WIRE REINFORCEMENT INSTITUTE®

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Technical Blog

A Comparison of Slab-on-Ground Reinforcement Solutions

Welded wire reinforcement's (WWR) extreme versatility is evidenced by industry estimators' and design technicians' creation of project-specific reinforcement packages. Such packages are intended to provide the best balance between the engineer's design intent, contractor ease of installation, and manufacturing economy."

In this article, we explore a hypothetical project for which four manufacturers furnish WWR solutions that each satisfy the structural design intent, but are comparatively unique enough that savvy contractor involvement would likely be the deciding factor in determining which solution is ultimately selected.

The relevant model project parameters are as follows:

1. The project is 90,000 square feet of slab-on-ground. The slab-on-ground is panelized such that control joints (i.e. weakened plane joints or contraction joints) are spaced in a 15'-0" x 15'-0" orthogonal pattern. The result is 400 slab "panels" to be cast in place on a properly-prepared sub-base.

2. The slab reinforcement is specified to be 0.120 in^2/foot in each direction (equivalent to #3 reinforcing bars @ 11" on center each way or #4 @ 20" on center each way).

3. Reinforcement is positioned 1-inch clear from the top of the 5-inch thick slab. Concrete 28-day compressive strength is 4,000 psi.

4. The Engineer-of-Record has included pre-approval language allowing for WWR substitution of the originally-specified reinforcing bar options, provided the following are satisfied:
    - The specified unit cross-sectional area of reinforcement is maintained
    - Maximum wire size shall not exceed the diameter of a #4 reinforcing bar
    - Maximum wire spacing shall not exceed 20" on center.
    - WWR lap splices are configured to satisfy ACI 318-19 requirements

5. Reinforcement noted is not continuous through the control joints.

6. Reinforcement yield strength shall be 60,000 psi minimum and 80,000 maximum.

7. Placement tolerance for reinforcing bars or wires positioned parallel to the control joint shall be such that their centerline is not less than one inch but not more than two inches from the joint.

All solution options presented satisfy the requirements established by the Engineer of Record in the notes above. Calculation of lap splice lengths in accordance with ACI 318-19 is shown for each option utilizing WRI's online calculator:

https://wirereinforcementinstitute.org/technical-resources/calculators-and-tools/lap-splice-calculator

Manufacturer A offers the following slab panel solution, consisting of D4.0 wires spaced at 4” on center in both directions.

Development Specific Inputs

Select Wire/Bar Size to be Developed/Spliced:

D - 4

Diameter of Reinforcement (in)	Cross-Sectional Area of Reinforcement (in^2)
0.226	0.04

Are available Welded Crosswires relied upon by the Designer to Contribute to the Development of the Reinforcement?

○ Yes ◉ No

Select Reinforcement Yield Strength, f_y (psi):

60,000	65,000	**70,000**	72,500
75,000	77,500	80,000	100,000

Select Concrete Specified Compressive Strength, f'_c:

4,000

Select Modification Factor: Concrete Weight λ	Modification Factor: Reinforcement Grade Ψ_g
1	1
Select Modification Factor: Coating Ψ_e	Modification Factor: Size Ψ_s
1	0.8
Select Modification Factor: Casting Position Ψ_t	Product $\Psi_t\Psi_e$
1	1

Reinforcement Positioning Inputs

Spacing of Wires Being Developed	Clear Cover Dimension
4	1

Use K_{tr} = 0 as a Design Simplification? (Recommended)

