Welded Wire Reinforced Precast Concrete Pipeline Project for the Louisville, KY International Airport Authority

A better solution than a cast-in-place box project

Louisville International Airport is the 8th largest air cargo airport in the world and the 5th largest in the U.S. Recognizing that efficient and effective air service is critical to the continued economic growth and development, plans were set in place 10 years ago for nearly a billion dollar expansion project which will provide an entirely new airport built over the site of the current one. Two new runways doubled the airfield’s capacity and allows simultaneous takeoffs and landings in all weather conditions. The new runways, with associated taxiways, aprons and related build up of the 3000 acre facility, substantially increased rain runoff. It necessitated a closed discharge system capable of handling over 1,200 cubic feet per second of storm water discharge. The primary storm interceptor was designed to consist of single, double and triple lines of 10’x5’ and 12’x5’ cast-in-place boxes.

Prior to bid letting, approval was given by the consulting engineers and the airport authority to allow 96” and 108” diameter precast reinforced concrete pipe as an alternate solution to the cast-in-place concrete boxes. Structural design of the reinforced concrete pipe was to be based on a 1,000,000 pound aircraft loading on a 17” thick concrete pavement with cover heights varying from 1.5’ to 20’.

More than 23,700 feet of reinforced concrete pipe (RCP) by CSR Hydro Conduit and Independent Concrete Pipe ranging from 18” to 108” diameter was required for the drainage facilities.

The largest pipe diameters are 96” and 108”, for the single, double and triple pipelines. They were installed in just 2 months. The project was completed on schedule and under budget. Independent Concrete’s plan to...
use precast reinforced concrete pipe won out over cast-in-place boxes with an installed savings of $3.4 million.

Working closely with the engineers, Independent Concrete engineers revised the plan to include 13,300 lineal feet of large precast pipe. The plan included 11,400 lineal feet of 108" diameter RCP and 1,850 lineal feet of 96" RCP in eight foot sections.

Welded wire reinforcement is required to satisfy the "D" load design and consider installation conditions. It is also used to enable immediate form stripping which allows for faster cycling and speeds up the production schedule. Heffern said, “We could cure the day’s early production so the pipe could be handled, then we cycled the pallets and headers and used them again the same day.” In accordance with ASTM Standard C76 WWR reinforcement cage configurations were full, circular inner and outer cages with quadrant mats. Stirrups were used in specific locations.

The success of the project was due to the hard work and expertise of many people brought to the job. Some of the participants involved were: Howard, Needles, Tammen & Bergendoff, the local Louisville design firm, MAC Construction & Excavating Inc., New Albany, IN and the combination of Independent Concrete Pipe and CRS Hydro Conduit, Louisville, KY.

To ensure a long lasting future, the precast concrete pipe industry consistently produces a uniform, high quality product. To make sure there is a healthy future for the industry, components that go into the manufacturing of pipe like welded wire reinforcement, must be manufactured economically while maintaining high quality.
Louisville Airport Inside Cage 108" RCP 2 x 12-W7.3 x W3.0
Inside Diameter + 1" Cover = 108" + 2" = 110"
Circumference (Cage Length) = 110 x $\pi = 345.575''$
No of Spaces = $\frac{345.575}{12} = 28.798 = 28$ spaces + $9\frac{1}{2}''$
Count 29 spaces - 30 Longitudinals
Overlap Longitudinal No. 30 $2\frac{1}{2}''$ Past Longitudinal No. 1
Use 55'' radius for full cage

Quadrant Mats
Inside Diameter + 1.505 Cover = 108 + 3.01'' = 111.01''
$1/4$ Circumference = 111.01 x $\pi / 4 = 87.187'' = 7.266$ spaces
Since longitudinals are on 12'' centers use 8 spaces - 9 Longitudinals
Use 56'' radius for quadrants mats
Louisville Airport
Outside Cage 108” LCP 2 x 12 - W5.7 x W2.5
Outside Diameter - Cover - Double Cage Thickness = 129.5 - 2(1) - 2(0.94) = 125.62
Use 62 3/4” radius
Circumference (Cage Length) = 125.62 x \(\pi\) = 394.647”

