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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.

Well prepared grade and proper alignment is essential before installing pipe.

A dump truck bed equipped with an air-controlled gate was used to accurately place the bedding material, #57 crushed stone.

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

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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.

Inlet structures were formed with steel reinforced concrete.

All parties agreed to an aggressive installation schedule. To assure timely production, Independent Concrete formed a joint venture with CRS Hydro Conduit, in Louisville for production of the 96" RCP. The 108" pipe was produced by Independent Concrete's Louisville plant.

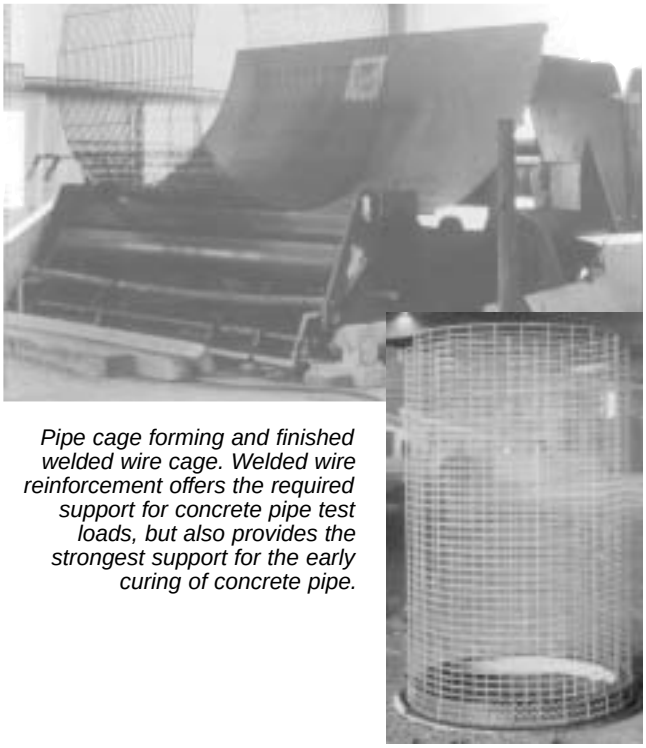
Paul Heffern, Corporate Engineer for Independent Concrete Pipe said they used PIPECAR software developed by Simpson, Gumpertz & Heger Inc., a computerized method to perform structural analysis. The program also produces exact areas of welded wire reinforcement (WWR) for specified pipe geometry, material properties and loading data.

New joint ring forms allowed as many as 24 pieces of 108" pipe to be manufactured per day using only 12 sets of rings.

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.

