WIRE REINFORCEMENT INSTITUTE®

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Technical Blog

Welded Wire Reinforcement in ASTM C1577 Box Culverts

ASTM International's C1577 *Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO LRFD*[1] is a terrific example of how well-suited welded wire reinforcement (WWR) is as a structural reinforcement in precast concrete structures. While C1577 is noted to be a document that is primarily a manufacturing and purchasing specification, it also contains an expansive tabulation of standard box section designs along with supporting WWR-related content and commentary.

Here are some basic aspects of WWR in ASTM C1577 that every designer, precaster, and contractor should know, and how WRI member producers are integral to the process of box culvert specification and manufacture.

I. WWR is the default structural reinforcement

ASTM A1064 WWR with a minimum specified yield stress of 65,000 psi is cited in ASTM C1577 as the default circumferential and longitudinal steel reinforcement in box sections. Higher yield strengths are available up to 80,000 psi, which, if specified as part of a modified or special design, can potentially produce more economical solutions due to proportional reductions in cross-sectional steel. Both plain and deformed WWR are permitted for use.

It is worth noting that ASTM C1577 allows for the use of grade 60 rebar, but only as an "alternate steel design". Similarly, the Specification allows for the use of synthetic and nonsynthetic fibers manufactured per ASTM C1116, but categorizes these fibers as a "nonstructural manufacturing material". Fibers are not a structural reinforcement and are not suitable as an alternative to WWR in precast bolx culverts.

II. The ASTM C1577 Specification includes tabulated standard box culvert designs.

ASTM C1577 not only defines manufacturing, ordering, and inspection requirements for precast concrete box culverts, but it also includes an expansive table of predefined box geometry and earth cover combinations derived from design in accordance with the AASHTO LRFD Bridge Design Specifications. Each of these "standard" designs are accompanied by corresponding cross-sectional steel reinforcement areas. The inclusion of this information is intended to simplify and expedite the process of integrating precast boxes into a given project in those instances where the project-specific criteria is in alignment with one of the "ready-made" C1577 box designs. It is a great example of taking a progressive approach to design-build construction.

III. WWR Manufacturing and Value-Added Technical Services

WWR manufacturers are staffed with engineering technicians who specialize in the derivation and detailing of WWR solutions for a broad array of reinforced concrete structures. The efficiency and precision of this value-added service is perhaps nowhere more evident than in the preparation of reinforcement submittals for precast box culverts conforming to ASTM C1577.

As it relates to the process of box culvert design and procurement, a contractor or precaster will typically partner with the WWR manufacturer and provide to them the box culvert geometry for which WWR is required. This is typically done using one of the following options.

- **Option 1 - ASTM C1577 Section 7.1 Design Tables:** the contractor/precaster requests that steel configurations be selected directly from one of the tabulated box designs in ASTM C1577 characterized by predetermined geometry and loading conditions. The WWR manufacturer takes these corresponding steel areas in combination with the defined box geometry and in turn, uses proprietary graphical manufacturing software to quickly derive the required WWR mat configurations. These WWR configurations are presented in a highly illustrative submittal package that accompanies the quote/order documentation.

- **Option 2 - ASTM C1577 Section 7.2 Modified and Special Design, *Manufacturer Assist:*** the contractor/precaster-requested box culvert has a unique geometry and/or loading configuration that precludes the direct use of one of the C1577 tabulated designs, in turn requiring the derivation of steel reinforcement areas on an application/condition-specific basis. To satisfy this request, the WWR manufacturer will, in turn, use commercially available box culvert design software for the purpose of deriving preliminary reinforcing steel areas and extents. With the preliminary reinforcing steel and geometric box requirements in hand, the WWR manufacturer then populates its graphical manufacturing software and derives the WWR mat configurations. These WWR configurations are presented in a highly illustrative submittal package that accompanies the quote/order documentation.

- **Option 3 - ASTM C1577 Section 7.2 Modified and Special Design Option, *Manufacturer Detailing*:** similar to Option 2, the contractor/precaster-requested box culvert has a unique geometry and/or loading configuration that precludes the direct use of one of the C1577 tabulated designs. But in this case the application/condition-specific steel reinforcement requirements have already been derived and in turn, provided to the WWR manufacturer. To satisfy this type of request, the WWR manufacturer takes an approach that is essentially identical to Option 1, whereby graphical manufacturing software is populated and used to derive the corresponding WWR mat configurations. These WWR configurations are presented in a highly illustrative submittal package that accompanies the quote/order documentation.