◉ Yes ○ No

Required Minimum Length Results

Development Length: ← 12 in →

Class B Lap Splice Length ← 12 in →

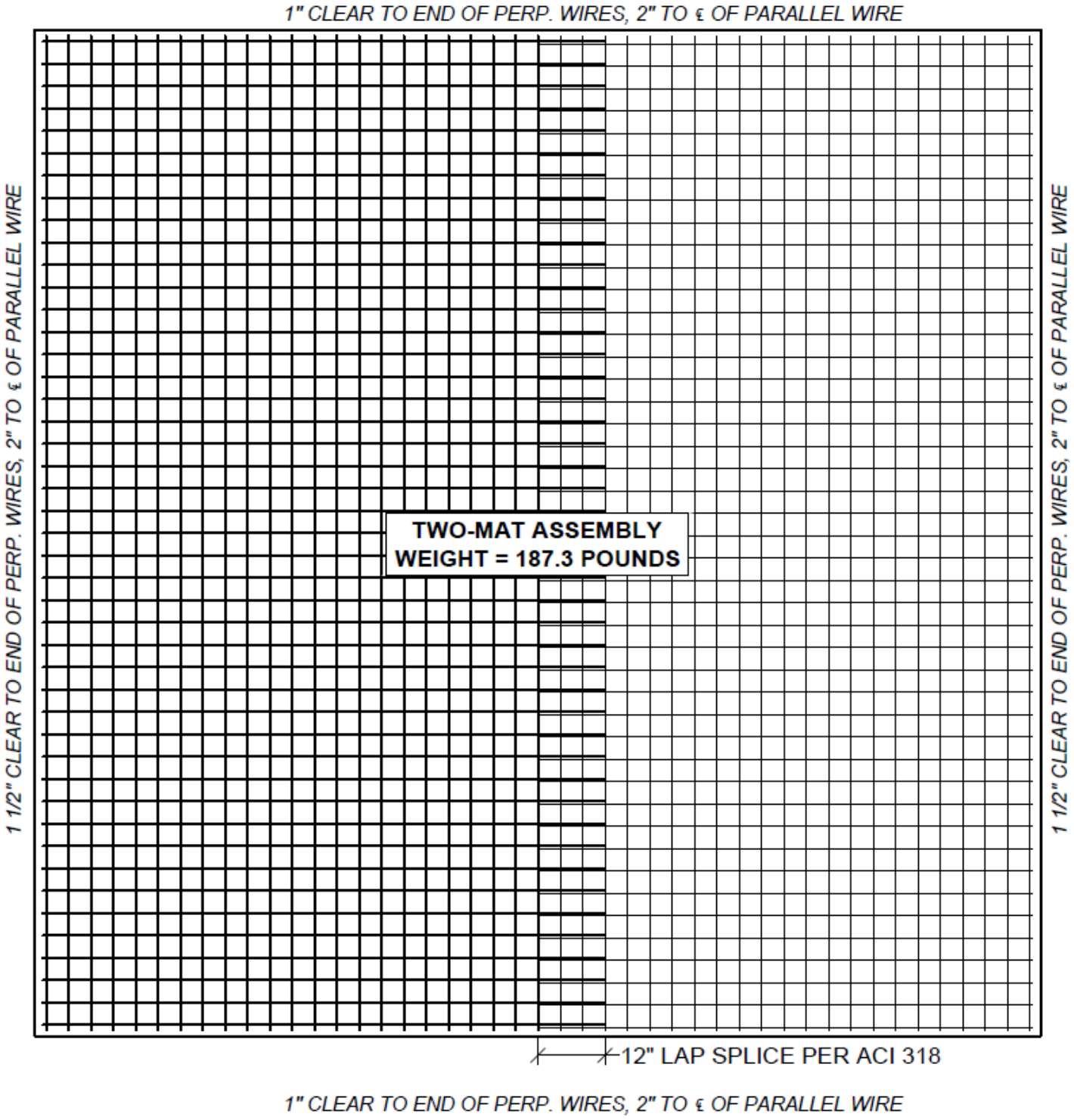
Additional Minimum Length Results

Variable c_b	1.113
Transverse Reinforcement Index K_{tr}	0
Confinement Term	2.5
Calculated Reference Development Length	6.0033 in
Prescriptive Minimum Development Length Dimension	12 in
Welded Deformed Wire Reinforcement Factor Ψ_w	1

Enter Email Address

4X4 D4.0/D4.0 88" (+0.5", +12") X 14'-10" (1",1")
97.733 POUNDS

4X4 D4.0/D4.0 84" (+4", +0.5") X 14'-10" (1",1")
89.589 POUNDS



Manufacturer B offers the following slab panel solution, consisting of D8.0 wires spaced at 8” on center in both directions.

