



CIVIL SOLUTIONS
ENGINEERING THE EARTH®

DESIGN CALCULATION PACKAGE

COL-EL Riverfront Trail Ph. 1.1

E 5th St & Broadway St
East Liverpool, OH 43920

January 15, 2026
Project No.: 25-1213

Prepared For:
Environmental Design Group, LLC
1200 E Market St Suite 780
Akron, OH 44305

Prepared By:
Civil Solutions, Inc.
Cincinnati, Ohio





CIVIL SOLUTIONS
ENGINEERING THE EARTH®

January 15, 2026

Environmental Design Group, LLC
1200 E Market St Suite 780, Akron, OH 44305

Attn: Eric Derstine
Associate Project Manager
P: (330) 238-1877
E: ederstine@envdesigngroup.com

**Re: Design Calculation Package
COL-EL Riverfront Trail Ph. 1.1
E 5th St & Broadway St, East Liverpool, OH 43920
Project No. 25-1213**

Dear Mr. Eric Derstine:

Civil Solutions has completed design calculations for the proposed COL-EL Riverfront Trail Ph. 1.1 project. These design calculations were prepared for the project's proposed preliminary Redi-Rock retaining wall design.

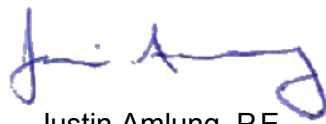
The following submittal package summarizes our engineering analysis, design assumptions, and calculations. Calculations for the proposed retaining wall were performed using the design software GEO5 2026.

We appreciate the opportunity to be of service to you on this project. Please contact us if you have any questions concerning these calculations or if we may be of further assistance as the project continues to develop.

Sincerely,
Civil Solutions


Josh Dahlenburg, E.I.T.
Project Engineer




Justin Amlung, P.E.
Geotechnical Engineer

3760 Fulton Grove Road, Cincinnati, Ohio 45245

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Calculation Package Discussion and Assumptions

1. The following calculations are based on the project geotechnical report prepared by CTL Engineering, Inc. and dated July 17, 2025 and the site civil drawings prepared by Environmental Design Group and dated July 25, 2025.
2. The retaining wall design was performed in general accordance with AASHTO LRFD and ODOT SS 870.
3. Six design scenarios were analyzed for this calculation package.
 - 3.1. 3.0' Total Wall Height
 - 3.2. 4.5' Total Wall Height
 - 3.3. 6.0' Total Wall Height
 - 3.4. 7.5' Total Wall Height
 - 3.5. 9.0' Total Wall Height
 - 3.6. 10.5' Total Wall Height
4. All head slopes exceeded 4H:1V, therefore a surcharge of 250 psf was excluded at the top of the retaining wall calculations per ODOT SS870.
5. The design assumes that the leveling pad for the retaining wall will bear on loose to medium dense sand with a 4,500 PSF bearing resistance and consist of a 6-inch-thick concrete leveling pad on top of a 12-inch-thick granular leveling pad for walls exceeding 6.0' total wall height per ODOT SS870.
6. The retaining walls will be backfilled with a minimum of 12" of free-draining #57 angular aggregate.
7. Table 1 shows the block section preliminary designs for each height and the associated leveling pad requirements.

	3.0' Wall Section	4.5' Wall Section	6.0' Wall Section	7.5' Wall Section	9.0' Wall Section	10.5' Wall Section
Block Section Design	28 Top 28 Bottom	28 Top 28 Middle 41 Bottom	28 Top 28 Middle 41 Middle 41 Bottom	28 Top 28 Middle 41 Middle 60 Middle 60 Bottom	28 Top 28 Middle 72 XL 72 XL	28 Top 28 Middle 41 Middle 52 XL 96 XL
Leveling Pad	12" thick ODOT 304	12" thick ODOT 304	12" thick ODOT 304	6" thick concrete on top of 12" thick ODOT 304	6" thick concrete on top of 12" thick ODOT 304	6" thick concrete on top of 12" thick ODOT 304

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio
January 15, 2026 ■ Project No. 25-1213



Design Calculations

Section 1: 3.0' Total Height

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Analysis of Redi Rock wall

Input data

Project : COL-EL Riverfront Trail Phase 1
Part : Design 3.0' Section
Customer : EDG
Author : JAD
Date : 1/14/2026
Project number : 25-1215

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : AASHTO - Extensible (straight slip surface)
Reduction coeff. of contact first block - base : 0.80

