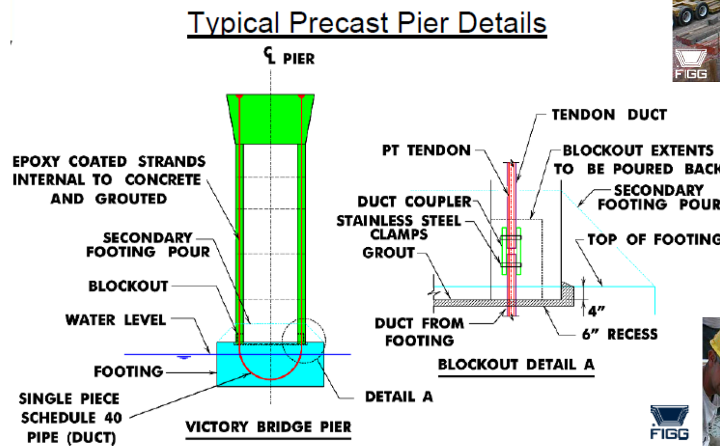




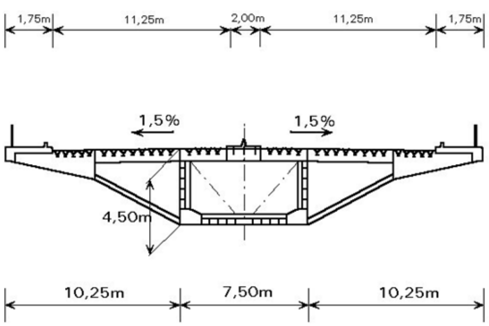
- Vertical Tendons (in Precast Piers)

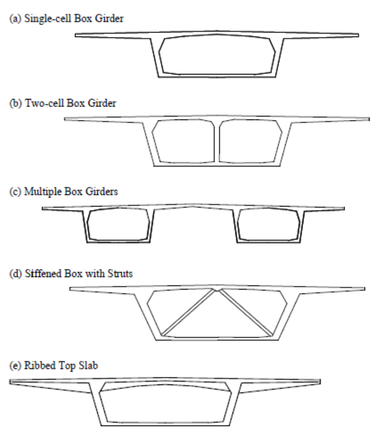


Precast Pier Details & Erection



Single-cell Box with Inclined Struts





- Current trends in cross-section design lead to single cell box girders for increasingly wider bridges. Ribs or struts are used to provide additional transverse capacity.

Precast Joints

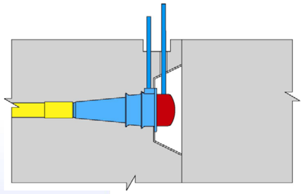
Precast Joints

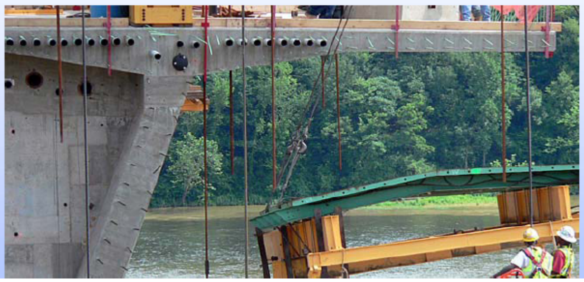
- Keys (i.e. no reinforcing across joints)
- Epoxy
  - Temporary Clamping
  - Temperature
- **Type A** joints includes cast-in-place concrete joints, wet concrete joints or epoxy joints.
- **Type B** joints consist of dry joints between precast units

Cast-in-Place Joints

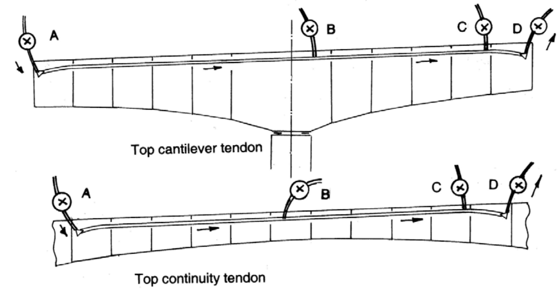
Cast-in-Place Joints

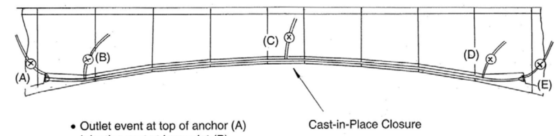
- Reinforcing Bars
- Joint Preparation
- Bulkheads