IV. Responsibility for Structural Design

In all cases, the information derived by the WWR manufacturer is submitted to the contractor/precaster as a basis for material order and manufacture and does not constitute a structural design. For Option 1 above, the structural design is prescriptive and derived entirely from ASTM C1577 tabular information. For Options 2 and 3 noted above, the structural design of the box culvert and all of its related components (including final reinforcing steel requirements) is ultimately the responsibility of a duly-licensed design professional.

This is an important clarification to make, considering the level of detail provided by WWR manufacturers in their submittals can sometimes be mistaken by the customer to be a

turnkey structural design. To avoid this confusion, the WWR manufacturer will typically include disclaimer language to establish the limits of what the submittal represents.

With that said, there are some selected instances where a WWR manufacturer is asked by the customer to provide the structural design services for the precast box culvert. In these cases, because the manufacturer itself wouldn't qualify as a licensed design professional, the manufacturer will typically retain a third party licensed design professional and will have the structural design carried out as a delegated additional service.

V. ASTM C1577 Steel Reinforcement Identification

ASTM C1577 identifies steel reinforcement based on slab and wall regions, with circumferential reinforcement oriented perpendicular to the precast box segment's lay length and longitudinal reinforcement oriented parallel to the lay length:

- As1 = circumferential steel at outside wall face
- As2 = circumferential steel at inside face of top slab
- As3 = circumferential steel at inside face of bottom slab
- As4 = circumferential steel at inside wall face
- As5 = longitudinal distribution steel at inside face of top slab
- As6 = longitudinal distribution steel at the outside face of the top slab. This reference is largely outdated as research has shown that a minimal steel area (0.03 in^2/ft) is adequate for all scenarios.
- As7 = circumferential steel at outside face of top slab
- As8 = circumferential steel at outside face of bottom slab
- Minimum longitudinal reinforcement for all slabs and walls = 0.03 in^2/ft

THIS ATTACHMENT IS FOR INFORMATION PURPOSES ONLY AND IS PROVIDED SOLELY AS A BASIS FOR ORDER AND MANUFACTURE OF WELDED WIRE REINFORCING PRODUCT. IT IS NOT INTENDED TO REPRESENT A STRUCTURAL DESIGN. BOX CULVERT DESIGN IS BY OTHERS.

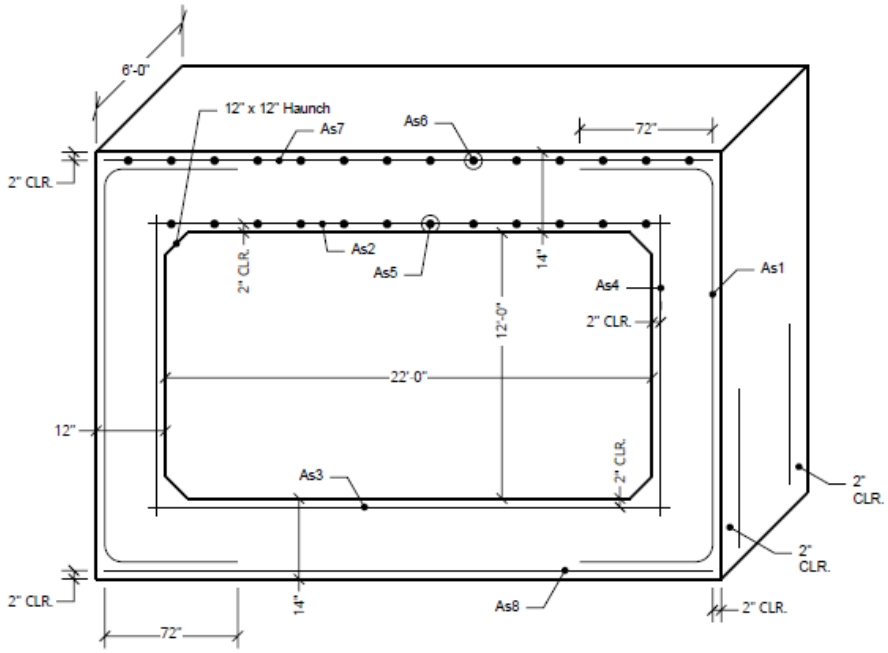
Checked			
Date		Rejected	Approved

ATTENTION

This information is provided for your review and approval. A signature is required before any material can be manufactured to these specifications.

