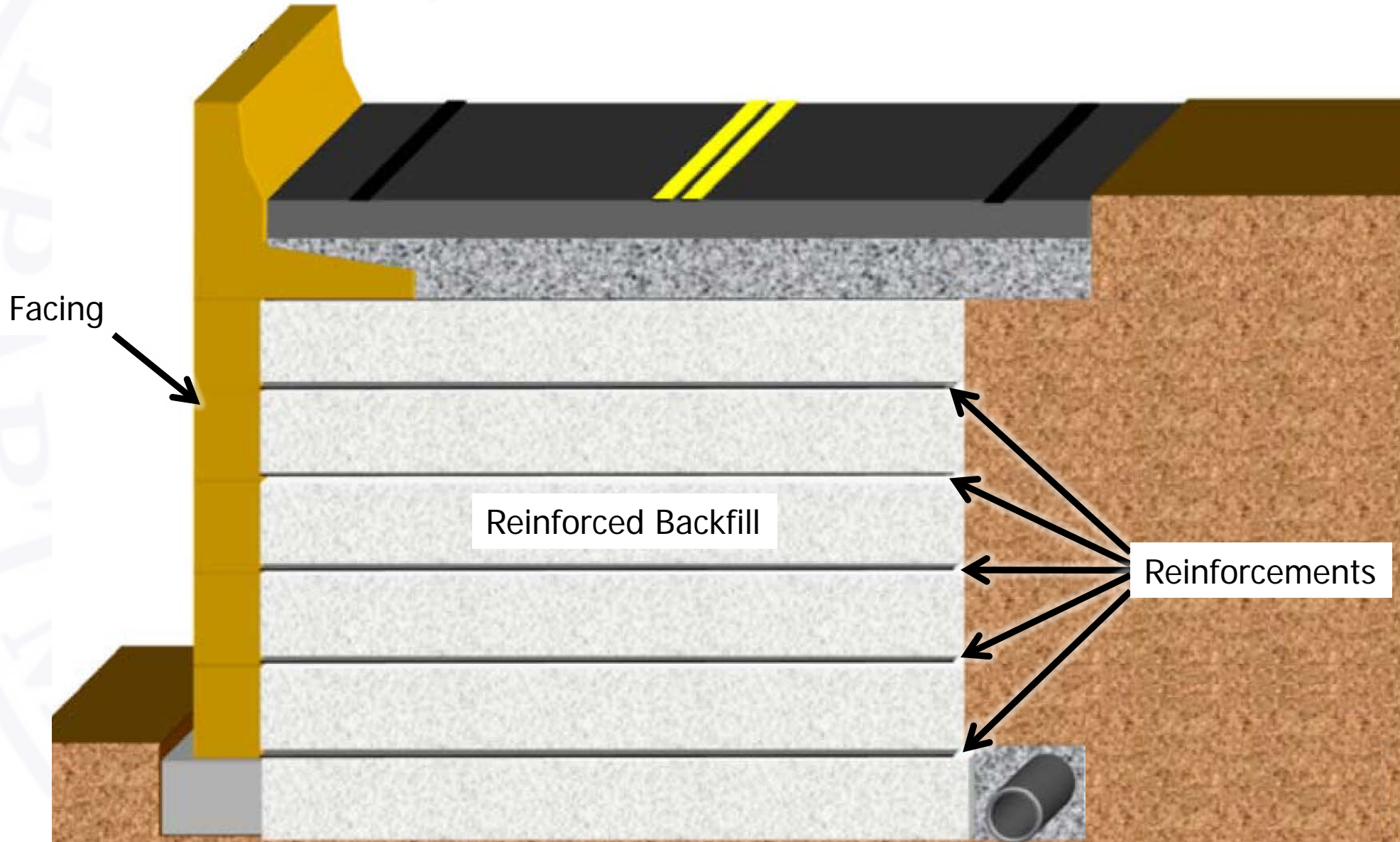


# Construction of MSE Walls for INDOT Projects

Peter J. Becker, PhD, PE

Indiana Department of Transportation  
Division of Research & Development

# Mechanically Stabilized Earth (MSE) Walls



# Applications

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- Retaining wall
- Abutments
- Wing Walls
- Landslide repair
- Crash wall
- Pedestrian ramps
- Phased construction

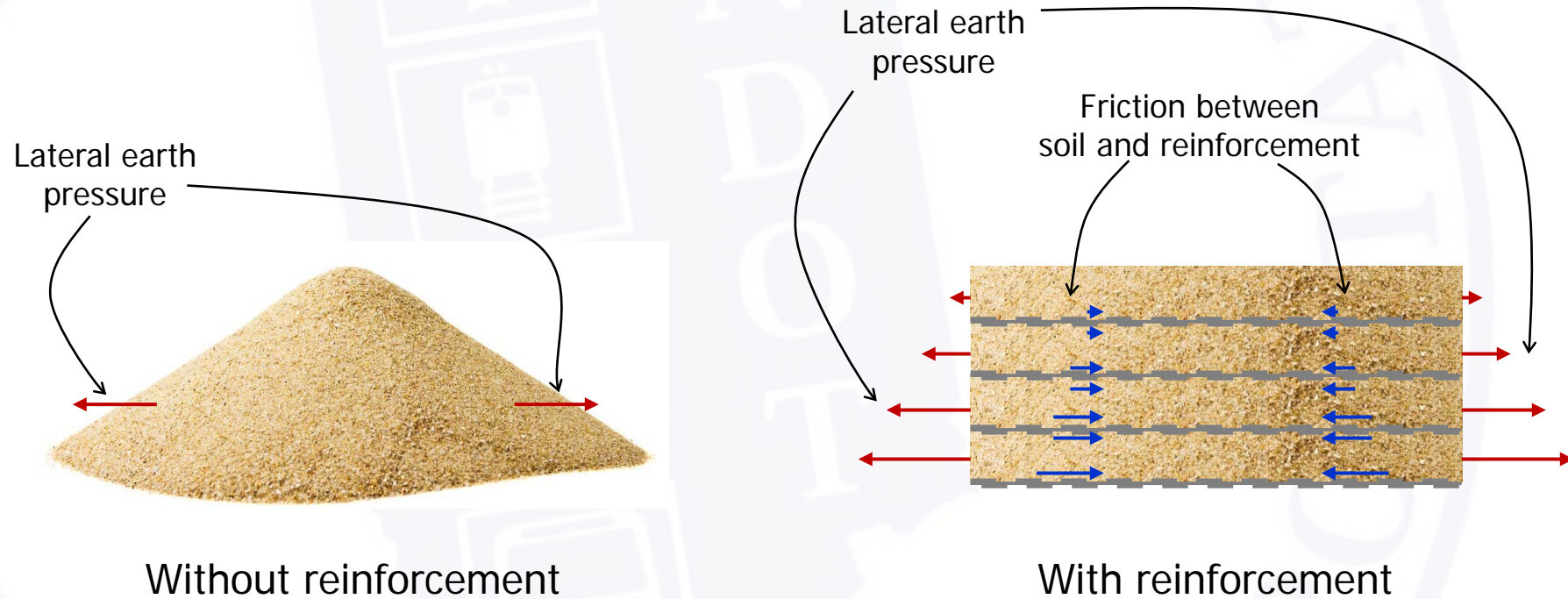






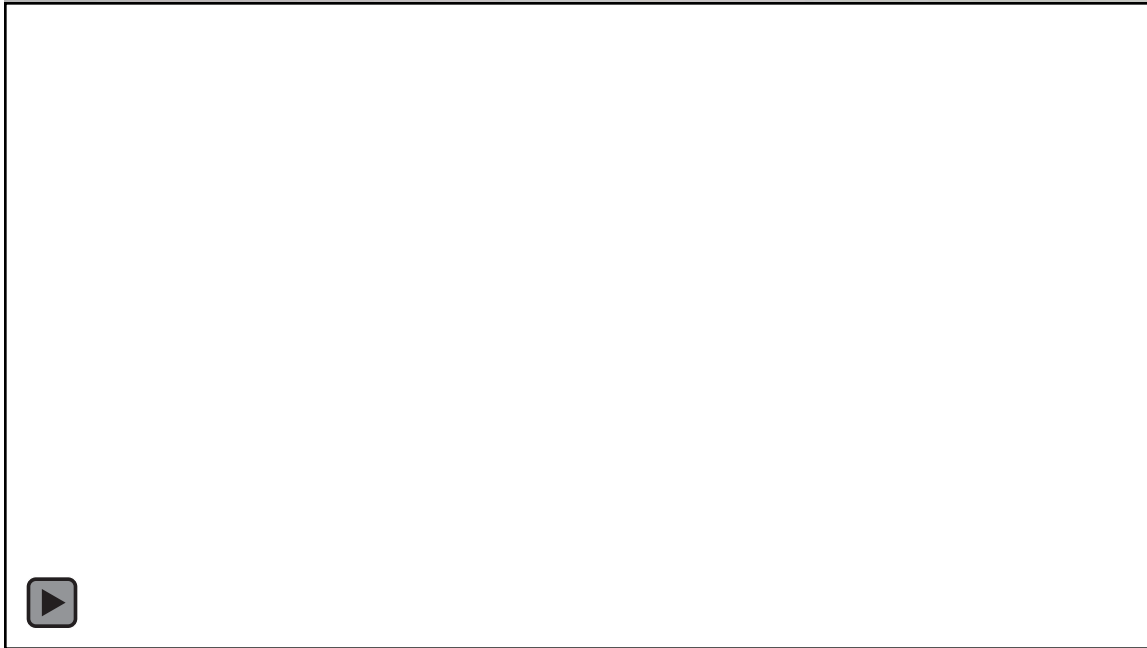


# Principle Behind Mechanically Stabilized Earth

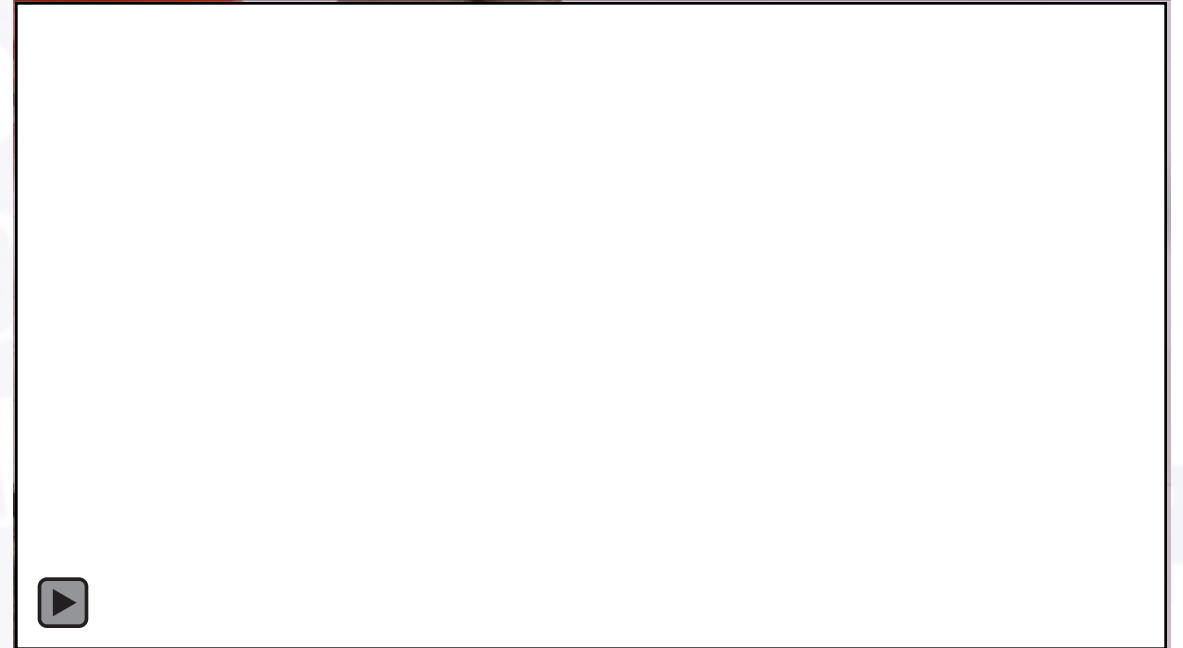


# Principle Behind Mechanically Stabilized Earth

No Reinforcement



With Reinforcement



How Geogrid Works: Lateral Restraint Demonstration



Tensor, a division of CMC  
5.53K subscribers



YouTube

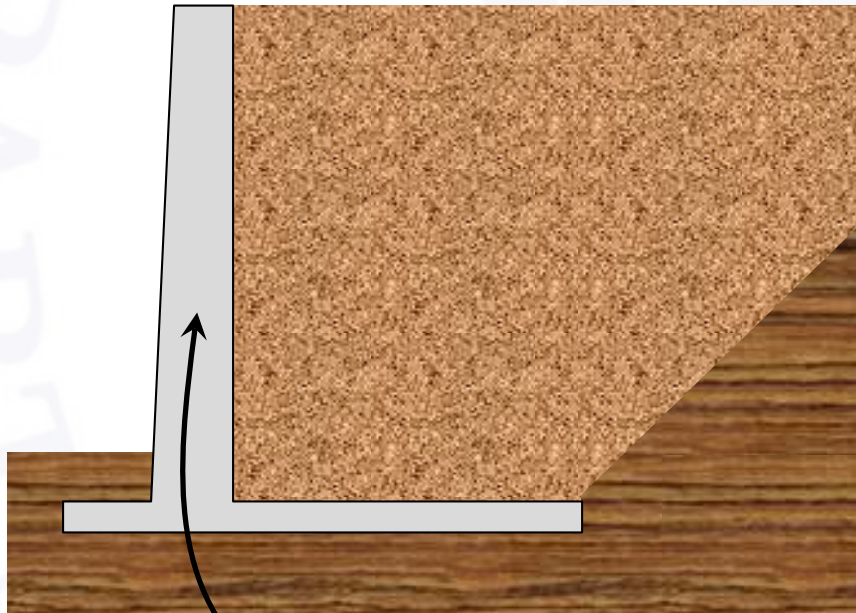
<https://youtu.be/Ra4B5Tx4Qck>

The logo for NextLevel INDIANA, featuring a stylized 'N' and the text "NextLevel INDIANA".

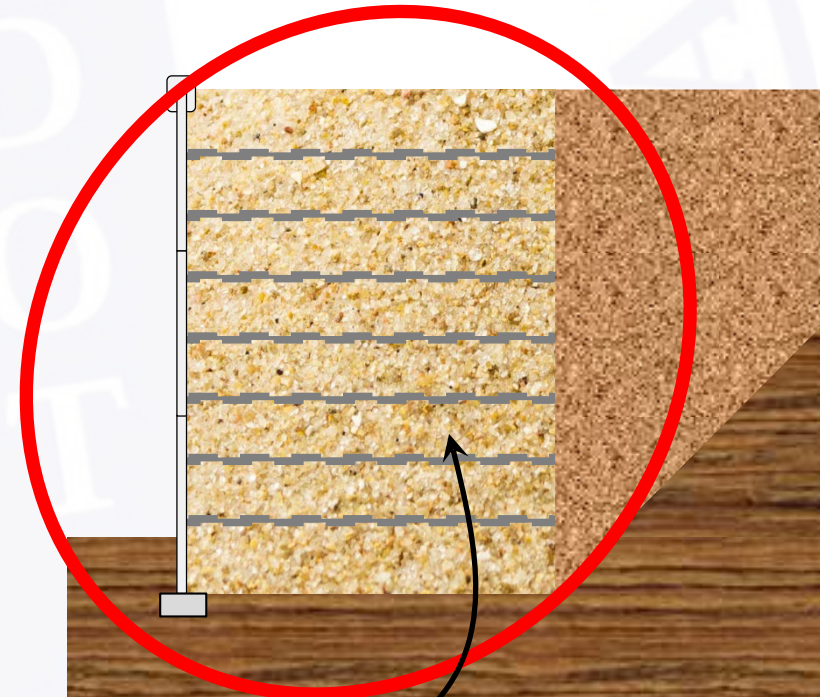


# Mechanically Stabilized Earth as a Retaining Structure

Cantilever Retaining Wall



MSE Wall



# Major Advantages

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- Simple and rapid construction
- Cost effective
  - Less site preparation
  - Unskilled labor and small equipment
  - Reduced ROW acquisition
  - Less space needed in front during construction
  - No deep foundations
- Technically feasible to heights > 100 ft

# Disadvantages

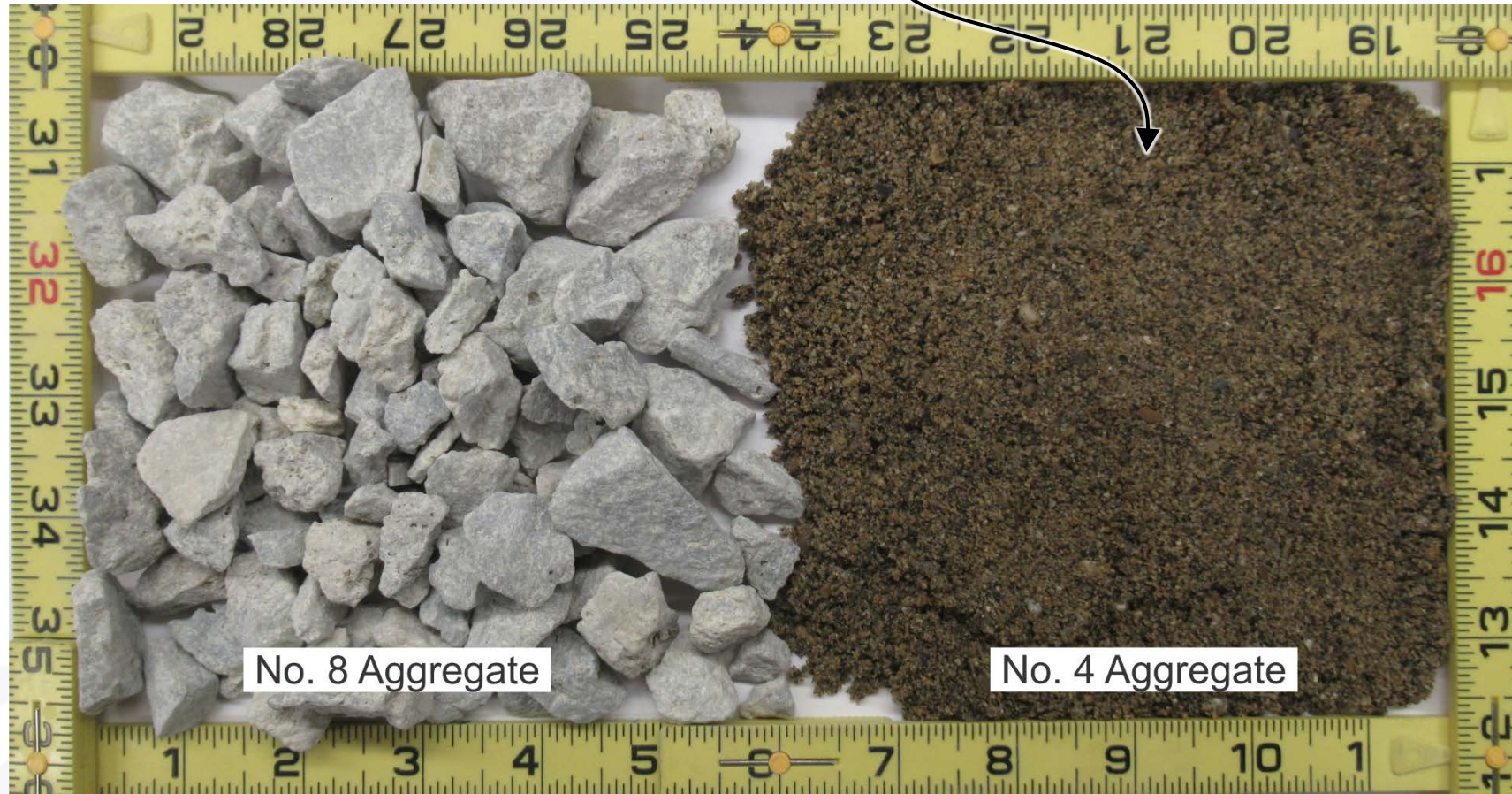
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- Requires large space behind facing
- Requires select fill
- Requires considerations of reinforcement corrosion/degradation
- Requires shared design responsibility between owners and suppliers

# Reinforced Backfill

## Example Materials

Will not be allowed for MSE wall reinforced backfill  
(beginning with contracts let on or after September 1, 2023)



# Reinforced Backfill

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## INDOT Standard Specification 731.05

MSE wall backfill, and the horizontal bench in front of the wall, shall consist of structure backfill type 3 in the reinforced backfill zone in accordance with 211, except that nominal size aggregate No. 30 shall not be used. Structure backfill in the retained backfill zone shall be type 3 or B borrow as shown on the plans.

# Reinforced Backfill

## INDOT Standard Specification 211.03.1(c)

Structure backfill in accordance with 904.05, except only nominal size aggregates 1 in., 1/2 in., No. 4 or No. 30, and coarse aggregate No. 5, No. 8, No. 9, No. 11, or No. 12 shall be used. If ACBF is used, it shall only be used in sizes that meet the size requirements for coarse aggregate No. 5 or No. 8.

Not allowed for MSE wall reinforced backfill

Will not be allowed for MSE wall reinforced backfill  
(beginning with contracts let on or after September 1, 2023)

# Reinforced Backfill

---

## INDOT Standard Specification 904.05

The material shall be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter. It shall consist of suitable sand, gravel, crushed stone, ACBF, or GBF. Structure backfill shall be in accordance with one of the gradations shown in the table below, or coarse aggregate No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, or No. 73 in accordance with the gradation requirements of 904.03(e). Coarse aggregate No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, or No. 73 shall be crushed stone or ACBF, class D or higher.

# Reinforced Backfill

## INDOT Standard Specification 904.03(e)

Sieve Sizes	Coarse Aggregate Sizes (Percent Passing)											
	Coarse Graded										Dense Graded	
	2	5	8	9	11, SC 11 <sup>(5)</sup>	12, SC 12 <sup>(5)</sup>	SC 16 <sup>(5)</sup>	43 <sup>(1)</sup>	91	93PG <sup>(6)</sup>	53 <sup>(1)</sup>	73 <sup>(1)</sup>
4 in. (100 mm)												
3 1/2 in. (90 mm)												
2 1/2 in. (63 mm)	100											
2 in. (50 mm)	80 - 100											
1 1/2 in. (37.5 mm)		100						100			100	
1 in. (25 mm)	0 - 25	85 - 98	100					70 - 90	100		80 - 100	100
3/4 in. (19 mm)	0 - 10	60 - 85	75 - 95	100				50 - 70			70 - 90	90 - 100
1/2 in. (12.5 mm)	0 - 7	30 - 60	40 - 70	60 - 85	100	100	100	35 - 50		98 - 100	55 - 80	60 - 90
3/8 in. (9.5 mm)		15 - 45	20 - 50	30 - 60	75 - 95	95 - 100	94 - 100			75 - 100		
No. 4 (4.75 mm)		0 - 15	0 - 15	0 - 15	10 - 30	50 - 80	15 - 45	20 - 40		10 - 60	35 - 60	35 - 60
No. 8 (2.36 mm)		0 - 10	0 - 10	0 - 10	0 - 10	0 - 35		15 - 35		0 - 15	25 - 50	
No. 16 (1.18 mm)							0 - 4					
No. 30 (600 μm)						0 - 4		5 - 20		0 - 5	12 - 30	12 - 30
No. 200 (75 μm) <sup>(2)</sup>								0 - 6.0			5.0 - 10.0 <sup>(4)</sup>	5.0 - 12.0
Decant (PCC) <sup>(3)</sup>		0 - 1.5	0 - 1.5	0 - 1.5	0 - 1.5	0 - 1.5			0 - 1.5			
Decant (Non-PCC)	0 - 2.5	0 - 2.5	0 - 3.0	0 - 2.5	0 - 2.5	0 - 2.0			0 - 2.5	0 - 2.0		
Decant (SC)					0 - 1.5	0 - 1.5	0 - 1.5					

Notes: (1) The liquid limit shall not exceed 25 (35 if slag) and the plasticity index shall not exceed 5. The liquid limit shall be determined in accordance with AASHTO T 89 and the plasticity index in accordance with AASHTO T 90.

(2) Includes the total amount passing the No. 200 (75 μm) sieve as determined by AASHTO T 11 and AASHTO T 27.

(3) Decant may be 0 - 2.5 for stone and slag.

ACBF only allowed for No. 5 and No. 8



# Reinforced Backfill

## INDOT Standard Specification 904.03(a)

Characteristic Classes	AP	AS	A	B	C	D	E	F
<b>Quality Requirements:</b>								
Freeze and Thaw Beam Expansion, % max. (Note 1) .....	.060							
Los Angeles Abrasion, % max. (Note 2) .....	40.0	30.0	40.0	40.0	45.0	45.0	50.0	
Freeze and Thaw, AASHTO T 103, Procedure A, % max. (Note 3).....	12.0	12.0	12.0	12.0	16.0	16.0	20.0	25.0
Sodium Sulfate Soundness, % max. (Note 3) .....	12.0	12.0	12.0	12.0	16.0	16.0	20.0	25.0
Brine Freeze and Thaw Soundness, % max. (Note 3).....	30	30	30	30	40	40	50	60
Absorption, % max. (Note 4).....	5.0	5.0	5.0	5.0	5.0			
<b>Additional Requirements:</b>								
Deleterious, % max.								
Clay Lumps and Friable Particles .....	1.0	1.0	1.0	1.0	2.0	4.0		
Non-Durable (Note 5) .....	4.0	2.0	4.0	4.0	6.0	8.0		
Coke .....					(See Note 6)			
Iron.....					(See Note 6)			
Chert (Note 7) .....	3.0	3.0	3.0	5.0	8.0	10.0		
Weight per Cubic Foot for Slag, lb, min. ....	75.0		75.0	75.0	70.0	70.0	70.0	
<b>Crushed Particles, % min. (Note 8)</b>								
Compacted Aggregates.....			20.0	20.0	20.0	20.0		
<b>Notes:</b>								
1. Freeze and thaw beam expansion shall be tested and re-tested in accordance with ITM 210.								
2. Los Angeles abrasion requirements shall not apply to BF.								

# Reinforced Backfill

## INDOT Standard Specification 904.05

Will not be allowed for MSE wall reinforced backfill  
(beginning with contracts let on or after September 1, 2023)

Sieve Sizes	Nominal Sizes and % Passing					
	2 in. (50 mm)	1 1/2 in. (37.5 mm)	1 in. (25.0 mm)	1/2 in. (12.5 mm)	No. 4 (4.75 mm)	No. 30 (600 μm)
2 1/2 in. (63 mm)	100					
2 in. (50 mm)	90 - 100	100				
1 1/2 in. (37.5 mm)	70 - 100	90 - 100	100	100		
1 in. (25.0 mm)	55 - 95	70 - 100	85 - 100			
3/4 in. (19.0 mm)	45 - 90	55 - 95	70 - 100			
1/2 in. (12.5 mm)	35 - 85	40 - 90	55 - 95	85 - 100	100	100
No. 4 (4.75 mm)	20 - 65	20 - 70	25 - 75	45 - 85	90 - 100	
No. 8 (2.36 mm)	10 - 50	10 - 55	15 - 60	25 - 75	75 - 100	
No. 30 (600 μm)	3 - 35	3 - 35	3 - 35	5 - 45	15 - 70	70 - 100
No. 200 (75 μm)	0 - 8	0 - 8	0 - 8	0 - 8	0 - 8	0 - 8

# Reinforced Backfill

## INDOT Standard Specification 211.03.1(c)

A type A certification in accordance with 916 shall be provided for the additional structure backfill. The results of the following shall be shown on the certification.

Property	Criteria	Test Method
pH (Note 1)	$5 < \text{pH} < 10$	AASHTO T 289
Organic Content (Note 2)	1% max.	AASHTO T 267
Permeability, min. (Note 3)	30 ft/day	AASHTO T 215

Notes:

1. One PH test is required for each bench of stone, each source of air-cooled blast furnace slag, and each source of gravel.
2. One organic content test is required for each source of gravel.
3. One permeability test is required for the smallest aggregate size from each source. Sizes No. 5, No. 8, and No. 9 do not require a permeability test.

For retaining wall systems containing metal components:

Property	Criteria	Test Method
Chlorides	< 100 ppm	AASHTO T 291
Sulfates	< 200 ppm	AASHTO T 290
Resistivity, min.	3,000 $\Omega$ -cm	AASHTO T 288
Internal friction angle, $\phi$ , min.	34°	AASHTO T 236* or T 297*

\* under consolidated drained conditions

These requirements waived if resistivity > 5,000  $\Omega$ -cm

Not required for coarse aggregates No. 5, No. 8, or No.9

# Certified Aggregate Producers Product List

Excel spreadsheet showing a list of certified aggregate producers and their products. The spreadsheet is titled "capp (2) - Excel" and is displayed in the "Home" tab. The data is organized into columns for CAP #, Src #, NAME, CITY/STATE, Q #, D #, Ratio, Size/desc, Ledges, Comments, District, Brand Name for AASHTOWare Project, Mat. Code for AASHTOWare Project, Source ID for AASHTOWare Project, Material Code Name, Brand Leng, Redistrib. File, and Revised 2/17/2023.