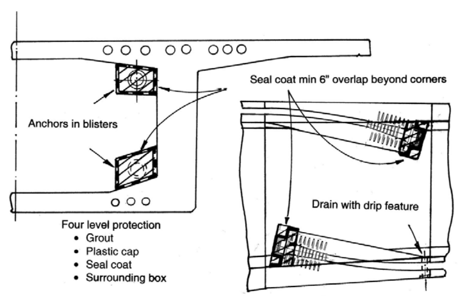
Grouting top & bottom slab cantilever and continuity tendon

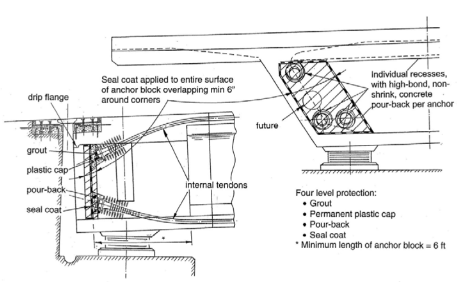




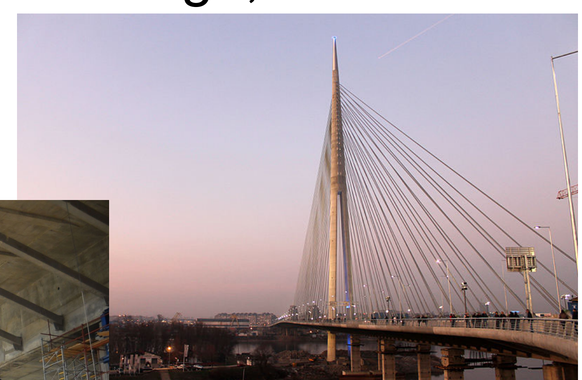
- Outlet event at top of anchor (A)
- Injection port at low point (B)
- Intermediate vent (C) when duct is longer than 150 ft
- Injection port (D) when (D) is more than 18" lower than vents (C) or (E)
- Outlet vent at top of anchor (E)

Anchor protection for interior & exterior anchors

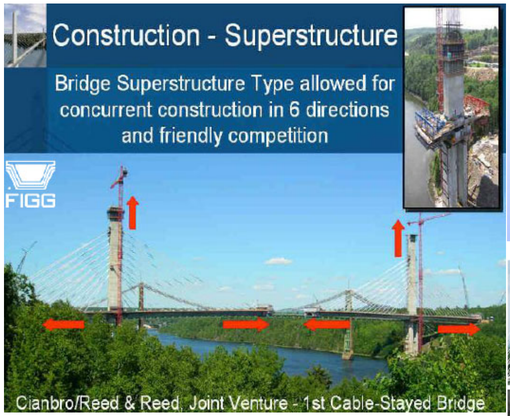




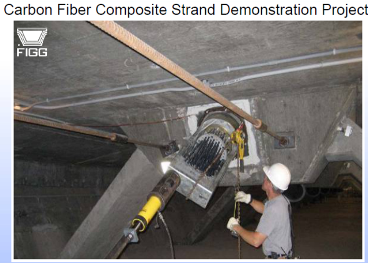
Sava River Bridge, Serbia



Cable-Stayed Bridge Demonstration Project



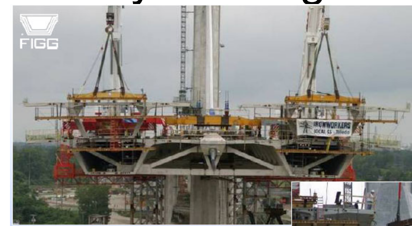
Carbon Fiber Composite Strand Demonstration Project