Geometry

No. group	Description	Count	Setback s [in]
1	Block 28	1	0.13
2	Top block 28	1	-

Calculation Package

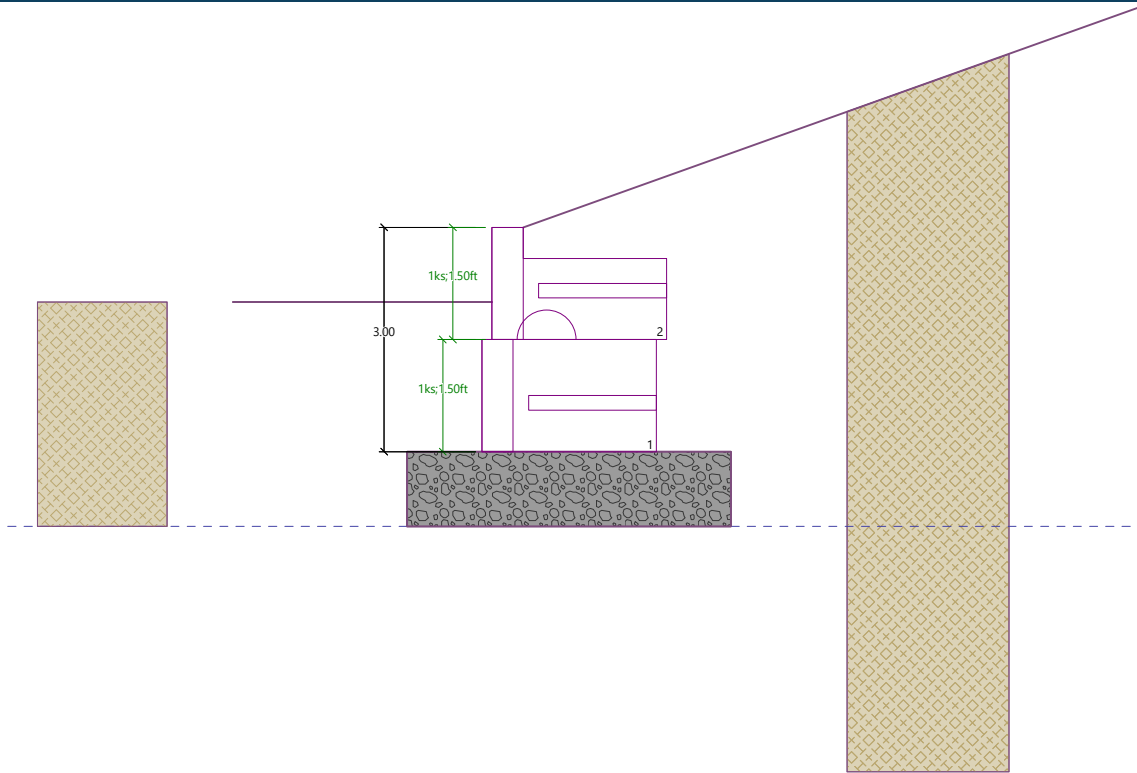
COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Name : Geometry

Stage - analysis : 1 - 0



Base

Geometry

Upper setback $a_1 = 1.00$ ft

Lower setback $a_2 = 1.00$ ft

Height $h = 1.00$ ft

Width $b = 4.33$ ft

Material

12" Granular

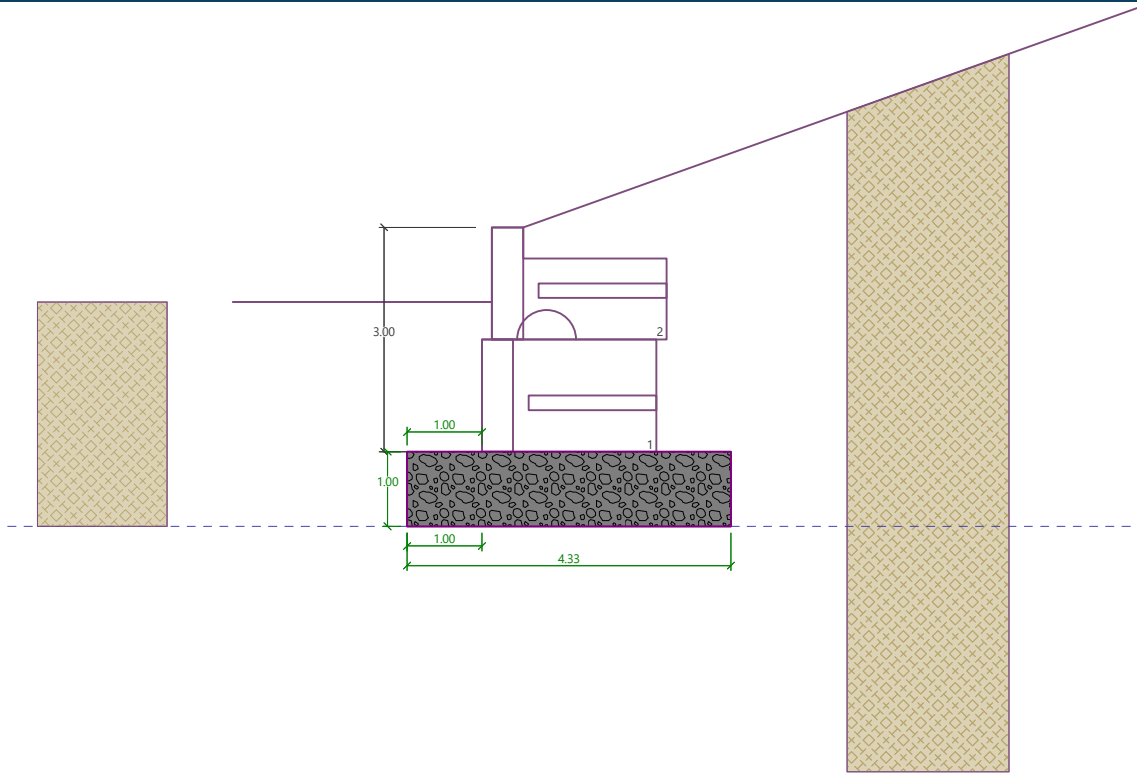
Dry Unit weight $\gamma = 120.00$ pcf

Internal Friction Angle = 34.00°

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Base**Stage - analysis : 1 - 0****Basic soil parameters**

Number	Name	Pattern	Φ_{ef} [°]	C_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Foundation & Retained Soil		32.00	0.0	128.00	76.50	24.00

All soils are considered as cohesionless for at rest pressure analysis.

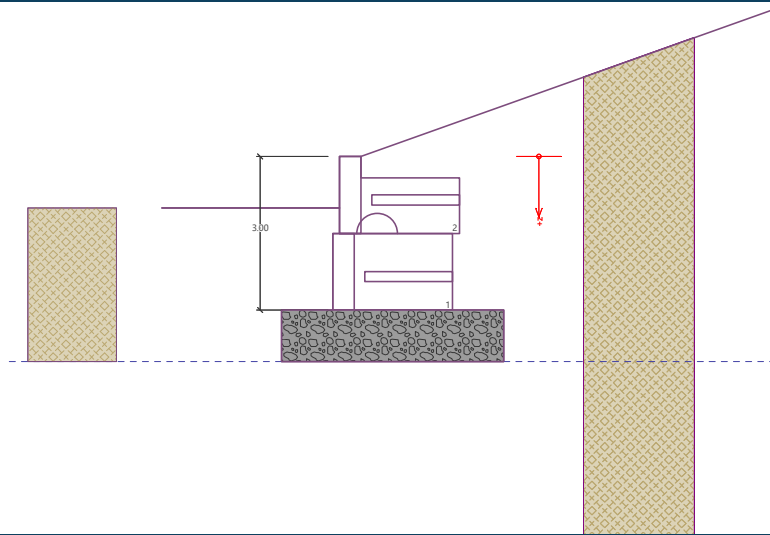
Geological profile and assigned soils

Number	Thickness of layer t [ft]	Depth z [ft]	Assigned soil	Pattern
1	-	0.00 .. ∞	Foundation & Retained Soil	

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Profile and assignment**Stage - analysis : 1 - 0****Terrain profile**

Terrain behind construction has the slope 1: 2.80 (slope angle is 19.65 °).