CAP #	Src #	NAME	CITY/STATE	Q #	D #	Ratio	Size/desc	Ledges	Comments	District	Brand Name for AASHTOWare Project	Mat. Code for AASHTOWare Project	Source ID for AASHTOWare Project	Material Code Name	Brand Leng	Redistrib. File	Revised 2/17/2023
0021	0021	ROCK CREEK STONE QUARRY	BLUFFTON, IN	Q142273	D181010	AP	8APICS	101-103, 201-202, 301-305		FT WAYNE	8APICS, 101-103, 201-202, 301-305,	904M00030	AGG00021	CA, Class AP, CS, 8	35	0	
0021	0021	ROCK CREEK STONE QUARRY	BLUFFTON, IN	Q142273	D180010	A	#9/CS	101-103, 201-202, 301-303	Dolomite	FT WAYNE	#9/CS, 101-103, 201-202, 301-303; Dolomite	904M00700	AGG00021	CA, Class A, CS, 9	43	0	
0021	0021	ROCK CREEK STONE QUARRY	BLUFFTON, IN	Q142273	D180020	B	SC1ICS	101-103, 201-202, 301-303	Dolomite	FT WAYNE	SC1ICS, 101-103, 201-202, 301-303; Dolomite	904M01371	AGG00021	CA, Class B, CS, 11-SC	45	0	
0021	0021	ROCK CREEK STONE QUARRY	BLUFFTON, IN	Q142273	D185070	D	#53ICS	101-103, 201-202, 301-305		FT WAYNE	#53ICS, 101-103, 201-202, 301-305,	904M02710	AGG00021	CA, Class D, CS, 53	35	0	
0021	0021	ROCK CREEK STONE QUARRY	BLUFFTON, IN	Q142273	D145060	D	#73ICS	101-103, 201-202, 301-305		FT WAYNE	#73ICS, 101-103, 201-202, 301-305,	904M02730	AGG00021	CA, Class D, CS, 73	35	0	
0041	0041	U.S. AGGREGATES, INC.	CLOVERDALE, IN	Q092246	D091040	AP	8APICS	3-403.3		CRAWFORDSVILLE	8APICS, 3-403.3;	904M00030	AGG00041	CA, Class AP, CS, 8	17	0	
0041	0041	U.S. AGGREGATES, INC.	CLOVERDALE, IN	Q092246	D090380	A	#11ICS	3-403.3		CRAWFORDSVILLE	#11ICS, 3-403.3;	904M00710	AGG00041	CA, Class A, CS, 11	17	0	
0041	0041	U.S. AGGREGATES, INC.	CLOVERDALE, IN	Q092246	D094070	D	#2ICS	3-403.3		CRAWFORDSVILLE	#2ICS, 3-403.3;	904M02850	AGG00041	CA, Class D, CS, 2	16	0	
0041	0041	U.S. AGGREGATES, INC.	CLOVERDALE, IN	Q092246	D096020	F	Revetment RiprapICS	3-403.3		CRAWFORDSVILLE	Revetment RiprapICS, 3-403.3;	904M05470	AGG00041	CA, Class F, CS, Revetment Riprap	30	0	
0041	0041	U.S. AGGREGATES, INC.	CLOVERDALE, IN	Q092246	D177020	F	Class I RiprapICS	3-403.3		CRAWFORDSVILLE	Class I RiprapICS, 3-403.3;	904M05500	AGG00041	CA, Class F, CS, Class I Riprap	26	0	
0041	0041	U.S. AGGREGATES, INC.	CLOVERDALE, IN	Q092246	D177030	F	Class 2 RiprapICS	3-403.3		CRAWFORDSVILLE	Class 2 RiprapICS, 3-403.3;	904M05530	AGG00041	CA, Class F, CS, Class II Riprap	26	0	
0041	0041	U.S. AGGREGATES, INC.	CLOVERDALE, IN	Q092246	D096030	F	Uniform RiprapAICS			CRAWFORDSVILLE	Uniform RiprapAICS;	904M05555	AGG00041	CA, Class F, CS, Uniform Riprap A	21	0	
0041	0041	U.S. AGGREGATES, INC.	CLOVERDALE, IN	Q092246	D142030	NA	Mineral Filler	3-403.3	Per Contract	CRAWFORDSVILLE	Mineral Filler, 3-403.3; Per Contract	904M06210	AGG00041	FA, CS, 16	37	0	
0045	2461	Milestone Contractors North, Inc	SOUTH BEND, IN	Q092248	D225010	D	#2ICS	Lvl 1 Ledge 11	Orig Src 2461	LA PORTE	#2ICS, Lvl 1 Ledge 11; Orig Src 2461	904M02850	AGG00045	CA, Class D, CS, 2	36	-2416	
0045	2461	Milestone Contractors North, Inc	SOUTH BEND, IN	Q092248	D205050	D	#53ICS	Level 1, Ledge 11	Orig Src 2461	LA PORTE	#53ICS, Level 1, Ledge 11; Orig Src 2461	904M02710	AGG00045	CA, Class D, CS, 53	40	-2416	
0045	2731	Milestone Contractors North, Inc	SOUTH BEND, IN	Q092248	D175010	D	#2BF		Orig Src 2731	LA PORTE	#2BF; ; Orig Src 2731	904M02980	AGG00045	CA, Class D, BF, 2	22	-2746	
0045	2451	Milestone Contractors North, Inc	SOUTH BEND, IN	Q092248	D094150	D	#53BF		Orig Src 2451	LA PORTE	#53BF; ; Orig Src 2451	904M03040	AGG00045	CA, Class D, BF, 53	23	-2406	
0045	2731	Milestone Contractors North, Inc	SOUTH BEND, IN	Q092248	D175020	D	#53BF		Orig Src 2731	LA PORTE	#53BF; ; Orig Src 2731	904M03040	AGG00045	CA, Class D, BF, 53	23	-2746	
0056	0056	MILESTONE RECYCLED - PLANT 43	LAFAYETTE, IN	Q092250	D094230	D	#53BB/Recycled PCC		See 203.18 Restrictions	CRAWFORDSVILLE	#53BB/Recycled PCC; ; See 203.18 Restrictions	904M00000	AGG00056	B-Borrow	46	0	
0056	0056	MILESTONE RECYCLED - PLANT 43	LAFAYETTE, IN	Q092250	D094230	D	#53BB/Recycled PCC		See 203.18 Restrictions	CRAWFORDSVILLE	#53BB/Recycled PCC; ; See 203.18 Restrictions	904M05310	AGG00056	CA, CS, Recycled PCC, 53	46	0	
0056	0056	MILESTONE RECYCLED - PLANT 43	LAFAYETTE, IN	Q092250	D11740	NA	TSBINS			CRAWFORDSVILLE	TSBINS; ;	904M06320	AGG00056	Structural Backfill, 25mm (1in)	11	0	
0056	0056	MILESTONE RECYCLED - PLANT 43	LAFAYETTE, IN	Q092250	D117130	NA	#4SBINS			CRAWFORDSVILLE	#4SBINS; ;	904M06340	AGG00056	Structural Backfill, 4.75mm (#4)	11	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D178020	NA	BBorrow			LA PORTE	BBorrow; ;	904M00000	AGG00057	B-Borrow	11	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D161020	AP	8APICS	201-302, 303		LA PORTE	8APICS, 201-302, 303;	904M00030	AGG00057	CA, Class AP, CS, 8	22	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D160140	A	#8ICS	201-302, 303		LA PORTE	#8ICS, 201-302, 303;	904M00690	AGG00057	CA, Class A, CS, 8	21	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D160150	A	#11ICS	201-302, 303		LA PORTE	#11ICS, 201-302, 303;	904M00710	AGG00057	CA, Class A, CS, 11	22	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D160160	A	QA11ICS	201-302, 303		LA PORTE	QA11ICS, 201-302, 303;	904M00770	AGG00057	CA, Class A, CS, QA	23	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D173180	A	QA12ICS	201-302, 303		LA PORTE	QA12ICS, 201-302, 303;	904M00770	AGG00057	CA, Class A, CS, QA	23	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D165110	D	#2ICS	201-302, 303		LA PORTE	#2ICS, 201-302, 303;	904M02850	AGG00057	CA, Class D, CS, 2	21	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D175040	D	#53ICS	201-302, 303		LA PORTE	#53ICS, 201-302, 303;	904M02710	AGG00057	CA, Class D, CS, 53	22	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D185030	D	#73ICS	201-302, 303		LA PORTE	#73ICS, 201-302, 303;	904M02730	AGG00057	CA, Class D, CS, 73	22	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D167030	F	Revetment RiprapICS	201-302, 303		LA PORTE	Revetment RiprapICS, 201-302, 303;	904M05470	AGG00057	CA, Class F, CS, Revetment Riprap	35	0	
0057	0057	SOUTH LAKE STONE	HEBRON, IN	Q162278	D227010	F	Class I RiprapICS	201-302		LA PORTE	Class I RiprapICS, 201-302;	904M05500	AGG00057	CA, Class F, CS, Class I Riprap	26	0	

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# Soil Reinforcement

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## INDOT Standard Specification 910.07(b)

### **(b) Ground Reinforcement**

The ground reinforcement shall be either a deformed steel strip or a welded-wire grid. The grid or strip used shall be consistent with that used in the pullout test and shall be consistent throughout the project.

# Soil Reinforcement: Steel Strip



# Soil Reinforcement: Welded Wire



# Soil Reinforcement

## INDOT Standard Specification 910.07(b)

Ground-reinforcement units shall be hot rolled from bars to the required shape and dimensions. Physical and mechanical properties of the units shall be in accordance with ASTM A572, grade 65. Tie strips shall be shop fabricated with hot-rolled steel in accordance with the minimum requirements of ASTM A1011, grade 50. Galvanization for ground-reinforcing units and tie strips shall be in accordance with ASTM A123, coating grade 85, for strip-type reinforcements or ASTM A641, class 5 or class C, for bar mat or grid-type reinforcements.

## INDOT Standard Specification 910.07(c)

Fasteners shall consist of 1/2 in. diameter, bolts, nuts, and washers and shall otherwise be in accordance with 910.02(g)1 with the exception that the hardware shall be coated in accordance with ASTM F2329.



# Pre-Cast Facing Panels



# Pre-Cast Facing Panels

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## INDOT Standard Specification 910.10(a)1

Precast concrete face panels shall be produced from a source listed on the QPL of Certified Precast Concrete Producers, in accordance with ITM 813. Concrete shall have a compressive strength equal to or greater than 4,000 psi at 28 days.

The target water/cementitious ratio for the concrete mix design shall not exceed 0.435. The cement content and target water/cementitious ratio of the concrete mix design shall be sufficient to obtain the specified minimum 28-day compressive strength. Air entraining admixture and chemical admixture Type A, B, C, D, or E from the QPL of PCC Admixtures and Admixture Systems may be used.

Ground-reinforcement connection hardware and reinforcing bar lifting devices shall be set in place and secured prior to beginning casting, in accordance with the dimensions and tolerances shown on the working drawings.

# INDOT Approved MSE Wall Systems

Questions or additional information about the contents of this page, please select and click on the respective List Name Contact Person.

List Name	Specification/ITM	Contact Person
<a href="#">Reflective Sheeting</a>	919.01(b)1	<a href="#">Dave Boruff</a>
<a href="#">Reinforcing Bar and WWR Epoxy Coaters</a>	910.01(b)9 & ITM 301	<a href="#">Jon Korff</a>
<a href="#">Reinforcing Bar Splicing Systems</a>	910.01(b)3	<a href="#">Jon Korff</a>
<a href="#">Retaining Wall Systems</a>	731.02, 731.05, & 735.05	<a href="#">Aamir Turk</a>
<a href="#">Seedling Sources</a>	914.08	<a href="#">Shawn Slaymon</a>
<a href="#">Snowplowable Raised Pavement Markers</a>	921.02(d)	<a href="#">Dave Boruff</a>
<a href="#">Soil Modifiers</a>	913.04(b)1,2, 913.05, & ITM 806	<a href="#">Nayyar Siddiki</a>

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# INDOT Approved MSE Wall Systems

January 27, 2023

## RETAINING WALL SYSTEMS

Specification Reference: 731.02, 731.05, & 735.05.

SM Material Codes: MSE Wall 731M00010, Bin Wall 732M00050

The following listed systems are for use in determining the retaining wall system to be installed on the project. Individual materials used in the construction of the wall shall be reported as the basis of acceptance on the material record.

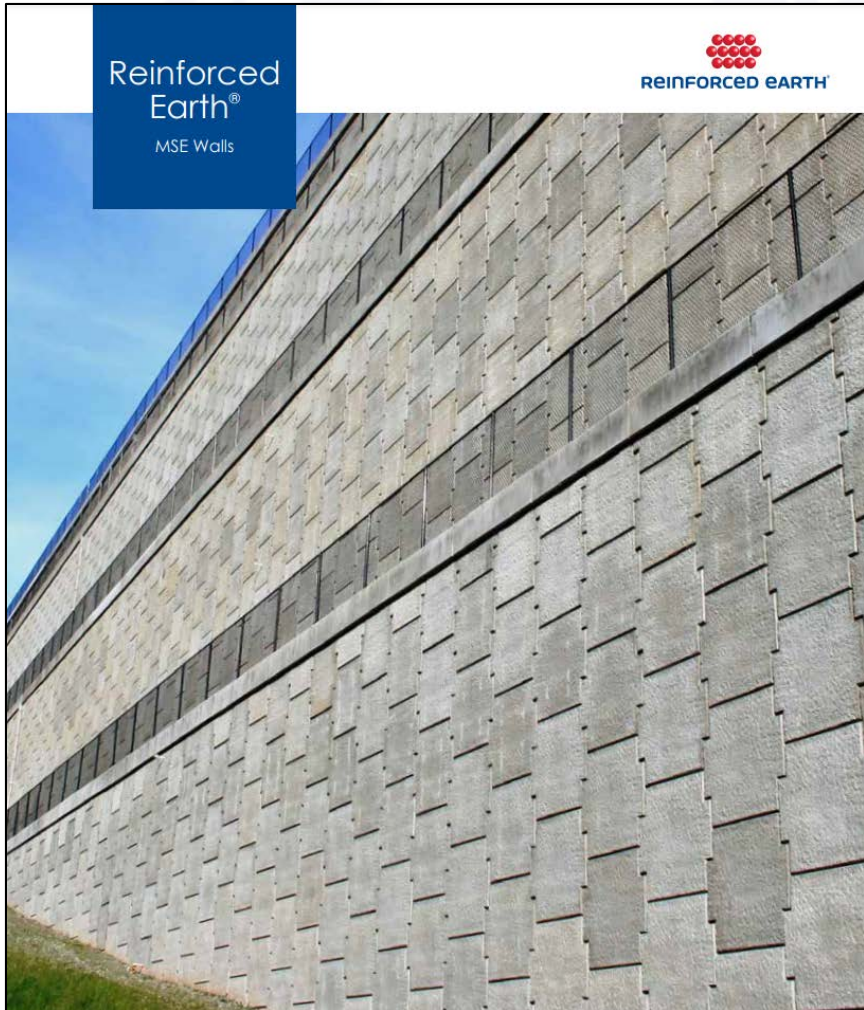
Source Code	Manufacturer Type	Approval Number	COMMENTS
-------------	-------------------	-----------------	----------

### MECHANICALLY STABILIZED EARTH RETAINING WALL

MSE0030	THE REINFORCED EARTH CO (REINFORCED EARTH)		
	RIBBED STEEL STRIPS WITH 4MM THICKNESS-----	W028967	
	HA LADDER REINFORCEMENT-----	W028968	

# INDOT Approved MSE Wall Systems

The Reinforced Earth Co (MSE0030)



Ribbed Steel Strips with 4mm Thickness (W028967)



HA Ladder Reinforcement (W028968)



# Construction Sequence

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1. Review submittals (Pre-Construction)
2. Delivery and storage of MSE Wall components
3. Foundation preparation
4. Leveling pad placement
5. Placement of initial panel course
6. Backfilling of initial panel course
7. Placement of subsequent panel courses
8. Placement of final panel course and coping

# Review Submittals

# Review Submittals

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- Working drawings
- Design calculations

## INDOT Standard Specification 731.04

Wall construction operations shall not begin until the Contractor receives written notice that the working drawings are approved.



# Components Delivery and Storage

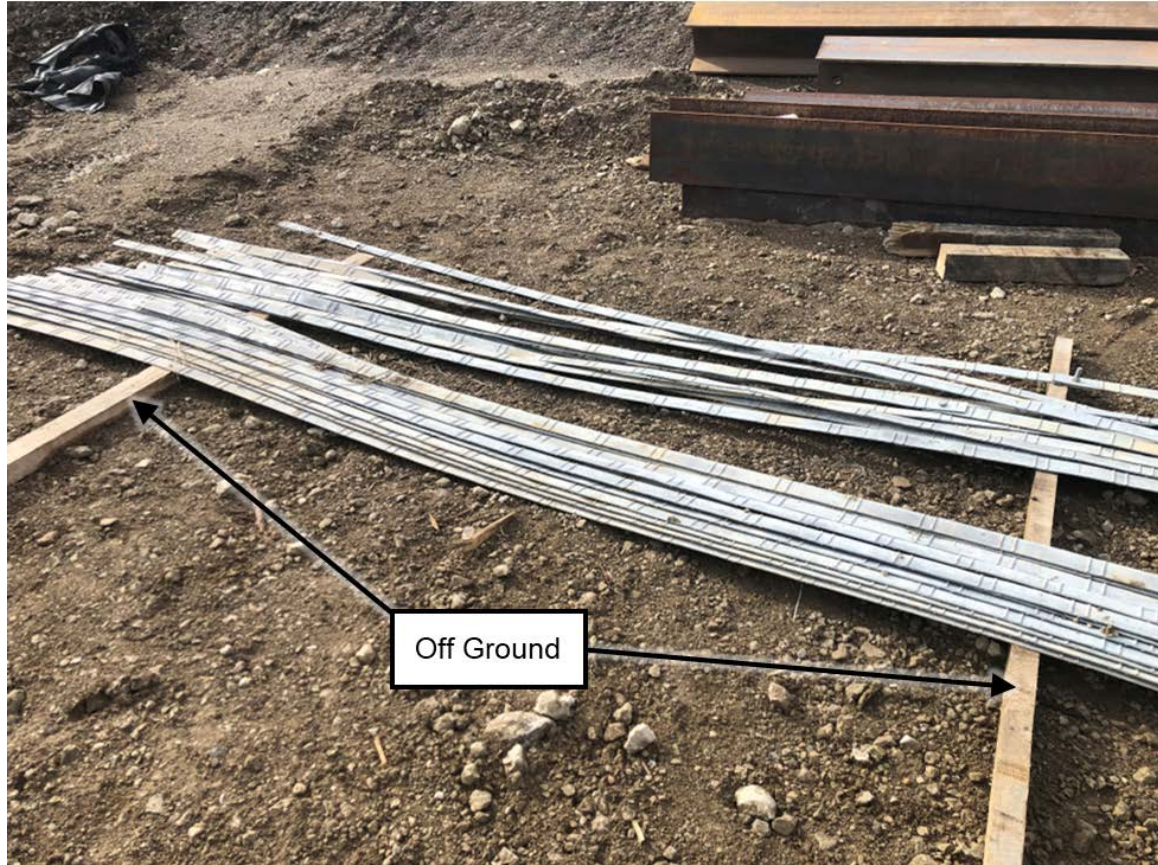
# Storing Pre-Cast Facing Panels On Site

## INDOT Standard Specification 731.09

Panels shall be stored on blocking to minimize contact with the ground or being covered by standing water. Panels placed in contact with the ground or covered by standing water shall have face discoloration removed by means of a chemical wash.



# Storing Soil Reinforcements On Site



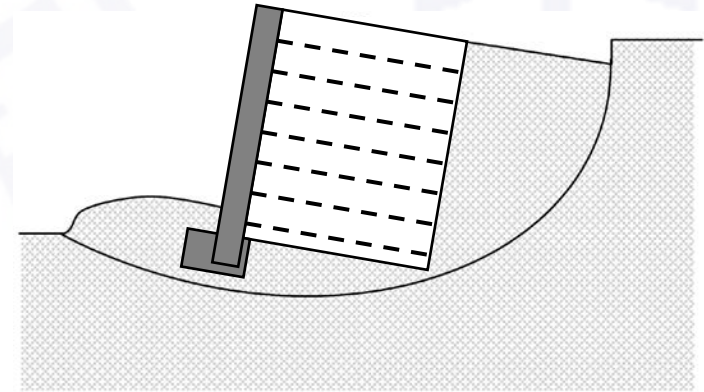
# Foundation Preparation

# MSE Wall External Stability

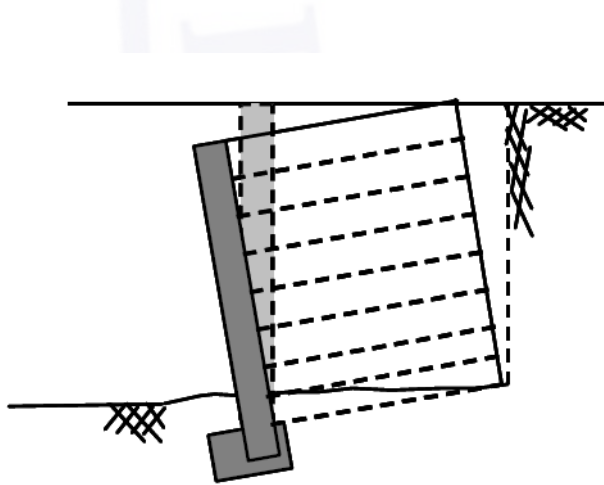
## INDOT Standard Specification 731.03

The design for the external stability shall include applied bearing pressure, overturning, sliding, and stability of temporary construction slopes.

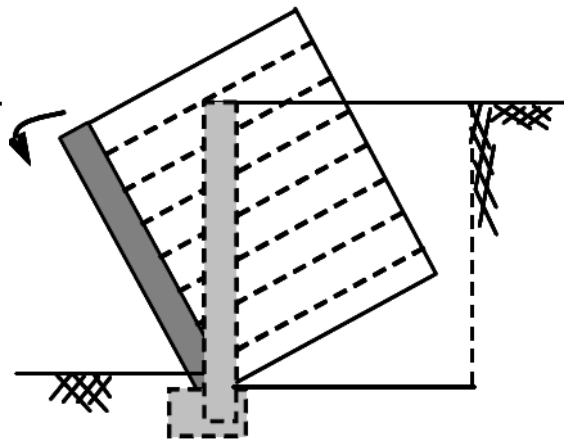
The internal, external, and compound stability shall be the responsibility of the Contractor. The global stability of the wall mass will be the responsibility of the Engineer.



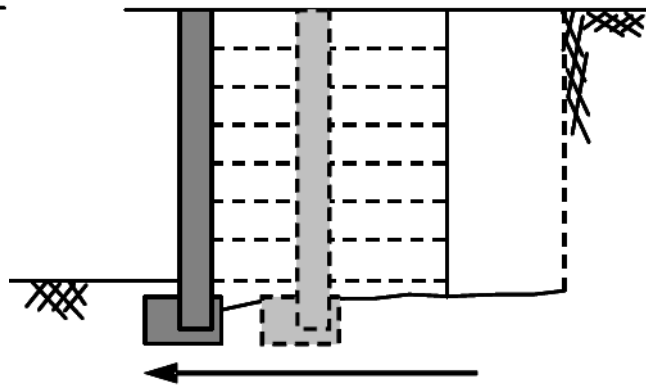
Global



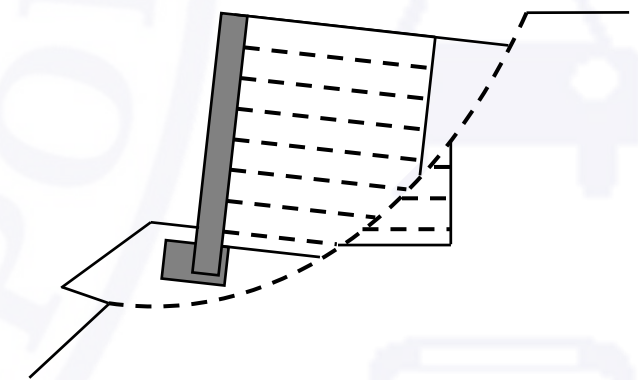
Bearing Pressure



Overturning



Sliding



Compound Level 1A

# Foundation Soil



# Foundation Preparation Sequence

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1. Excavation
2. Remove and Replace Unsuitable Soils
3. Compaction and Grading
4. Proofrolling
5. DCP Verification Testing

# Foundation Preparation: Excavation

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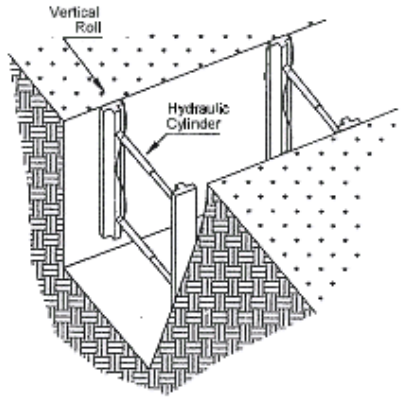
## INDOT Standard Specification 731.08

The Contractor shall notify the Engineer a minimum of 7 calendar days or other time as mutually agreed upon before beginning the excavation so that measurements can be taken of the undisturbed ground.

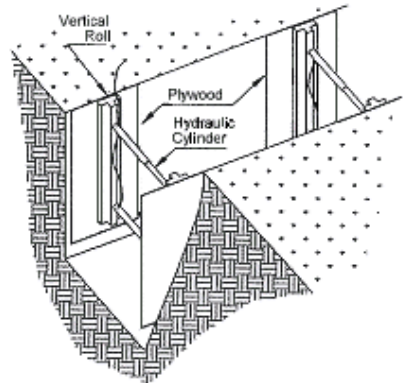
Prior to starting excavation operations at the wall site, clearing and grubbing shall be in accordance with 201.03. The area shall be cleared and grubbed to the excavation in accordance with the limits shown on the plans. All timber, stumps, or debris shall be disposed of in accordance with 201.03. Excavation shall include the construction and subsequent removal of all necessary bracing, shoring, sheeting, and cribbing. Excavation shall also include all pumping, bailing, and draining.



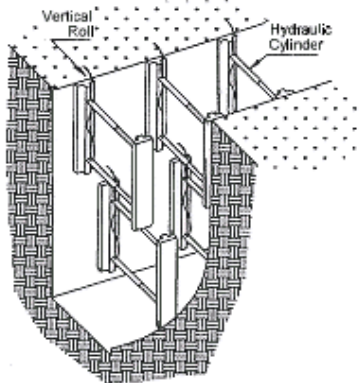
# Foundation Preparation: Excavation Shoring



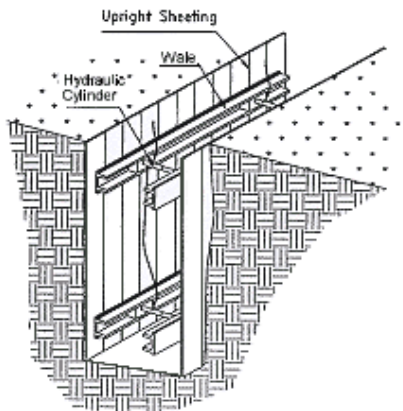
Vertical Aluminum Hydraulic Shoring (Spot Bracing)



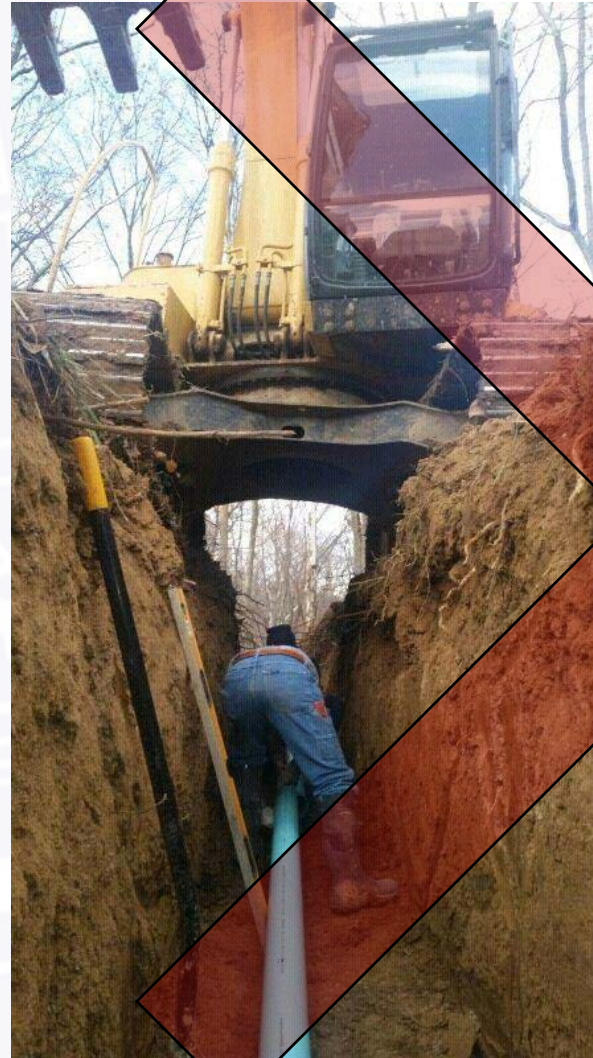
Vertical Aluminum Hydraulic Shoring (With Plywood)



Vertical Aluminum Hydraulic Shoring (Stacked)



Aluminum Hydraulic Shoring Water System (Typical)



# Foundation Preparation: Remove and Replace Unsuitable Soils

## INDOT Standard Specification 731.07

If unsuitable foundation material is encountered, it shall be removed and replaced with B borrow in accordance with 211.02 and compacted in accordance with 211.04.

## INDOT Standard Specification 211.02

The material used for special filling shall be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter and shall be known as B borrow. It shall consist of suitable sand, gravel, crushed stone, ACBF, GBF, or other approved material. The material shall contain no more than 10% passing the No. 200 (75  $\mu$ m) sieve and shall be otherwise suitably graded. The use of an essentially one-size material will not be allowed unless approved.

## INDOT Standard Specification 211.04

B borrow and structure backfill types 1, 2, and 3 shall be compacted with mechanical tamps or vibrators in accordance with the applicable provisions of 203.23 except as otherwise set out herein.

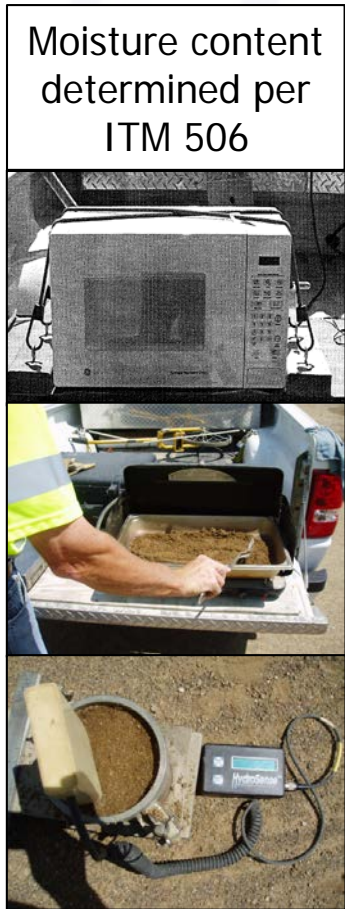
## INDOT Standard Specification 203.23

- Compact to 95% relative compaction per AASHTO T99
- Verify compaction using Dynamic Cone Penetrometer

# Foundation Preparation: Remove and Replace Unsuitable Soils

## INDOT Standard Specification 203.23

### Verify Relative Compaction Using Dynamic Cone Penetrometer



Possible B-borrow soils

Textural Classification	Maximum Dry Density (pcf)	Optimum Moisture Content Range (%)	Acceptable Minimum DCP value for 6 in. for 95% compaction	Acceptable Minimum DCP value for 12 in. for 95% compaction	Acceptable Minimum DCP value for 6 or 12 in. for 100% compaction
<b>CLAY SOILS</b>					
Clay	< 105	19 - 24	6		*
Clay	105 - 110	16 - 18	7		*
Clay	111 - 114	14 - 15	8		*
<b>SILTY SOILS</b>					
Silty	115 - 116	13 - 14		9	*
Silty	117 - 120			11	*
<b>SANDY SOILS</b>					
Sandy	121 - 125	8 - 12		12	*
Sandy	> 125			15	*
<b>GRANULAR SOILS - STRUCTURE BACKFILL and A-1, A-2, A-3 SOILS</b>					
No. 30				6	9
No. 4				7	10
1/2 in.				11	14
1 in.				16	19

Note: \* Test section required in accordance with ITM 513.