Development Specific Inputs

Select Wire/Bar Size to be Developed/Spliced:

D - 8

Diameter of Reinforcement (in)	Cross-Sectional Area of Reinforcement (in^2)
0.319	0.08

Are available Welded Crosswires relied upon by the Designer to Contribute to the Development of the Reinforcement?

○ Yes ◉ No

Select Reinforcement Yield Strength, f_y (psi):

60,000	65,000	70,000	72,500
75,000	77,500	80,000	100,000

Select Concrete Specified Compressive Strength, f'_c:

4,000

Select Modification Factor: Concrete Weight λ	Modification Factor: Reinforcement Grade Ψ_g
1	1

Select Modification Factor: Coating Ψ_e	Modification Factor: Size Ψ_s
1	0.8

Select Modification Factor: Casting Position Ψ_t	Product $\Psi_t\Psi_e$
1	1

Reinforcement Positioning Inputs

Spacing of Wires Being Developed	Clear Cover Dimension
8	1

Use K_{tr} = 0 as a Design Simplification? (Recommended)

◉ Yes ○ No

Required Minimum Length Results

Development Length: 12 in

Class B Lap Splice Length: 12 in

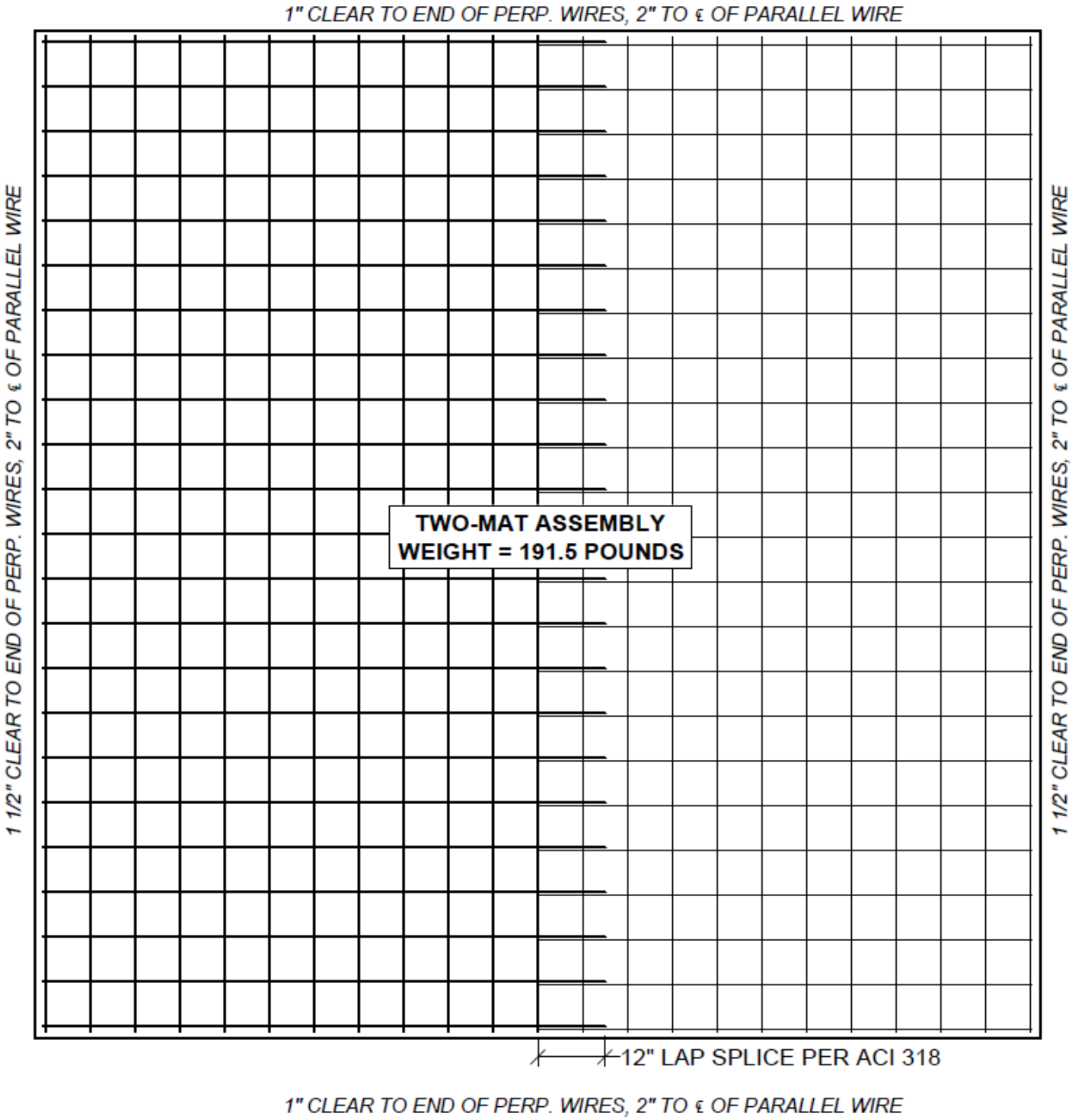
Additional Minimum Length Results

Variable c_b	1.1595
Transverse Reinforcement Index K_{tr}	0
Confinement Term	2.5
Calculated Reference Development Length	8.4736 in
Prescriptive Minimum Development Length Dimension	12 in