Approved by: _____

Date: _____



BOX CULVERT SECTION

Total Boxes = 26
Weight Per Box = 3299.51 lbs.
Total Project Weight = 42.89 tons

#	REQ'D AREA	ACTUAL AREA	FABRIC SIZE	LENGTH
As1	1.140	1.140	D19.0	25'-11"
As2	1.320	1.320	D22.0	22'-8"
As3	1.320	1.320	D22.0	22'-8"
As4	0.340	0.360	D6.0	12'-8"
As5	0.340	0.345	D23.0	69"
As6	0.030	0.060	D4.0	69"
As7	0.340	0.360	D6.0	23'-8"
As8	0.340	0.360	D6.0	23'-8"

WWR MANUFACTURER, INC.

PROJECT: ABC ROADWAY
LOCATION: ANYTOWN, USA
CUSTOMER: XYZ PRECAST
DATE: 2022

ALL WIRE MEETS ASTM A1064.
WIRE IS GRADE 65 MIN. FOR SMOOTH AND GRADE 70 MIN. FOR DEFORMED.

An excerpt from a WWR manufacturer's submittal to the customer. Note the summary of required steel areas, box geometry, and clarifying language regarding the submittal's intent. This solution is comprised of eight (8) total WWR mats per box segment.

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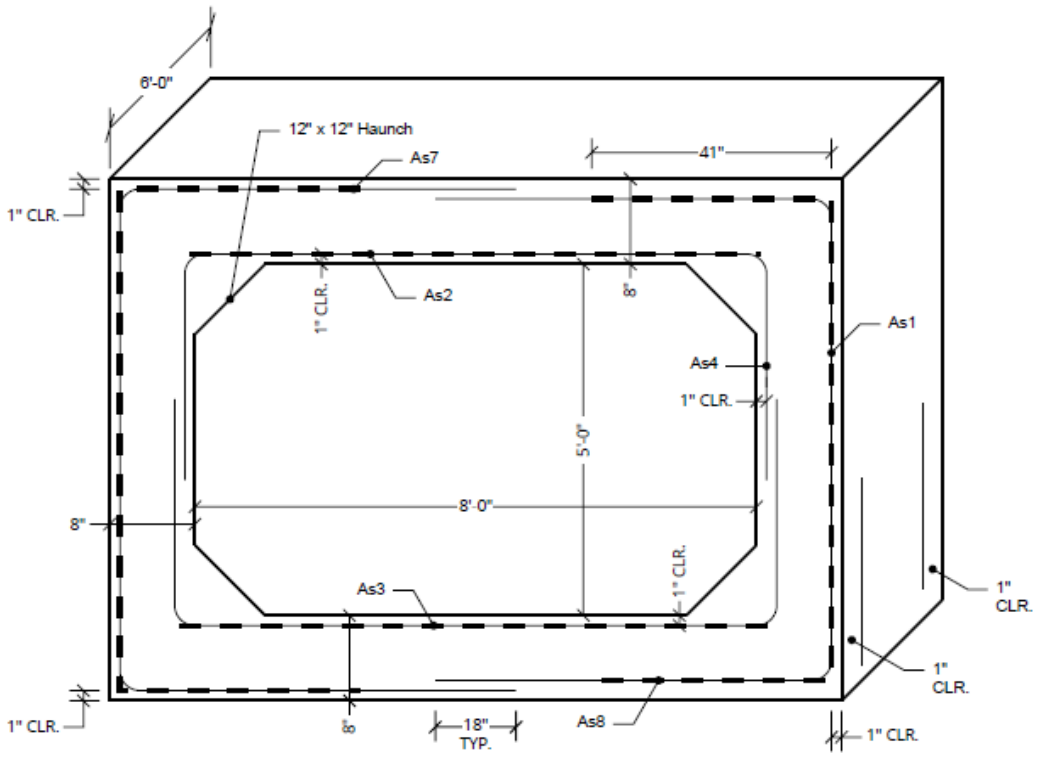


BOX CULVERT SECTION

Total Boxes = 53
Weight Per Box = 478.5 lbs.
Total Project Weight = 12.68 tons

#	REQ'D AREA	ACTUAL AREA	FABRIC SIZE	LENGTH
As1	0.330	0.330	D6.5 + D4.5	13'-0"
As2	0.410	0.420	D6.5 + D7.5	8'-0"
As3	0.420	0.420	D6.5 + D7.5	8'-0"
As4	0.190	0.195	D6.5	
As5				
As6				
As7	0.192	0.195	D6.5	9'-2"
As8	0.192	0.195	D6.5	9'-2"

ALL WIRE MEETS ASTM A1064.
WIRE IS GRADE 65 MIN. FOR SMOOTH AND GRADE 70 MIN. FOR DEFORMED.