# Foundation Preparation: Compaction and Grading

## INDOT Standard Specification 731.07

Prior to wall construction, the foundation for the structure shall be **graded for a width equal to or exceeding the length of the ground reinforcement** or as shown on the plans. **The foundation, if not in rock, shall then be compacted in accordance with 203.**



Textural Classification	Maximum Dry Density (pcf)	Optimum Moisture Content Range (%)	Acceptable Minimum DCP value for 6 in. for 95% compaction	Acceptable Minimum DCP value for 12 in. for 95% compaction	Acceptable Minimum DCP value for 6 or 12 in. for 100% compaction
<b>CLAY SOILS</b>					
Clay	< 105	19 - 24	6		*
Clay	105 - 110	16 - 18	7		*
Clay	111 - 114	14 - 15	8		*
<b>SILTY SOILS</b>					
Silty	115 - 116	13 - 14		9	*
Silty	117 - 120			11	*
<b>SANDY SOILS</b>					
Sandy	121 - 125	8 - 12		12	*
Sandy	> 125			15	*
<b>GRANULAR SOILS - STRUCTURE BACKFILL and A-1, A-2, A-3 SOILS</b>					
No. 30				6	9
No. 4				7	10
1/2 in.				11	14
1 in.				16	19

Will depend on foundation soil classification

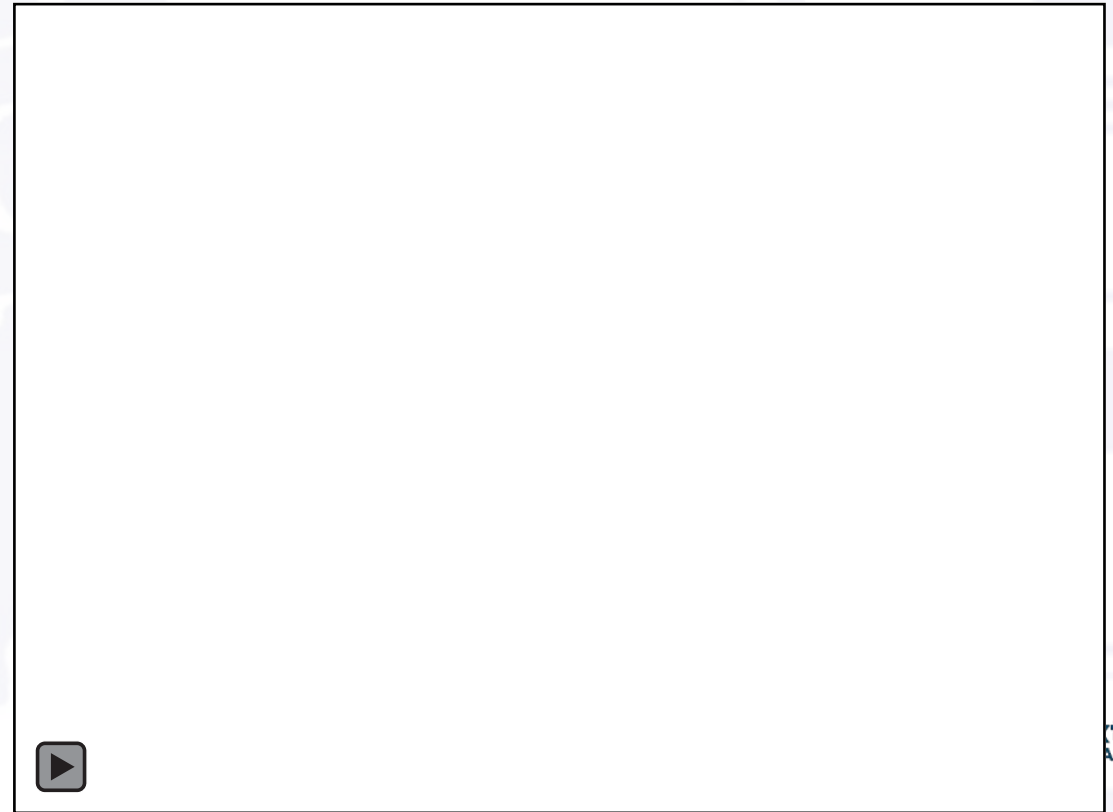
Note: \* Test section required in accordance with ITM 513.

# Foundation Preparation: Proofrolling

INDOT Standard Specification 731.07

The foundation shall be **proofrolled in accordance with 203.26**. If unsuitable foundation material is encountered, it shall be removed and replaced with B borrow in accordance with 211.02 and compacted in accordance with 211.04.

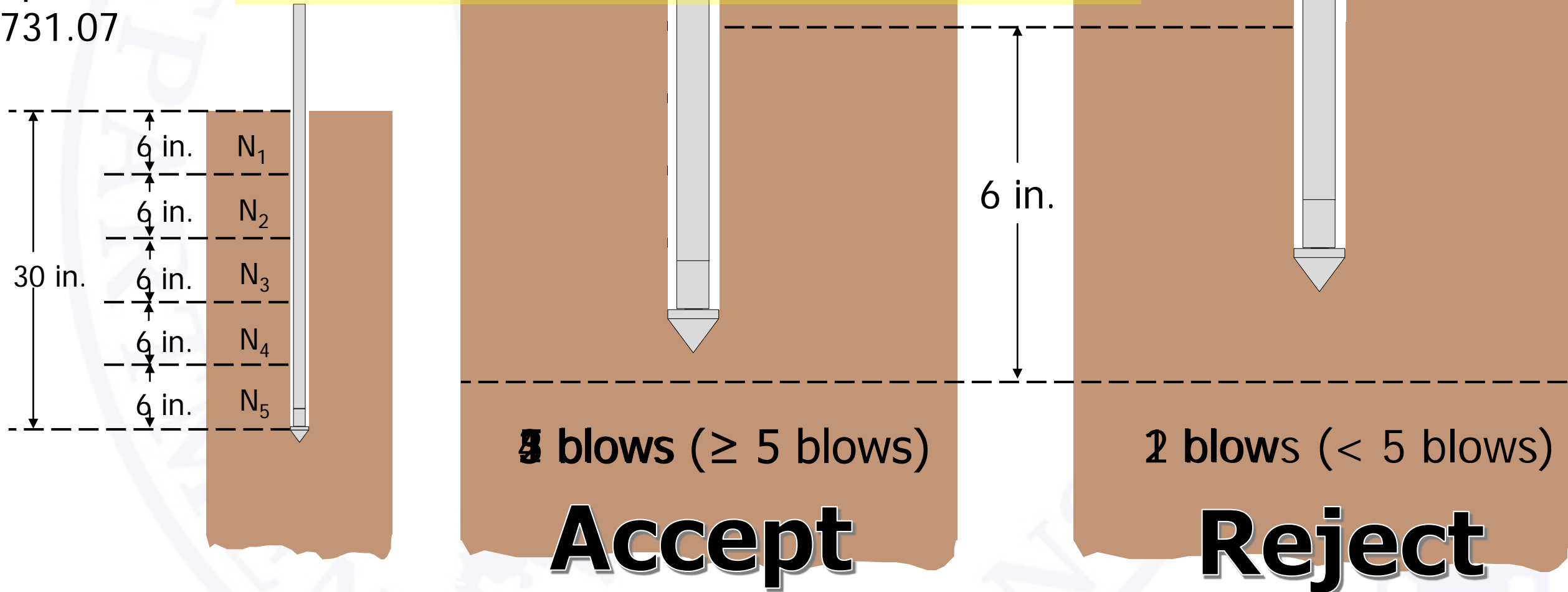
The



# Foundation Preparation : DCP Verification Testing

INDOT  
Standard  
Specification  
731.07

A DCP measurement is defined as the number of blows per 6 in. increment for a total penetration of 30 in., based on five sets of DCP readings at each location. A minimum of five blows of the DCP for each 6 in. increment is considered acceptable.



# Foundation Preparation: DCP Verification Testing

## INDOT Construction Memorandum 15-08

### INDOT Construction Verification Chart For Factored Bearing Resistance Based on DCP Blow Counts

DCP Blows for 12 inches	Factored Bearing Resistance (psf)	DCP Blows for 12 inches	Factored Bearing Resistance (psf)
10	4,000.00	21	7,600.00
11	4,300.00	22	8,000.00
12	4,600.00	23	8,300.00
13	5,000.00	24	8,600.00
14	5,300.00	25	9,000.00
15	5,600.00	26	9,300.00
16	6,000.00	27	9,600.00
17	6,300.00	28	10,000.00
18	6,600.00	29	10,300.00
19	7,000.00	30	10,600.00
20	7,300.00	31	11,000.00

**Note:** This table is applicable only for fine grained (cohesive) soils.  
For sand & gravel, please contact the Office of Geotechnical Services.

### From Road/Bridge Plans...

#### **NOTE:**

1. ALL STATIONS AND OFFSETS ARE BASED OFF OF LINE "S-2".
2. ALL STATIONS, OFFSETS, AND DIMENSIONS ARE MEASURED ALONG THE REAR FACE OF THE MSE WALL.
3. MSE WALL FACTORED BEARING RESISTANCE = 7,000 PSF.
4. THE LEVELING PAD, LEVELING PAD STEP LOCATIONS, ELEVATIONS, DRAIN LOCATION, DIMENSIONS, AND RESULTING STRUCTURE BACKFILL AND B BORROW BACKFILL QUANTITIES OUTSIDE THE NEAT LIMITS ARE FOR INFORMATION ONLY.
5. FOR SECTIONS A-A AND B-B, SEE DWG. NO. WD-03.

# Leveling Pad Placement



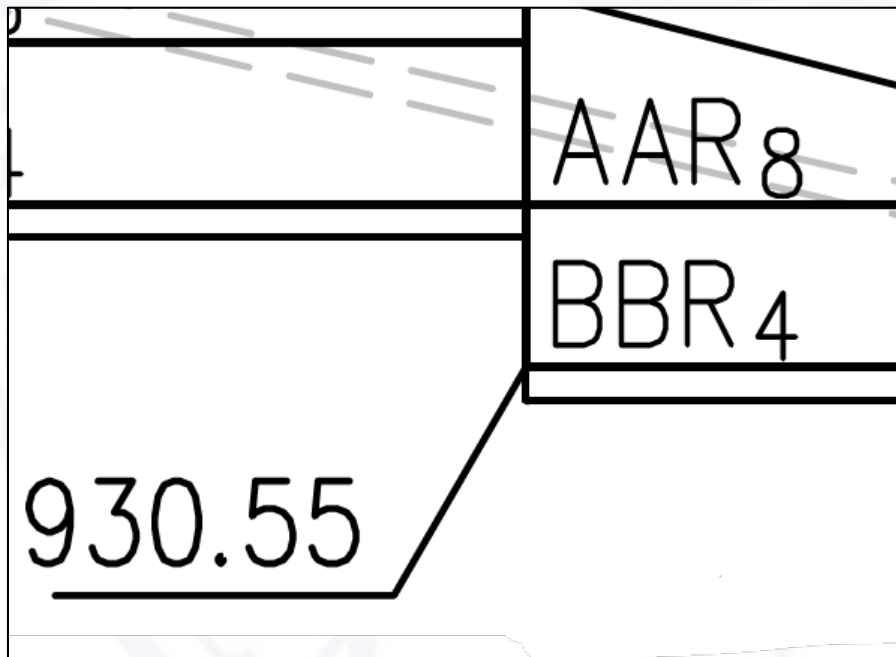
# Leveling Pad



# Leveling Pad Placement: Elevation Approval

## INDOT Standard Specification 731.08

After the excavation for the wall has been performed, the Contractor shall notify the Engineer. The material beneath the leveling pad shall be compacted in accordance with 203. Concrete for the leveling pad shall not be placed until the Engineer has approved the depth of the excavation and the foundation material. The leveling pad shall be in accordance with 731.07.



# Leveling Pad Placement: Curing

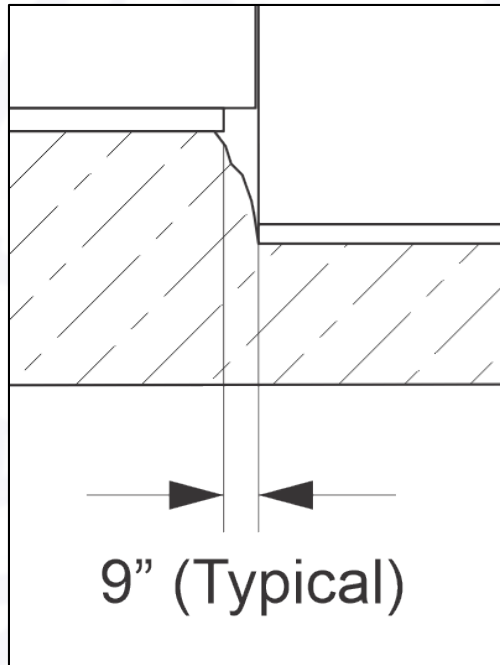
INDOT Standard Specification 731.07

An unreinforced concrete leveling pad shall be provided at each foundation level as shown on the plans. The leveling pad shall be cured in accordance with 702.22 for a minimum of 12 h before placement of concrete face panels.



Mainly deals with protective covering curing methods

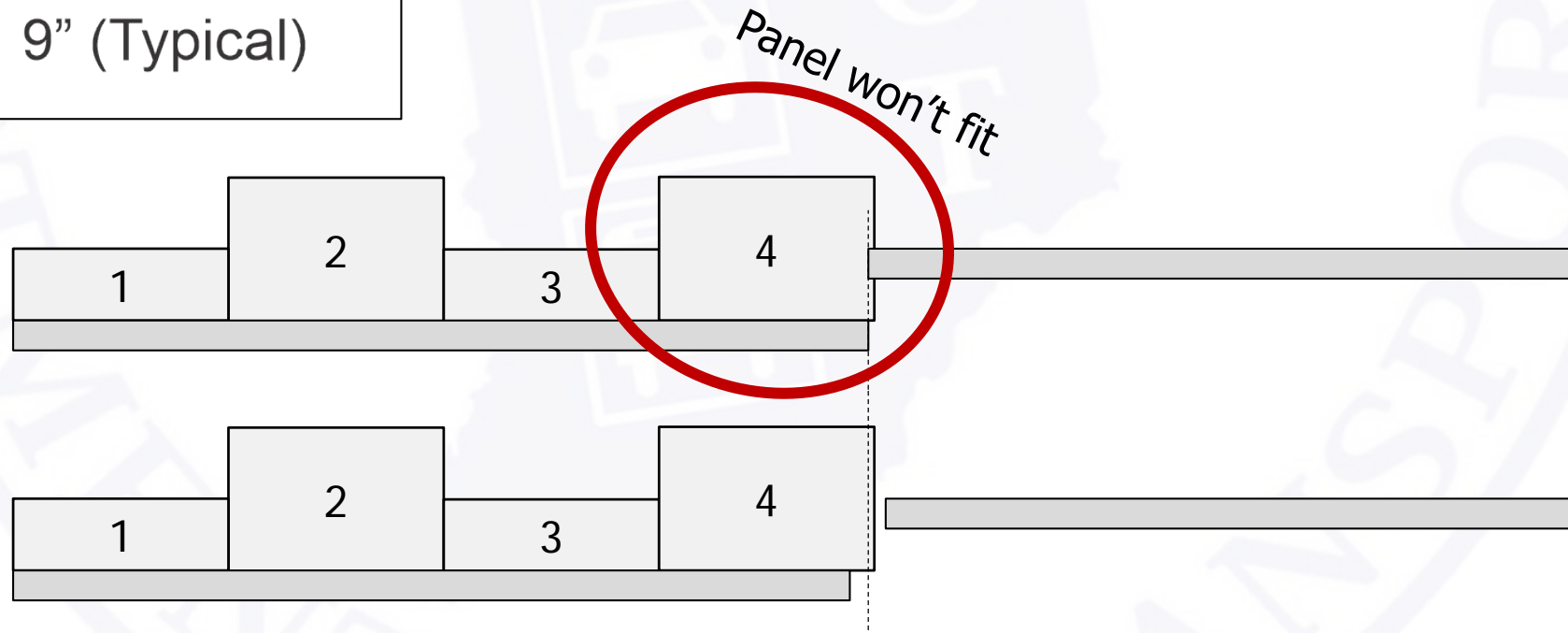
# Leveling Pad Placement: Step-Ups



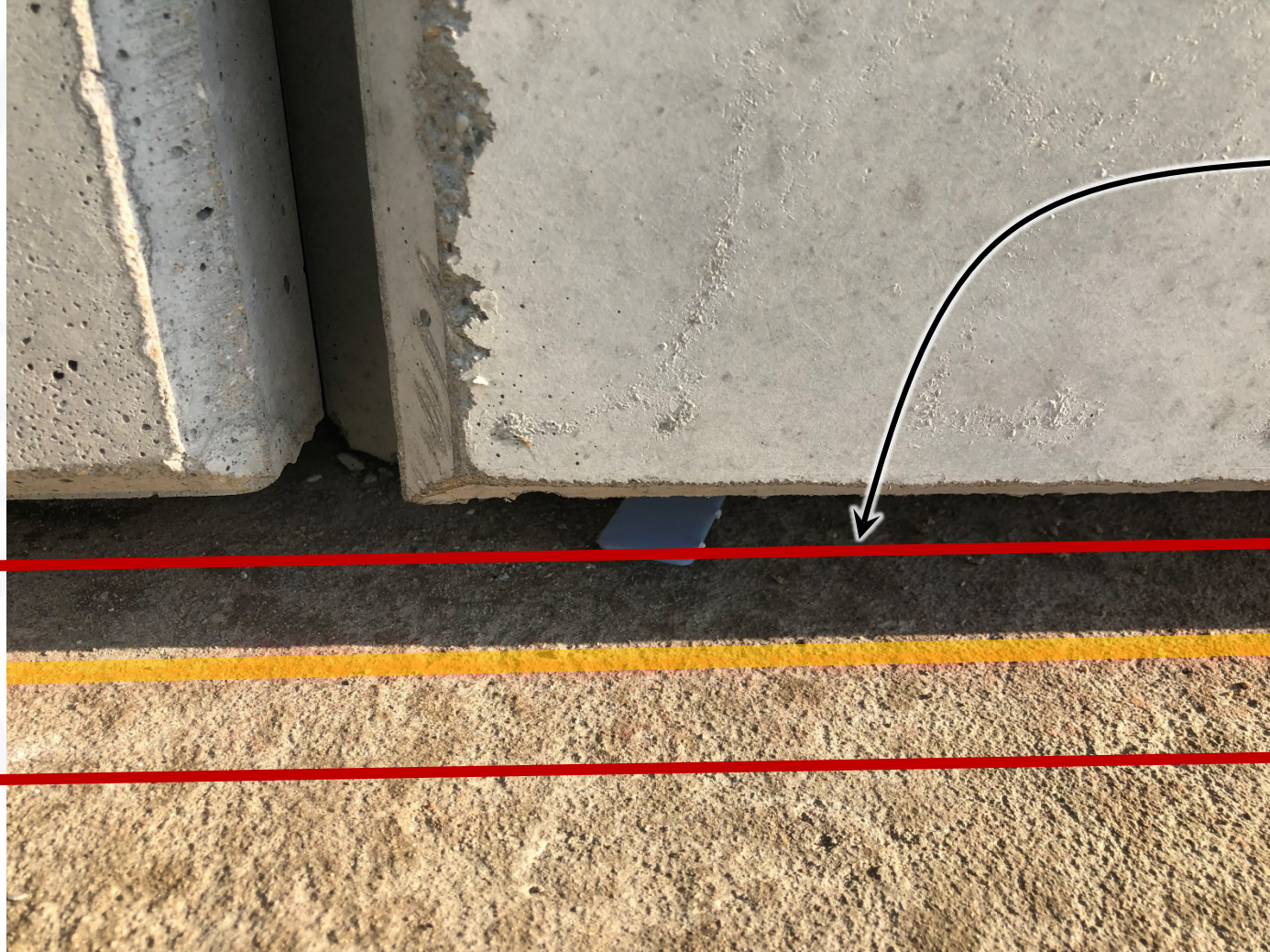
## Typical MSE Wall System Vendor Guidelines:

- Pour Higher elevation leveling pad first
- Leave a 9"  $\pm$  3" horizontal gap between the higher and lower leveling pads

Recommended but not required  
by INDOT specifications



# Leveling Pad Placement: Layout Line



Layout Line (Chalk Line)  
for placing first panel course

Recommended but not required by  
INDOT specifications

# Initial Panel Course Placement

# Initial Panel Course Placement Sequence

---

1. Lift and place panels
2. Set panel batter
3. Brace panels
4. Place adjacent panels
5. Place geotextile joint covering
6. Place and compact structure backfill
7. Place first layer of soil reinforcement
8. Backfill first layer of soil reinforcement
9. Check alignment of panel course

# Initial Panel Course Placement: Starting Point

---

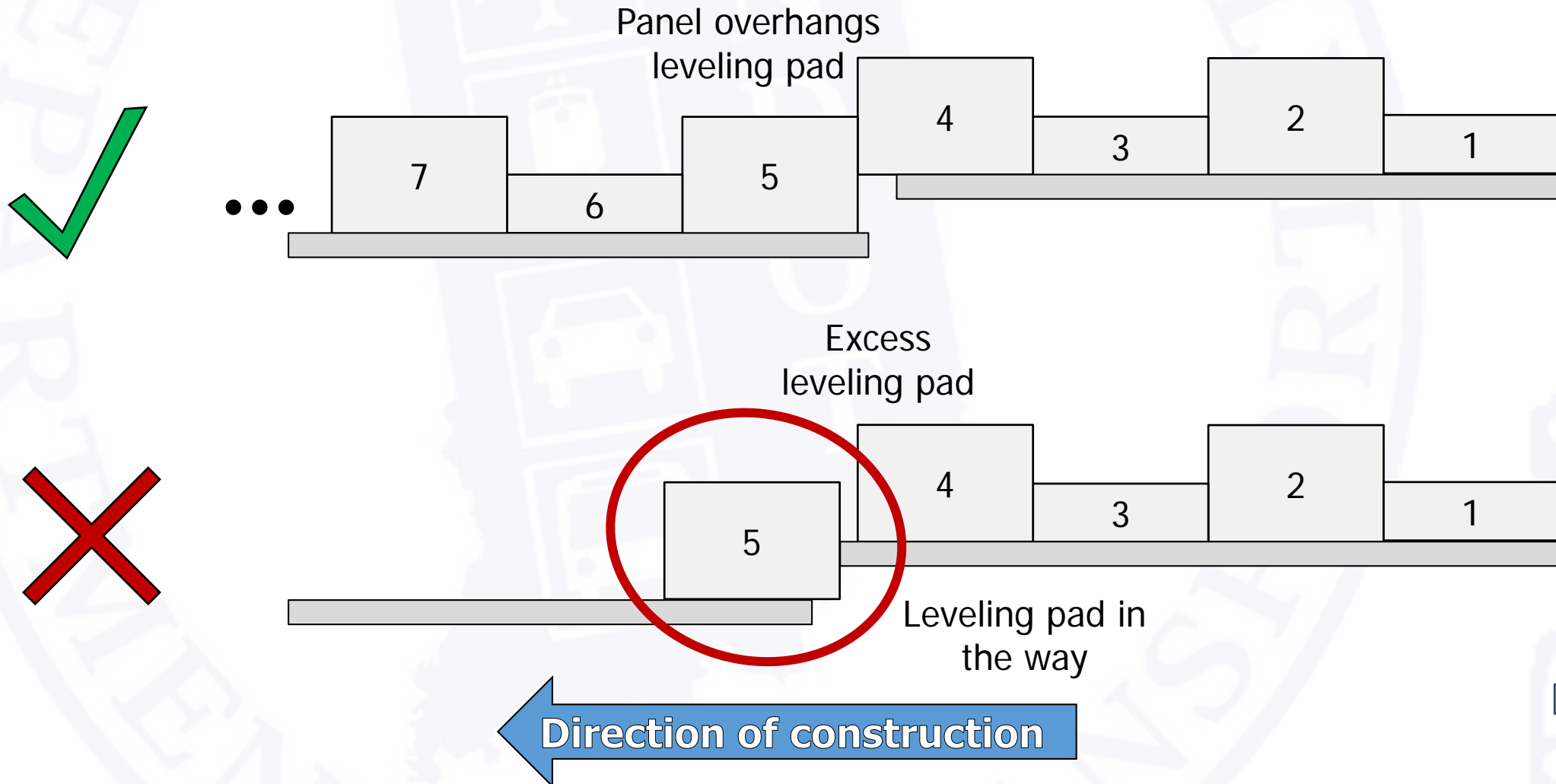
Begin placing panels at:

- Fixed location (e.g., existing structure)
- Lowest elevation leveling pad



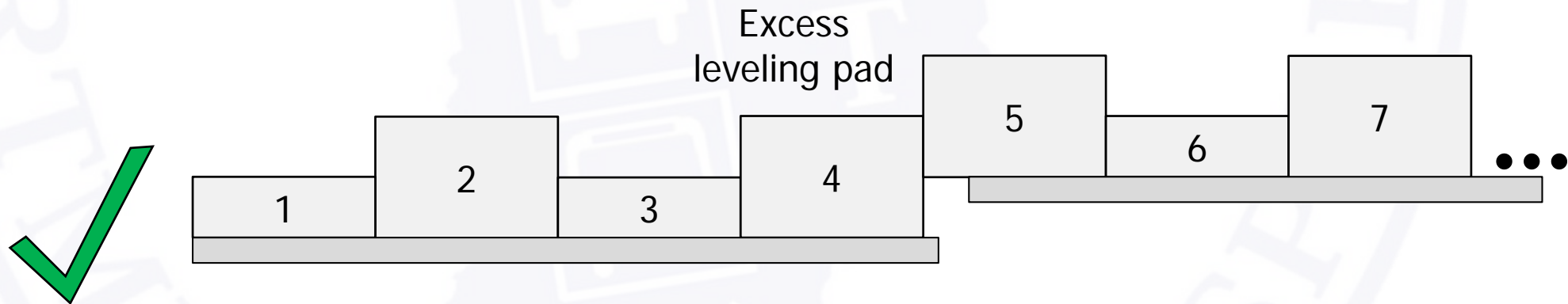
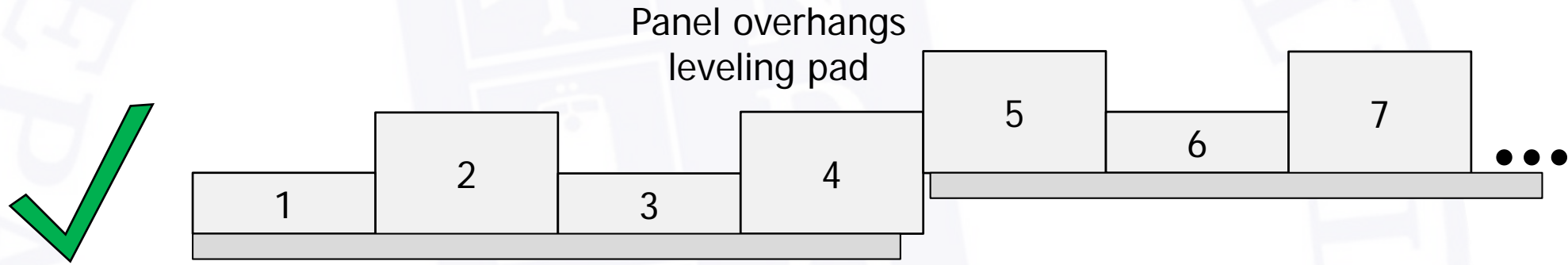
# Initial Panel Course Placement: Starting Point

Beginning panel placement at highest elevation leveling pad:



# Initial Panel Course Placement: Starting Point

Beginning panel placement at lowest elevation leveling pad:

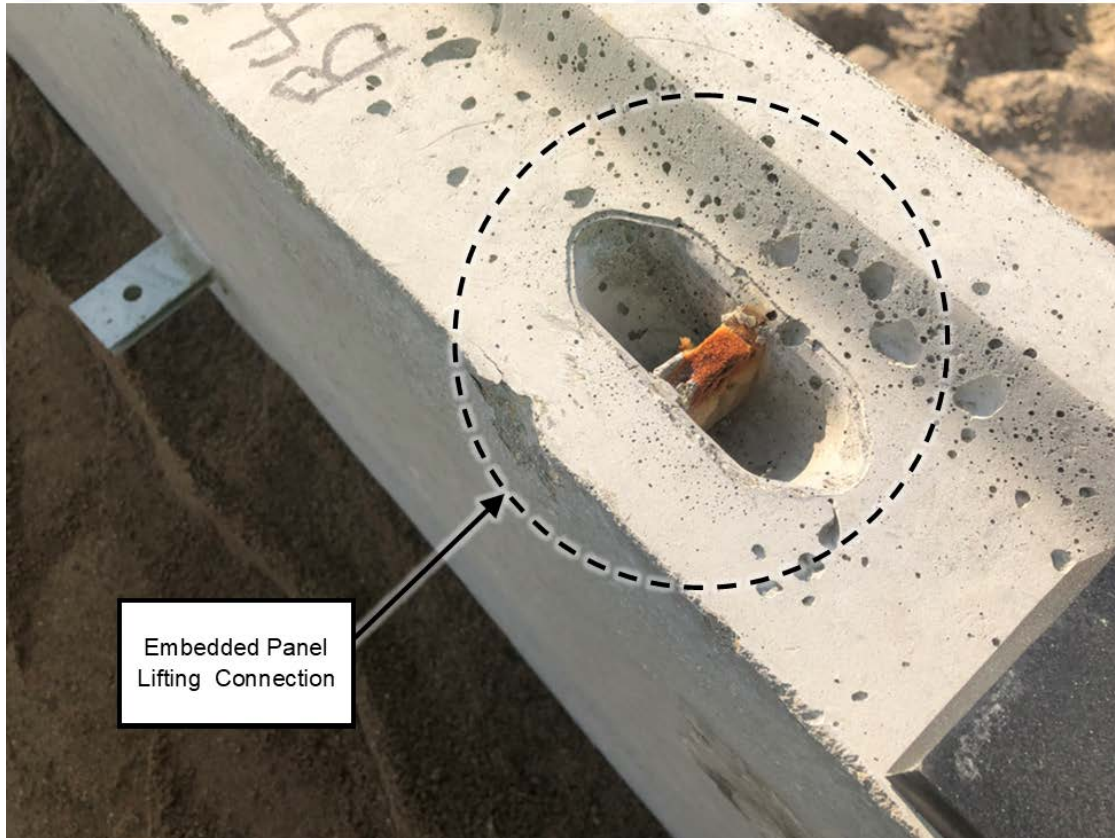


Direction of construction

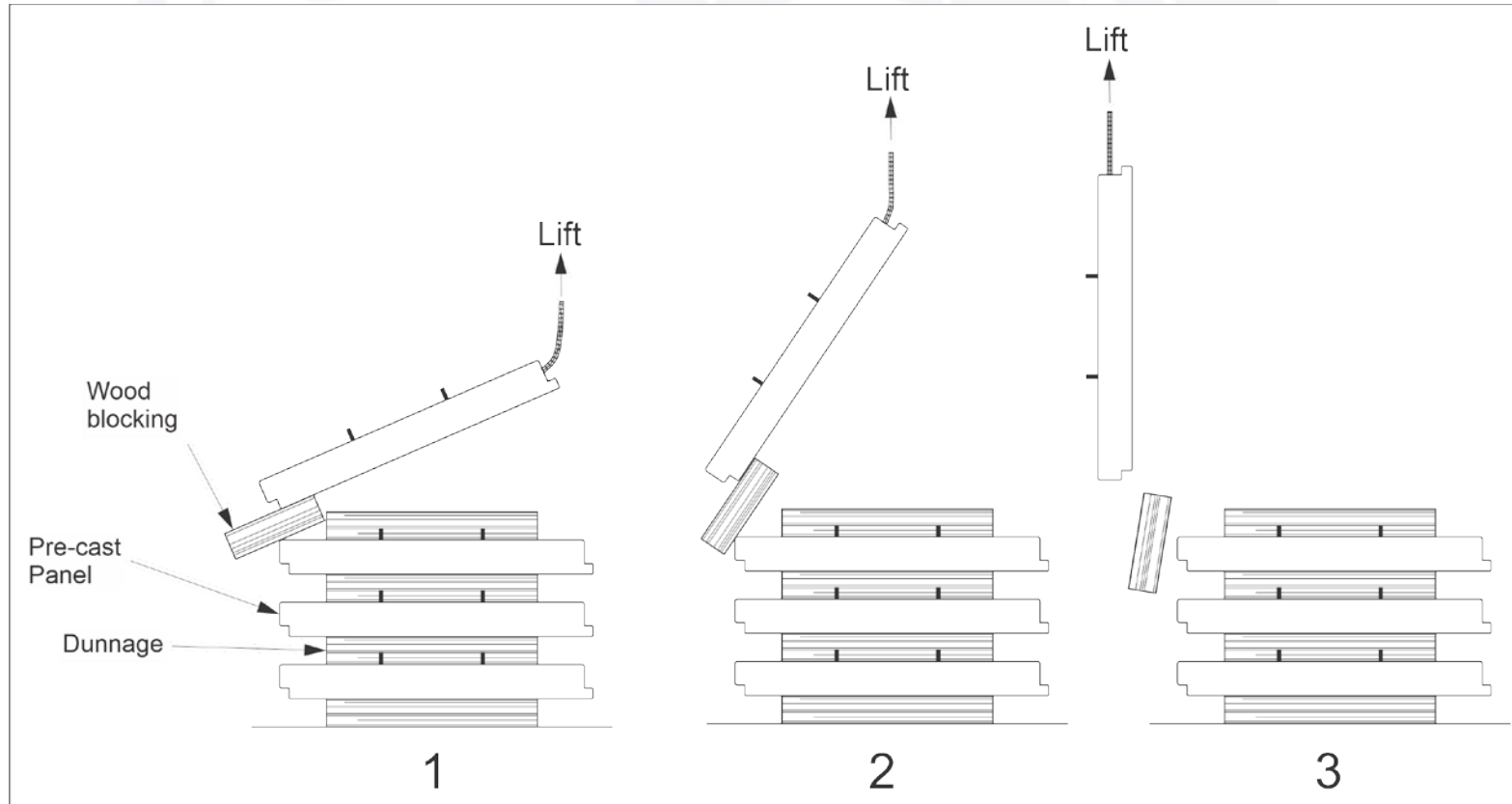
# Initial Panel Course: Lifting Panels

INDOT Standard Specification 731.09

Concrete face panels shall be handled by means of a **lifting device set into the upper edge of each panel.**