Welded Deformed Wire Reinforcement Factor Ψ_w	1

Enter Email Address

8X8 D8.0/D8.0 88" (+0.5", +12") X 14'-10" (1",1")
100.892 POUNDS

8X8 D8.0/D8.0 80" (+8", +0.5") X 14'-10" (1",1")
90.593 POUNDS



Manufacturer C offers the following slab panel solution, consisting of D16.0 wires spaced at 16” on center in both directions.

Development Specific Inputs

Select Wire/Bar Size to be Developed/Spliced:

D - 16

Diameter of Reinforcement (in)	Cross-Sectional Area of Reinforcement (in^2)
0.451	0.16

Are available Welded Crosswires relied upon by the Designer to Contribute to the Development of the Reinforcement?

○ Yes ◉ No

Select Reinforcement Yield Strength, f_y (psi):

60,000 | 65,000 | **70,000** | 72,500 | 75,000 | 77,500 | 80,000 | 100,000

Select Concrete Specified Compressive Strength, f'_c:

4,000

Select Modification Factor: Concrete Weight λ	Modification Factor: Reinforcement Grade Ψ_g
1	1

Select Modification Factor: Coating Ψ_e	Modification Factor: Size Ψ_s
1	0.8

Select Modification Factor: Casting Position Ψ_t	Product $\Psi_t\Psi_e$
1	1

Reinforcement Positioning Inputs

Spacing of Wires Being Developed	Clear Cover Dimension
16	1

Use K_{tr} = 0 as a Design Simplification? (Recommended)