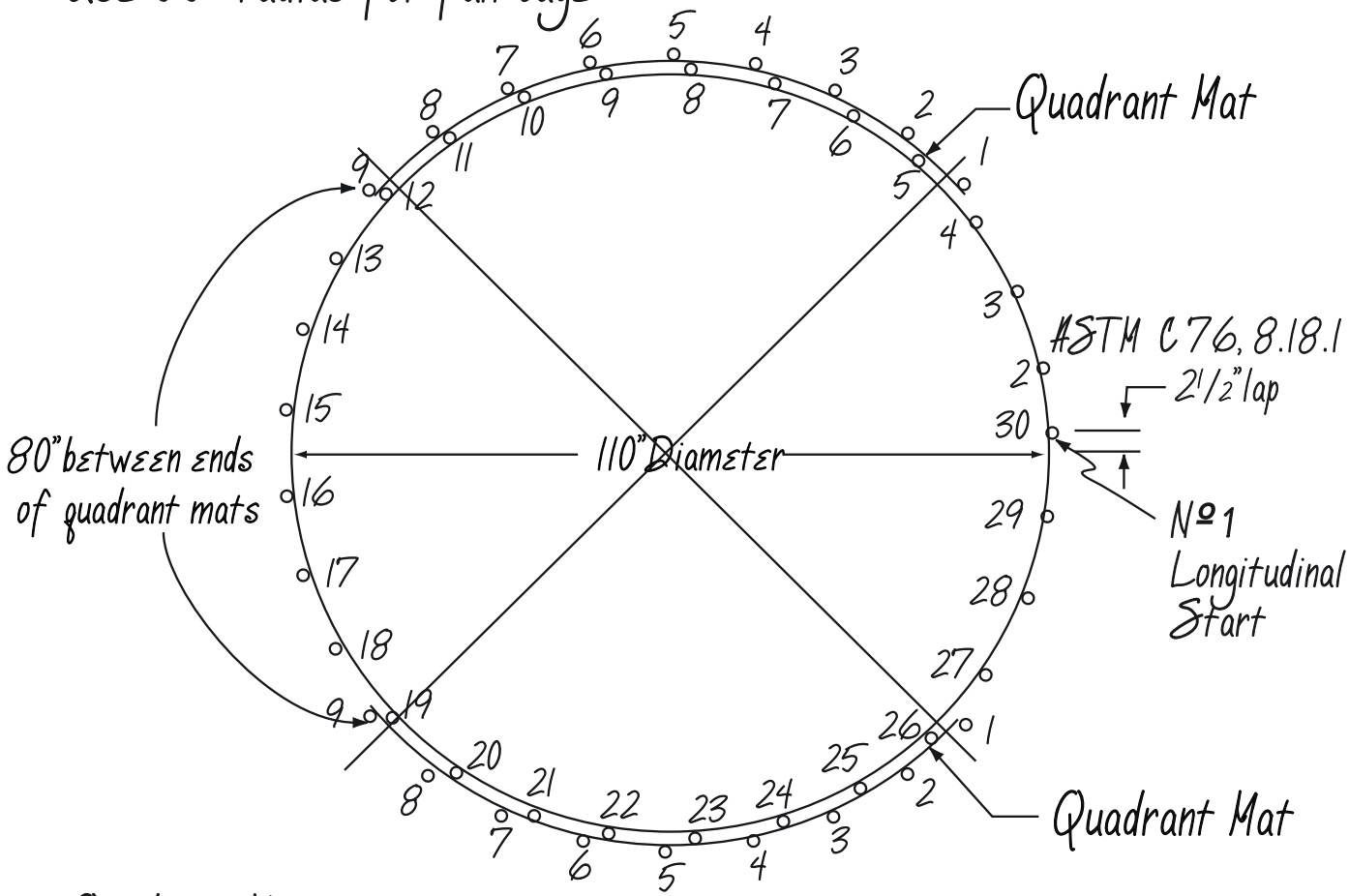
To ensure a long lasting future, the precast concrete pipe industry consistently produces a uniform, high quality product. To make sure there is a healthy future for the industry, components that go into the manufacturing of pipe like welded wire reinforcement, must be manufactured economically while maintaining high quality.



Pipe cage forming and finished welded wire cage. Welded wire reinforcement offers the required support for concrete pipe test loads, but also provides the strongest support for the early curing of concrete pipe.

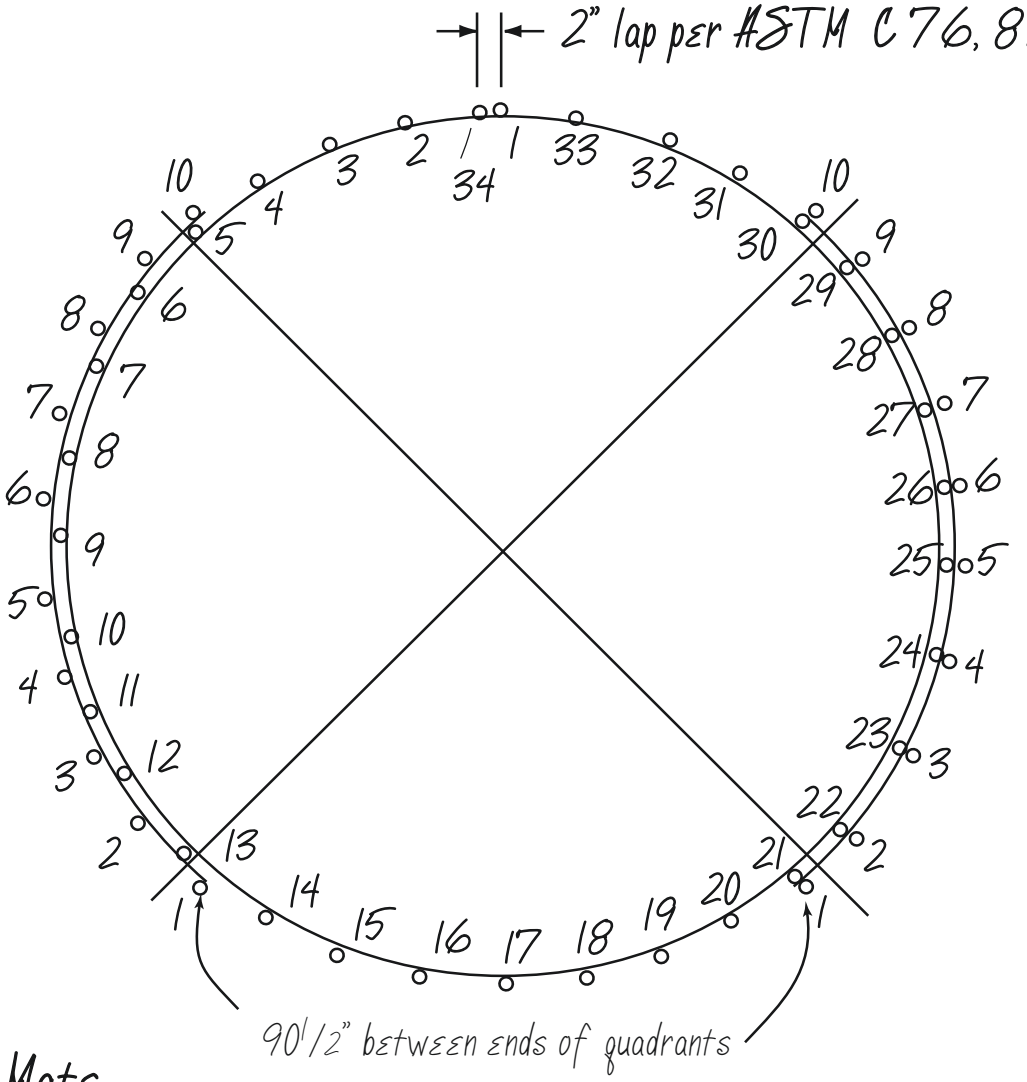
The following Calculations were provided by Mr. Heffern . . .