Penobscot Narrows Bridge & Observatory, ME

Penobscot Narrows Bridge & Observatory, ME

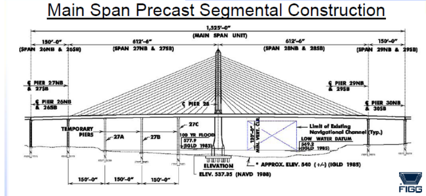
Cable-Stayed Bridge Construction



- 3 pairs of segments erected in cantilever
  - Epoxied segment joints
  - Segments post-tensioned

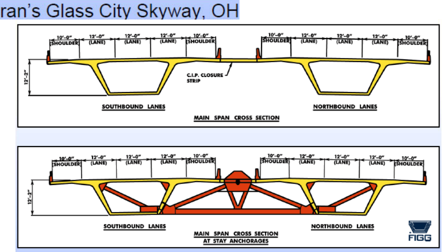
Veteran's Glass City Skyway, OH

Main Span Precast Segmental Construction



- Backspans: Span-by Span
- Mainspan: One-Directional Cantilever

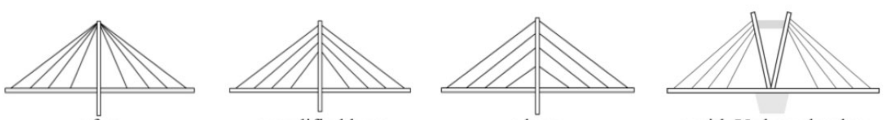
Veteran's Glass City Skyway, OH



Typical Pre-Cast Cross-Sections: Main Span

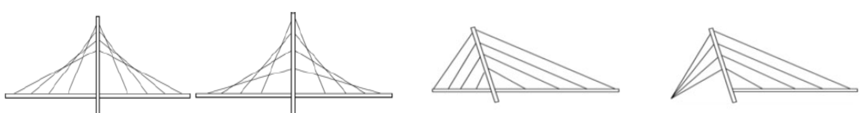
Veteran's Glass City Skyway, OH

Typology of Cable-Stayed Bridges



- fan
- modified harp
- harp
- with V-shaped pylon

Type 1 - symmetric forward cable arrangement with straight pylon



- reversed-modified harp
- reversed-harp
- back-stay cables distributed
- back-stay cables merged

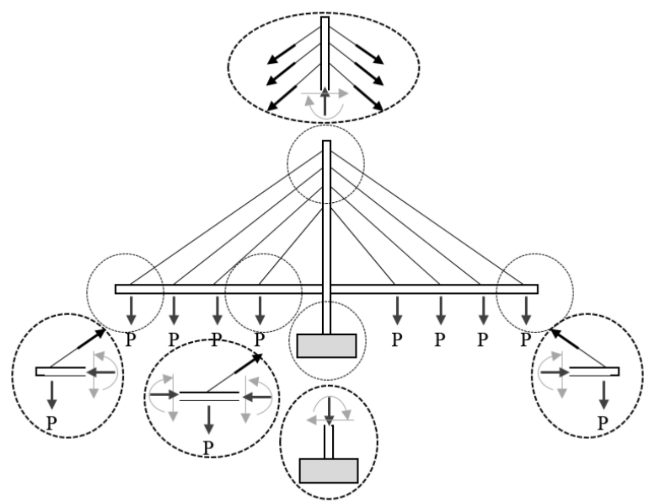
Type 2 - symmetric reverse cable arrangement with straight pylon

Type 3 - asymmetric cable arrangement with inclined pylon

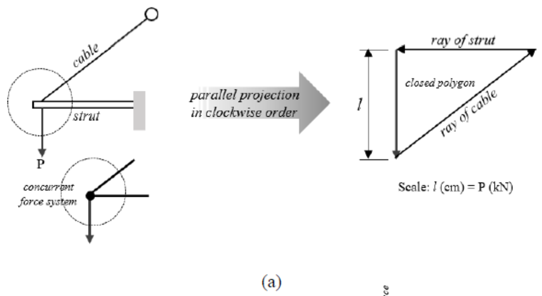
Type 4 - asymmetric cable arrangement without back-stays