◉ Yes ○ No

Required Minimum Length Results

Development Length: ← 12 in →

Class B Lap Splice Length: ← 15.57 in →

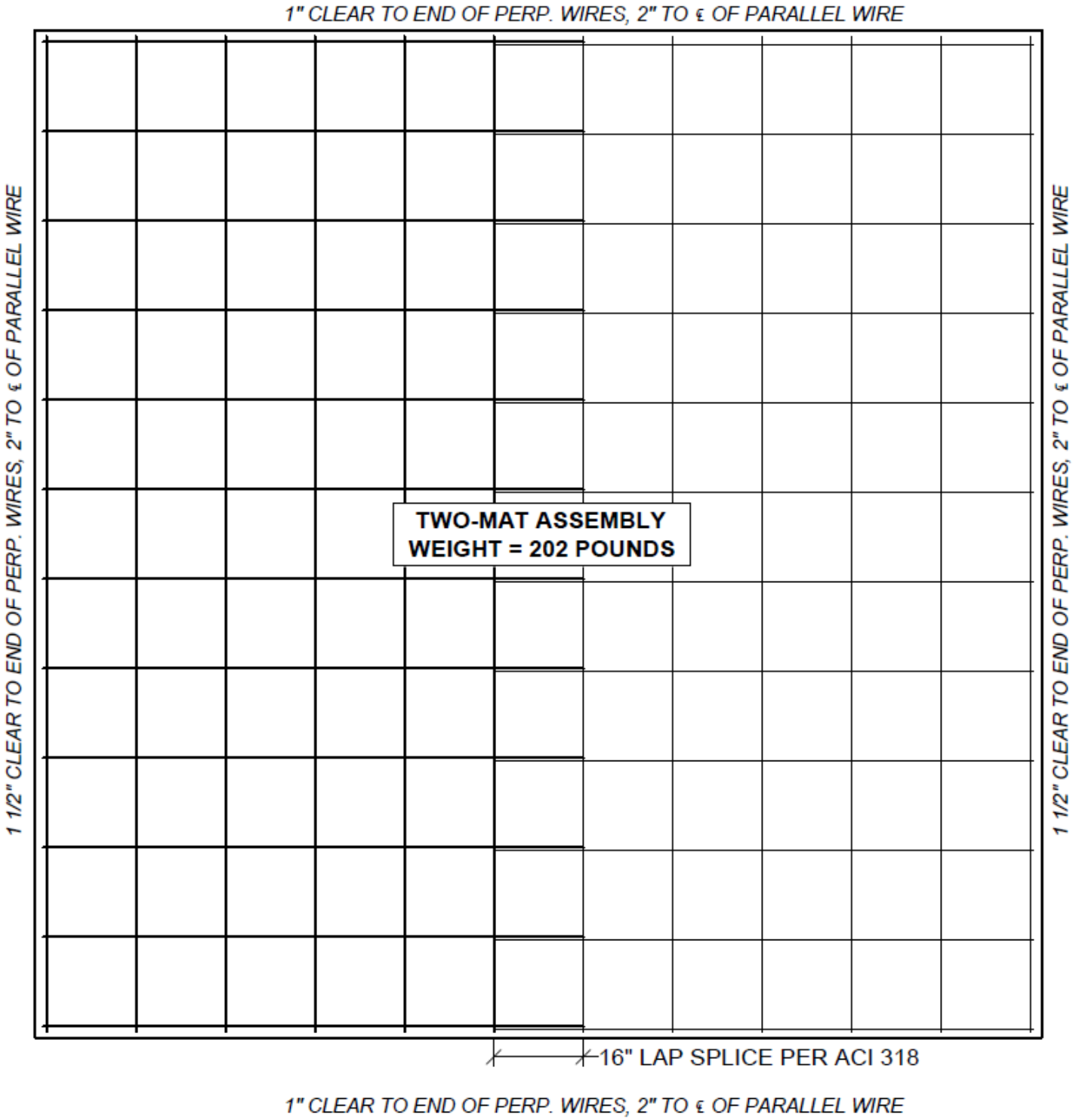
Additional Minimum Length Results

Variable c_b	1.2255
Transverse Reinforcement Index K_{tr}	0
Confinement Term	2.5
Calculated Reference Development Length	11.98 in
Prescriptive Minimum Development Length Dimension	12 in
Welded Deformed Wire Reinforcement Factor Ψ_w	1

Enter Email Address

16X16 D16.0/D16.0 80" (+0.5", +16") X 14'-10" (1",1")
100.995 POUNDS

16X16 D16.0/D16.0 80" (+0.5", +16") X 14'-10" (1",1"),
100.995 POUNDS, PLAN ROTATE 180-DEGREES



Manufacturer D offers the following slab panel solution, consisting of plain (nondeformed) W4.0 wires spaced at 4” on center in both directions.

Development Specific Inputs

Select Wire/Bar Size to be Developed/Spliced:

W - 4

Diameter of Reinforcement (in)	Cross-Sectional Area of Reinforcement (in^2)
0.226	0.04

Are available Welded Crosswires relied upon by the Designer to Contribute to the Development of the Reinforcement?