Water influence

GWT behind the structure lies at a depth of 4.00 ft

GWT in front of the structure lies at a depth of 4.00 ft

Subgrade at the heel is not permeable.

Uplift in foot. bottom due to different pressures is not considered.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Foundation & Retained Soil

Soil thickness in front of structure $h = 3.00$ ft

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : Strength I

Reduction of soil/soil friction angle : reduce to $2/3 \phi$ (AASHTO)**Verification No. 1****Active pressure behind the structure - partial results**

Layer No.	Thickness [ft]	α [°]	ϕ_d [°]	c_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	4.00	12.16	32.00	0.0	128.00	24.00	0.530	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	4.00	512.0	0.0	271.5	219.2	160.2

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Forces acting on construction

Name	F_{hor} [lb/ft]	App.Pt. z [ft]	F_{vert} [lb/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-1.63	1293.5	2.20	0.900	0.900	1.250
Active pressure	438.4	-1.33	320.4	4.04	1.500	1.500	1.500
Water pressure	0.0	-4.00	0.0	3.47	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 4504.1$ lbfft/ft

Overturning moment $M_{ovr} = 876.8$ lbfft/ft

Capacity demand ratio CDR = 5.14

Wall for overturning is SATISFACTORY

Check for slip

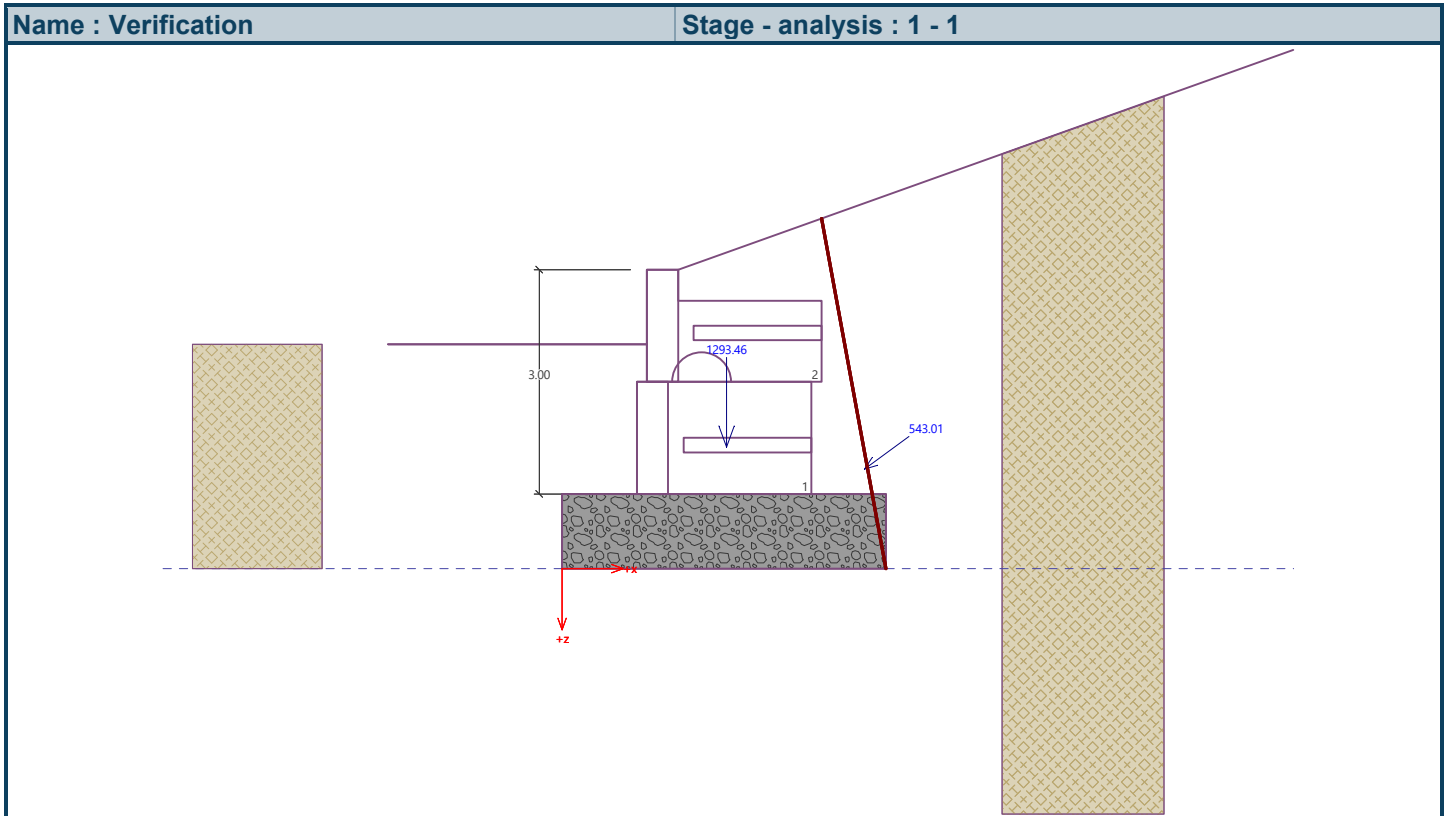
Resisting horizontal force $H_{res} = 1027.75$ lb/ft