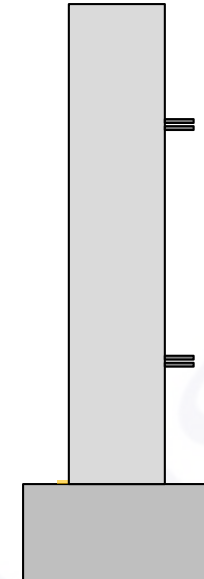
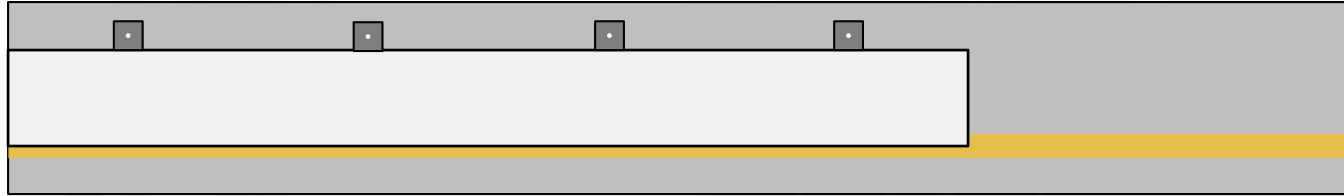
# Initial Panel Course: Lifting Panels



Typical MSE wall vendor supplied guidelines for lifting panels from stacks

Recommended but not required by INDOT specifications

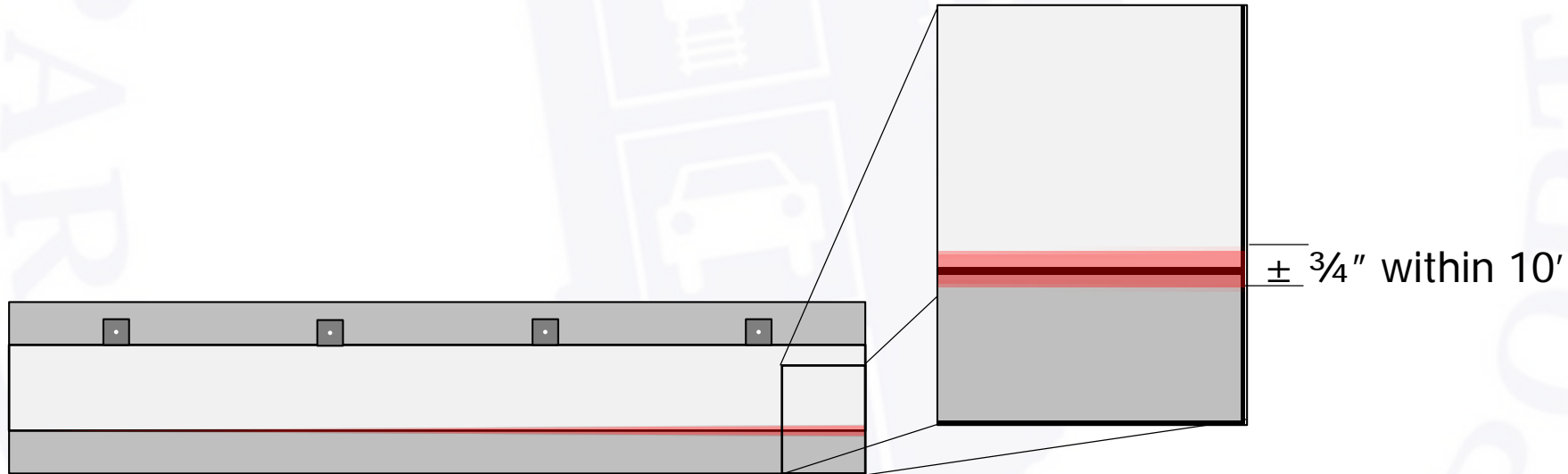
# Initial Panel Course: Placing Panels



# Initial Panel Course: Placing Panels

INDOT Standard Specification 731.09

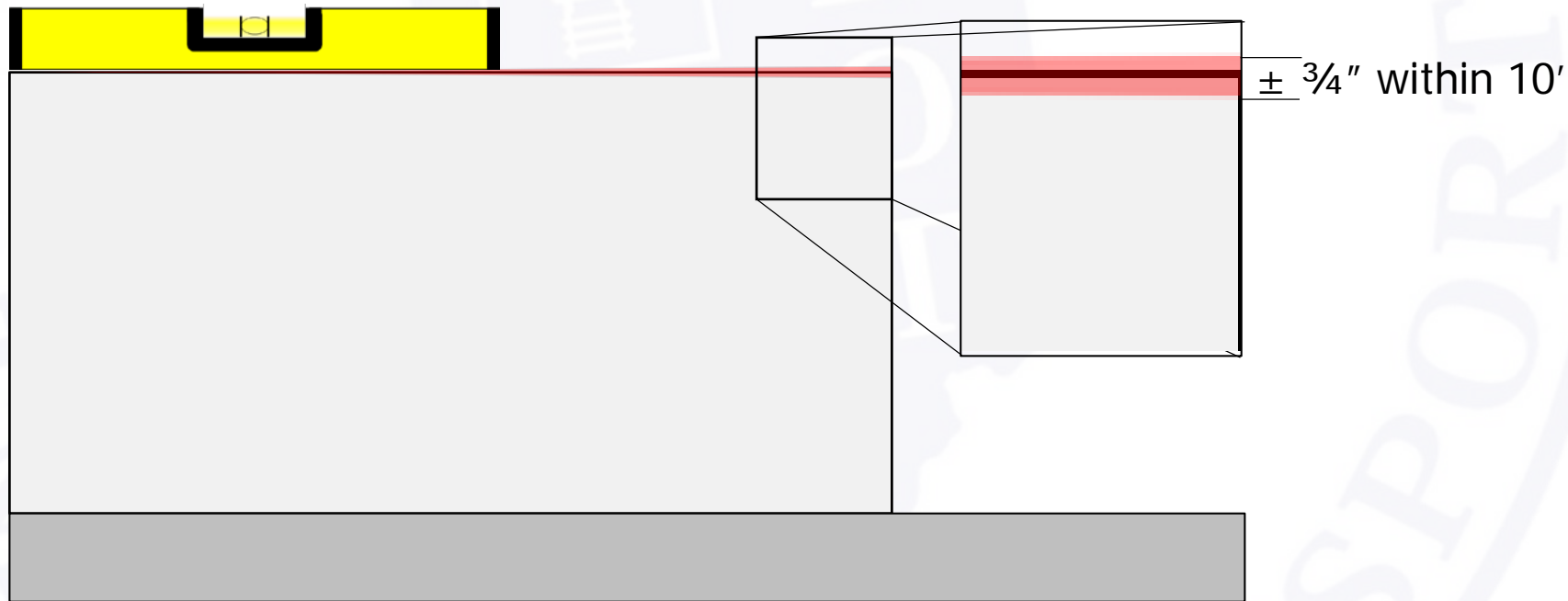
Plumb, vertical tolerances, and horizontal alignment tolerances shall not exceed  $\frac{3}{4}$  in. as measured with a 10 ft straightedge.



# Initial Panel Course: Placing Panels

INDOT Standard Specification 731.09

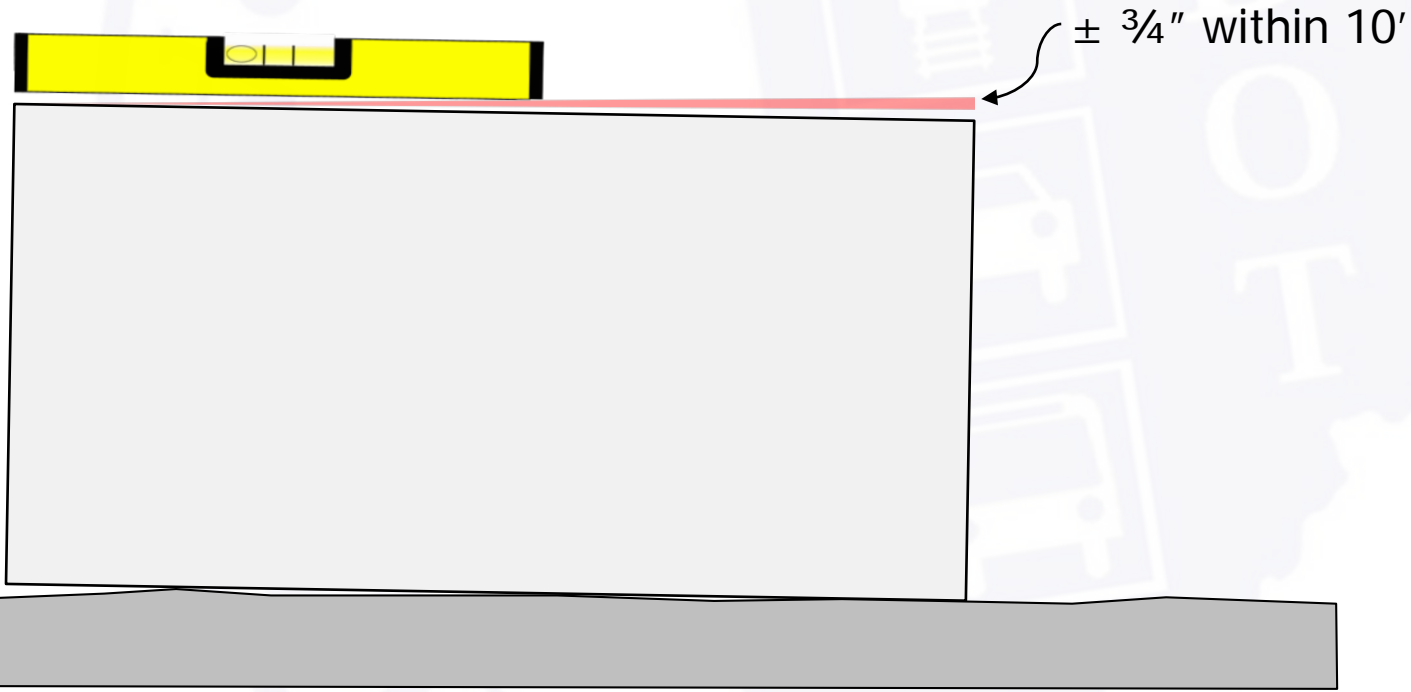
Plumb, vertical tolerances, and horizontal alignment tolerances shall not exceed  $\frac{3}{4}$  in. as measured with a 10 ft straightedge.



# Initial Panel Course: Placing Panels

INDOT Standard Specification 731.09

Plumb, vertical tolerances, and horizontal alignment tolerances shall not exceed 3/4 in. as measured with a 10 ft straightedge.



Typical MSE wall vendor supplied shims

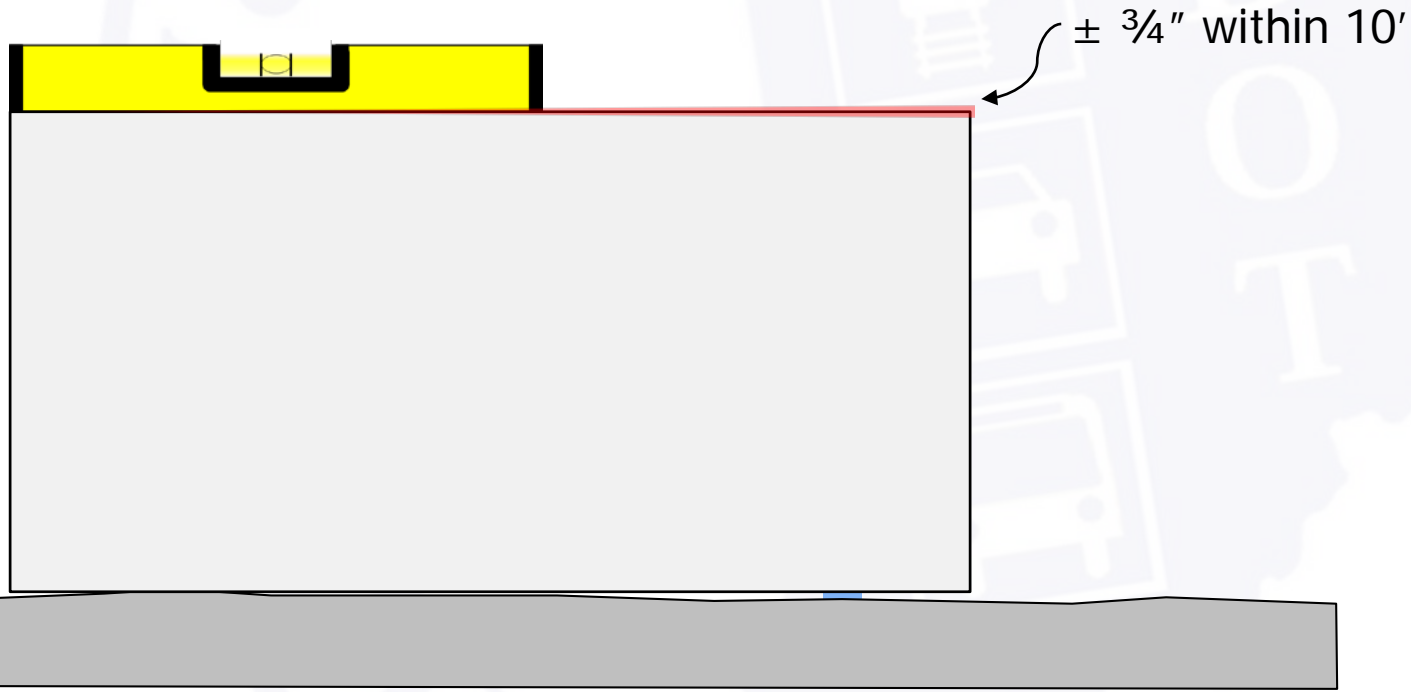
No requirements in  
INDOT specifications



# Initial Panel Course: Placing Panels

INDOT Standard Specification 731.09

Plumb, vertical tolerances, and horizontal alignment tolerances shall not exceed 3/4 in. as measured with a 10 ft straightedge.



Typical MSE wall vendor supplied shims

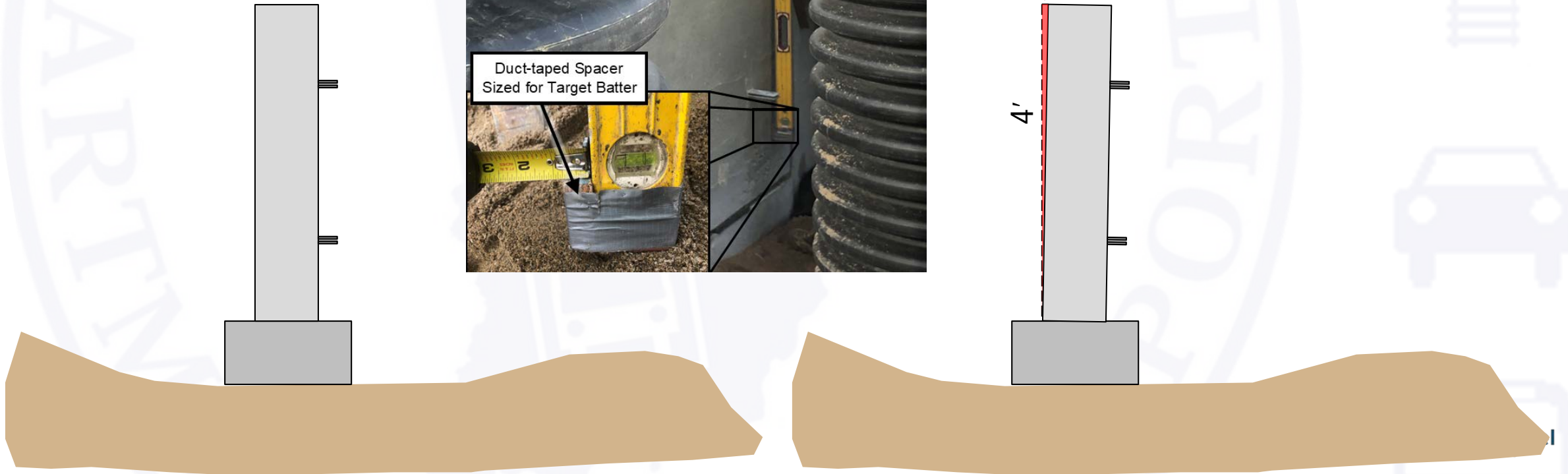
No requirements in  
INDOT specifications

# Initial Panel Course: Set Panel Batter

- Backfill will push panel out during and after construction
- Rotate toward backfill
- $\frac{1}{2}$ " horizontal per 4 ft vertical is typical (though depends on backfill type)



No requirements in INDOT specifications

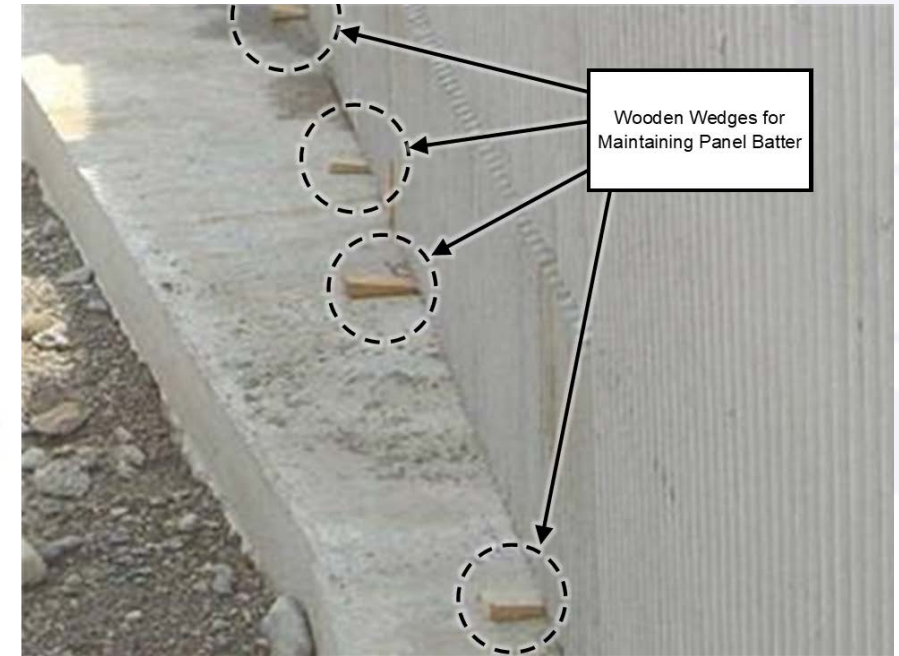
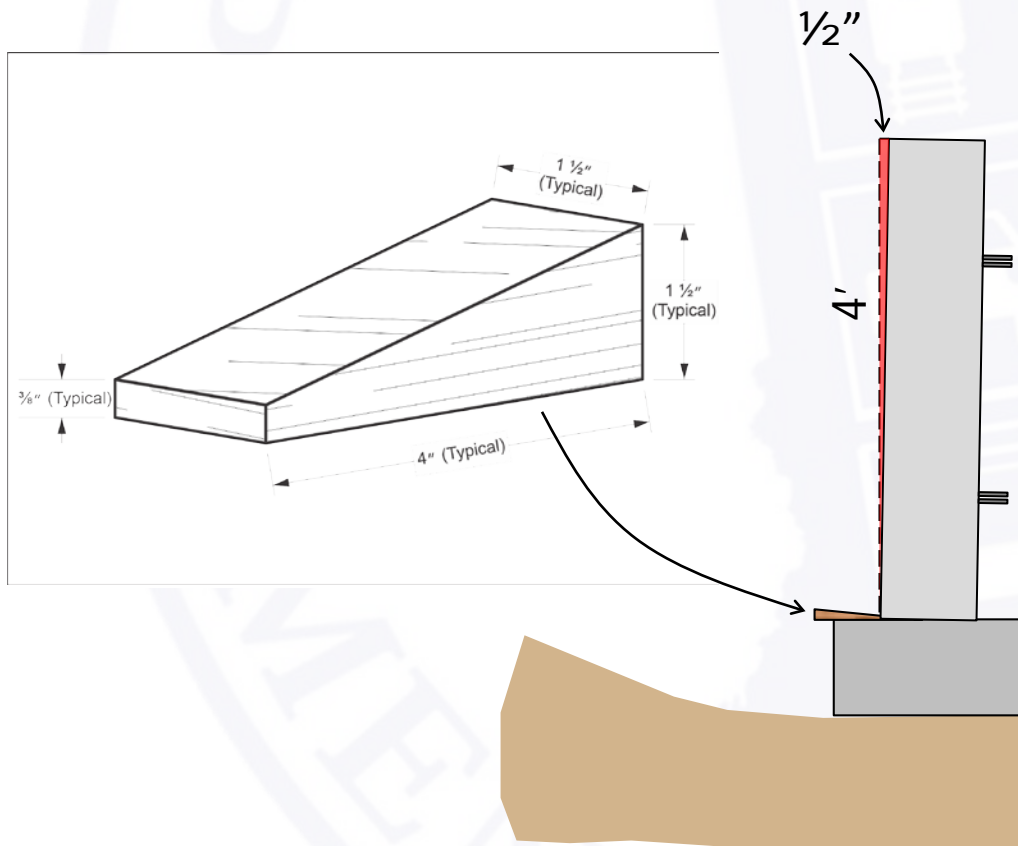


# Initial Panel Course: Set Panel Batter

## INDOT Standard Specification 731.09

As backfill material is placed behind the panels, the panels shall be **maintained in vertical position** by means of **temporary wooden wedges** placed in the joint at the junction of the two adjacent panels on the external side of the wall.

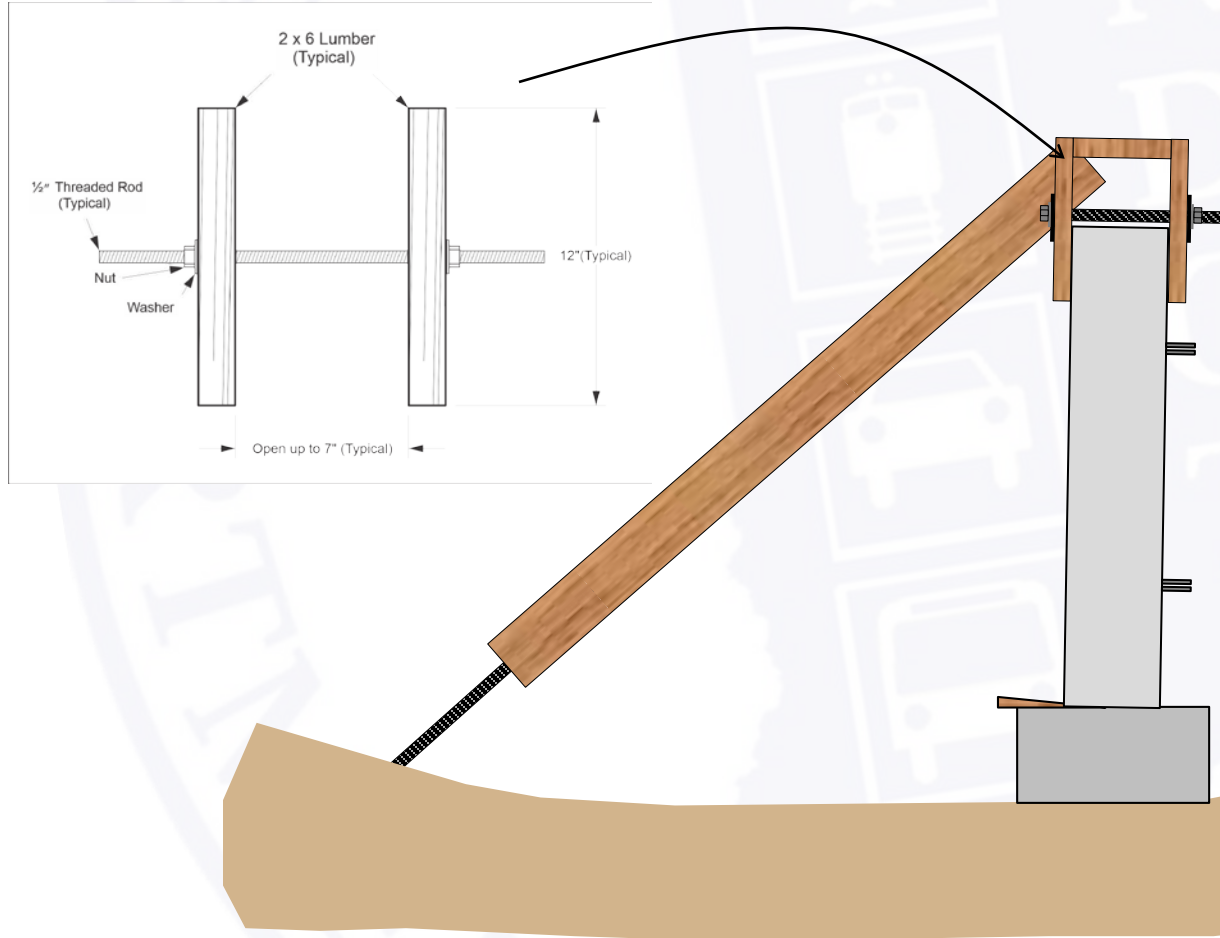
As backfill material is



# Initial Panel Course: Bracing Panels

INDOT Standard Specification 731.09

External bracing will be required for the initial lift.



# Initial Panel Course: Place Adjacent Panels

## INDOT Standard Specification 731.10

Panels without an uninterrupted vertical joint shall have a **minimum joint thickness of 3/4 in.** Joint covering shall be provided and attached to the rear face of

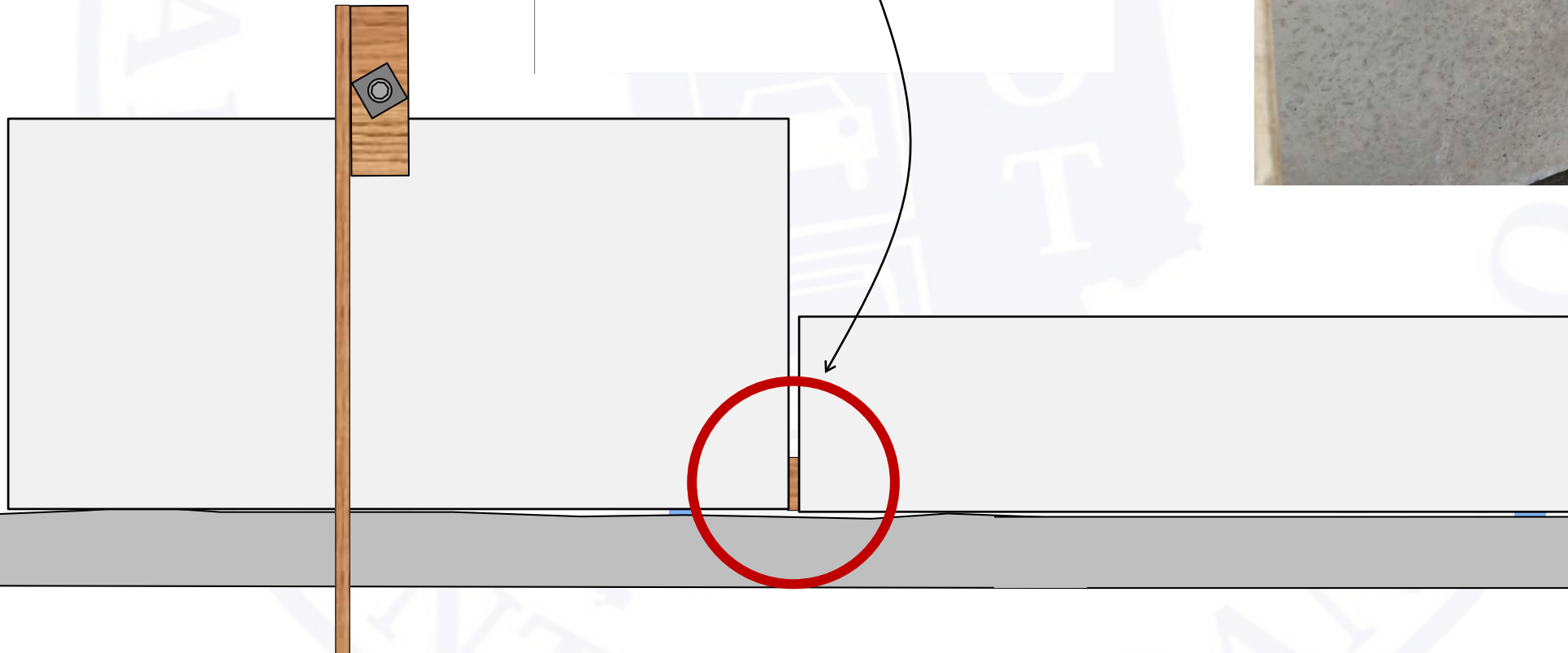
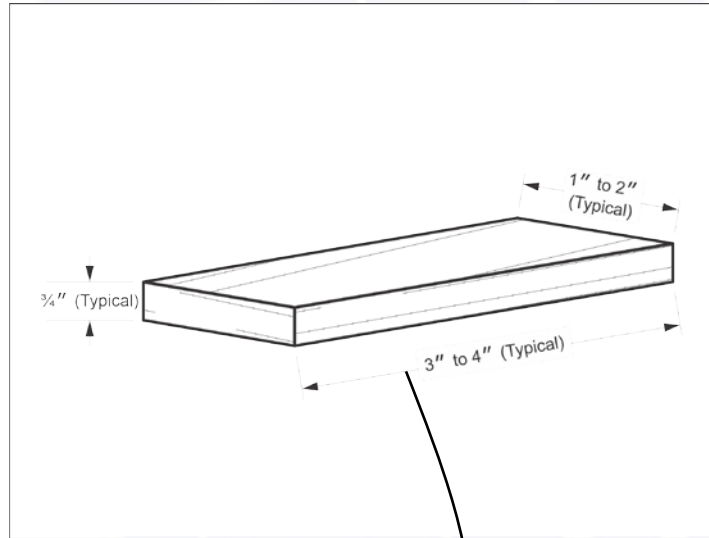
Typical vertical joint spacing for approved MSE wall systems is  $\frac{3}{4}$  in.



