Effect of Holes on Precast Concrete

PRESENTED BY RICK J. AMLIN, P.E.
Firm Overview

Established in 1976

118 Employees

Three Offices
- Endwell, NY
- Vernon, NY
- Chevy Chase, MD

Design Services
- Architectural
- Civil
- Mechanical & Plumbing
- Electrical
- Structural
- Environmental
- Survey (Building & Land)
- Construction Administration

ISO 9001:2008 Certified Company
Facilities Services

• Architecture
• Building Information Modeling (BIM)
• Structural
• Site/Civil

• Sustainable Design
• Mechanical - HVAC & Plumbing
• Fire Protection
• Electrical
Environmental Services

- Asbestos Project Design
- Asbestos Project Management
- Asbestos Survey Services
- Lead-Based Paint Services
- Hazardous Materials Sampling
- Indoor Air Quality Evaluations
- Industrial Hygiene Investigation
- Water Sampling
- Osha Compliance Audits
- Environmental Science
Survey & Mapping Services

Services:

- High Definition 3D Laser Scanning
- Topographic & Utility Surveys & Mapping
- Residential & Commercial Surveys
- Subdivisions & Lot Line Adjustments
- Right-of-Way Surveying & Mapping
- Building Construction Surveys
- Construction Stakeout Services
- ALTA / ACSM Land Title Surveys
- Easments & Right-of-Way Surveys & Mapping
- Lease Description Mapping
- FEMA Elevation Certificates
- Global Positioning Systems (GPS) Services
- Wetland Mapping
- Photogrammetric Control Surveys
- Gas Well Permit Surveys & Mapping
- Other Surveying Services
Transportation Services

• Bridge Engineering
• Highway Engineering
• Traffic Engineering
• Pedestrian & Recreational Enhancements
• Disaster Recovery Services
• Construction Inspection & Support
Precast Services

Services:

• Design Services
  • Shop Drawings
  • Project Drawings
  • Structural Design
  • Technical Consulting
  • Quality Control Plans
  • Design and Estimating Software
  • Handling Analyses

• Box Culverts

• Utility Vaults

• Noise Walls

• Arch Bridges

• Reinforced Concrete Pipe

• Manholes

• Retaining Walls/Wingwalls

• Modular Buildings

• Septic Tanks

• Prestressed Bridges
South Abbott Road Bridge 28-3 over Neuman Creek

Delta teamed with Lakelands Concrete Products, Inc. to provide the Erie County Department of Public Works with a new bridge. The South Abbott Road Bridge 28-3 (BIN 3327370) over Neuman Creek in Orchard Park, New York included PCC span units, headwalls, and wingwalls. Delta provided structural design services including calculations for the PCC span units, headwalls, and wingwalls. Delta also provided handling analysis services and reviewed installation drawings and shop drawings compiled by Lakelands.
This project provided the design for and handling of large precast concrete containment trench units. The precast units (45 feet long, 10 feet wide and 2 feet thick) weighed over 125,000 pounds each and act as a secondary containment trench at a rail-loading chemical facility in southern Louisiana. The unit was cast upside down in a form that was custom built by The Spillman Company of Columbus, Ohio. Delta’s scope of work included shop drawings, lifting and handling analysis, and the design of the overturning operation. Delta worked closely with the precast manufacturer, the crane and rigging provider, and the form builder throughout the project to ensure that all design and manufacturing requirements were addressed.
In October 2012, storm surge from Superstorm Sandy caused damage to the Oyster Bay region of Long Island, New York and completely destroyed West Shore Road, a major route between beach communities. This project delivered a solution to this urgent problem for local residents by providing a rapidly deployable design approach that substituted precast concrete for a traditional poured approach. The key to the project was to develop a rapid and structurally sound method to rebuild the retaining wall that supported long spans of the roadway. The Stone Strong System retaining wall eliminated the need for open excavation and long forming and curing times required by the traditional poured solution. The contractor was able to install approximately 750 feet of retaining wall per day and was able to backfill it immediately. This project was completed by the important summer 2013 tourist season.
Town of Manchester, VT
Route 7A Precast Arch Bridge

This project presented a number of design challenges combined in the design of one 8 x 28 foot arch bridge. The design requirements included mating to an existing marble arch, contouring to following a change in stream direction to the desired outlet, and accommodation for an existing sanitary sewer outlet. The design solution and detailing were complicated by the culvert geometry, opening and railing. The bridge geometry needed to marry the proposed layout to the limitations of the precast forming system and the structural design had to consider several load combinations to find the controlling case. Delta provided the structural design and detailed shop drawings for the bridge. In addition to the curved orientation, an opening in the arch units was designed to accommodate an existing sanitary sewer near the outlet end. Structural design had to consider the opening, traffic live load and lateral load from a traffic parapet railing with lamp post. Project installation proceeded without a hitch. Precise manufacturing enabled the precast units to match the cast in place foundations exactly.
This project involved the construction of twenty three (23) ground-mounted precast concrete noise barrier walls with drilled cast-in-place caisson foundations and spread footings. The design involved coordination of multiple utility crossings for the layout. Delta was responsible for using the Conceptual Type, Size, and Location (TS&L) plans developed by others and advancing the design to Final Plan submission. Delta was also responsible for advancing the review of shop drawings. The project involved the following design tasks: project coordination, utility coordination, foundation design, rock socket design, special panel design, special foundation designs, project layout including spiral curves, compilation of final TS&L plans and Quality Assurance forms for submittal.
Private Residence Precast Pedestrian Bridge Design

