
LECTURE 13
May 17, 2005
Where we have been

- Basics
- Allowable Stress
- Ultimate Strength
- Shear
- Camber
- Basic Bridge Design
- Continuous Spans
Final Exam

☐ 2 Hours
☐ Tuesday May 24th 7pm -9pm
☐ Not Cumulative in respect to calculations, but understand concepts
☐ Covers: Lectures 6 – 12 (shear to continuous beams)
☐ Open Book, Open Notes
☐ Questions?
Totally Precast Concrete Bridges
Is it possible to design an “Instant Bridge?” Almost! There are many ways to put a bridge together quickly with precast concrete products.
The speed and variety of precast prestressed products and methods give designers many options. Consider these advantages of an all-precast bridge...
Fast construction benefits owner agencies by reducing the duration of the work zone. Fast construction reduces traffic handling costs and accident exposure risks. There’s less inconvenience to the traveling public, fewer delays, and fewer motorist complaints. According to a report by the Texas Transportation Institute, costs incurred by drivers passing through a work zone (along with engineering costs) can be $10,000 to $20,000 per day. A recent Federal report indicates user costs of $50,000 per day for work zones in urban areas.

Benefits to Owner Agencies:

- Reduction in the duration of work zones
- Reduced traffic handling costs
- Reduced accident exposure risks
- Less inconvenience to the traveling public
- Fewer motorist complaints
Contractors benefit from reduced exposure to traffic hazards. More work can be accomplished in less time, with fewer weather delays.

Costs are lower for forms, skilled field labor, scaffolding and shoring, and cranes.

Benefits to Contractors:

- Reduced exposure to hazards
- More work -- less time
- Fewer weather delays
- Lower costs
- Less skilled labor
After foundations have been completed, scheduling can be controlled by a single contractor working with a familiar material.
Precast concrete structural elements should always be plant produced under carefully controlled conditions...by plants that are Certified by PCI.

Plant-produced Elements
... so all structural elements benefit from the excellent quality and corrosion resistance of prestressed concrete.

Quality and Corrosion Resistance
Fully-cured precast concrete structural elements can be stockpiled in advance of need...

Stockpiled in Advance
Immediate Delivery and Erection

...and can be scheduled for “just-in-time” delivery and erection...
There’s no curing time required at the jobsite, as with cast-in-place concrete. Bridge piers can be erected in a day, and beams can follow immediately.

No Curing Time
The following photos illustrate the many products and construction methods that enable very rapid project completion. In addition to the often-used superstructure elements of girders and deck slabs, substructure components such as these piers can also be precast.
Precast concrete piles are quite popular in much of the country. They come in different sizes and shapes, ranging from 10-inch square piles to 66-inch diameter hollow cylinder piles.
Pile caps also can be precast concrete, reducing exposure, forming and curing in the field.
Piers can be made of precast concrete pieces quickly assembled in the field.
Abutments can also be made of precast.
The Sucker Creek Bridge in Hague, New York, consists of precast concrete box beams supported on precast concrete abutments assembled into a jointless, rigid frame.
In San Juan, Puerto Rico, the totally precast concrete Baldorioty de Castro Avenue bridges were built in record-setting time, attractively, and economically.
Each of four bridges, ranging in length from 700 to 900 feet, was erected in about 24 hours. This was well within the owner’s construction allowance of 72 hours per bridge, a condition established to minimize disruption to one of the city’s highly traveled corridors.
In addition to speed, the bridges also met the city’s budgetary needs. The four box-beam bridges were constructed for $2 million less than the next lowest bid for another material.

Puerto Rico
Totally precast bridge systems may be the only viable solution in harsh field conditions.

The Confederation Bridge connecting Canada’s Prince Edward Island to mainland New Brunswick is such an example.

The bridge spanned the eight-mile-wide Northumberland strait, which experiences severe winters and is covered with ice floes for five months of the year.
Even in such harsh conditions, precast concrete was able to meet the owner’s requirements of a 100-year service life, a 3½-year construction period, and attractiveness.