# Initial Panel Course: Placing Adjacent Panels

Typical vertical joint spacers

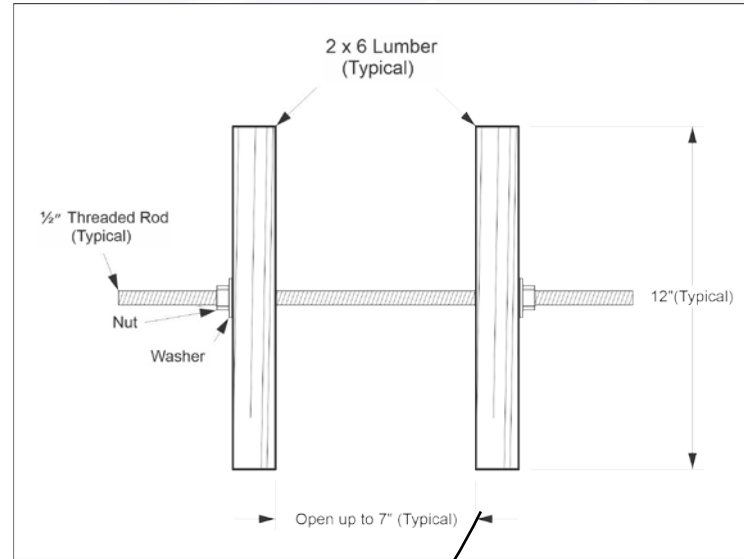
No requirements in INDOT specifications



# Initial Panel Course: Placing Adjacent Panels

Typical panel clamp

No requirements in  
INDOT specifications



# Initial Panel Course: Placing Adjacent Panels





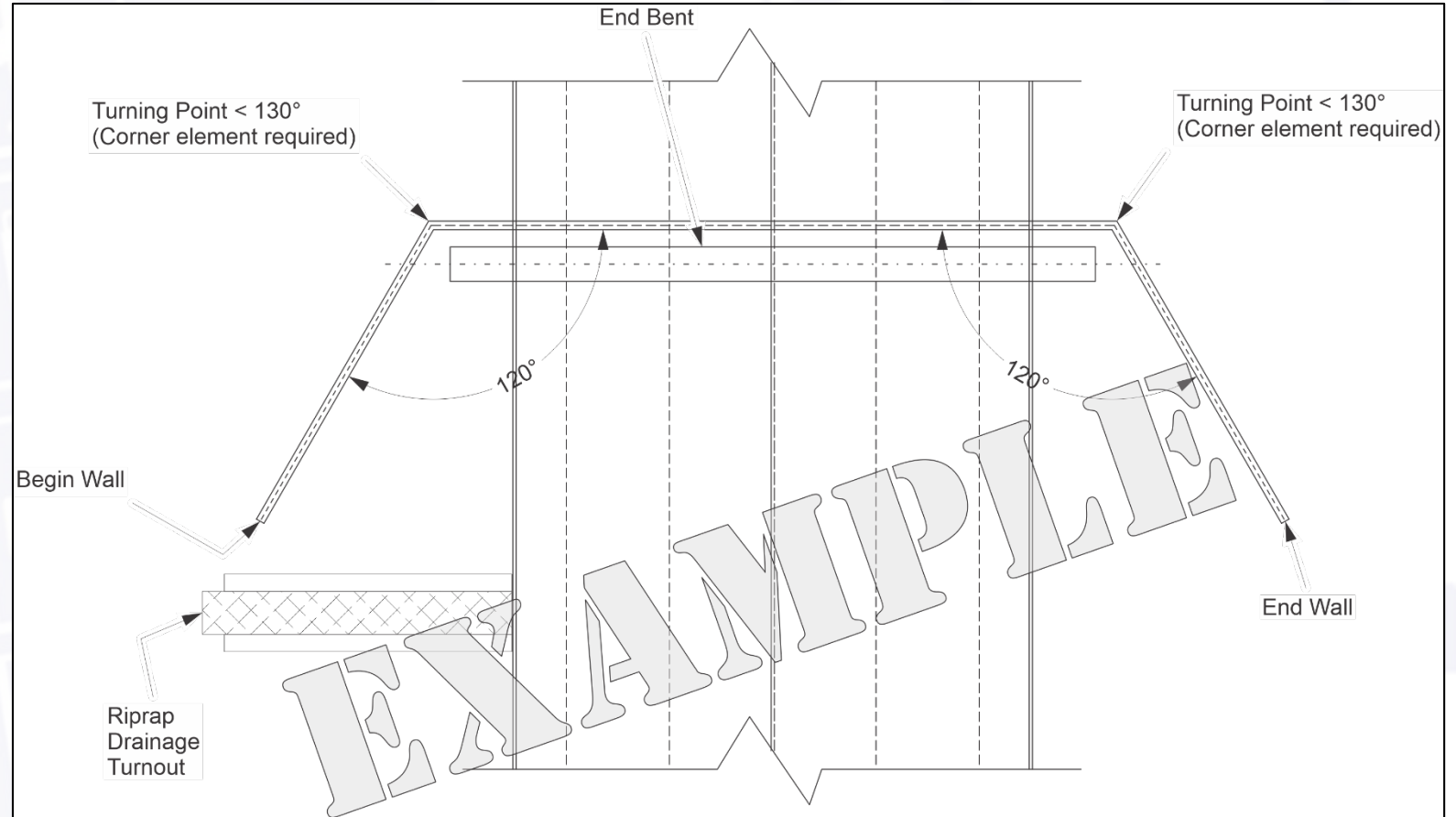
# Corner Elements

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## INDOT Standard Specification 731.02

Where walls or wall sections intersect with an included angle of  $130^\circ$  or less, a vertical corner element separate from the standard panel face shall abut and interact with the opposing panels. The corner element shall have ground reinforcement connected specifically to that panel. All turn-point locations where the wall forms an angle that are shown on the working drawings shall correspond to those shown on the plans unless otherwise approved in writing by the Engineer.

# Corner Elements

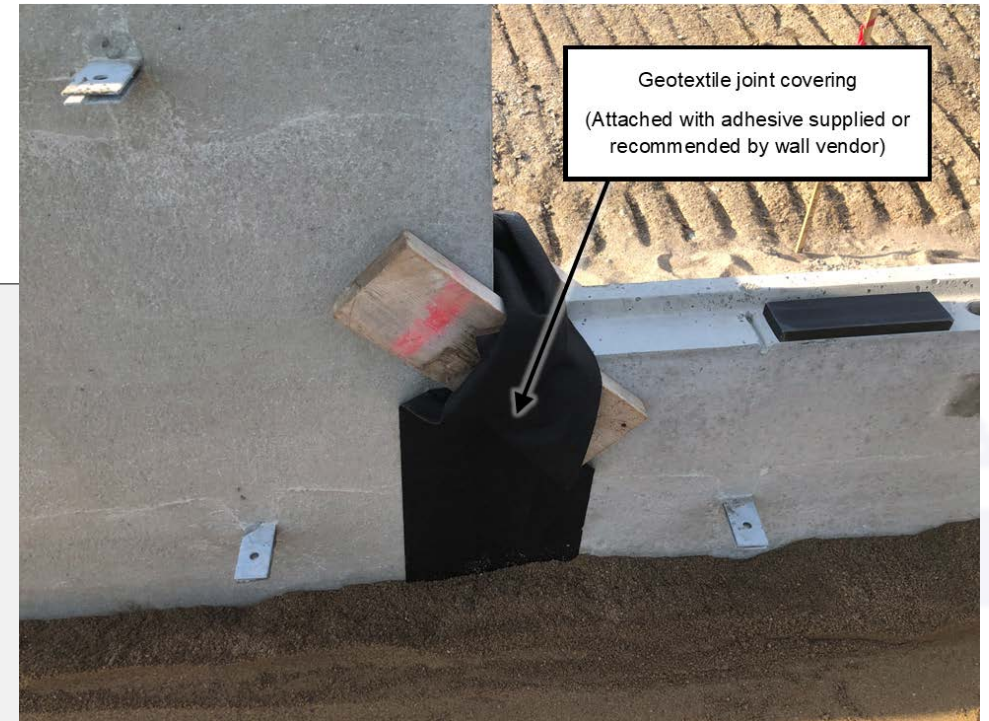


# Initial Panel Course: Place Geotextile Joint Covering

## INDOT Standard Specification 731.10

Joint covering shall be provided and attached to the rear face of the panels. Geotextiles used to cover the joint behind the MSE wall facing panels shall be in accordance with 918.02(a), Type IB.

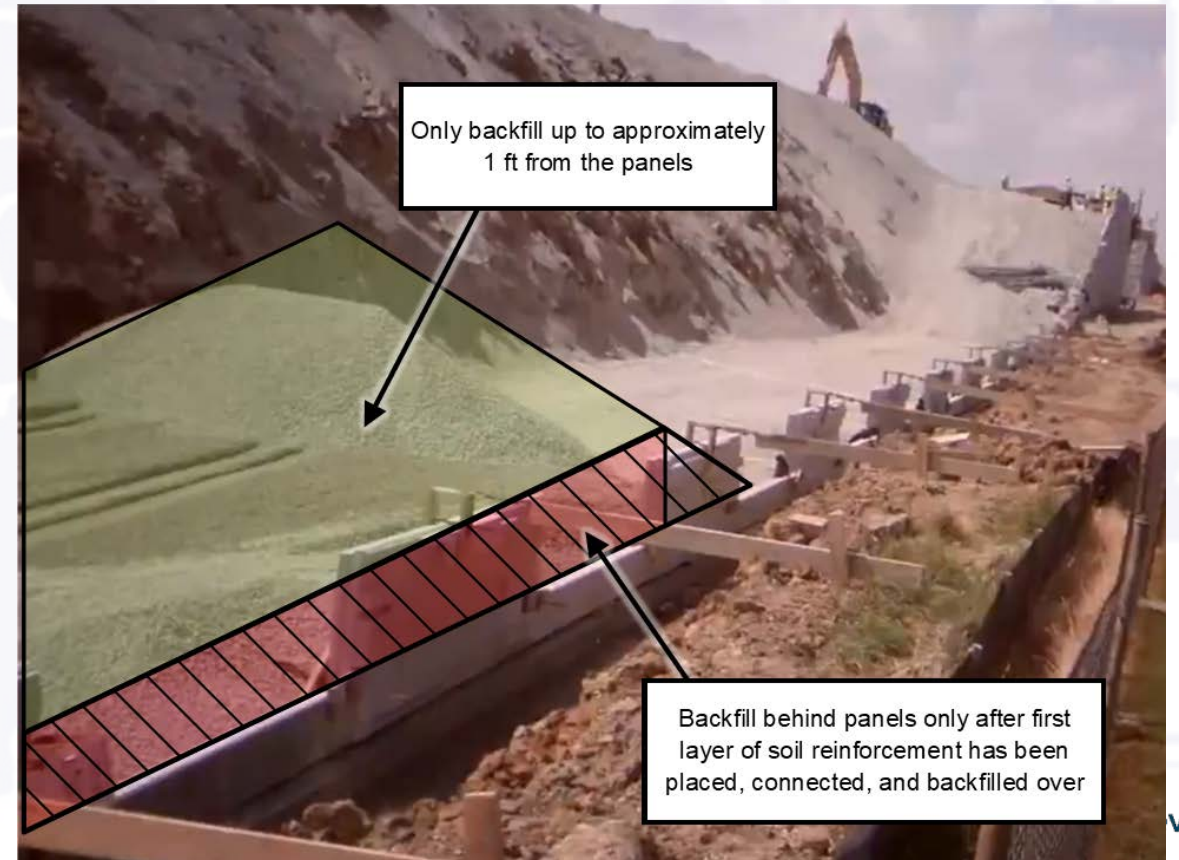
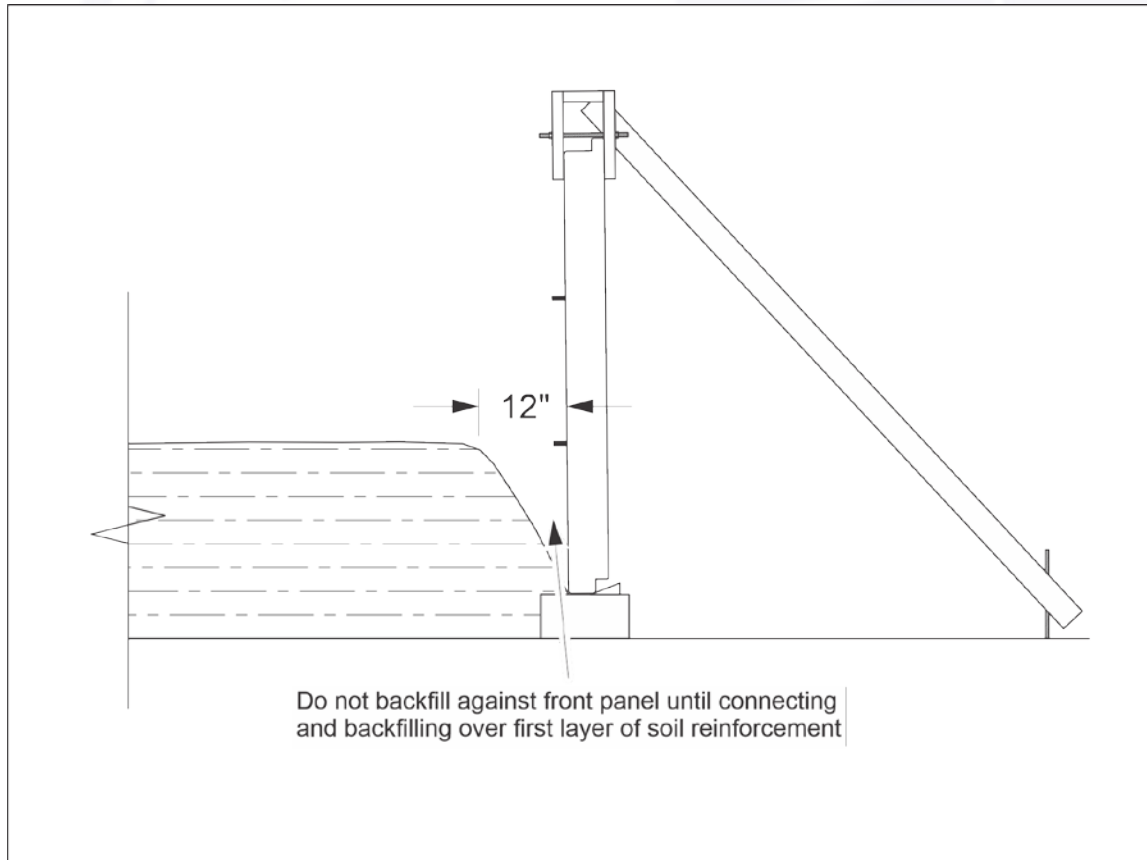
Test	Method, ASTM	Type 1B
Grab Tensile Strength, min.	D4632	200 lb
Grab Elongation	D4632	< 50%
CBR Puncture Strength, min.	D6241	600 lb
Deterioration in Tensile Strength due to UV Degradation 500 hrs, min.	D4355 D6637	70% strength retained
Apparent Opening Size, AOS	D4751	≤ No. 40 sieve, for soils < 40% passing the No. 200 sieve
Permittivity	D4491	≥ 2.1 sec <sup>-1</sup>



# Initial Panel Course: Placing Structure Backfill

## INDOT Standard Specification 731.11

Backfill shall be placed so as to avoid damage or disturbance to the wall materials or misalignment of the concrete face panels.



# Initial Panel Course: Compacting Structure Backfill

## INDOT Standard Specification 731.11

Compaction equipment shall be in accordance with 409.03(d). The vibratory roller shall be equipped with a variable amplitude system and a speed control device. It shall have a minimum vibration frequency of 1,000 vibrations per minute. A roller in accordance with 409.03(d)4 may be used.

## INDOT Standard Specification 409.03(d)

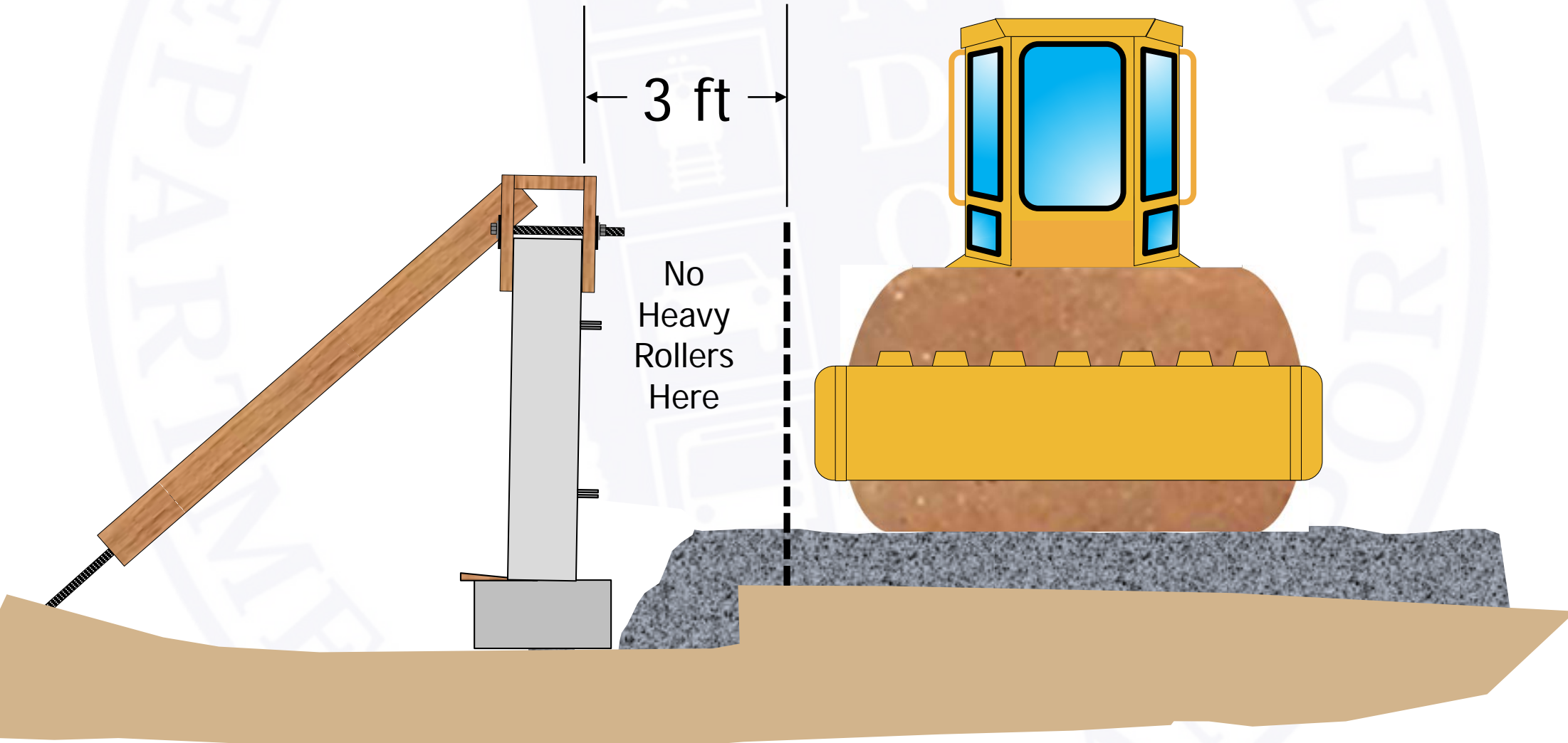
Compaction equipment shall be self-propelled, steel wheel or pneumatic tire types, in good condition, and capable of reversing direction without backlashing. All roller wheels shall be equipped with scrapers to keep the wheels clean, have water spraying devices on the wheels, and steering devices capable of accurately guiding the roller.

## INDOT Standard Specification 409.03(d)4

A vibratory roller shall have both drums equipped for vertical impact forces, a variable amplitude system, a speed control device, and have a minimum vibration frequency of 2,000 vibrations per minute. A reed tachometer shall be provided for verifying the frequency of vibrations.



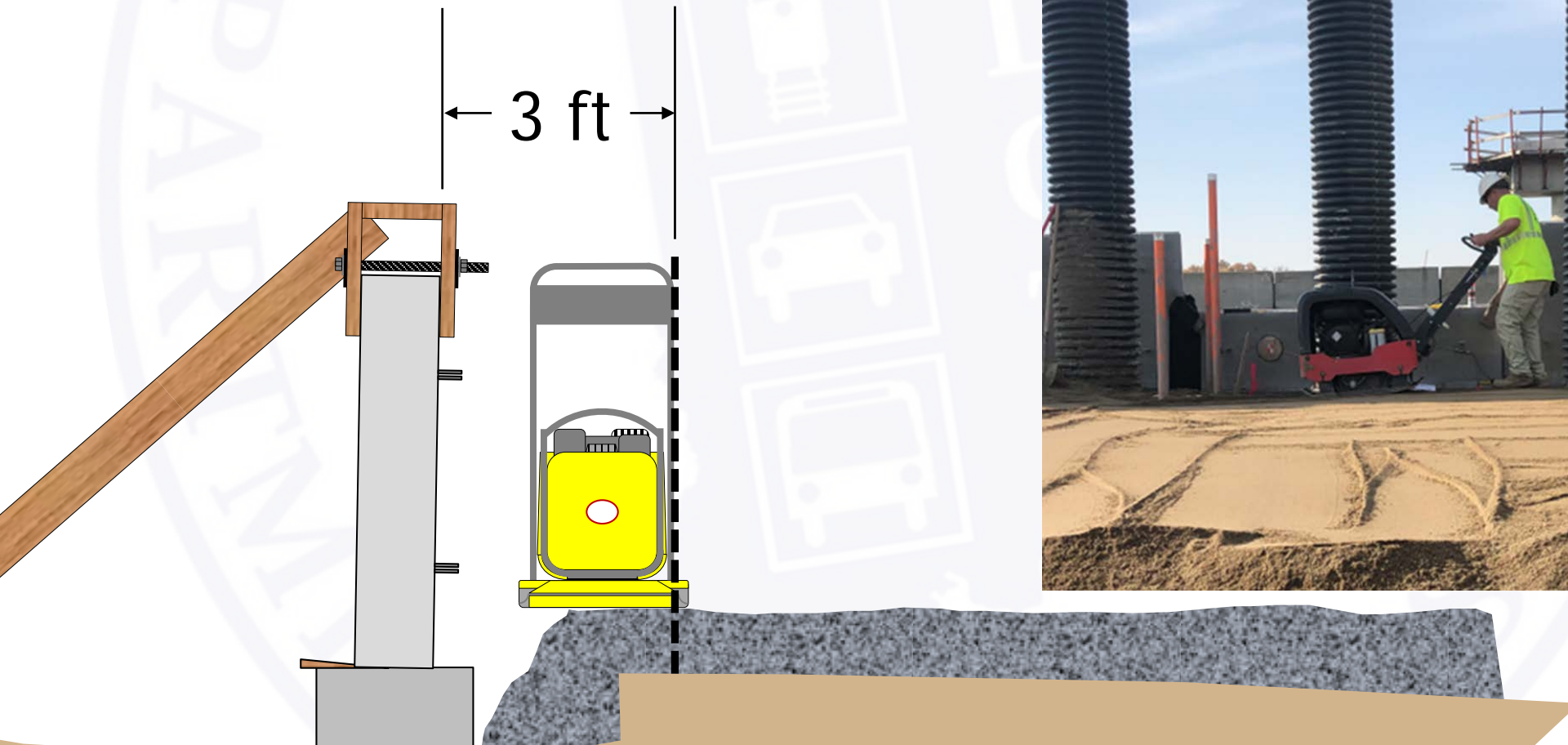
# Initial Panel Course: Compacting Structure Backfill



# Initial Panel Course: Compacting Structure Backfill

## INDOT Standard Specification 731.11

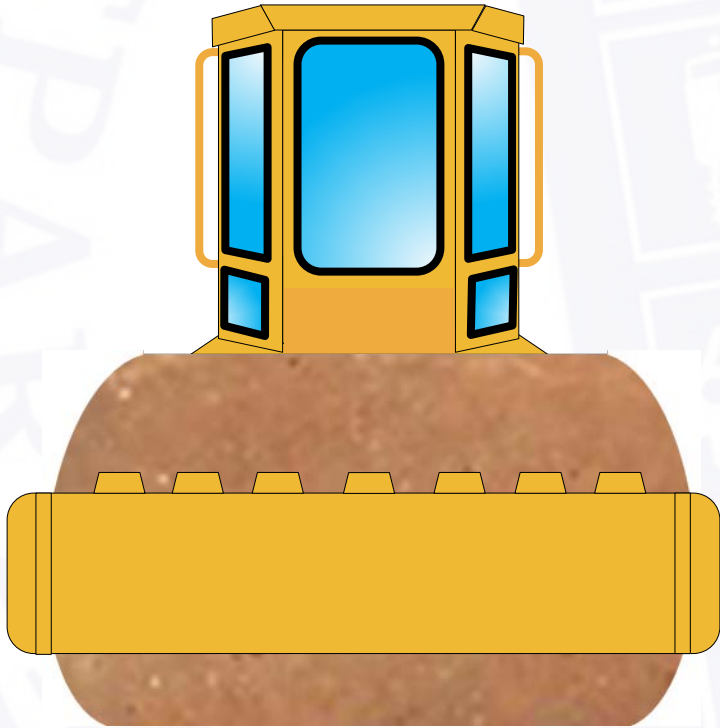
Compaction within 3 ft of the back face of the concrete face panels shall be achieved by means of a minimum of five passes with a lightweight mechanical tamper, roller, or an alternative vibratory system.



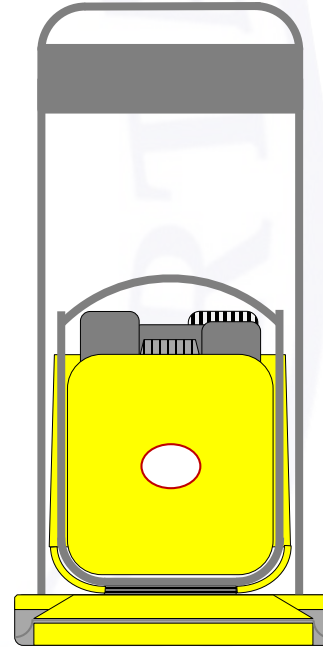
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The maximum loose lift thickness shall not exceed 8 in.



However, lifts within 3 ft of the wall shall not exceed 5 in. in loose thickness.



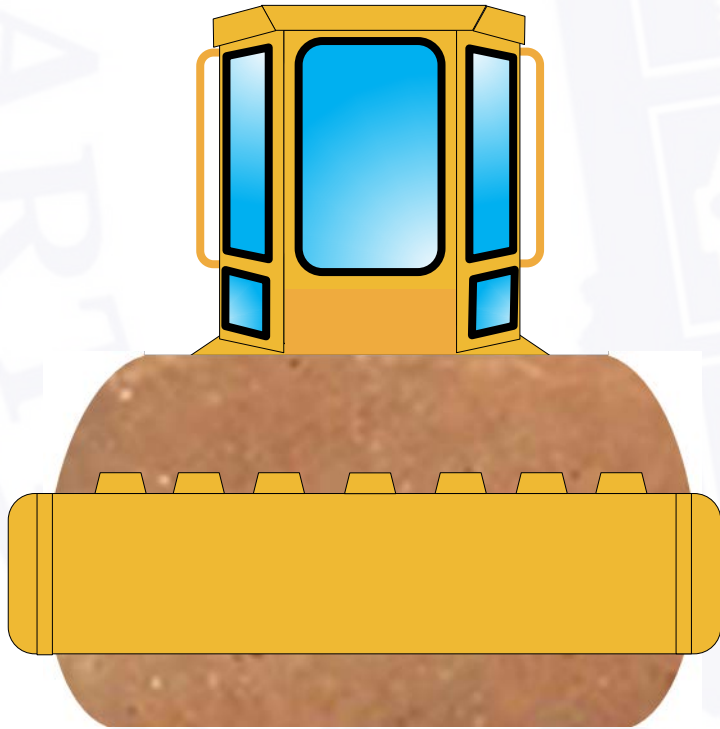
This lift thickness shall be decreased if necessary, to obtain the specified density.



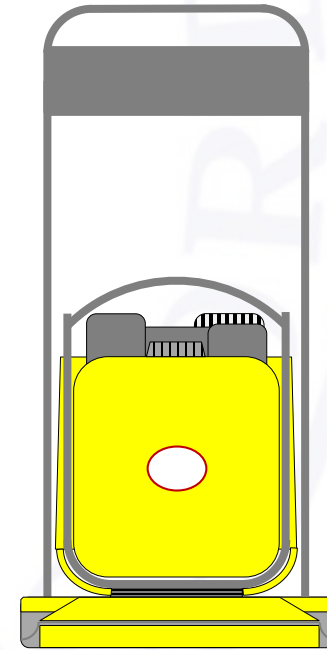
# Initial Panel Course: Compacting Structure Backfill

## INDOT Standard Specification 731.11

compaction shall consist of four passes with a vibratory roller and one pass with the same roller in static mode.