Active horizontal force $H_{act} = 657.59$ lb/ft

Capacity demand ratio CDR = 1.56

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Dimensioning No. 1

Active pressure behind the structure - partial results

Layer No.	Thickness [ft]	α [°]	Φ_d [°]	C_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	3.00	-2.57	32.00	0.0	128.00	24.00	0.345	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	3.00	384.0	0.0	132.7	123.5	48.5

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-1.38	773.9	1.22	0.900	0.900	1.250
Active pressure	185.2	-1.00	72.7	2.38	1.500	1.500	1.500
Water pressure	0.0	-3.00	0.0	2.47	1.000	1.000	1.000

Verification of most stressed block No. 1

Check for overturning stability

Resisting moment $M_{res} = 1111.5$ lbfft/ft

Overturning moment $M_{ovr} = 277.8$ lbfft/ft

Capacity demand ratio CDR = 4.00

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 434.67$ lbf/ft

Active horizontal force $H_{act} = 277.83$ lbf/ft

Capacity demand ratio CDR = 1.56

Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	-82.2	2097.46	657.59	0.000	484.4
2	-66.4	1644.75	657.59	0.000	379.8

Service load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-62.4	1613.88	438.40

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force $e = 0.000$

Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 4500.0$ psf

Partial factor on bearing capacity $\gamma_{Rv} = 0.55$

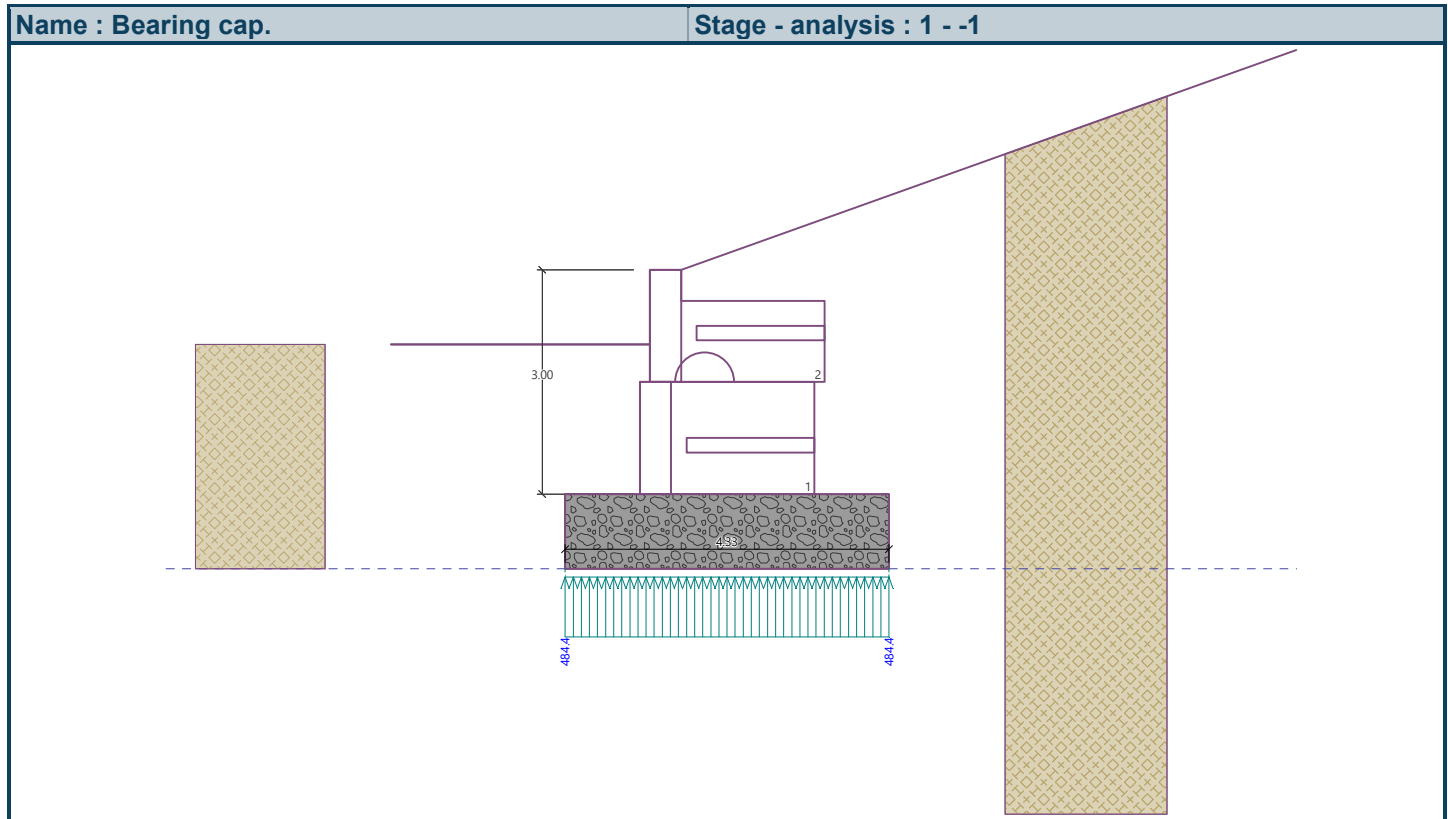
Max. stress at footing bottom $\sigma = 484.4$ psf

Allowable bearing capacity of foundation soil $R_d = 2475.0$ psf

Capacity demand ratio $CDR = 5.1$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Slope stability analysis

Analysis 1

Circular slip surface

Slip surface parameters					
Center :	x =	2.81 [ft]	Angles :	α_1 =	-21.24 [°]
	z =	29.06 [ft]		α_2 =	54.63 [°]
Radius :	R =	32.25 [ft]			
The slip surface after optimization.					