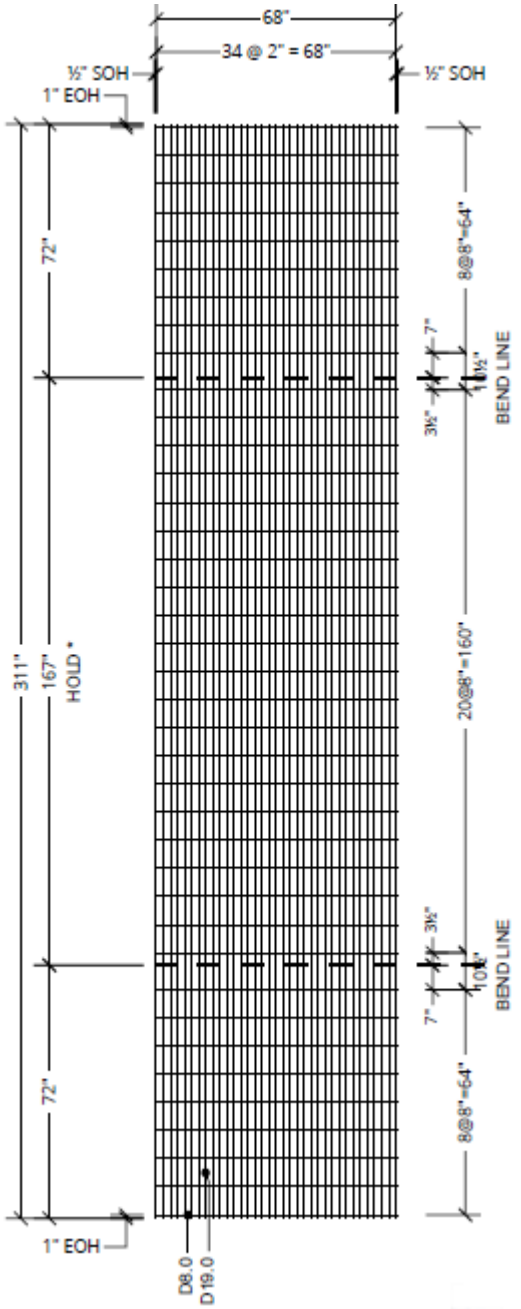
WWR MANUFACTURER, INC.

PROJECT: ABC ROADWAY
LOCATION: ANYTOWN, USA
CUSTOMER: XYZ PRECAST
DATE: 2022

An excerpt from a WWR manufacturer's submittal to the customer. This solution is comprised of four (4) total WWR mats per box segment, putting on display the efficiency that WWR brings to the precast box culvert manufacturing process. Note how required wall and slab steel areas are achieved on a common mat.

VI. WWR Versatility

The versatility of manufactured WWR wire sizes and mat geometry allows for multiple steel reinforcement requirements to be accommodated on a common sheet. The ability to draw incremental wire sizes facilitates the achievement of precise steel areas otherwise not easily accomplished with traditional deformed reinforcing bars. Because ASTM C1577 dictates that circumferential reinforcement be spaced at a maximum of 4 inches on center (not less than 2 inches on center), and longitudinal reinforcement be spaced not to exceed 8 inches on center, the ability to produce incremental wire sizes allows for the production of WWR mats that maintain "standard" whole-number wire spacing increments while still closely matching the specified steel areas.