Welded Crosswires are Mandatory

○ Yes ◉ No

Select Reinforcement Yield Strength, f_y (psi):

60,000	65,000	70,000	72,500
75,000	77,500	80,000	100,000

Select Concrete Specified Compressive Strength, f'_c:

4,000

Select Modification Factor: Concrete Weight λ	Modification Factor: Reinforcement Grade Ψ_g
1	1

Reinforcement Positioning Inputs

Spacing of Crosswire	Spacing of Wires Being Developed
4	4

Required Minimum Length Results

Development Length: 6 in

Lap Splice Length 6 in

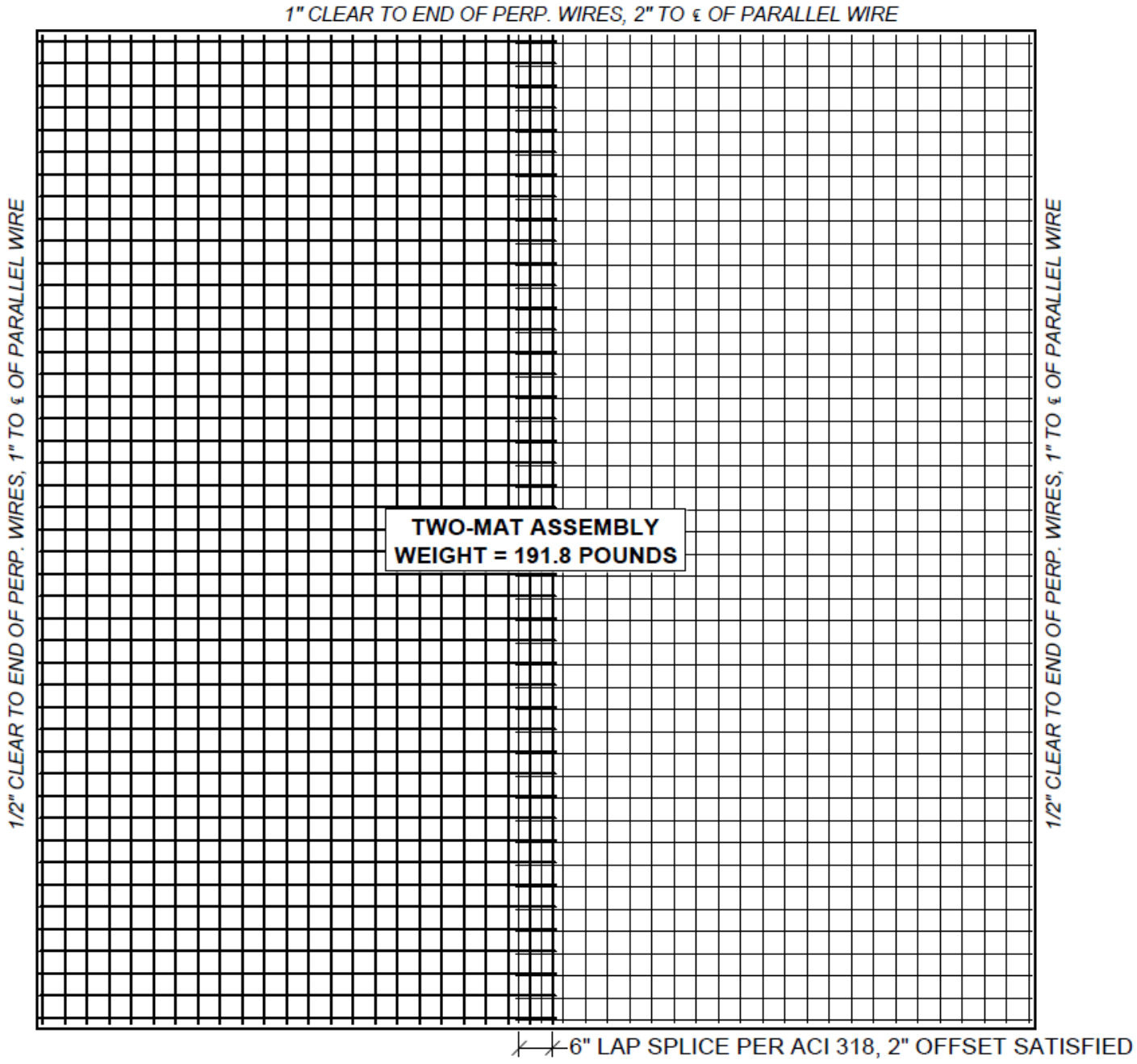
Additional Minimum Length Results

Prescriptive Minimum Development Length Dimension	6 in
Prescriptive Minimum Lap Splice Length Dimension	6 in
Calculated Development Length Dimension	6 in
Calculated Lap Splice Length Dimension	6 in