Total weight of soil above the slip surface: 18947.0 lbf/ft

The restrictions of points of circular slip surface

Keep the left end point of the slip surface

Slope stability verification (Bishop)

Sum of active forces : $F_a = 5501.7$ lbf/ft

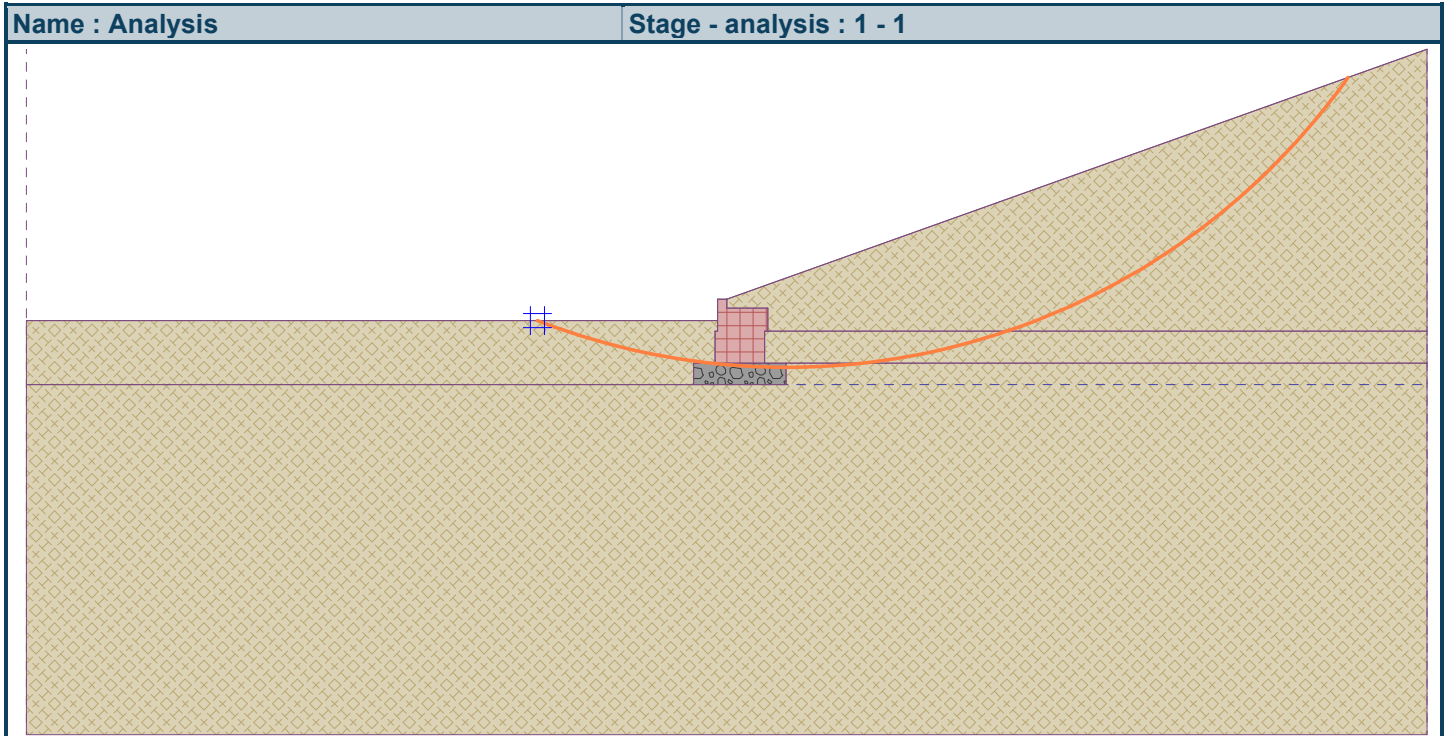
Sum of passive forces : $F_p = 11913.5$ lbf/ft

Sliding moment : $M_a = 177429.5$ lbfft/ft

Resisting moment : $M_p = 384210.9$ lbfft/ft

Factor of safety = $2.17 \geq 1.50$

Slope stability ACCEPTABLE



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio
January 15, 2026 ■ Project No. 25-1213



Design Calculations Section 2: 4.5' Total Height

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Analysis of Redi Rock wall

Input data

Project : COL-EL Riverfront Trail Phase 1
Part : Design 4.5' Section
Customer : EDG
Author : JAD
Date : 1/14/2026
Project number : 25-1213

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : AASHTO - Extensible (straight slip surface)
Reduction coeff. of contact first block - base : 0.80

Geometry

No. group	Description	Count	Setback s [in]
1	Block 41	1	0.13
2	Block 28	1	0.13
3	Top block 28	1	-