As1

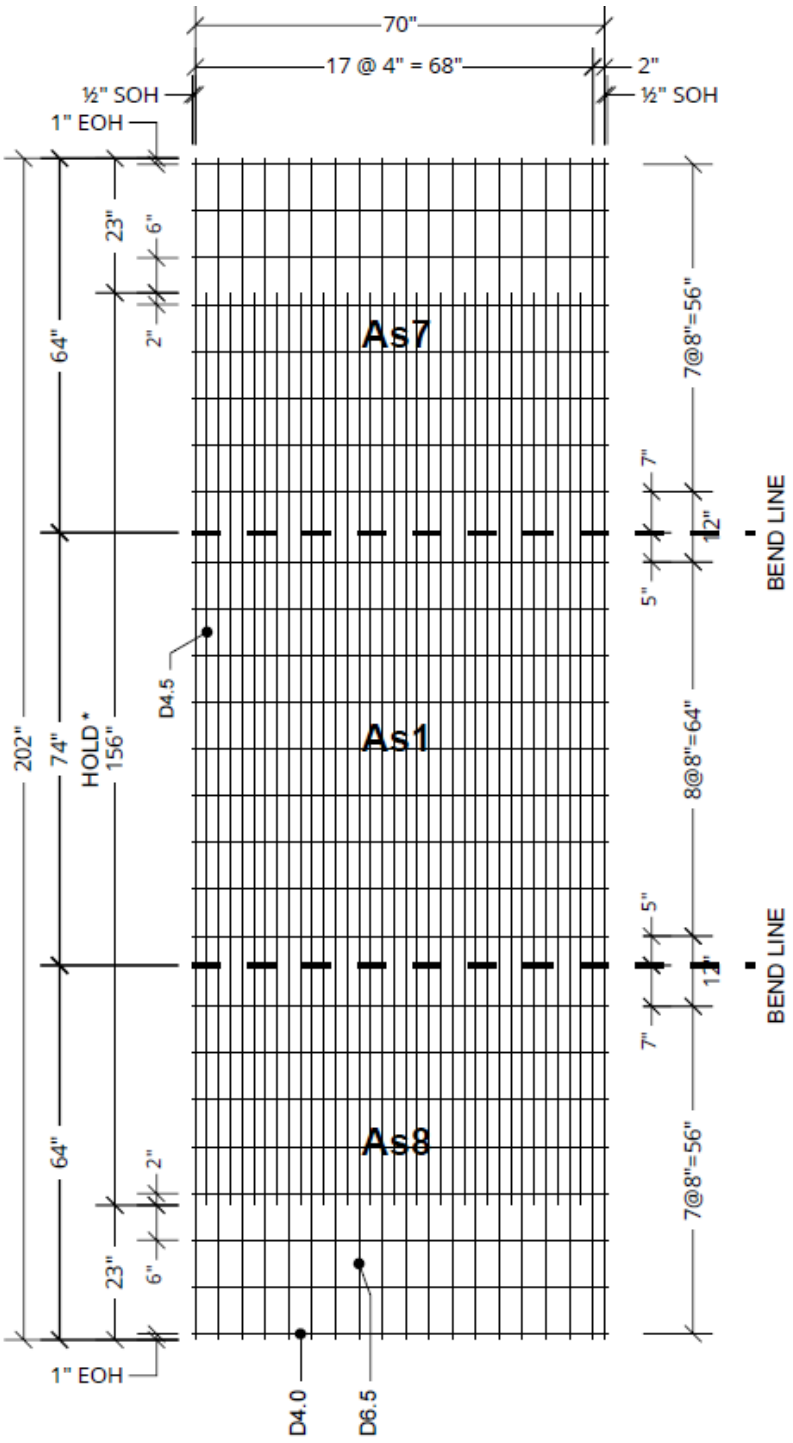
2xV D19.0 x D8.0 x 68"(+½", +½") x 25'-11"(1", 1")

CW = 1" - 8 @ 8" - 10.5" - 20 @ 8" - 10.5" - 8 @ 8" - 1"

52 sheets	NO.		SIZE	LENGTH	WEIGHT
LINE WIRE	35	D	19.0	25'-11"	585.90
SHORT LINE					
CROSS WIRE	39	D	8.0	69"	60.99
TOTAL					646.89

* Hold Out to Out Dimension Tolerance (+0", -.5")

An excerpt from a WWR manufacturer's submittal to the customer, showing D19.0 circumferential wires associated with the outside wall face with bend lines indicating that 90-degree extensions will terminate in the top and bottom slabs.