Confederation Bridge
It just makes economic sense to evaluate conversion of cast-in-place to precast concrete. This was done for the Edison Bridge in Florida. Precast piers and beams were spliced to produce tall pier bents.

Edison Bridge
Florida
The state of Texas has constructed several bridges with segmental precast concrete piers. The attractive piers and pier caps are hollow members. Some are made of high-performance concrete. Such segments may be match-cast, similar to segmental box girder bridges, or separated by a thin mortar bed, much like giant masonry units.
In Houston, the *Louetta Road Overpass* utilized precast concrete match-cast piers, as well as precast, prestressed U-beams and stay-in-place deck panels.

Louetta Road Bridge
Texas
Another famous bridge is the Sunshine Skyway Bridge over Tampa Bay in Florida. The piles, piers and pier caps were constructed of precast concrete elements connected together with post-tensioning threadbars.
Making Bridges Longer...

- Why?
  - Spans greater that 165 ft are generally not economical
  - Transportation problems
  - Lifting restrictions

- Result?
  - Owners and designers go with steel alternative.
  - Good for the steel industry
  - Bad for the prestressed industry!
Making Bridges Longer...

- Solutions?
  - New high strength materials
  - New beam shapes
  - Continuity
  - Splices
Making Bridges Longer...

- Wider bottom flanges mean more strands in the “right” places
- NU I-girders
- Washington Super Girders
- New England Bulb-Tee
Making Bridges Longer...

Figure 11.2.1.3-2 shows the maximum span of a NU2000 (78.7 in.-deep) beam.
Making Bridges Longer...

- Use of 0.6” diameter strands.
- Same center-to-center spacing as 0.5” diameter!
- 40% more pretension force with only a 20% increase in diameter!
Continuity

- Make simple spans continuous over the piers by:
  - Deck Reinforcement
  - Post-Tensioning
  - Coupling beams with high strength rods
  - Coupling beams with prestressing strands
Continuity: Deck Reinforcement

- Method discussed previously
- Simple span for dead load, continuous for live loads.
- The reinforcement in the deck resists the negative moment from the continuous live loads.
- Simplest Method
Continuity: Post-Tensioning

- More expensive – generally
- Very efficient
- Pre-compression of the deck in the negative moment region reduces deck cracking at the piers
- Post-tensioning resists some of the beam self-weight and deck.
Continuity: Post-Tensioning

- CIP deck
- CIP splice
- Post-tensioning tendons
- End block
Continuity: Coupled High-Strength Rods

- Similar to Deck reinforcement method
- Threaded rods (non-prestressed) in the top flanges regions resist negative moment
- Provides continuity for deck weight, super-imposed dead loads and live loads.
Continuity: Coupled High-Strength Rods

- 30" x 4" x 3" Rectangular steel bar with holes @ 3" o.c. for threaded rods (typ.)
- 1-3/8" φ, Grade 150 ksi threaded rod (typ.)
- Steel bar (typ.)
- Nut and washer (typ.)

a) Plan View  
b) View A-A
Continuity: Coupled High-Strength Rods

a) Beam Showing High Strength Rods

b) Spliced Negative Moment Reinforcement
Continuity: Coupled Prestressing Strands

- Utilizes prestensioned strands that are left extended at the ends of beams.
- Before placing the deck, the strands are spliced and tensioned.
- Procedure is complex and new, but results show promise and may reduce costs associated with post tensioning.
Splices

☐ Utilizes prestressing and post-tensioning to provide much longer spans.

☐ May be competitive to steel options. Especially as the price of steel continues to rise. . .
Splices

a) Flat End CIP Splice

b) Multiple Ribbed Keys CIP Splice

c) Single Shear Key CIP Splice
d) Match-Cast Shear Key Epoxy Splice
e) Dapped-End with End Blocks Open Joint with Bearings or CIP Splice
Splices: Cast-in-Place Post-Tensioned Splice
Splices: Cast-in-Place Post-Tensioned Splice

b) Duct Splice Detail at Pier

Top of beam

Post-tensioning ducts

8" long duct couplers split and placed over 3" projection, taped and vented

C of splice and pier
Splices: Cast-in-Place Post-Tensioned Splice