Calculation Package

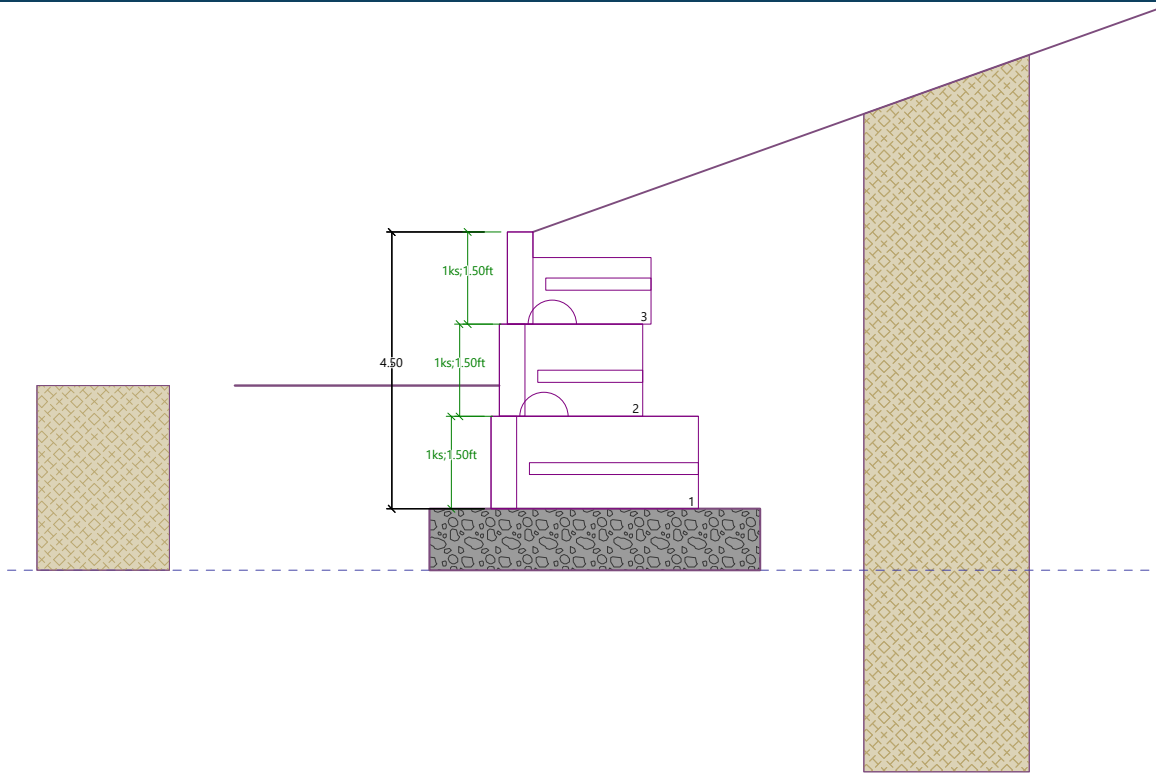
COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Name : Geometry

Stage - analysis : 1 - 0



Base

Geometry

Upper setback $a_1 = 1.00$ ft

Lower setback $a_2 = 1.00$ ft

Height $h = 1.00$ ft

Width $b = 5.38$ ft

Material

12" Granular

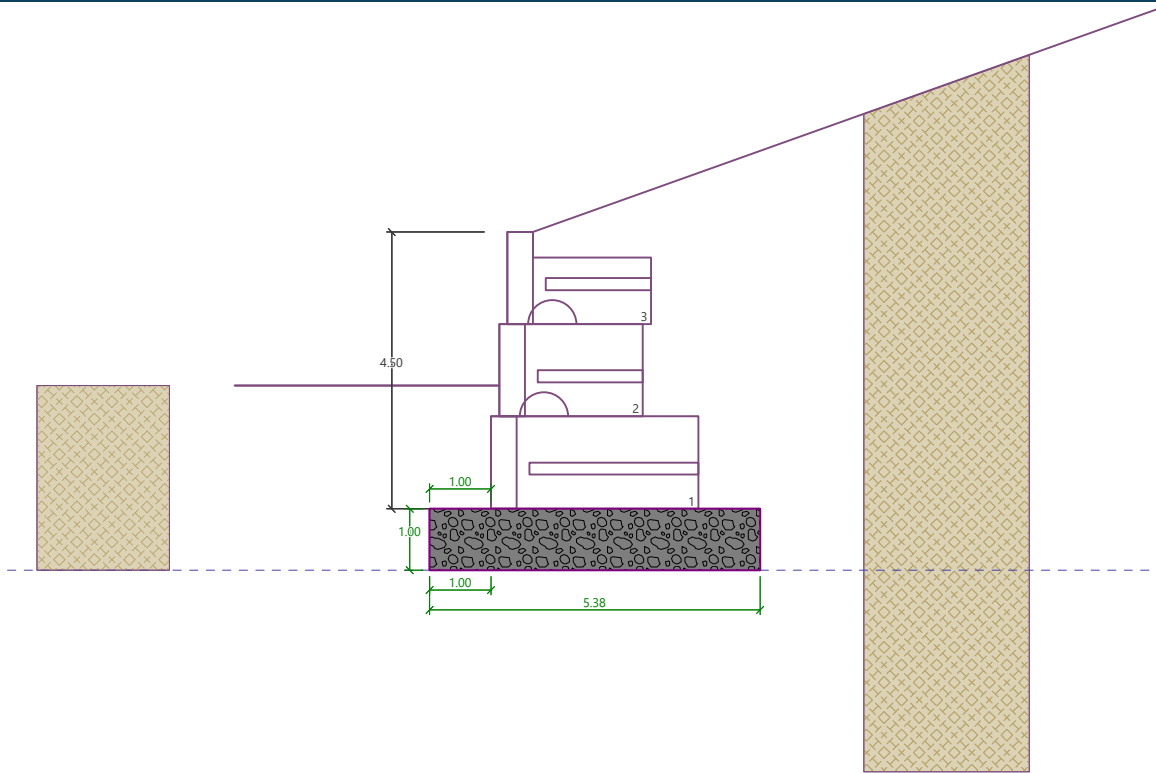
Dry Unit weight $\gamma = 120.00$ pcf

Internal Friction Angle = 34.00°

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Base**Stage - analysis : 1 - 0****Basic soil parameters**

Number	Name	Pattern	Φ_{ef} [°]	C_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Foundation & Retained Soil		32.00	0.0	128.00	76.50	24.00

All soils are considered as cohesionless for at rest pressure analysis.