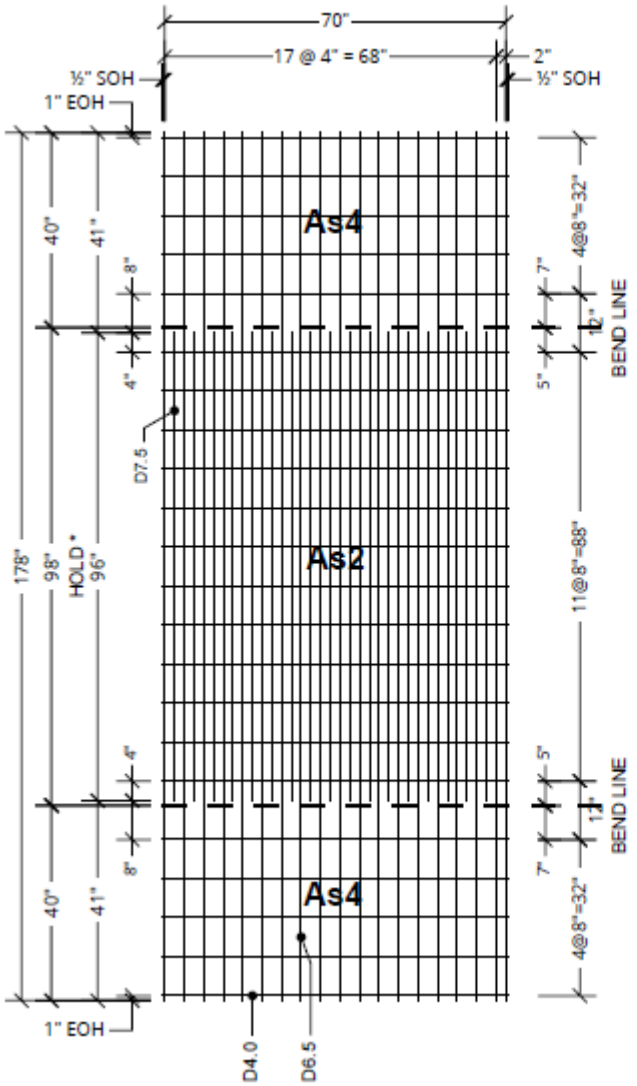


As1-7-8

2xV D6.5 / D4.5 x D4.0 x 70"(+½", +½") x 16'-10"(1", 1")
ALTERNATE D6.5 x 16'-10" w/ D4.5 x 13'-0" @ 4" (2", 2")
CW = 1" - 7 @ 8" - 12" - 8 @ 8" - 12" - 7 @ 8" - 1"

106 sheets	NO.		SIZE	LENGTH	WEIGHT
LINE WIRE	19	D	6.5	16'-10"	70.67
SHORT LINE	17	D	4.5	13'-0"	33.81
CROSS WIRE	25	D	4.0	71"	20.11
TOTAL					124.60

An excerpt from a WWR manufacturer's submittal to the customer showing circumferential wires associated with the outside wall face with bend lines indicating that 90-degree extensions will terminate in the top and bottom slabs and simultaneously satisfy the outside face reinforcement requirements for the slabs. The introduction of additional intermediate D4.5 circumferential wires achieves the higher cross-sectional steel requirement in the As1 (outside wall face) region compared to that which is required in the As7 (outside face of the top slab) and As8 (outside face of the bottom slab) regions.



As2-4

2xV D6.5 / D7.5 x D4.0 x 70"(+½", +½") x 14'-10"(1", 1")
ALTERNATE D6.5 x 14'-10" w/ D7.5 x 8'-0" @ 4" (4", 4")
CW = 1" - 4 @ 8" - 12" - 11 @ 8" - 12" - 4 @ 8" - 1"

53 sheets	NO.		SIZE	LENGTH	WEIGHT
LINE WIRE	19	D	6.5	14'-10"	62.28
SHORT LINE	17	D	7.5	8'-0"	34.68
CROSS WIRE	22	D	4.0	71"	17.70
TOTAL					114.65

An excerpt from a WWR manufacturer's submittal to the customer showing circumferential wires associated with the inside face of the top slab with bend lines indicating that 90-degree extensions will terminate within the inside faces of the walls, simultaneously satisfying the reinforcement requirements for both slab and walls. The introduction of additional D7.5 intermediate circumferential wires achieves the higher cross-sectional steel requirement in the As2 (inside face of the top slab) region compared to that which is required in the As4 (inside face of the wall) regions.

VII. Quality Control

Section 7 of ASTM C1577 not only defines the design requirements for precast box culverts but, in combination with Section 12, also establishes strict provisions for reinforcement positioning, extents, and terminations within the box structure. Because WWR is a manufactured structural reinforcement with tight fabrication tolerances, it is a natural fit for use in precast box culvert production characterized by a high level of quality control. An added bonus is the WWR manufacturer's ability to leverage proprietary graphical software to expedite the process of WWR mat detailing and takeoff, with the software itself automatically accounting for C1577 prescriptive requirements.

An assembly of WWR mats around the inner core form.

An assembly of WWR mats around the inner core form with a portion of the outer form visible

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1. *ASTM C1577-20e1 is the current edition of the specification at the time of blog publication.*

For more information on WWR, refer to www.wirereinforcementinstitute.org.