Enter Email Address

4X4 W4.0/W4.0 92" (+0.5", +0.5") X 14'-10" (1",1")
95.924 POUNDS

4X4 W4.0/W4.0 92" (+0.5", +0.5") X 14'-10" (1",1")
95.924 POUNDS



ATTRIBUTE	MANUFACTURER A	MANUFACTURER B	MANUFACTURER C	MANUFACTURER D
WWR STYLE	4X4 D4/D4	8X8 D8/D8	16X16 D16/D16	4X4 W4/W4
STEEL AREA EACH DIRECTION	0.120 IN^2 PER FOOT	0.120 IN^2 PER FOOT	0.120 IN^2 PER FOOT	0.120 IN^2 PER FOOT
TOTAL WWR MATS	800	800	800	800
UNIQUE MAT TYPES	2	2	1	1
STEEL WEIGHT AND (MATERIAL PREMIUM)	74,920 POUNDS (N/A)	76,600 POUNDS (+2.2%)	80,800 POUNDS (+7.8%)	76,720 POUNDS (+2.4%)
EXPECTED SUPPORT SPACING (WRI TF-702)	2-3 FEET	3-4 FEET	4-6 FEET	2-3 FEET
REINFORCEMENT CO-PLANAR?	YES	YES	YES	NO
LAP SPLICE "BUILD-UP"	NO	NO	NO	YES
STEP-THROUGH CONFIGURATION?	NO	NO	YES	NO

The above tabulation presents several attributes that go beyond merely satisfying the designer's specified requirements. The involvement of the contractor and relevant placing subcontractor (if applicable) as early on in the process as possible is critical to help arrive at the selection that best satisfies the project time and labor criteria. Conversations between the WWR manufacturing technical staff and the contractor are extremely important.

Questions and observations may arise in reviewing the above compilation of WWR project data; some are summarized below.

- A focus on lowest steel tonnage is often a short-sighted approach to reinforcement takeoff. The material cost and labor component of chair installation can't be ignored. Lighter reinforcement comprised of smaller wire diameters will require tighter support spacing, while heavier reinforcement allows for wider support spacing resulting the need for fewer supports to maintain the intended placement tolerance.

- All solutions presented are manageable from a mat inventory standpoint: keeping track of one mat type is obviously the simplest possible solution. Keeping track of two unique mat types requires some added attention in the field for staging and placement but is still extremely manageable. As WWR mat inventories increase to include numerous unique WWR styles, the process of placement is eased considerably by the provision of highly-detailed placement drawings prepared by the manufacturer's technical detailer.

- Plain welded wire reinforcement cannot maintain co-planar positioning of lapped mats due to the presence of "anchor" wires within the lap region itself. As such, a stacked arrangement occurs in the area where the mats are lap spliced, and this requires both designer attention as well as contractor attention in the field related to placement tolerance.

- Will the concreting operation be improved by WWR mats that allow for workers to be able to step through the reinforcement mats? With 4-inch and 8-inch spacing, worker traffic on top of the mats is unavoidable.

- If a plain welded wire reinforcement option and deformed welded wire reinforcement have identical wire size and spacing, the deformed WWR option will generally result in lower overall steel weight. Instances in which steel tonnage of plain WWR might be less than a deformed WWR option are typically limited to situations in which the reinforcement casting position requires more than 12 inches of concrete to be placed below the plane of horizontal placement, and/or when the reinforcement is to be coated. Both of these scenarios require lap splice length modification factors to be applied, resulting in considerably longer lap splice lengths for deformed welded wire, while plain welded wire reinforcement lap splices are not impacted. For normal slab-on-ground applications, however, the need for these lap splice modification factors to be applied is quite rare and deformed welded wire reinforcement ends up being the more economical solution.

Maximizing the advantages of WWR utilization on a project is always a function of collaboration between the engineer, contractor, and manufacturer. The introduction of WWR as a reinforcement solution on a project carries with it a baseline benefit to time and labor allocation on the jobsite when compared to loose bar reinforcement placed individually. This benefit can be further optimized through purposeful and candid interaction of the stakeholders involved, with attributes like those presented in this article being discussed and thoughtfully worked through.

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