Geological profile and assigned soils

Number	Thickness of layer t [ft]	Depth z [ft]	Assigned soil	Pattern
1	-	0.00 .. ∞	Foundation & Retained Soil	

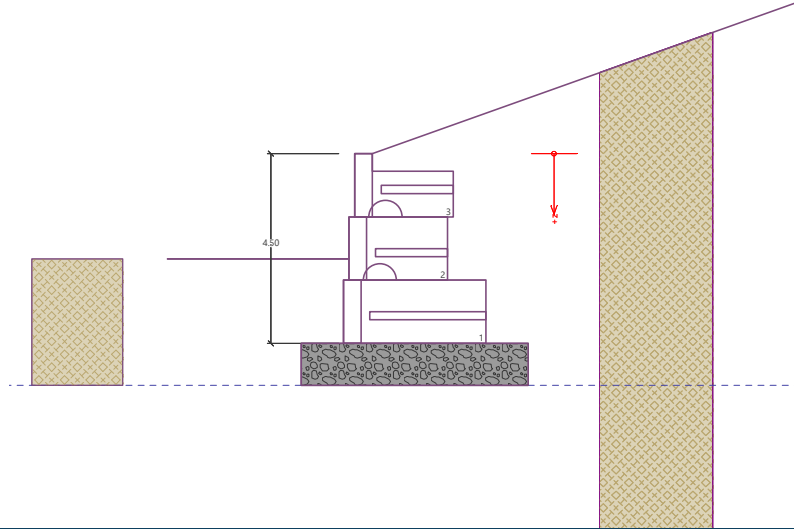
Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Profile and assignment

Stage - analysis : 1 - 0



Terrain profile

Terrain behind construction has the slope 1: 2.80 (slope angle is 19.65 °).

Water influence

GWT behind the structure lies at a depth of 5.50 ft

GWT in front of the structure lies at a depth of 5.50 ft

Subgrade at the heel is not permeable.

Uplift in foot. bottom due to different pressures is not considered.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Foundation & Retained Soil

Soil thickness in front of structure $h = 3.00$ ft

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : Strength I

Reduction of soil/soil friction angle : reduce to $2/3 \phi$ (AASHTO)

Verification No. 1

Active pressure behind the structure - partial results

Layer No.	Thickness [ft]	α [°]	ϕ_d [°]	c_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	5.50	17.91	32.00	0.0	128.00	24.00	0.630	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	5.50	704.0	0.0	443.8	330.3	296.4

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Forces acting on construction

Name	F_{hor} [lb/ft]	App.Pt. z [ft]	F_{vert} [lb/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-2.16	2060.4	2.56	0.900	0.900	1.250
Active pressure	908.2	-1.83	815.2	4.79	1.500	1.500	1.500
Water pressure	0.0	-5.50	0.0	3.60	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 10609.6$ lbfft/ft

Overturning moment $M_{ovr} = 2497.5$ lbfft/ft

Capacity demand ratio CDR = 4.25

Wall for overturning is SATISFACTORY

Check for slip

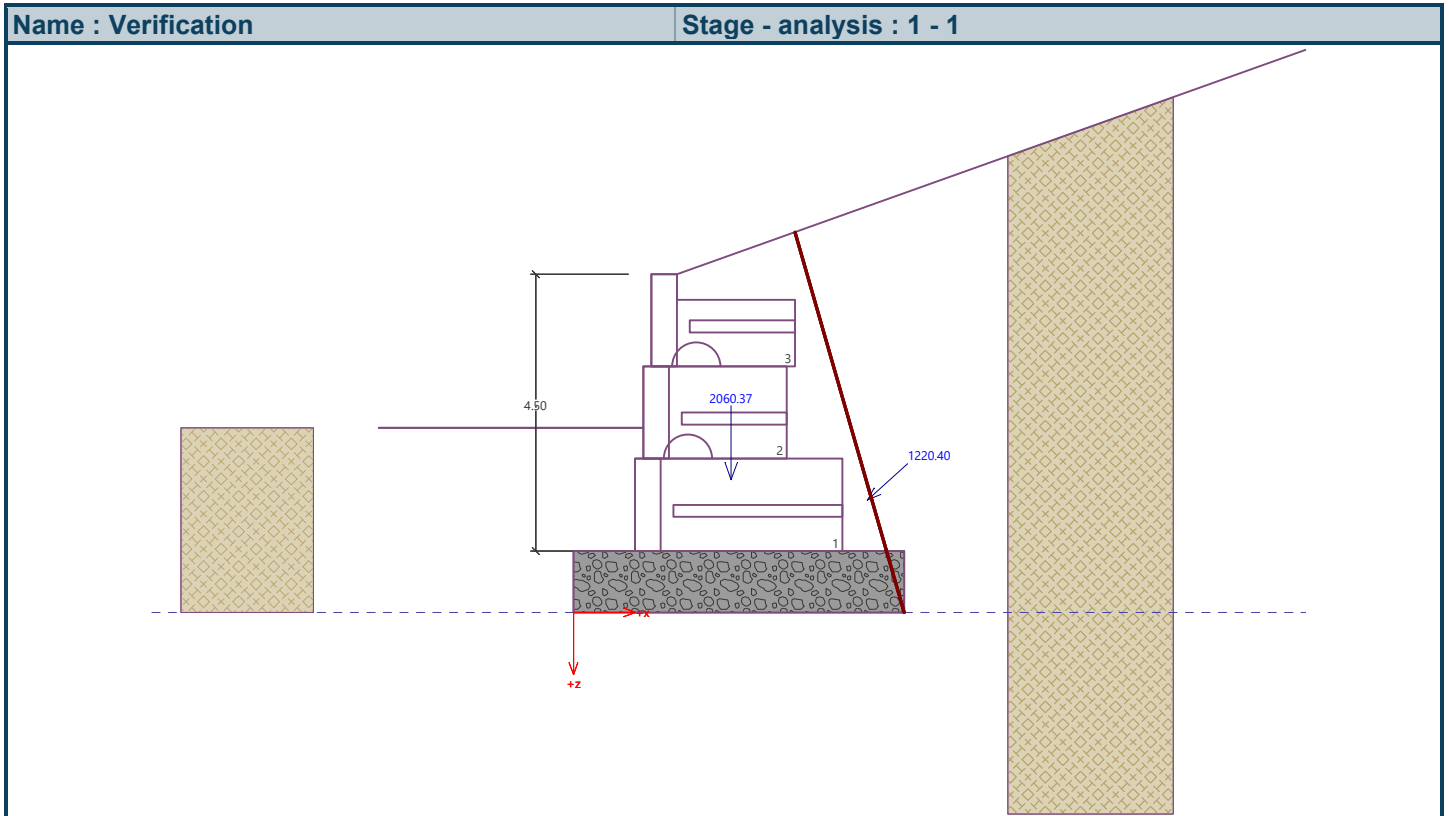
Resisting horizontal force $H_{res} = 1922.80$ lb/ft