- with counteracting tower
- with curved truss pylon

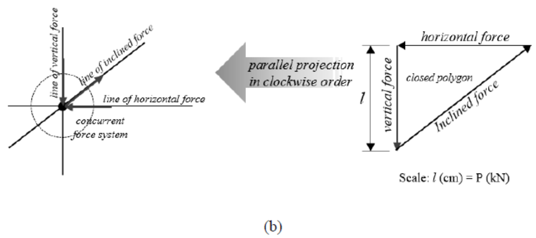
Free Body Diagram for Member Forces in a Cable-Stayed Bridges



Form and Force Diagrams of a Basic Three-force System

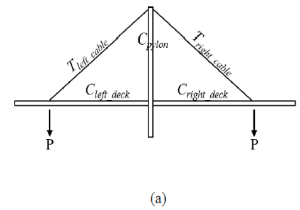


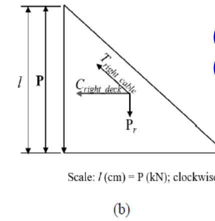
(a) from form diagram to force diagram



(b) from force diagram to form diagram

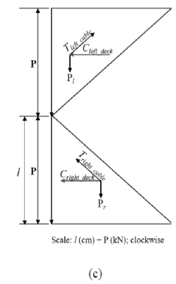
Form and Force Diagrams for a Simple Symmetric Cable-stayed Bridge System

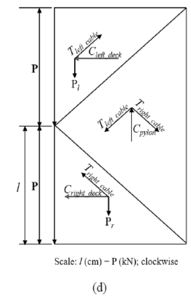




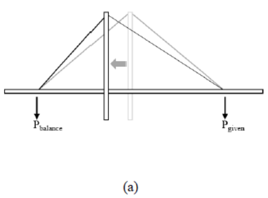
(a) form diagram
(b) force diagram for the right end loading

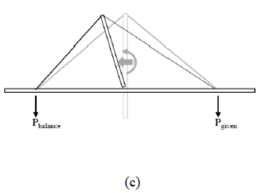
(c) force diagram for both loadings
(d) force diagram completed



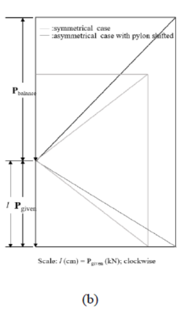


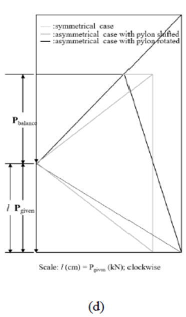
Form and Force Diagrams for a Simple Asymmetric Cable-stayed Bridge System





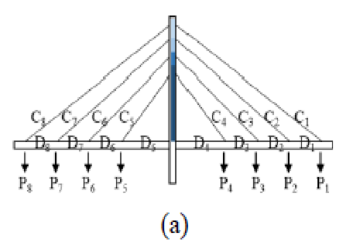
(a) form diagram for a straight tower
(c) form diagram for an inclined tower

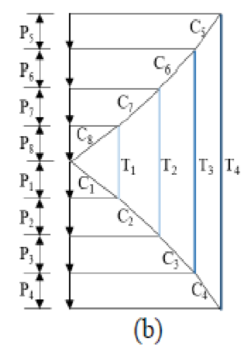




(b) form diagram for the straight tower
(d) form diagram for the inclined tower

Symmetric forward cable arrangement (modified harp case)