This project consisted of the design of an hour-glass-shaped precast concrete bridge at a private residence located in Shelter Island, New York. The structure spans approximately forty five (45) feet and is supported by elastomeric bearings at each end. The bridge consists of a one foot thick slab section with ten (10) inch walls at the edge with an opening for precast access stairs located near the supports. The bridge was designed as an integral “C” shaped channel using RISA-3D software and Enercalc software in accordance with AASHTO and ACI 318 design codes.
Private Residence
Precast Deck and Foundation

This project involved the design of a precast concrete raised deck system for a private residence in Copake Lake, New York. The deck support structure was constructed entirely of precast concrete including spread footing, columns, perimeter beams, and deck. The final structure was topped with a wearing surface and included a perimeter safety railing for safety. Delta was responsible for the design and detailing of all precast elements for the project. The design was executed in accordance with ASCE 7-05 and utilized RISA-3D and Enercalc software for the development of calculations.
Caney Fork & Western Railroad Culvert Design

This project consisted of the design of a three barrel precast concrete culvert to carry railroad loadings over a stream in Coffee County, Tennessee. The three culverts (15 foot span x 6 foot rise) were placed side-by-side and were designed to carry a Cooper E80 railroad loading. The culverts were designed in accordance with AASHTO Standard Specifications 17th Edition and AREMA – Part 16 and used the FHWA Box Car Program for Structural Design of Reinforced Concrete Box Culverts. Concrete headwalls were added as a secondary pour using dowel bar splicers.
City of Indianapolis
Precast Concrete
Pedestrian Promenade

This high visibility project was designed for the City of Indianapolis as part of the preparation for hosting Super Bowl XLVI in February 2012. A three block pedestrian promenade that was originally conceived as primarily a cast-in-place (CIP) concrete project was reengineered to be a primarily precast concrete project solution. Delta was responsible for the design of the precast concrete components of the new solution including precast beams, utility vaults, stormwater sluiceways, and other system components.
Delta teamed with Kistner Concrete Products, Inc. to provide the New York State Department of Transportation (NYSDOT) with new Arch PCC span units and the north end precast spandrel wall for New York State Route 104 in Orleans County. Structural design services included calculations for Arch PCC span units, design for the connection of the spandrel wall to the arch sections, and the development of load ratings for the arch sections of the structure. Delta also provided handling analysis services as well as the review of installation drawings and shop drawings developed by Kistner.
PennDOT Architectural Eagle Panels

This project involved the design of an architectural precast concrete panel with a raised relief American Eagle design embedded on the form liner. The panels were used in the construction of abutments on a bridge that carries the Boulevard of the Allies in Pittsburgh, PA. This project was a Pennsylvania Department of Transportation project. Delta was responsible for the overall design of the panel which involved stripping calculations, handling calculations, and in-place connections. Delta was also responsible for coordinating the review of shop drawings for this project.
Effects of Holes in Precast Concrete

Ginny pigs...ask questions / give comments

Finite Element Modeling
- Uniform loads
- In one plane (horizontal or vertical)
- Looking at walls only...not floor
- Green good, red & blue bad

Load Paths
- cantilever from floor
- spans horizontally wall to wall

Load concentrated above hole
“Y” moments

Vertical bending
Load path
Cantilevering off floor
Horizontal shear at walls

Shear occurs when elements can not move together

No shear above hole

High shear at corners

Removed hole

Removed load

Little effect on wall shear
Vertical shear at floor

- Floor stopping wall from moving
- Removed hole
- Removed load from that area
- Little change in shear

Isolated spikes at opening are disregarded
Move hole to top edge of mono base

Horizontal bending less removed top cord of wall

Did not consider deflection without top cord holding wall flat probably deflecting inwards
Vertical bending
Vertical shear
Problems / things to watch for

Slot opening near bottom changes load path
- Horizontal bending
- No load shared in vertical direction
- Not considering floor, but can see change
Slotted hole
Vertical bending

Concentrated at edge of opening
Horizontal shear

Colors are scaled based on magnitude
High concentration at edges washes out remaining values

Would have to eliminate elements with concentrated values to see effects on rest of model
Vertical shear

Same concentration and washed out effect
Problem: knock out

Horizontal bending

Strength is removed but load is still applied if knock out is not used

Pulling iron above knock out could magnify problem
Knockout
Vertical bending
Horizontal shear

Little effect
Problem: Risers (no support from floor)

only load path available is horizontal to walls

Horizontal moment is concentrated below opening
Horizontal shear

Little effect
HOW MUCH IS TOO MUCH?

Replacement bars

- Half each side
- In the same plane

Max 2.5%

As < .025*Ac

ex. 6” wide x 8” tall above hole

.025*x*8 = 1.2 sq in = 4-#5 bars or 3-#6 bars
Horizontal shear

Little effect
Problem: Horizontal shear

Effects are washed out due to concentrated magnitudes at opening

Offset holes / corner holes can cause significant problems with shear

Handling can also be an issue
Manhole tops
Manhole risers thru hole

Effect is to want to egg shape riser like a vertical pipe

Concentration at opening

Need to run more models for magnitudes
Horizontal shear

OK since elements above hole are moving together
One hole

Similar effect for one hole or two holes
Tall mono base

The top half of the structure is starting to act like a riser and would be subject to the same one way load path limitation.
Top slabs

Uniform load only

Replacement bars
Load paths

Uniform load only

Shear can become a problem