Louisville Airport Inside Cage 108" RCP 2 x 12-W7.3 x W3.0
Inside Diameter + 1" Cover = 108" + 2"=110"
Circumference (Cage Length)= 110xπ=345.575"
№ of Spaces = 345.575 / 12 = 28.798 = 28 spaces + 9 1/2"
Count 29 spaces - 30 Longitudinals
Overlap Longitudinal №30 2 1/2" Past Longitudinal №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 π /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" RCP 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 π = 394.647"
№ 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" /π = 125.414" Count 33 spaces - 34 Longitudinals



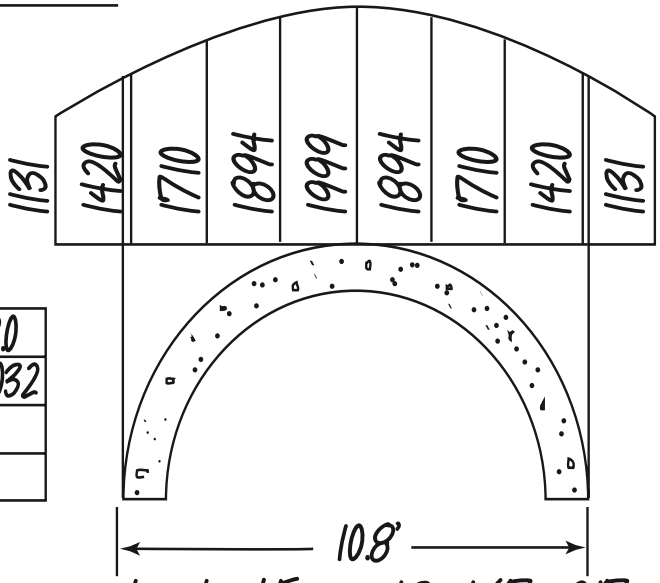
Quadrant Mats
Fill cage diameter + cage thickness = 125.414 + (2)(0.47) = 126.354
Use 63 1/8" radius
1/4 Circumference = 1/4 x 126.354 x π = 99.238" = 8 spaces + 3 1/4"
Since longitudinals are on 12" centers use 9 spaces - 10 Longitudinals

Louisville Airport RW 17R-35L Design 2

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

T.C. 470.25
Inv. 453.68
Depth 16.57' = 198.84"
135.75
Height of cover H = 63.09" = 5 26'

X/Rs	0.0	0.4	0.8	1.2	1.6	2.0
Coeff.	0.076	0.072	0.065	0.054	0.043	0.032
Pressure	1999	1894	1710	1420	1131	
Distance	0	1.75	3.5	5.25	7.0	