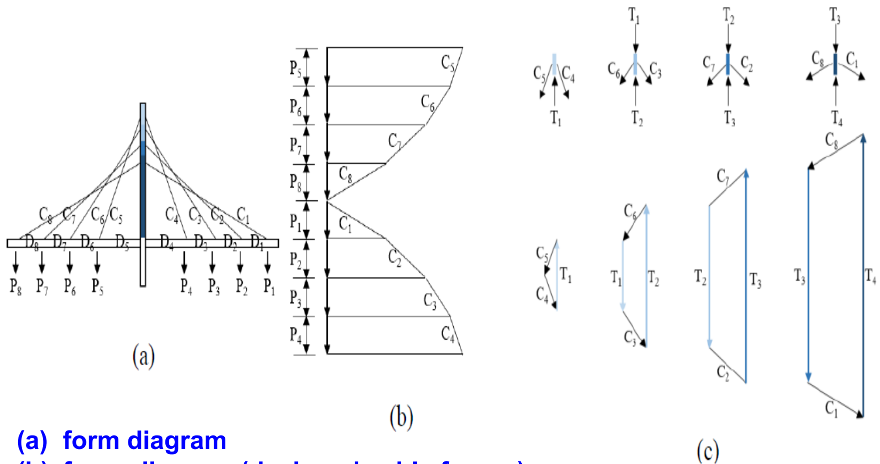




Legend:
P: Point loading
D: Deck
C: Cable
T: Tower

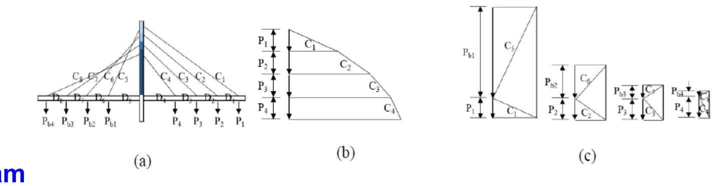
(a) form diagram
(b) force diagram

Symmetric forward cable arrangement (reverse of the modified harp case)



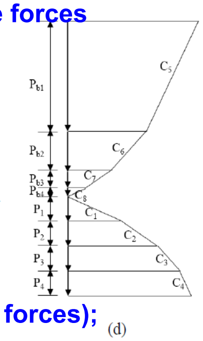
(a) form diagram
(b) force diagram (deck and cable forces)
(c) force diagram (tower forces)

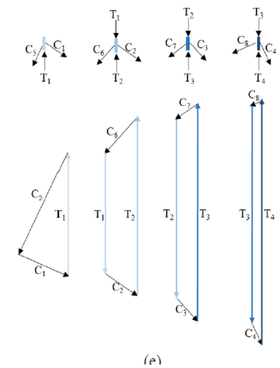
Asymmetric Cable Layout with Forward and Reverse Arrangement



(a) form diagram
(b) force diagram (deck and cable forces for right side)
(c) balanced loadings

Step 1: Construction of force polygon for right side span
Step 2: Determination of balanced loadings
Step 3: Construction of force polygon for decks, cables, and loadings
Step 4: Construction of force polygon for towers

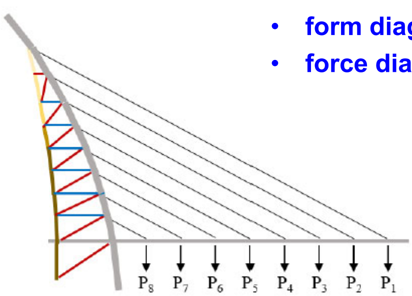




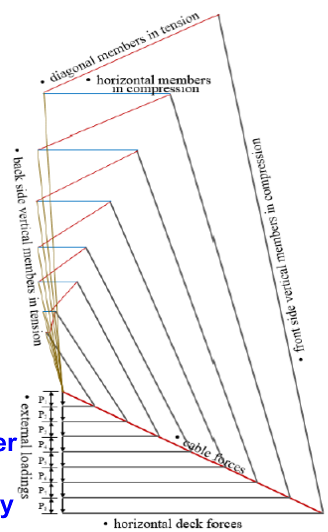
(d) force diagram (deck and cable forces);
(e) force diagram (tower forces)

Form and Force Diagrams showing Multi-level Load Path

- form diagram
- force diagram



The Sheikh Jaber Al-Ahmad Al-Sabah Causeway



Bridge Reconstruction

Bridge Destruction and Construction
- Port Mann Bridge Construction
- Port Mann Bridge Deconstruction

Bridge Replacement
- NJDOT Accelerated Bridge Construction

Bridge Widening
- Illinois Tollway Fox River Bridge