Compaction shall be achieved by a minimum of five passes



# Initial Panel Course: Compacting Structure Backfill

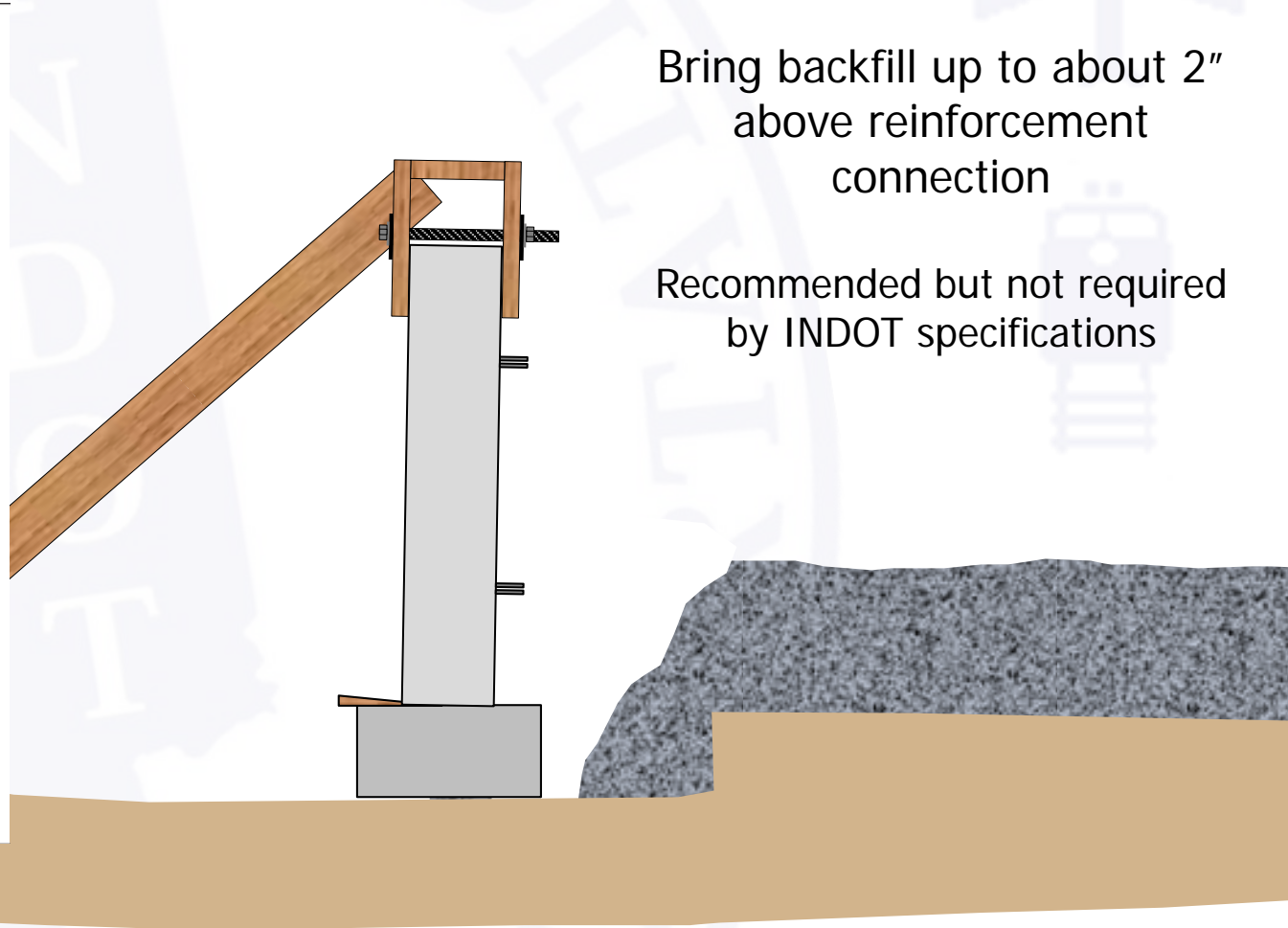
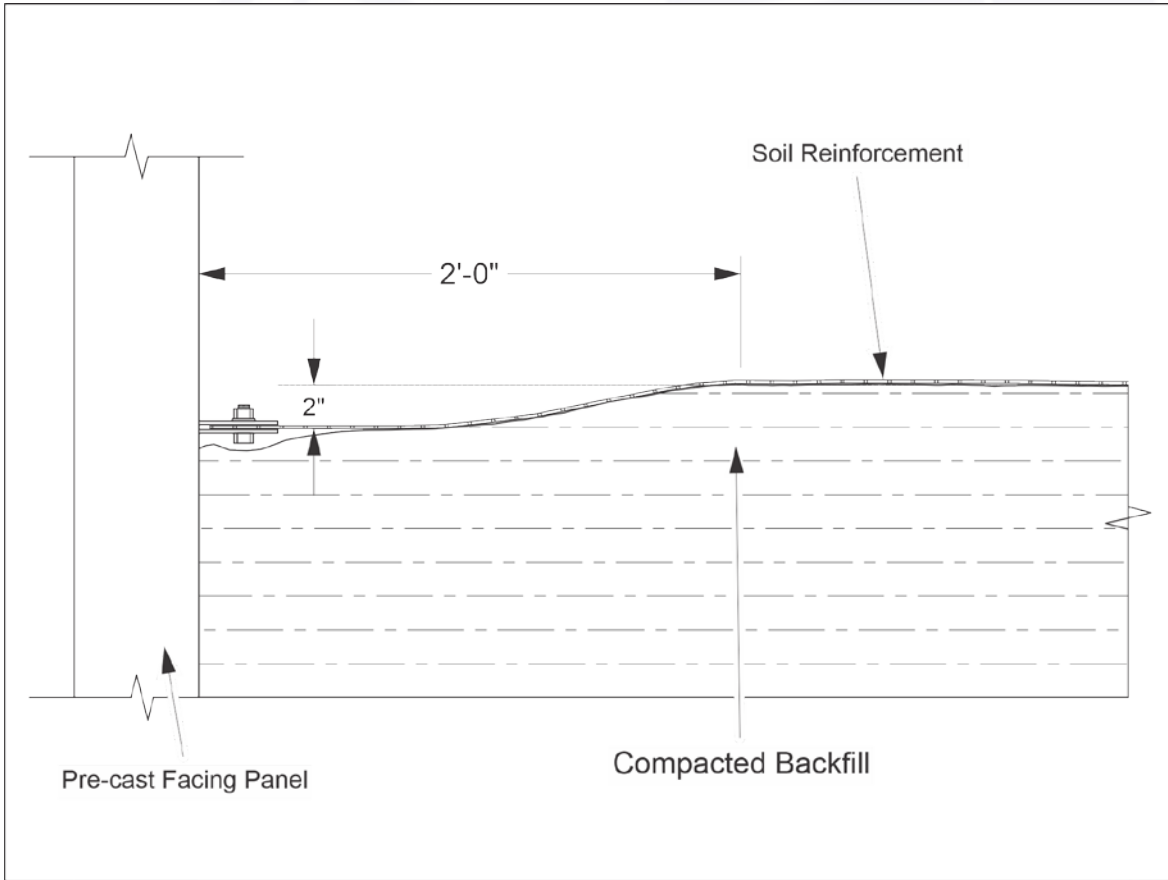
## INDOT Standard Specification 203.23



Textural Classification	Maximum Dry Density (pcf)	Optimum Moisture Content Range (%)	Acceptable Minimum DCP value for 6 in. for 95% compaction	Acceptable Minimum DCP value for 12 in. for 95% compaction	Acceptable Minimum DCP value for 6 or 12 in. for 100% compaction
<b>CLAY SOILS</b>					
Clay	< 105	19 - 24	6		*
Clay	105 - 110	16 - 18	7		*
Clay	111 - 114	14 - 15	8		*
<b>SILTY SOILS</b>					
Silty	115 - 116	13 - 14		9	*
Silty	117 - 120			11	*
<b>SANDY SOILS</b>					
Sandy	121 - 125	8 - 12		12	*
Sandy	> 125			15	*
<b>GRANULAR SOILS - STRUCTURE BACKFILL and A-1, A-2, A-3 SOILS</b>					
No. 30				6	9
No. 4				7	10
1/2 in.				11	14
1 in.				16	19

Note: \* Test section required in accordance with ITM 513.

# Initial Panel Course: Compacting Structure Backfill

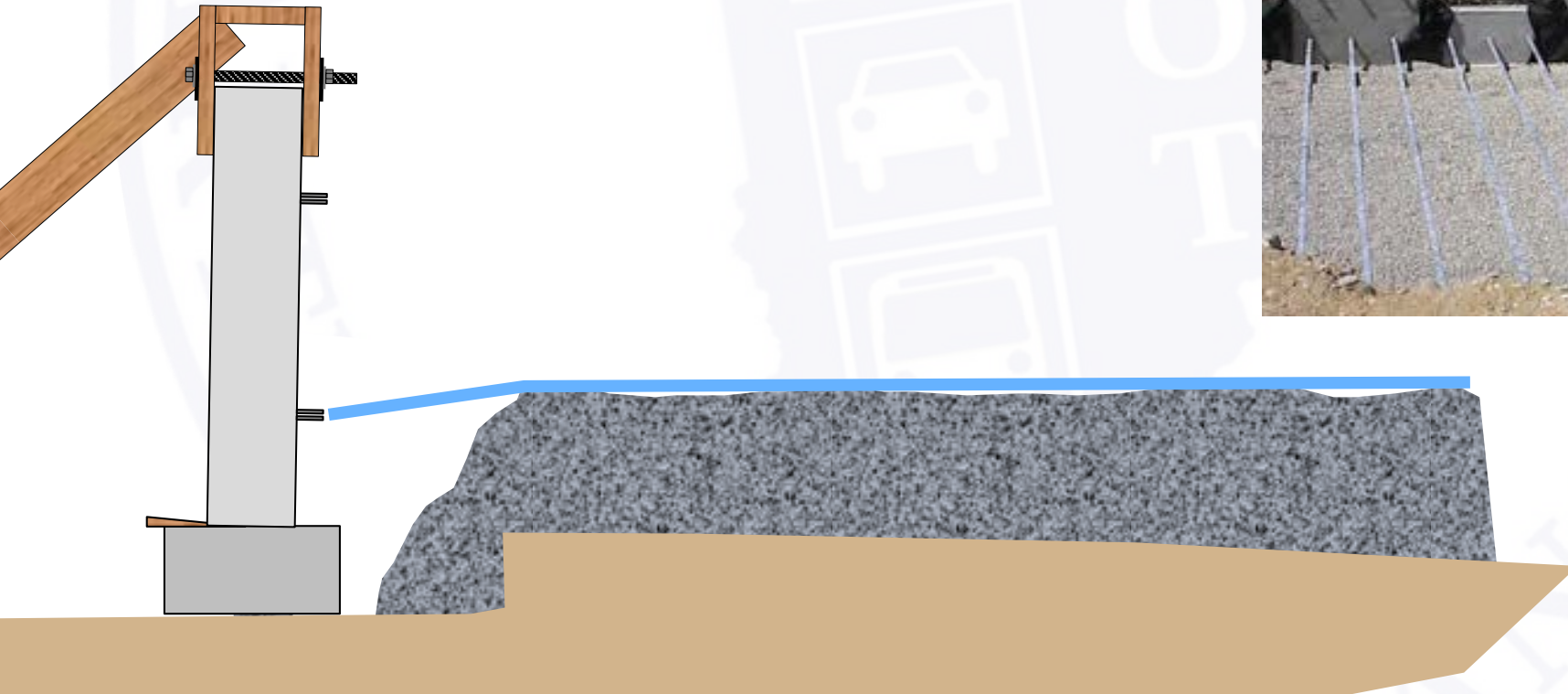


(Backfill will continue to densify during construction, so reinforcements will then end up level with their panel connections)

# Initial Panel Course: Placing Soil Reinforcement Layer

## INDOT Standard Specification 731.09

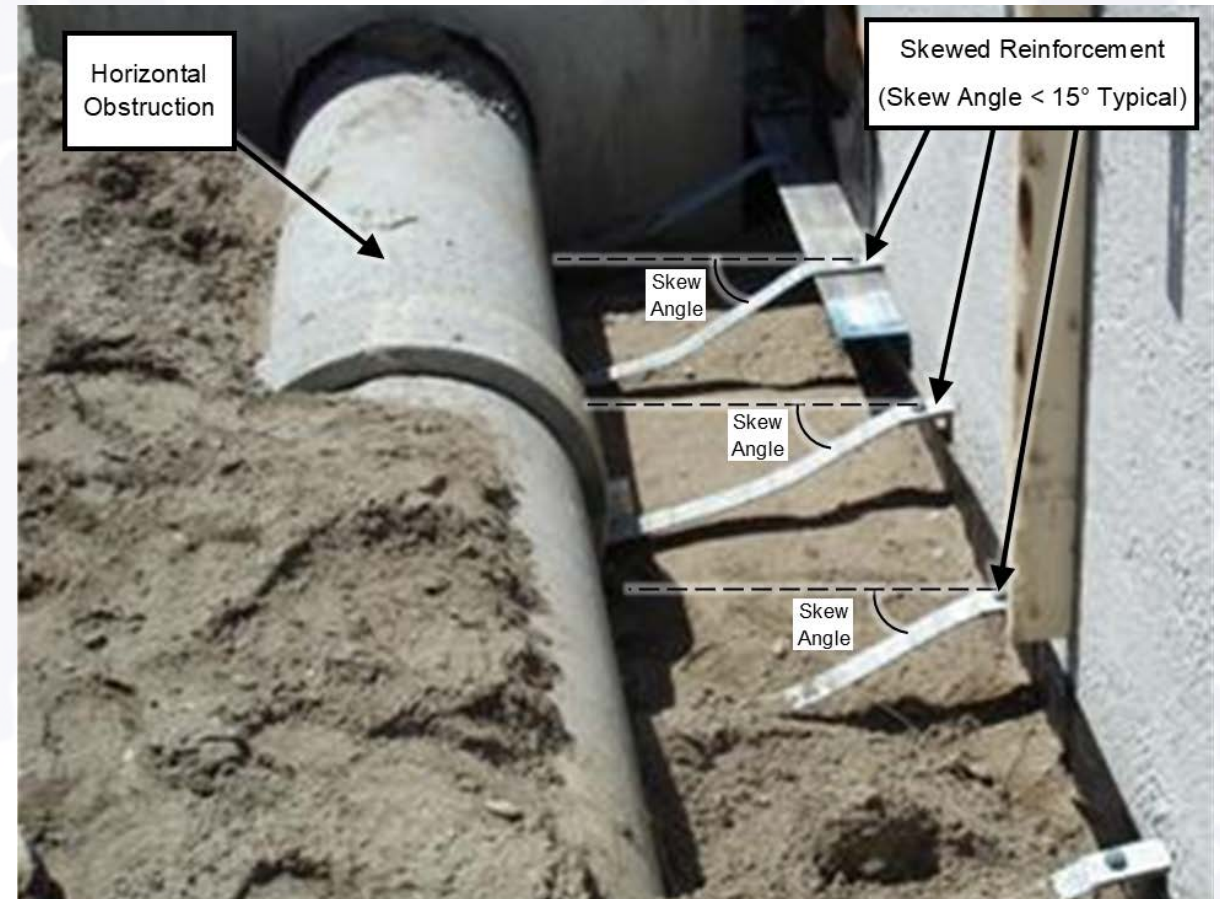
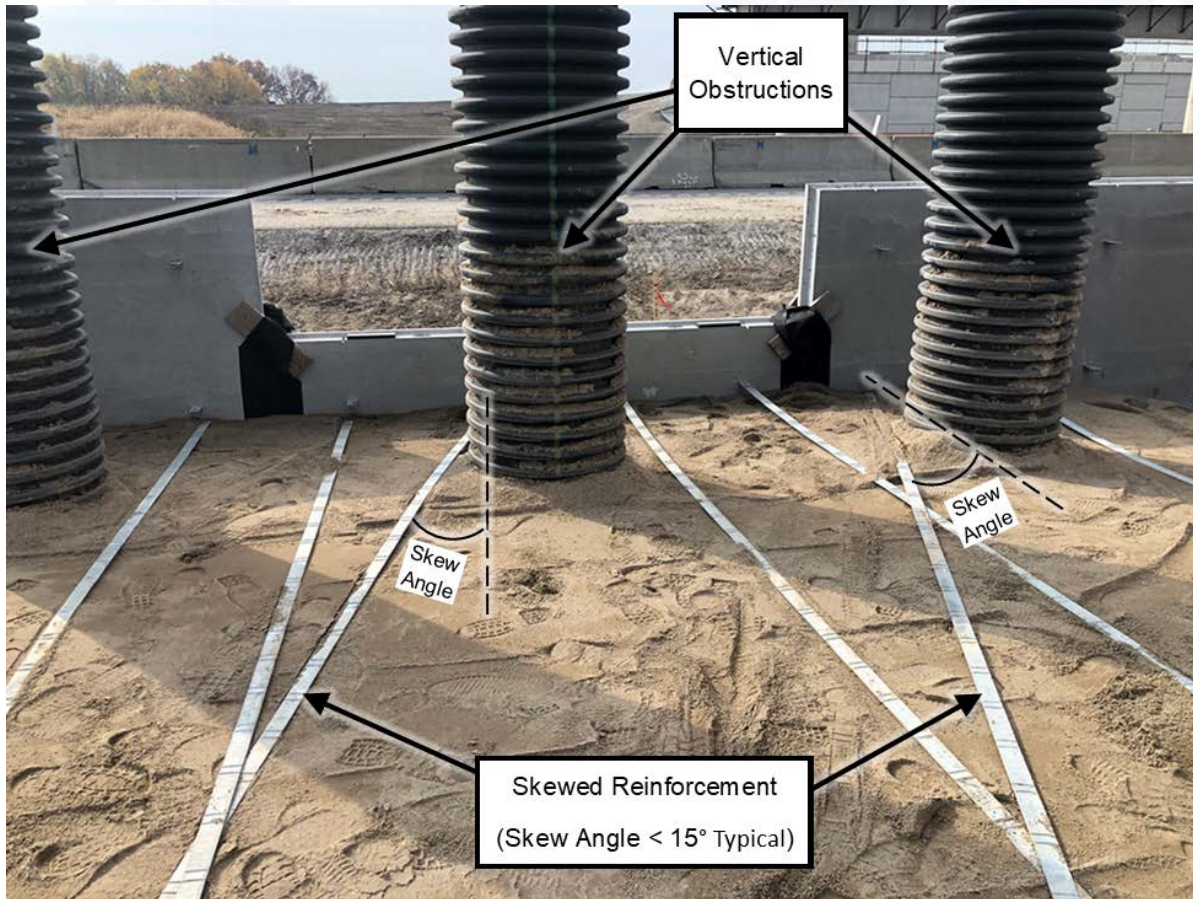
Ground reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans or as directed.



# Initial Panel Course: Placing Soil Reinforcement Layer

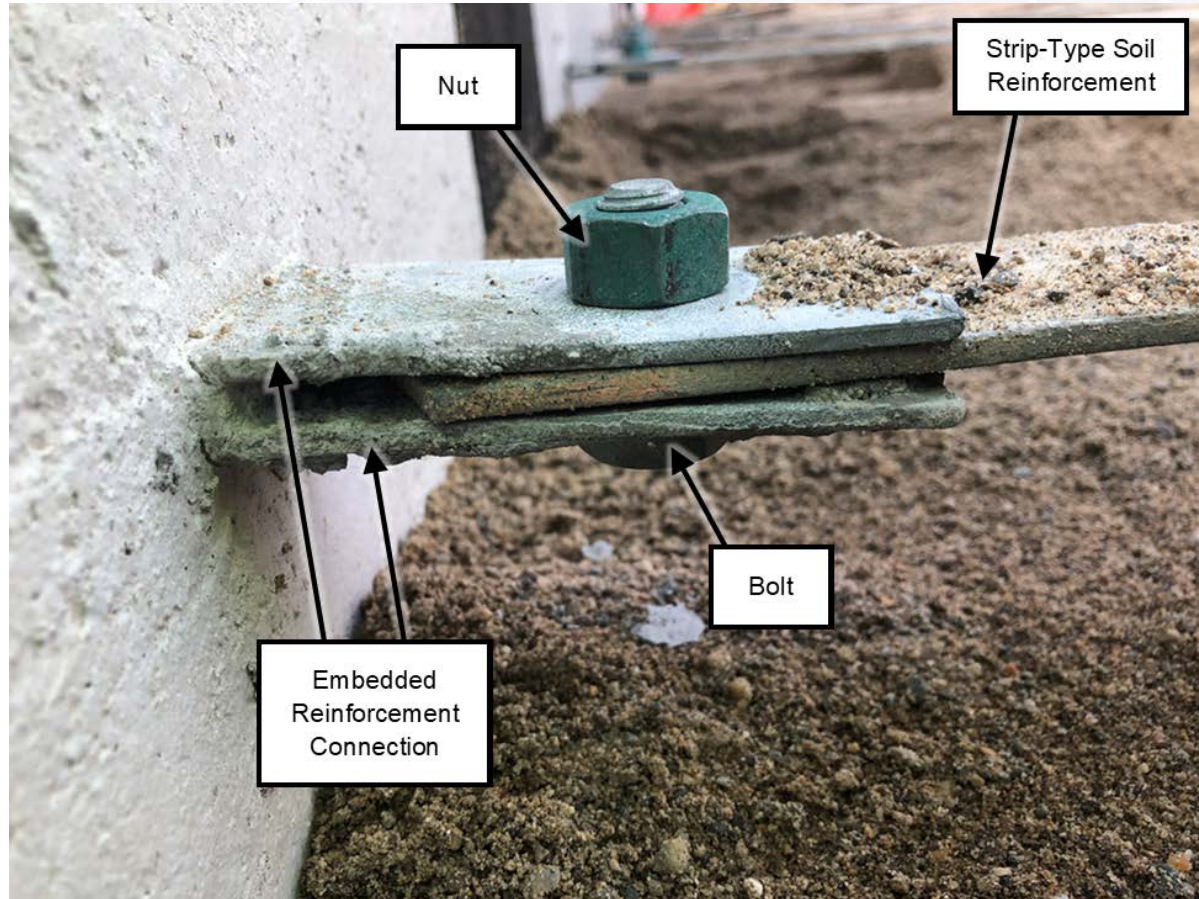
## INDOT Standard Specification 731.09

Ground reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the plans or as directed.



# Initial Panel Course: Placing Soil Reinforcement Layer

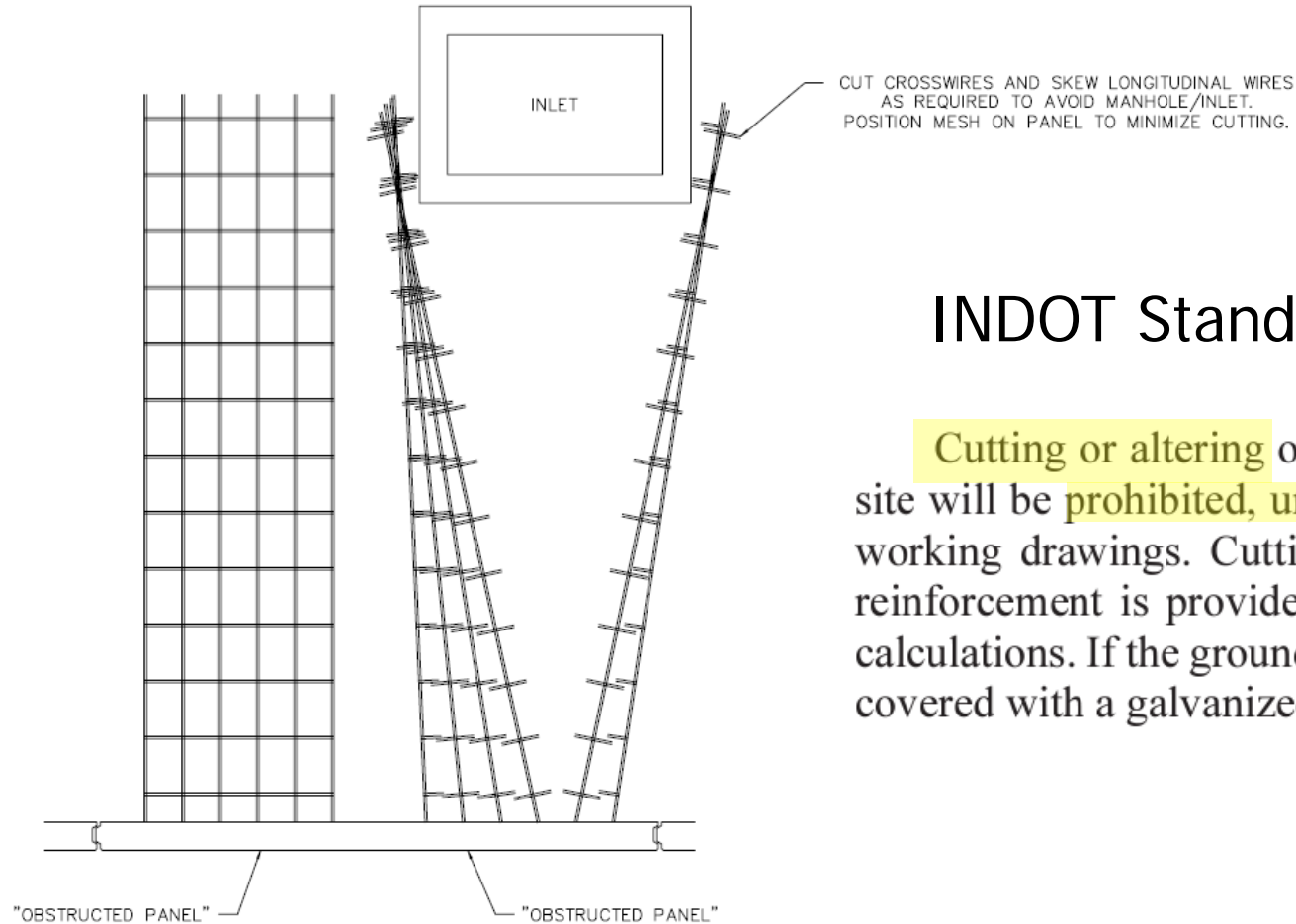
Typical connections for strap reinforcement



Example connection for welded wire reinforcement



# Initial Panel Course: Placing Soil Reinforcement Layer



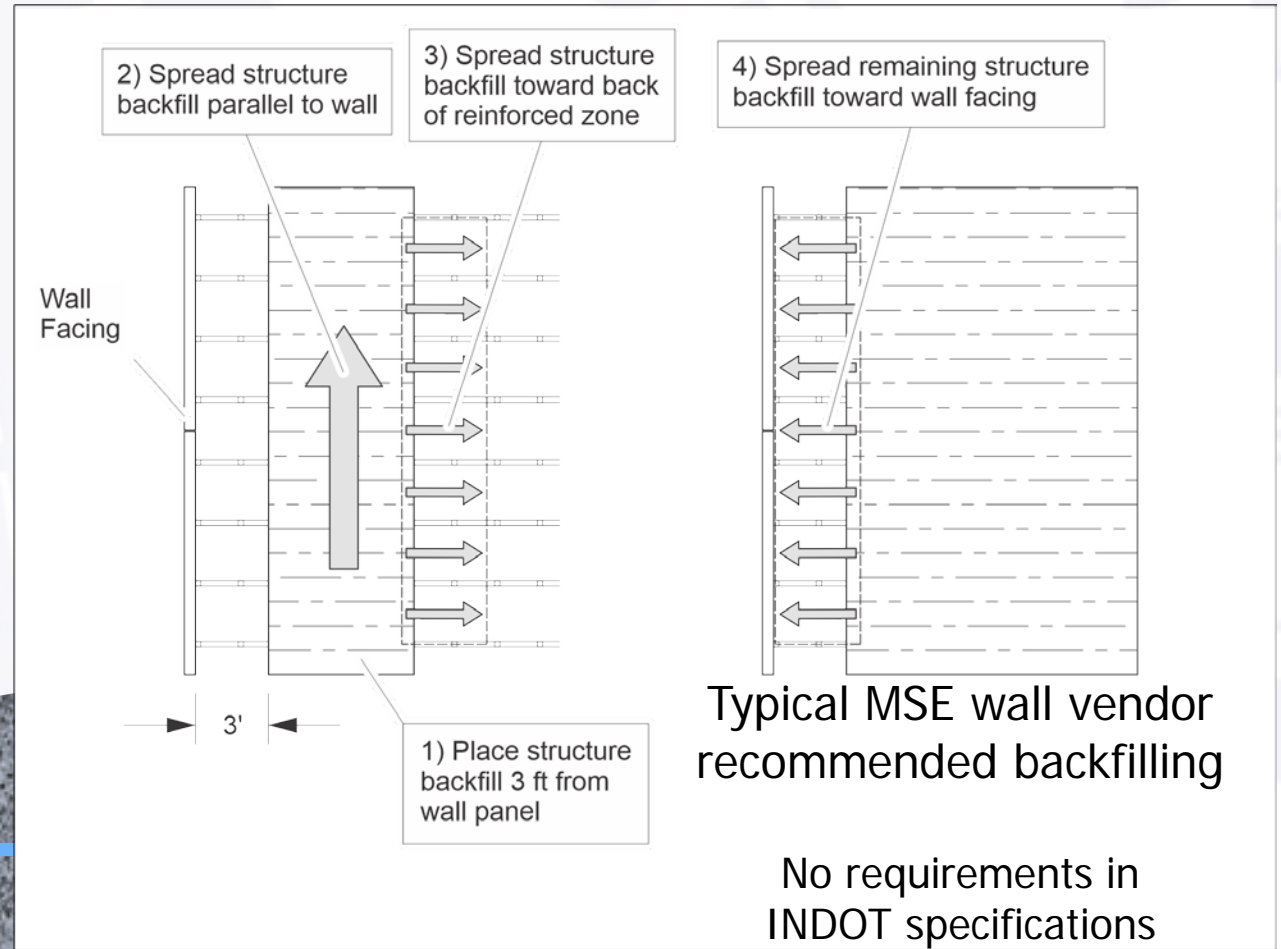
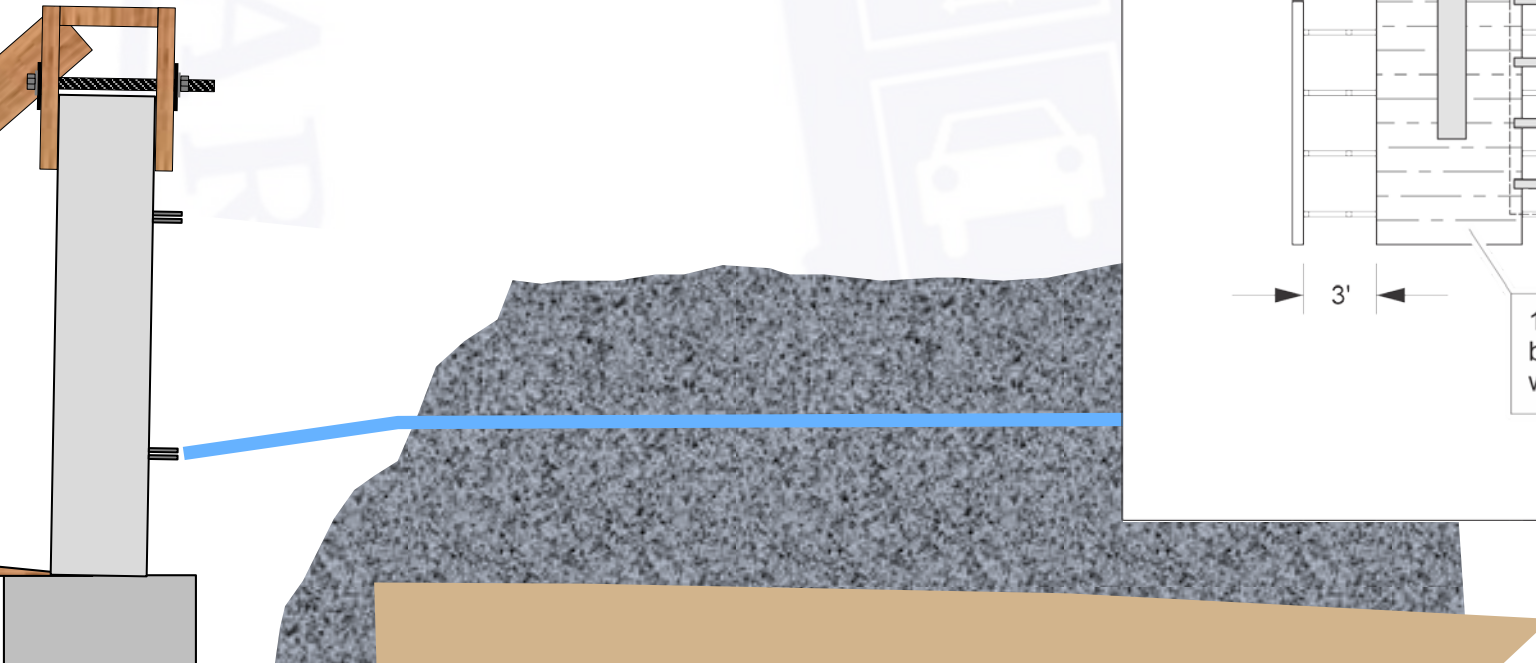
## INDOT Standard Specification 731.11

Cutting or altering of the basic structural section of ground reinforcement at the site will be prohibited, unless the cutting is preplanned and detailed on the approved working drawings. Cutting shall be considered only if adequate additional ground reinforcement is provided to produce the required strength shown in the approved calculations. If the ground reinforcement is shortened in the field, the cut ends shall be covered with a galvanized paint or coal tar to prevent corrosion of the metal.