Dead Load Factor = 1.3

Unit Wt = $\frac{V_{cone}\,h + V_{soil}\,H}{h + H}$

$V_{eff.} = \frac{150 \times 17/12 + 125 \times 5\,26}{17 + 63\,09/12}$

$V_{eff.} = 130.35$

Live Load Factor = 1.3 x 1.67 = 2.17

$W_L = [p_2 + 2/3\,(p_2 - p_1)]\,B_E$

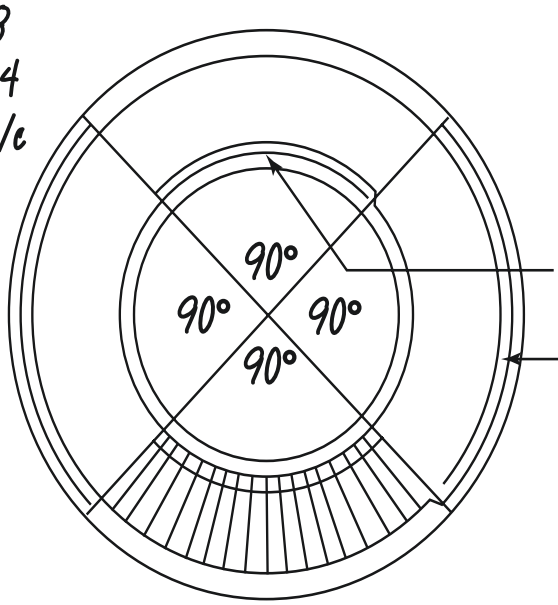
$W_L = [1420 + 2/3\,(1999 - 1420)]\,10.8$

$W_L = 19{,}505$ Kpf

Steel Areas Required

Inside Cage #S1 = 0.792
Outside Cage #S0 = 0.618
Stirrups A_S = 0.104
17 Lines @ Invert on 6" c/c

(sq. in. per ft.)

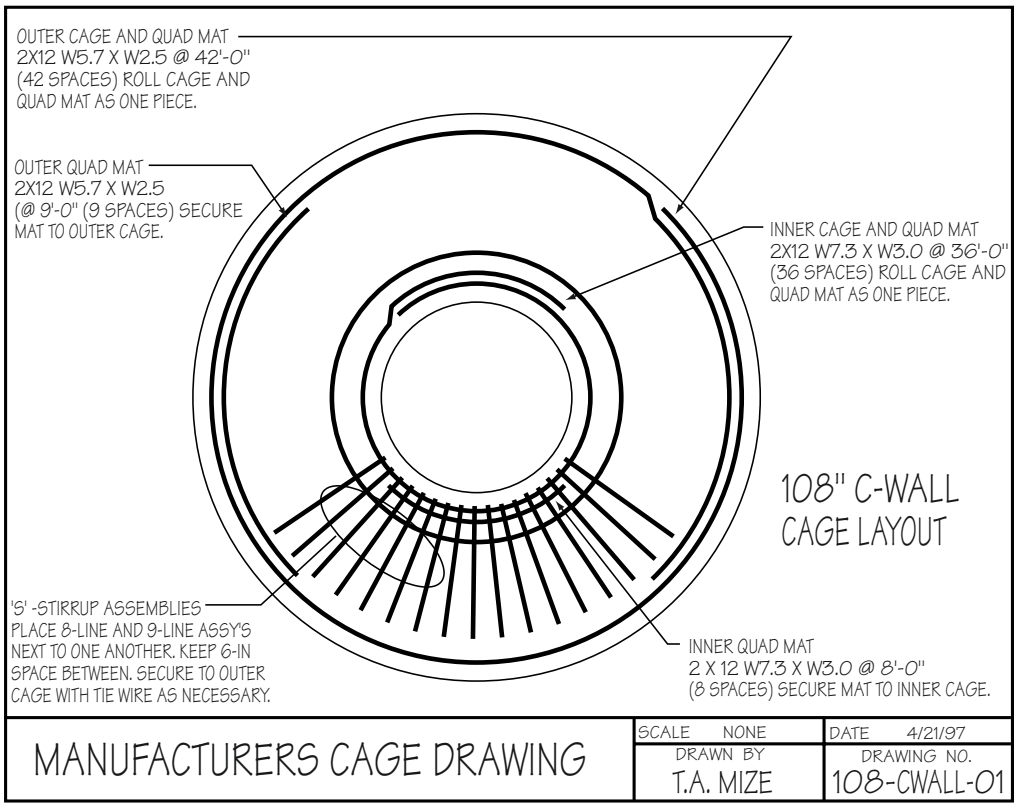


Steel Areas Supplied

Inside Cage #S1 = 0.876
Outside Cage #S0 = 0.684
Stirrups A_S = 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	.95
Diagonal Tension	.9
Radial Tension	.9
Limiting Crack Width Factor	.9

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 it's 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.