Nº of Spaces = 394.647 / 12 = 32.887 = 33 spaces does not allow a 2” lap, therefore decrease diameter based on 33 spaces less 2” lap
33 x 12” - 2” = 394” /\(\pi\) = 125.414” Count 33 spaces - 34 Longitudinals

Quadrant Mats
Fill cage diameter + cage thickness = 125.414 + (2)(0.47) = 126.354
Use 63 1/8” radius

1/4 Circumference = 1/4 x 126.354 x \(\pi\) = 99.238” = 8 spaces + 3 1/4”
Since longitudinals are on 12” centers use 9 spaces - 10 Longitudinals
Louisville Airport RW 17R-35L

Sta 159 + 00 Culvert A Triple 108" M.H. No 310

T.C. 470.25
Inv. 453.68
Depth 16.57" - 198.84"

Height of cover H = 63.09" = 5.26'

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Dead Load Factor = 1.3
Unit Wt = Vcone h + Vsoil h
Veff. = \( \frac{150 \times 7}{12} + \frac{125 \times 5.26}{17} + 63.09/12 \)
Veff. = 130.35

Live Load Factor = 1.3 x 1.67 = 2.17
WL = \([ p_2 + \frac{2}{3} (p_2 - p_1)] Be \)
WL = \([1420 + \frac{2}{3} (1999 - 1420)] 10.8 \)
WL = 19,505 Kpf

Steel Areas Required
Inside Cage ASI = 0.792
Outside Cage ASO = 0.618
Stirrups AS = 0.104
17 Lines @ Invert on 6" c/c

Steel Areas Supplied
Inside Cage ASI = 0.876
Outside Cage ASO = 0.684
Stirrups AS = 0.24
17 Lines @ Invert on 6" c/c

Double Wrap 2 x 12-W7.3 x W3.0
Double Wrap 2 x 12-W5.7 x W2.5
**Design Parameters**

**Live Load:** 1,000,000 lbs. on two landing gears with Type C Tricycle spaced 24 feet apart consisting of 8 tires on a 6-foot x 20-foot imprint.

**Earth Load:** Unit weight of 125 pounds per cubic foot.

**Pavement:** 17 inches thick weighing 150 lbs. per cubic foot.

**GEOMETRY:** CIRCULAR PIPE ANALYSIS AND DESIGN

Pipe Inside Diameter 108 in.
Pipe Wall Thickness 10.75 in.

**INSTALLATION CONDITIONS** — Radial Load System

Depth of Fill Variable
Soil-Structure Interaction Coefficient 1.2
Load Angle 240 deg
Bedding Angle for Soil, Water, and Live Load 120 deg
Bedding Angle for Pipe Weight Reaction 120 deg

**MATERIAL PROPERTIES**

Steel Reinforcing Yield Stress 70 ksi
Reinforcing Type: Welded Wire Fabric (# of Layers) 2
Design Concrete Strength 6 ksi
Concrete Density 1 50 pcf

**LOAD FACTORS**

Dead Load Factor (Shear and Moment) 1.3
Dead Load Factor (Thrust) 1.0
Live Load Factor (Shear and Moment) 2.17
Live Load Factor (Thrust) 1.0
Internal Pressure Factor (Thrust) 1.8

**PHI FACTORS**

Flexure
Diagonal Tension
Radial Tension
Limiting Crack Width Factor

**PROCESS FACTORS**

Radial Tension Process Factor 1.0
Shear Process Factor 1.0

**FLUID LOAD DATA**

Depth of Fluid 108 in.
Fluid Density 62.4 pcf
Pressure Head 0 ft.

**LIVE LOAD DATA**

Live Load Variable
Distribution Length along Pipe Diameter 129.5 in.
Distribution Length along Pipe Axis 12 in.

**CAGE REINFORCING TYPE**

DOUBLE CIRCULAR

**CONCRETE COVERS**

Inside Face 1 in.
Outside Face 1 in.

**MAXIMUM REINFORCING SPACING**

Inside Reinforcing Spacing, Asi 2 in.
Outside Reinforcing Spacing, Aso 2 in.

"This project will have a positive impact on the growth and prosperity of the City of Louisville for many years to come". The WRI and its members are proud to write about this unique pipeline project and echo Independent Pipe's remarks in wishing the City of Louisville, KY and the Louisville Airport Authority much success in their future endeavors.