### **OBSTRUCTION DETAIL (PLAN)**

# Initial Panel Course: Backfill first layer of reinforcement

Backfill needs to be placed in such a way that reinforcements are not damaged





# Initial Panel Course: Backfill first layer of reinforcement

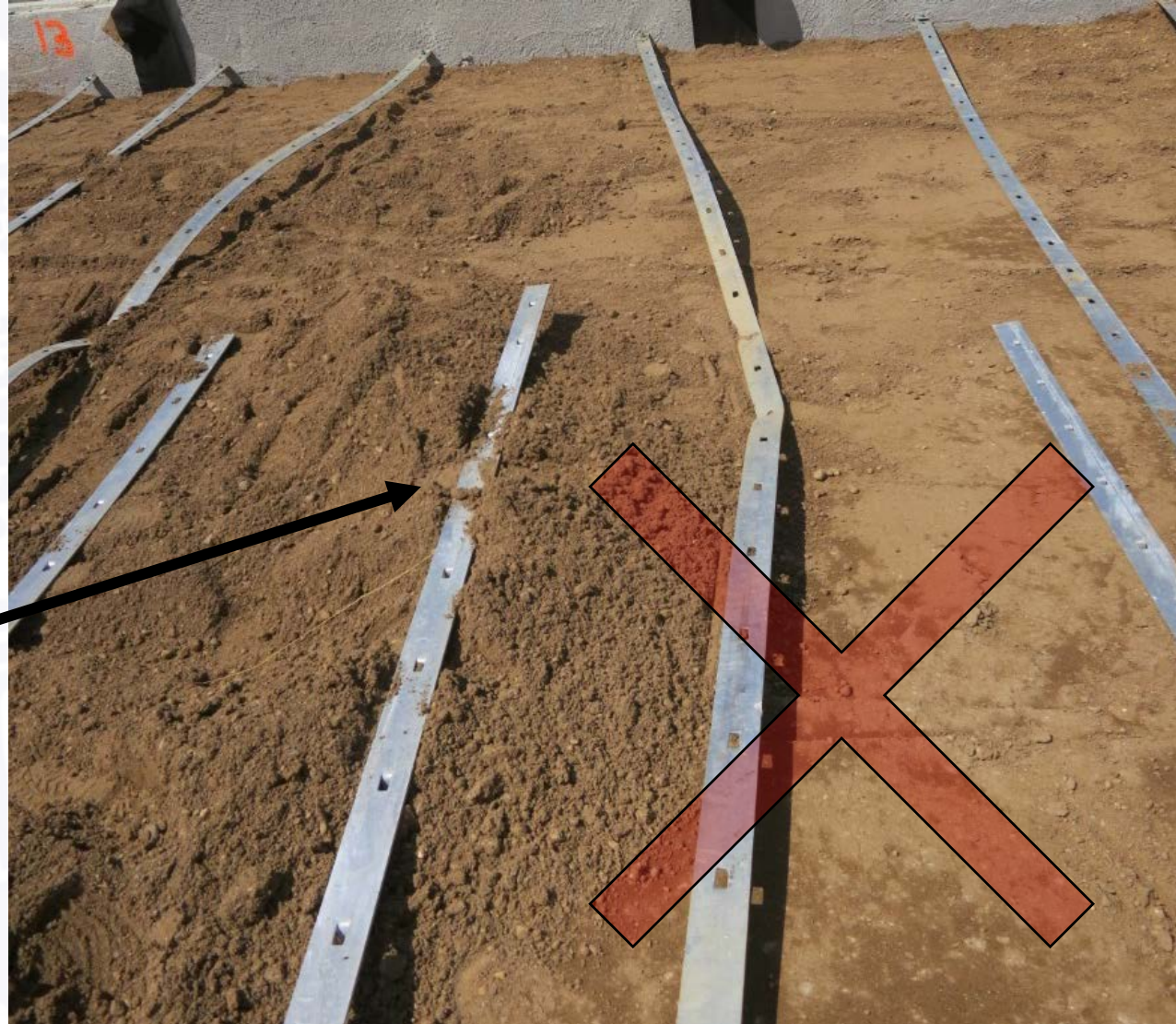
Backfill needs to be placed in such a way that reinforcements are not damaged



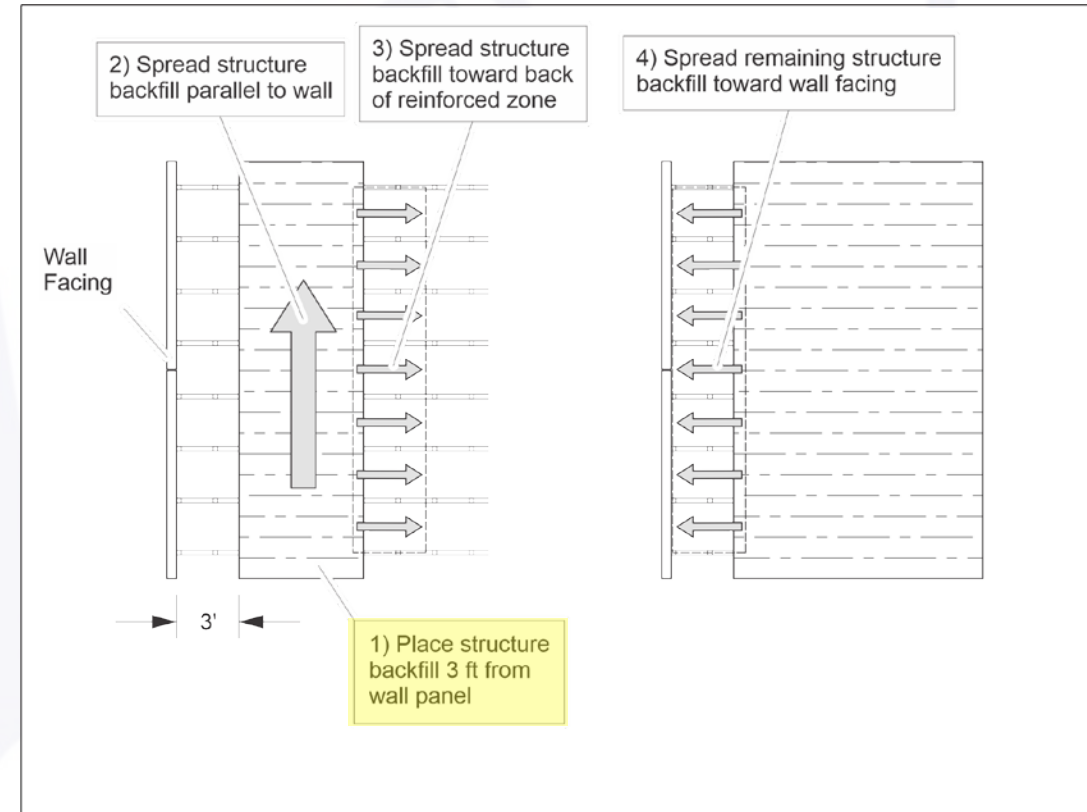
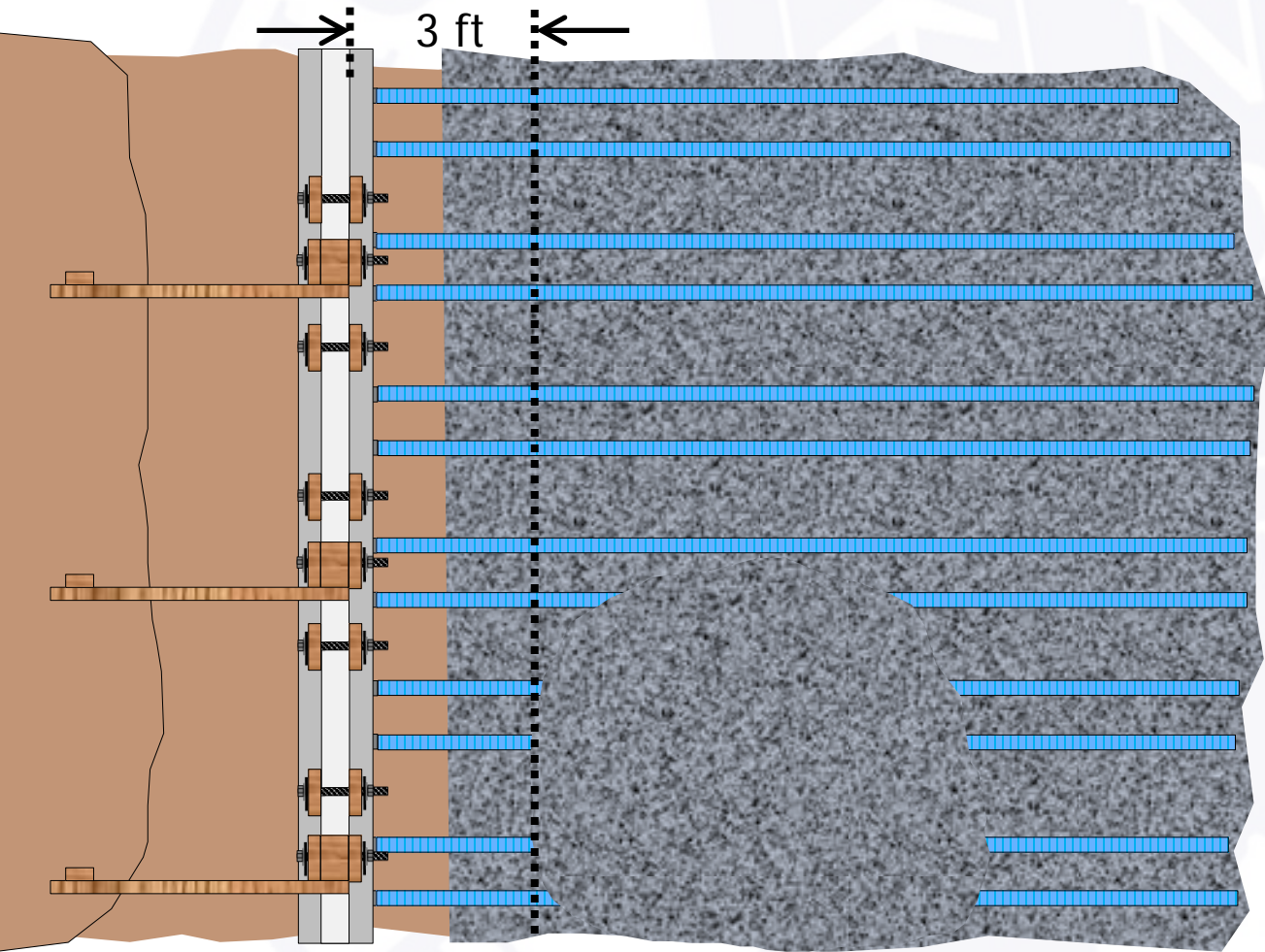
# Initial Panel Course: Backfill first layer of reinforcement

Backfill needs to be placed in such a way that reinforcements are not damaged

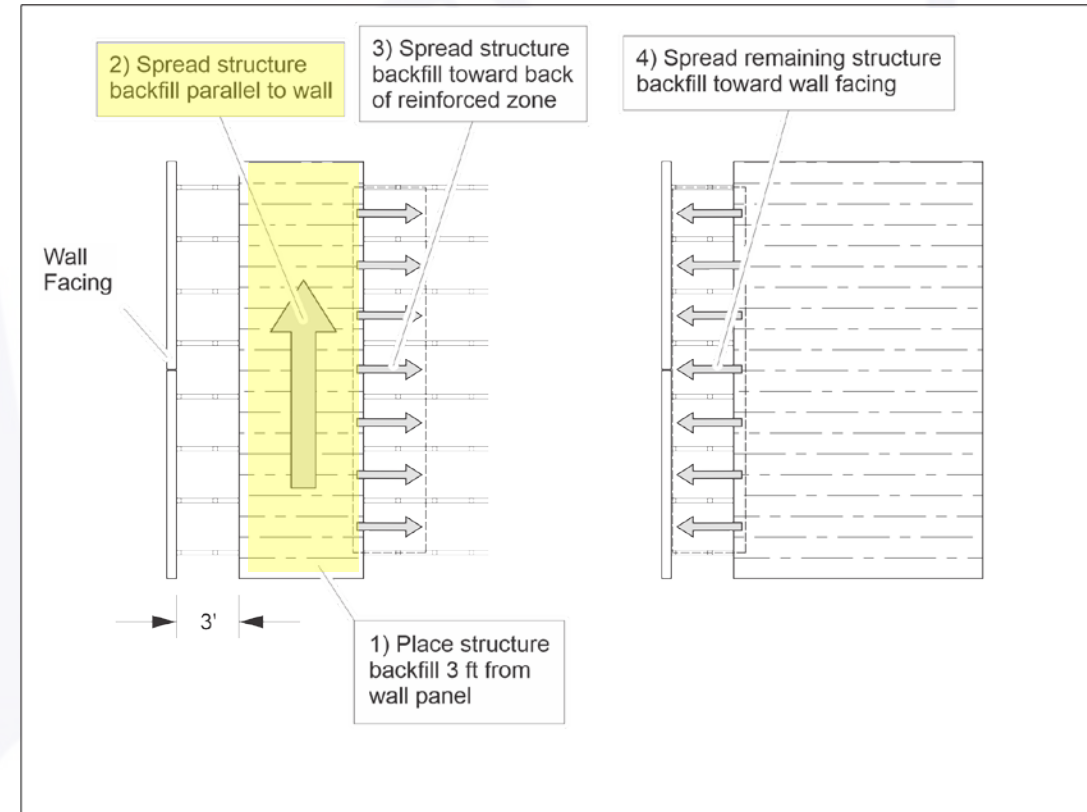
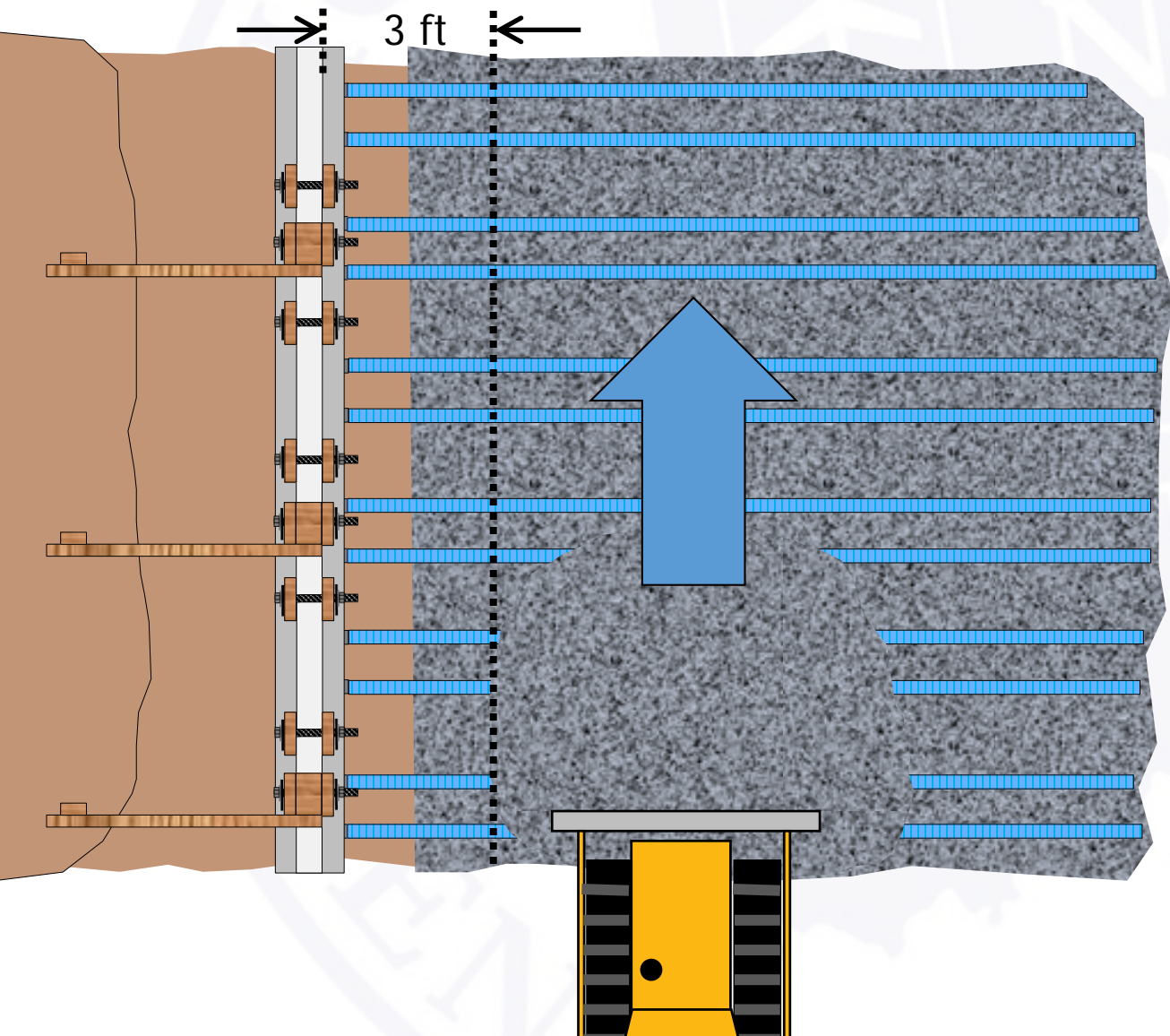
Construction equipment likely trafficked uncovered reinforcement



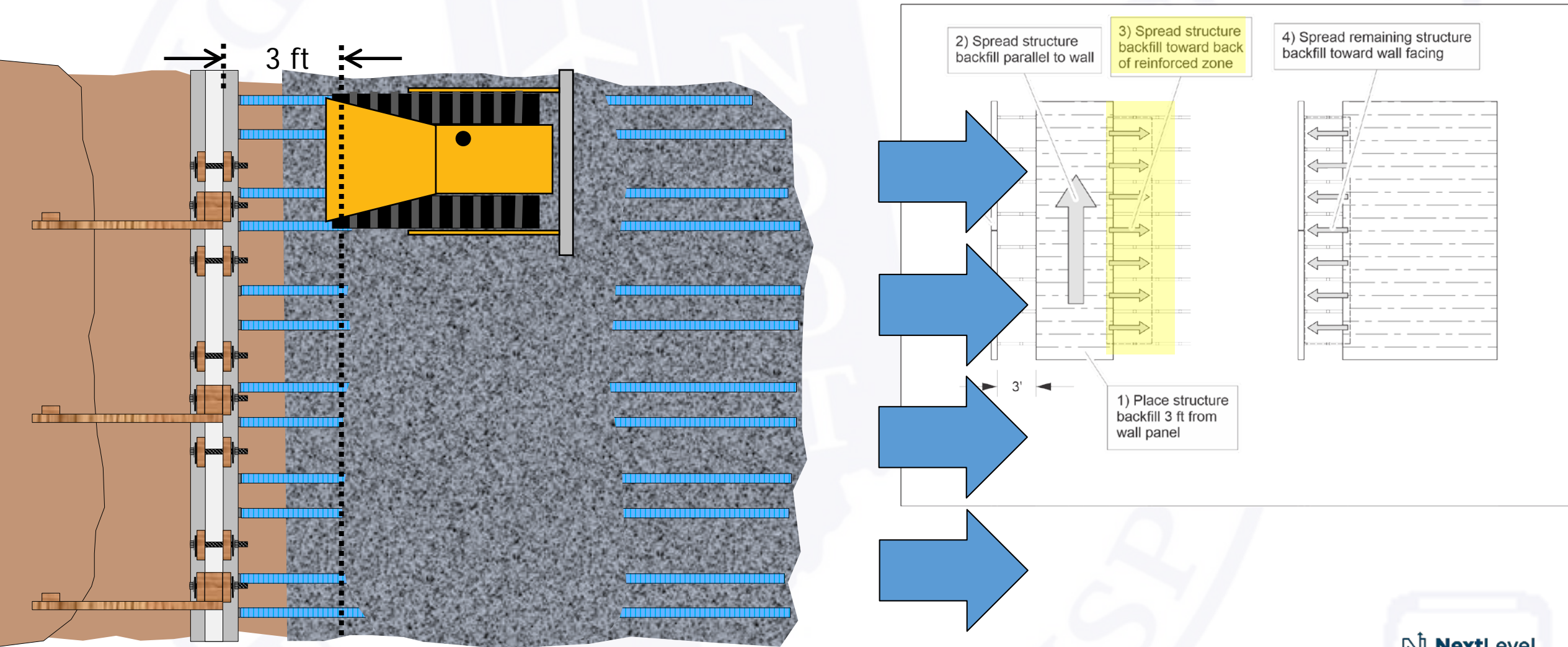
# Initial Panel Course: Backfill first layer of reinforcement



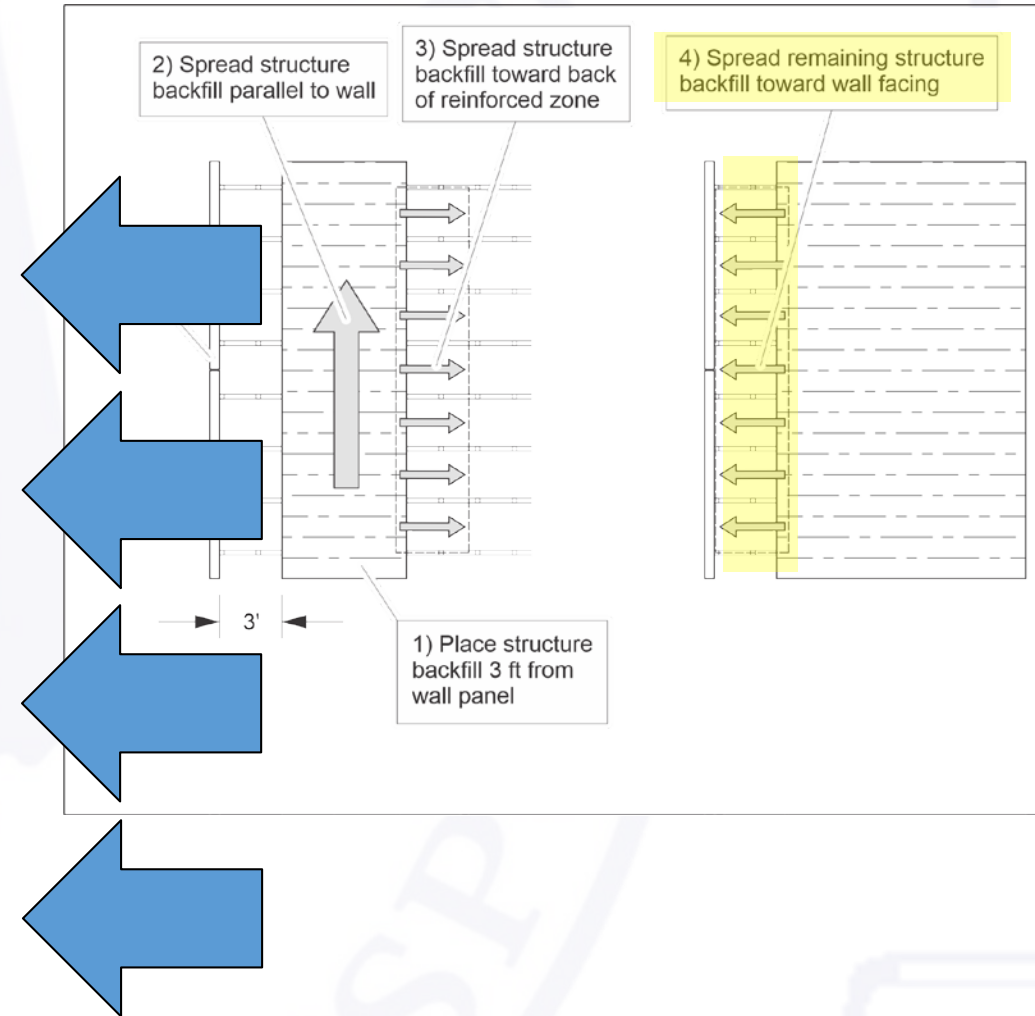
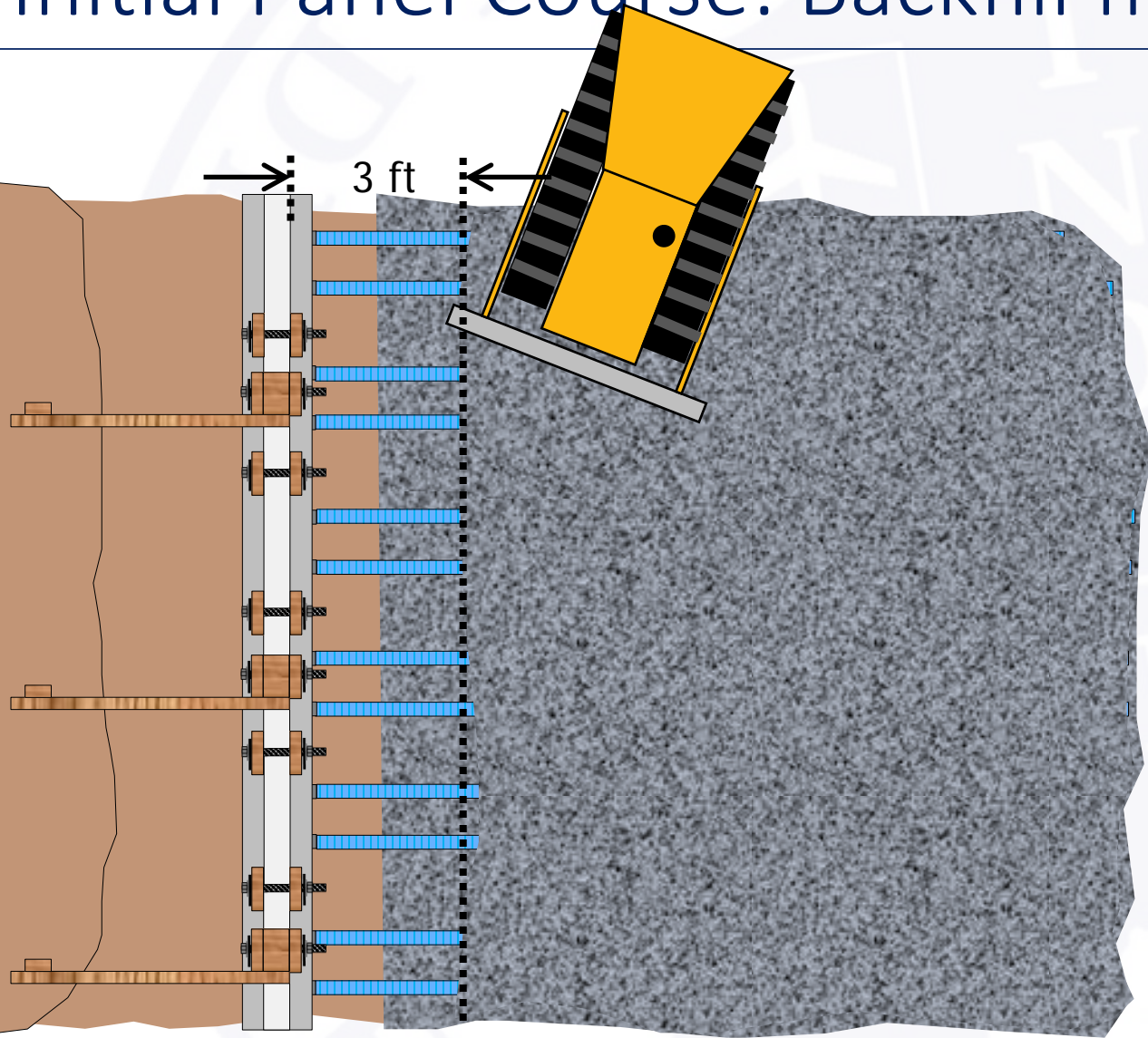
# Initial Panel Course: Backfill first layer of reinforcement



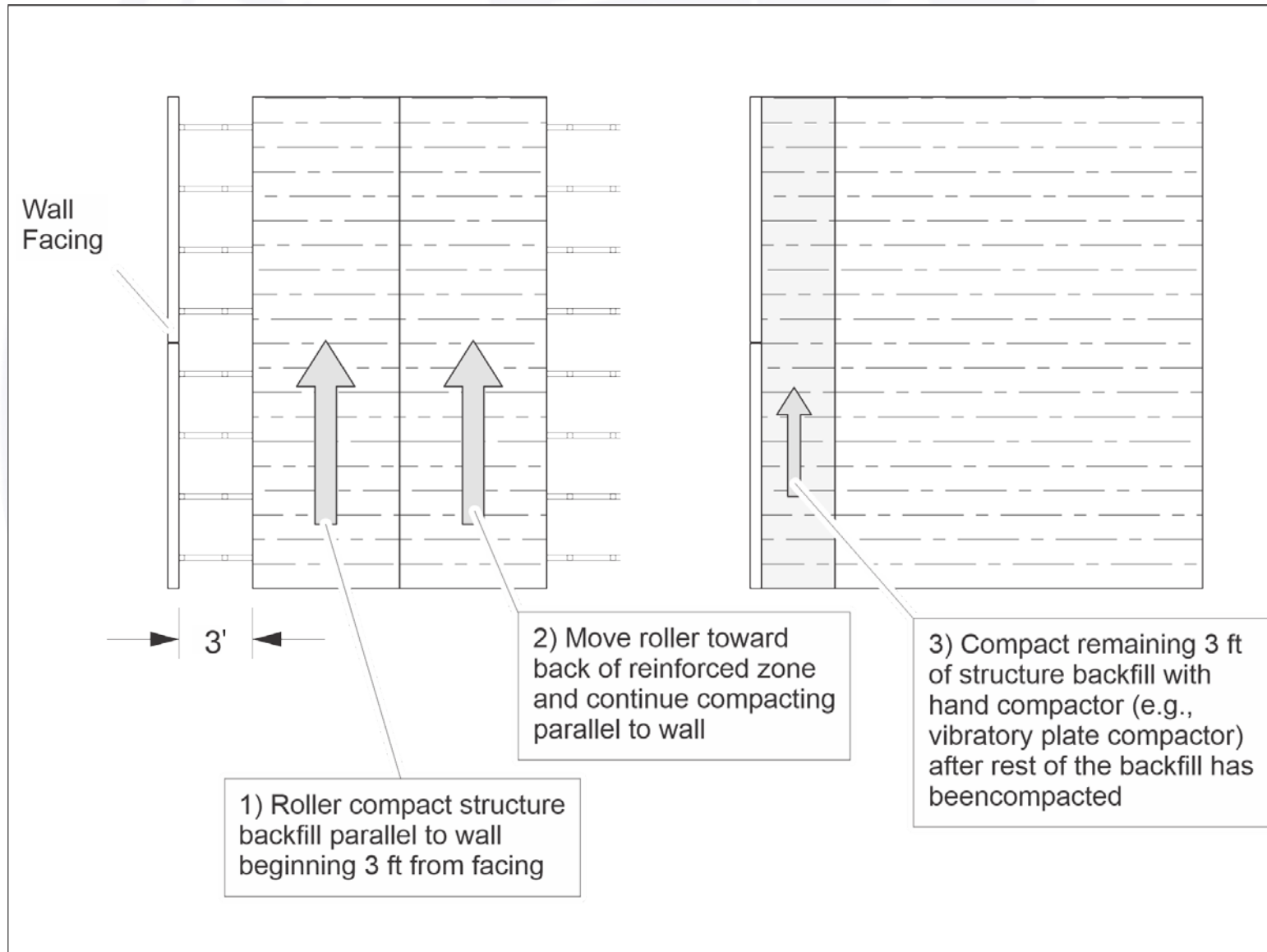
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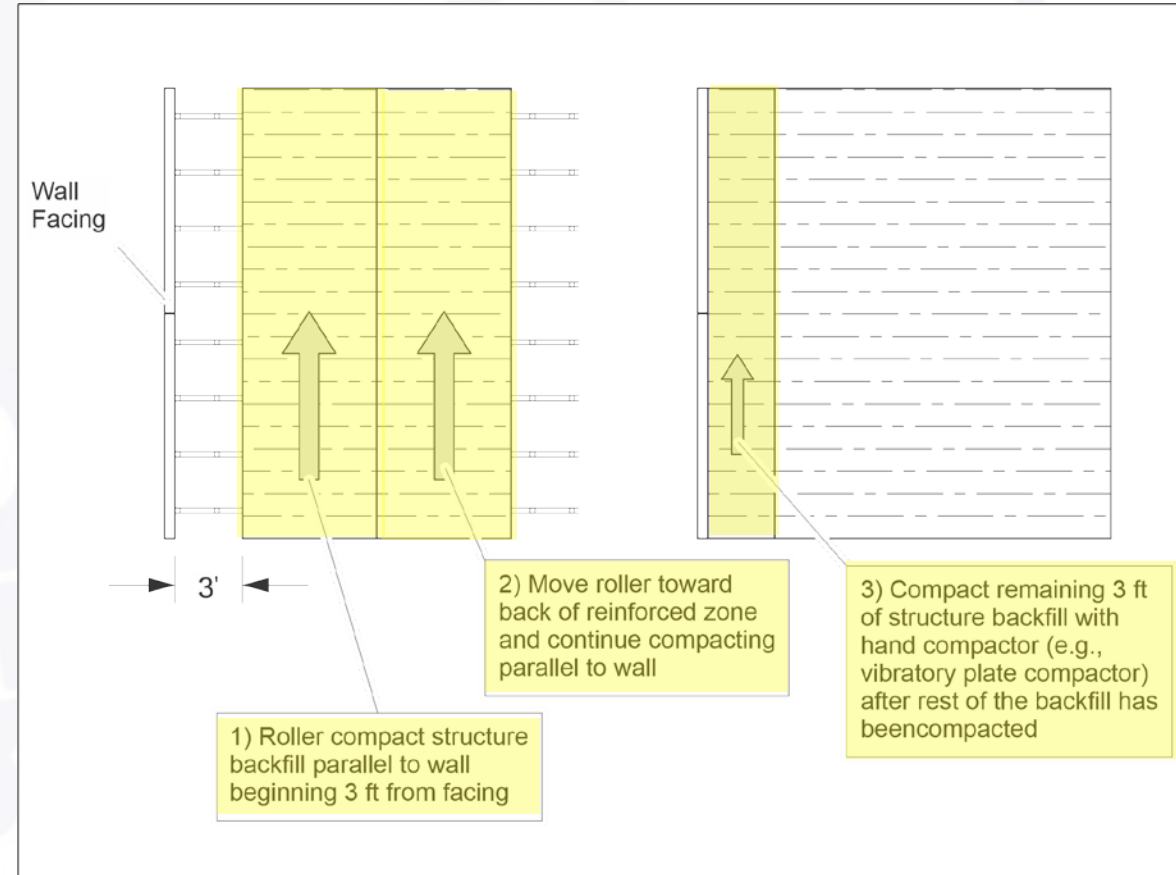
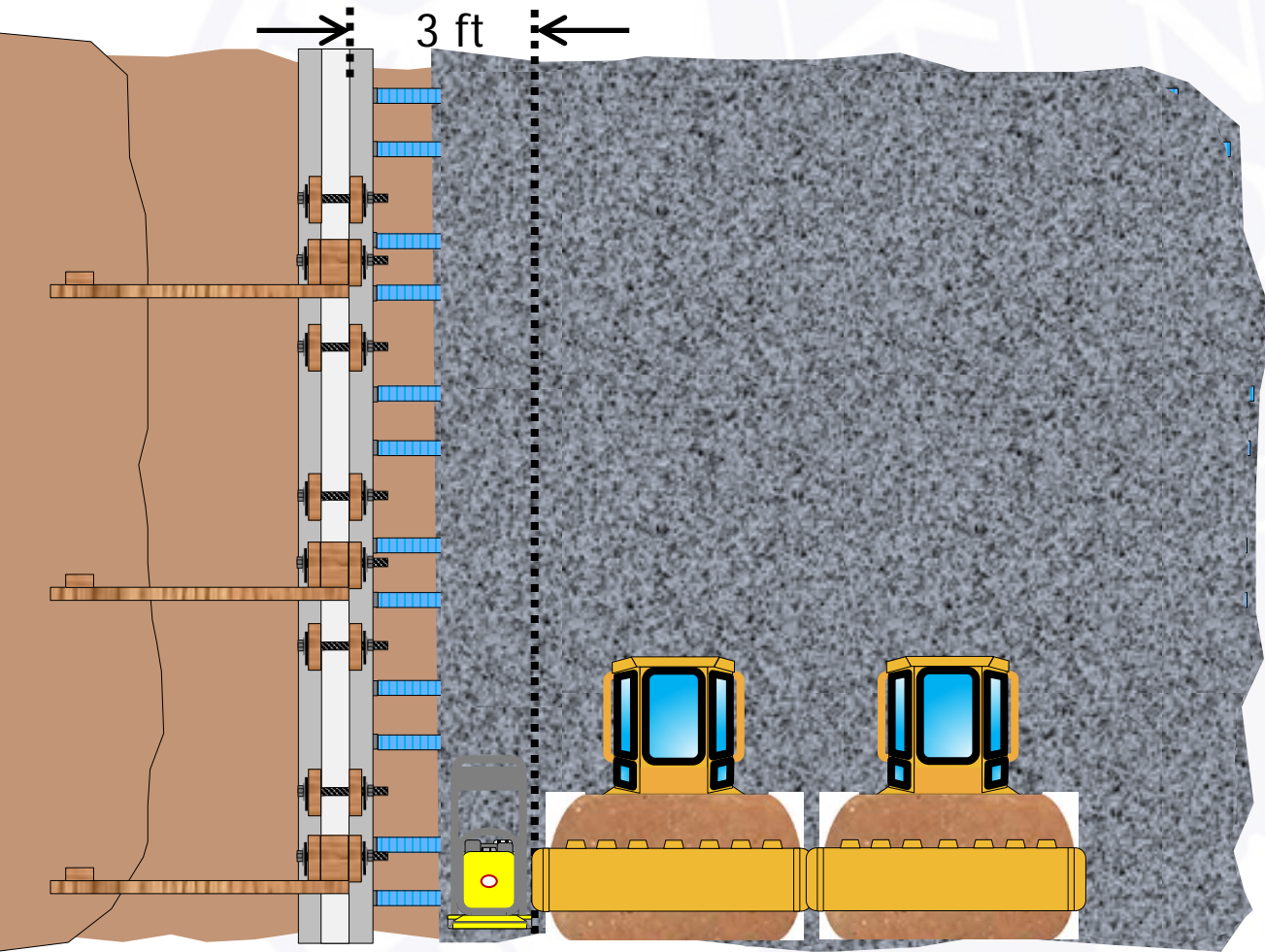
# Initial Panel Course: Backfill first layer of reinforcement



Typical MSE wall vendor recommended compacting of backfill covering reinforcements

No requirements in INDOT specifications

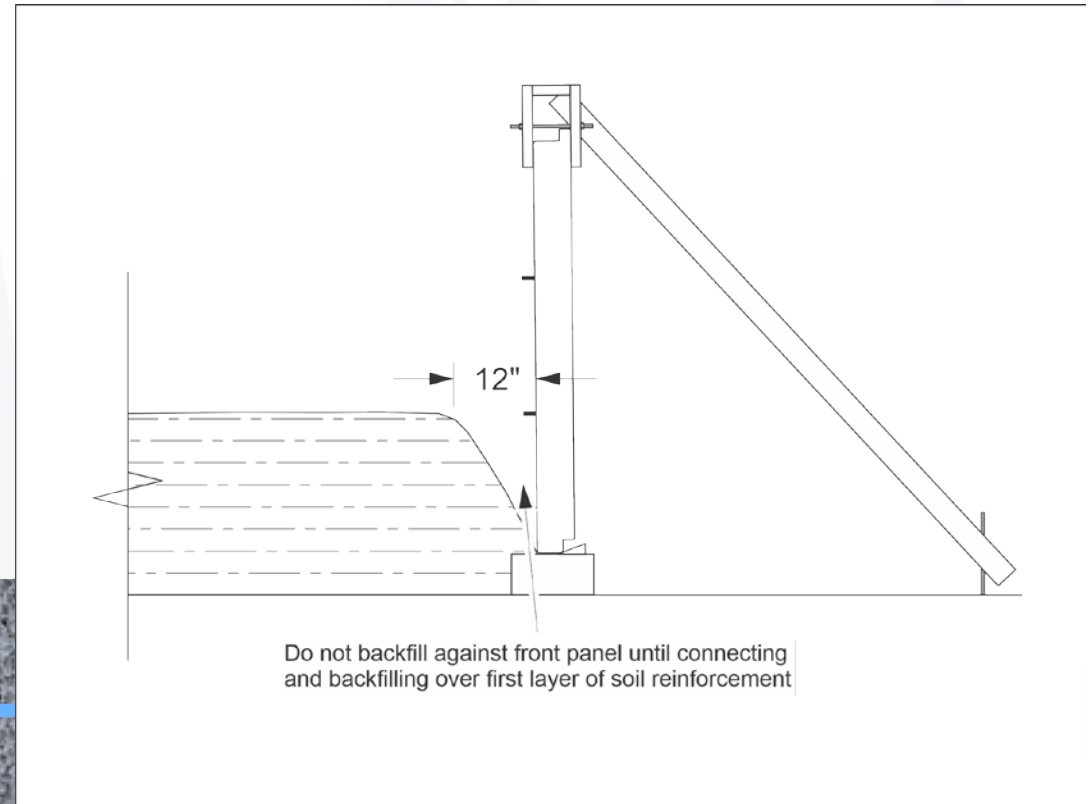
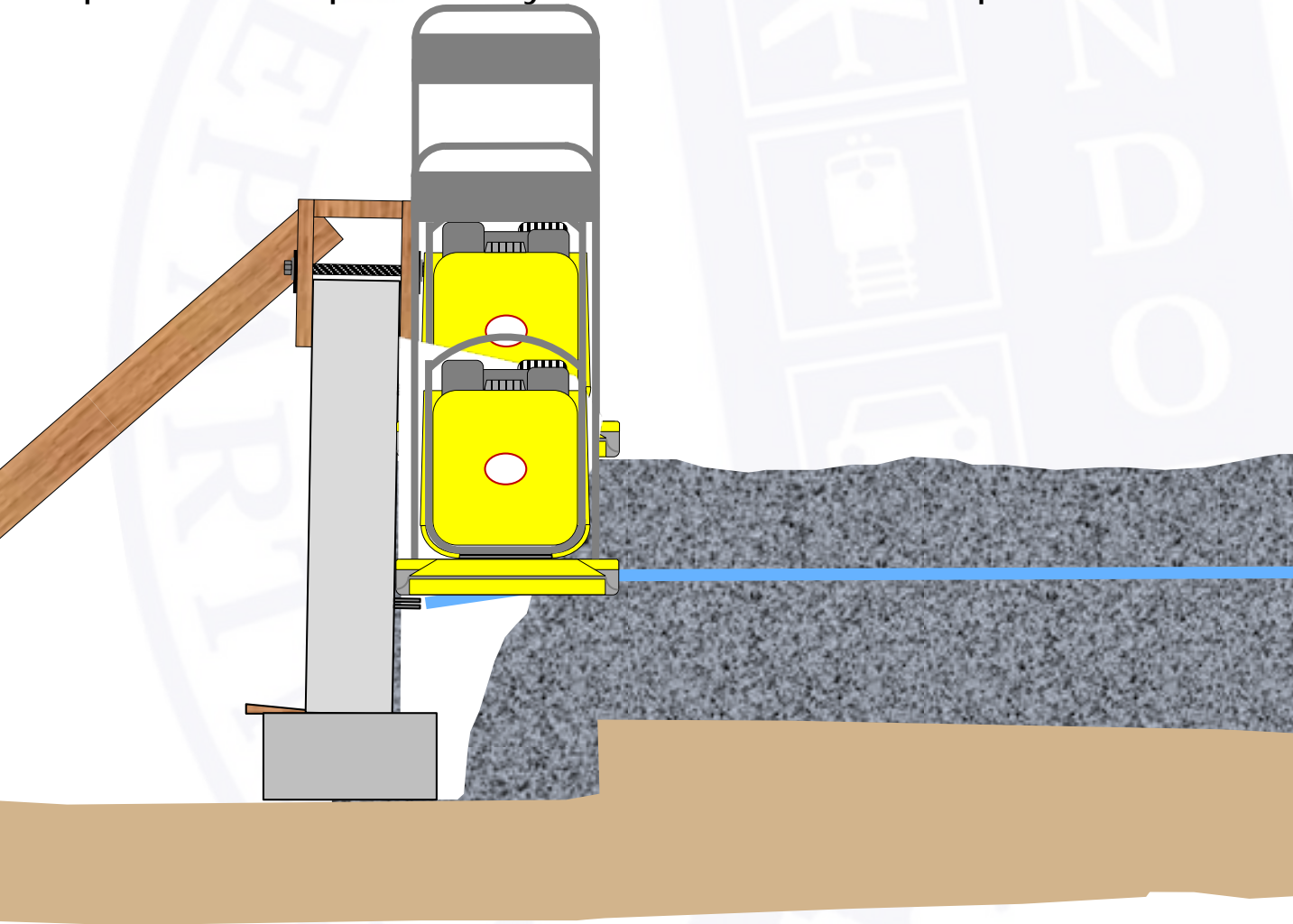
# Initial Panel Course: Backfill first layer of reinforcement





# Initial Panel Course: Backfill first layer of reinforcement

With first layer of reinforcement backfilled and compacted, 1 ft space behind panels may be backfilled and compacted



# Initial Panel Course: Check alignment of panel course

INDOT Standard Specification 731.09

Alignment shall be checked at each layer of panels after the backfill behind the panels has been compacted, and the results shall be recorded.

Plumb, vertical tolerances, and horizontal alignment tolerances shall not exceed  $\frac{3}{4}$  in. as measured with a 10 ft straightedge. The maximum allowable offset in panel joints shall be  $\frac{3}{4}$  in. For a wall of over 10 ft height, the overall plumb from top to bottom of the wall shall not exceed 0.05 in./ft of wall height.



# Subsequent Panel Courses

# Subsequent Panel Courses Placement Sequence

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1. Place bearing pads
2. Remove bracing as needed
3. Place, align, and clamp next row of pre-cast facing panels
4. Place geotextile joint covering
5. Connect and backfilled reinforcement
6. Remove wooden wedges as needed
7. Check alignment for panel course
8. Repeat

Also...

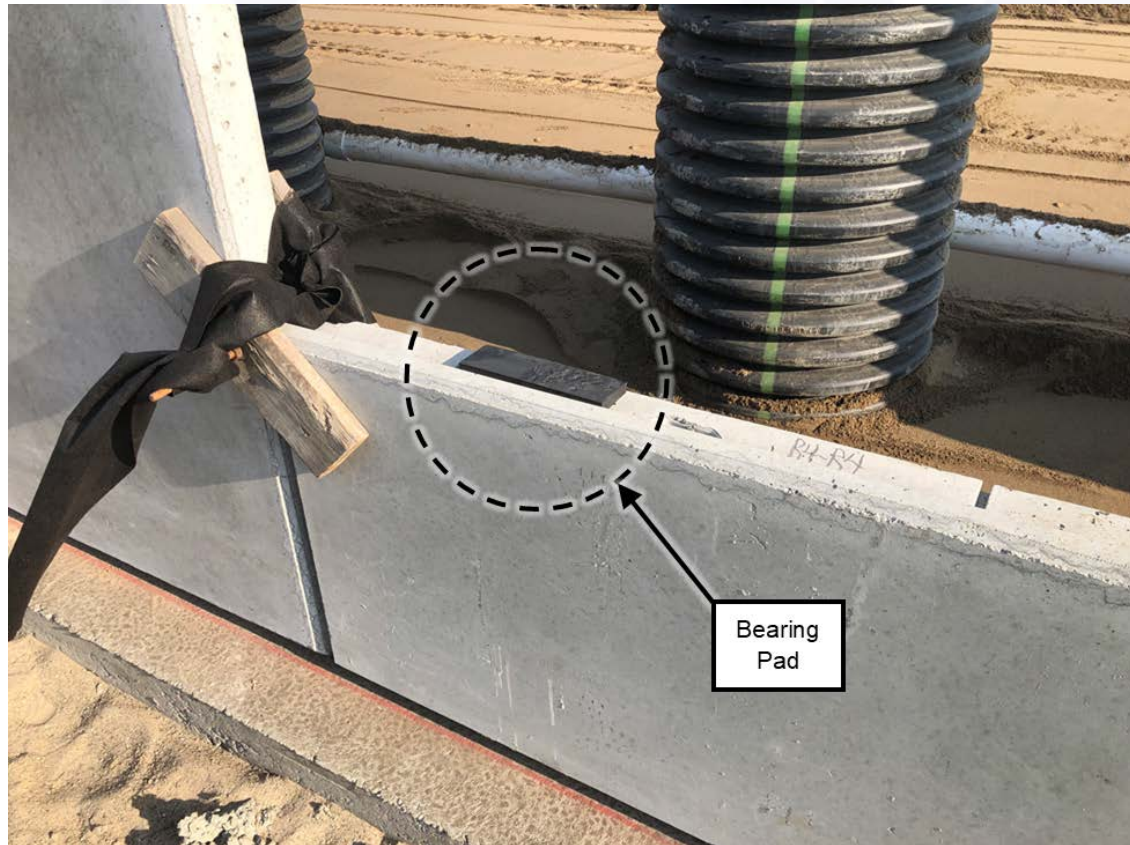
Install Internal Drain

Place Embedment

# Subsequent Panel Courses: Place Bearing Pads

## INDOT Standard Specification 731.10

Horizontal and vertical joint spacers shall be provided between adjacent face panels to prevent concrete-to-concrete contact and chipping if differential settlement occurs.



Chipped concrete possibly from lack of bearing pad



# Bearing Pads



## INDOT Standard Specification 901.10(b)

The horizontal and vertical joint spacers shall include compression blocks, pins, or other **manufacturer's recommended materials** to provide a uniform joint.

# Subsequent Panel Courses: Remove Bracing as Needed

INDOT Standard Specification 731.09

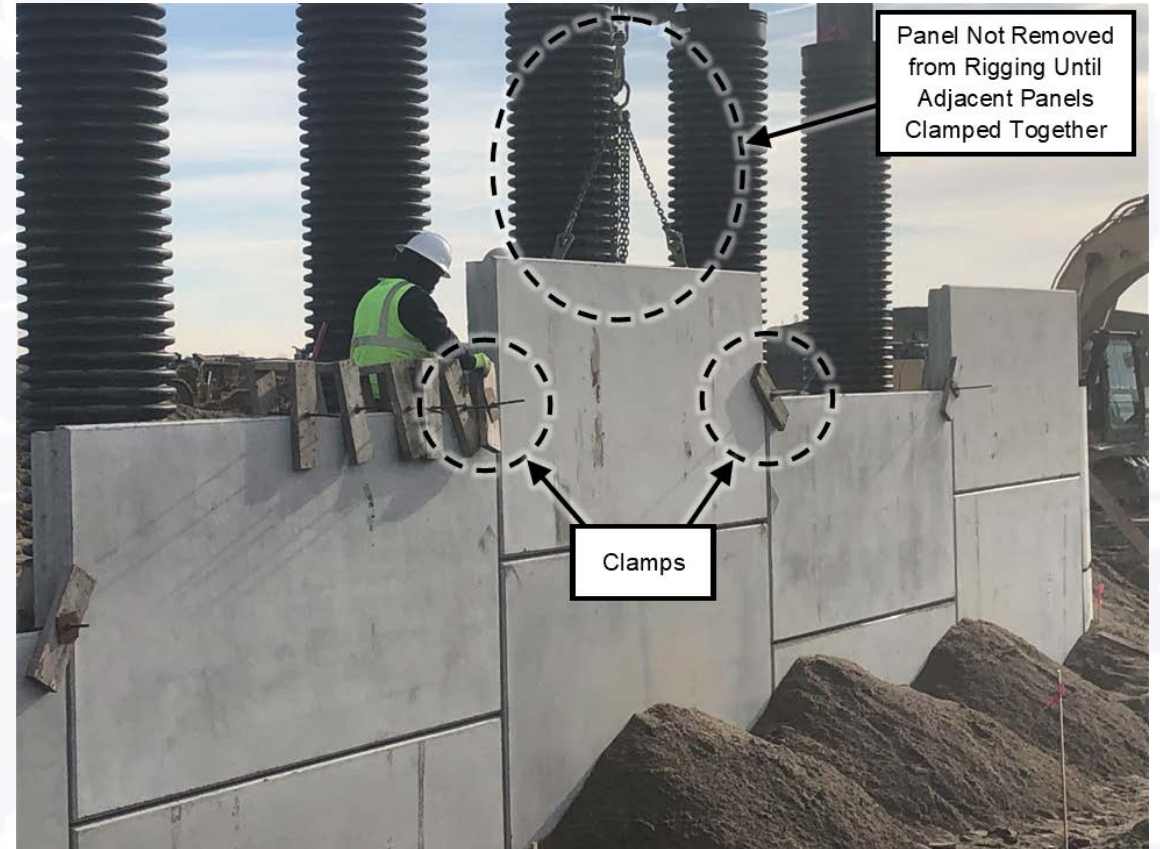
External bracing will be required for the initial lift.

Contractor opted to brace panel within second course

(little support from adjacent half-panel)



# Subsequent Panel Courses: Place, Align, and Clamp Next Course of Panels





# Subsequent Panel Courses: Place Geotextile Joint Covering

INDOT Standard Specification 731.10



# Subsequent Panel Courses: Connect and Backfill Reinforcement

INDOT Standard Specification 731.09



INDOT Standard Specifications 731.10, 203.23, & 203.24



# Subsequent Panel Courses: Connect and Backfill Reinforcement

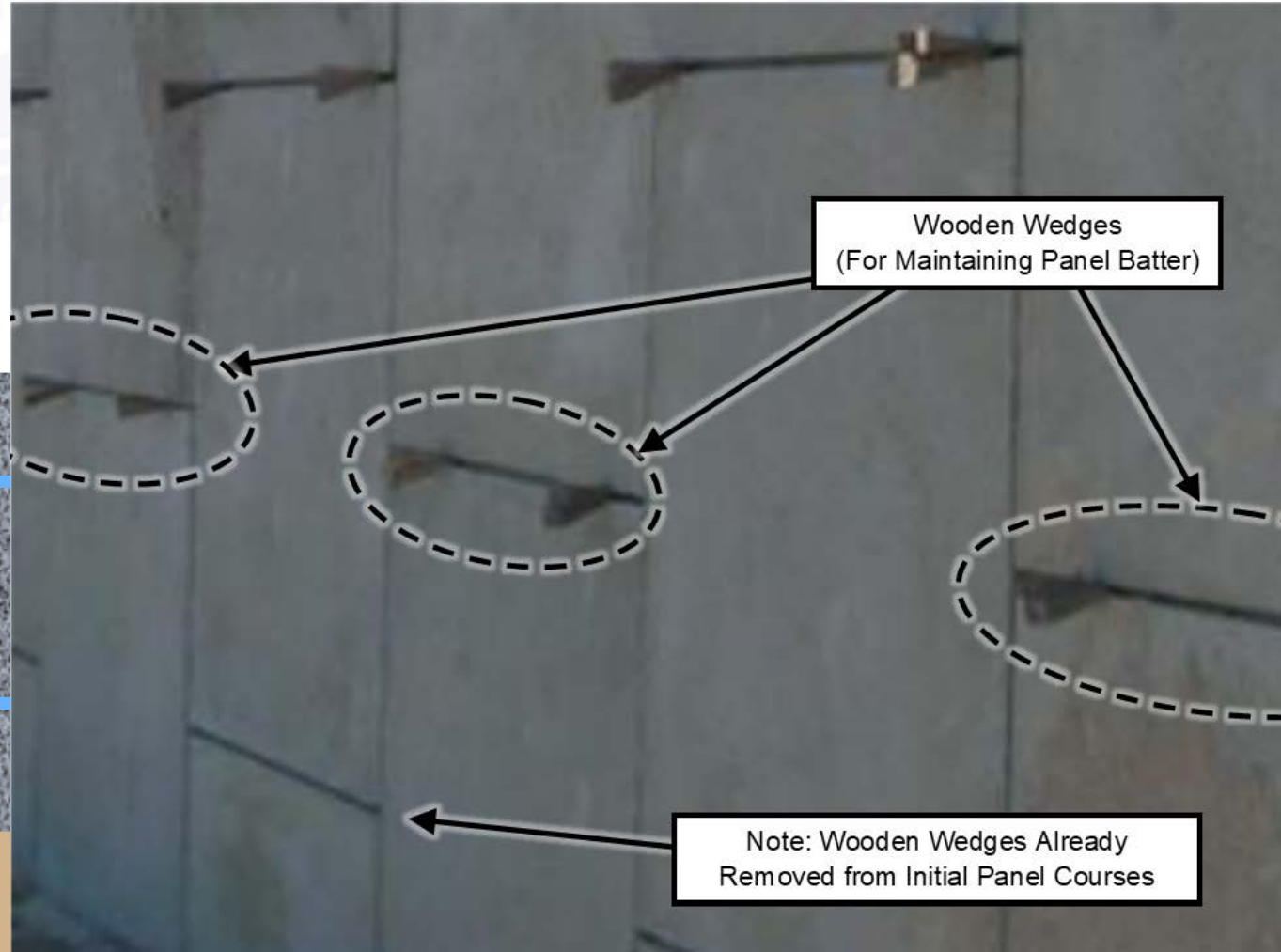
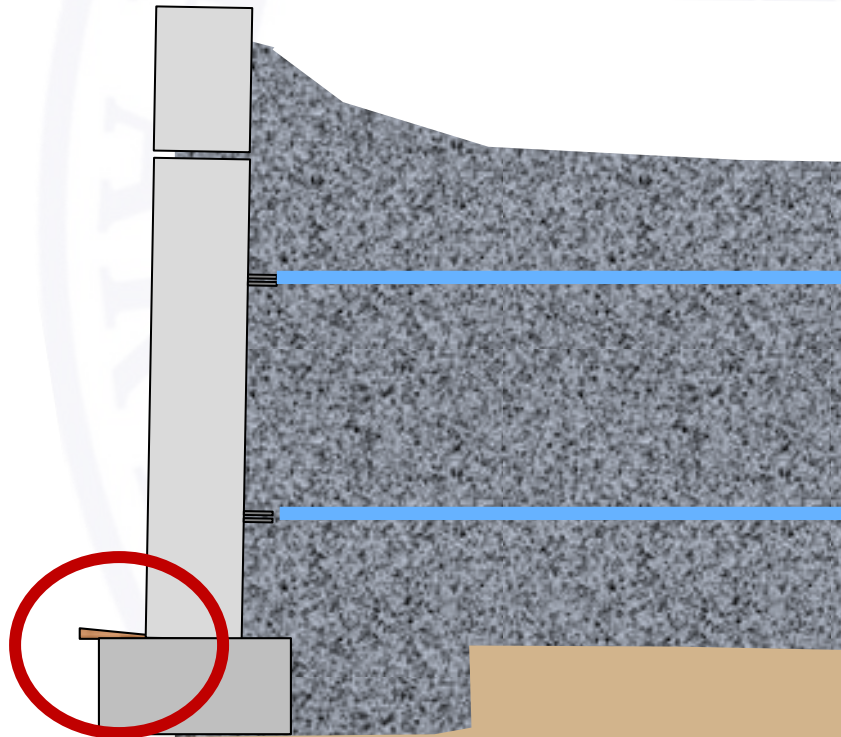
INDOT Standard Specifications 731.10, 203.23, & 203.24



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No. 30				6	9
No. 4				7	10
1/2 in.				11	14
1 in.				16	19

Note: \* Test section required in accordance with ITM 513.

# Subsequent Panel Courses: Remove wooden wedges as needed



# Subsequent Panel Courses: Check alignment of panel course

INDOT Standard Specification 731.09

Alignment shall be checked at each layer of panels after the backfill behind the panels has been compacted, and the results shall be recorded.

Plumb, vertical tolerances, and horizontal alignment tolerances shall not exceed  $\frac{3}{4}$  in. as measured with a 10 ft straightedge. The maximum allowable offset in panel joints shall be  $\frac{3}{4}$  in. For a wall of over 10 ft height, the overall plumb from top to bottom of the wall shall not exceed 0.05 in./ft of wall height.



# Install Internal Drain

## INDOT Standard Specification 731.08

When an internal drainage system is shown on the plans, the drain pipe shall be 6 in. underdrain pipe in accordance with 715.02(d). The remainder of the internal drainage system shall be in accordance with 718, longitudinal underdrains. Video inspection will not be required.



# Place Embedment



No requirements from INDOT standard specifications for embedment construction

Though, it should be placed as soon as it is practical

# Place Coping



# Place precast Coping



# Place cast-in-place coping





# Thank you for your attention!

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## Questions?

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