Active horizontal force $H_{act} = 1362.30$ lb/ft

Capacity demand ratio CDR = 1.41

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

**Dimensioning No. 1****Active pressure behind the structure - partial results**

Layer No.	Thickness [ft]	α [°]	Φ_d [°]	C_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	4.50	9.74	32.00	0.0	128.00	24.00	0.494	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	4.50	576.0	0.0	284.5	236.6	158.0

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overturn.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-1.92	1414.8	1.51	0.900	0.900	1.250
Active pressure	532.3	-1.50	355.6	3.12	1.500	1.500	1.500
Water pressure	0.0	-4.50	0.0	2.60	1.000	1.000	1.000

Verification of most stressed block No. 1**Check for overturning stability**Resisting moment $M_{res} = 3581.8$ lbfft/ftOverturning moment $M_{ovr} = 1197.6$ lbfft/ft

Capacity demand ratio CDR = 2.99

Joint for overturning stability is SATISFACTORY**Check for slip**Resisting horizontal force $H_{res} = 974.87$ lbf/ftActive horizontal force $H_{act} = 798.42$ lbf/ft

Capacity demand ratio CDR = 1.22

Joint for verification is SATISFACTORY**Bearing capacity of foundation soil****Design load acting at the center of footing bottom**

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	255.9	3798.26	1362.30	0.013	724.1
2	165.4	3077.13	1362.30	0.010	583.6

Service load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	213.7	2875.57	908.20

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force $e = 0.013$

Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 4500.0$ psf

Partial factor on bearing capacity $\gamma_{Rv} = 0.55$

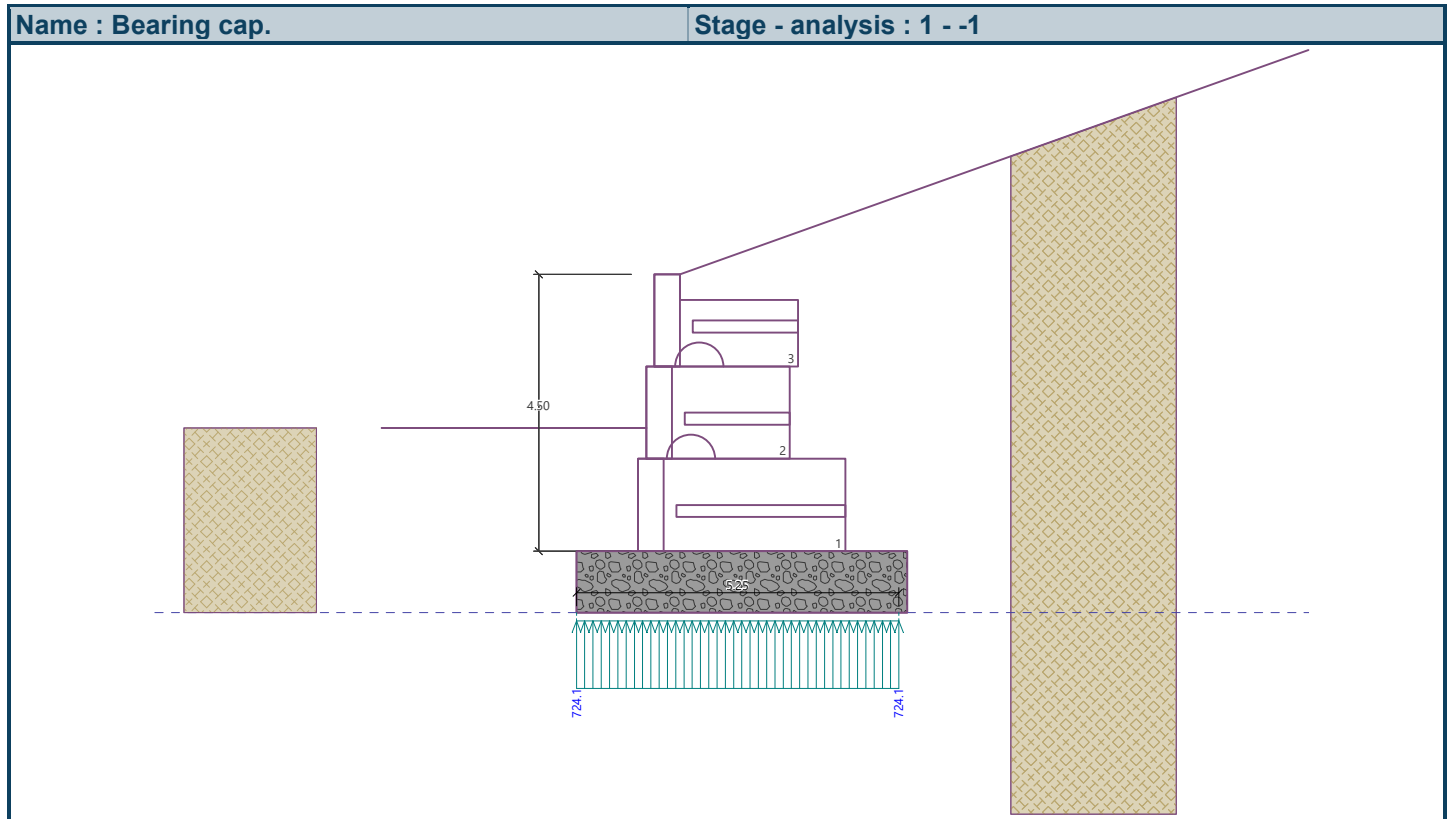
Max. stress at footing bottom $\sigma = 724.1$ psf

Allowable bearing capacity of foundation soil $R_d = 2475.0$ psf

Capacity demand ratio $CDR = 3.4$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

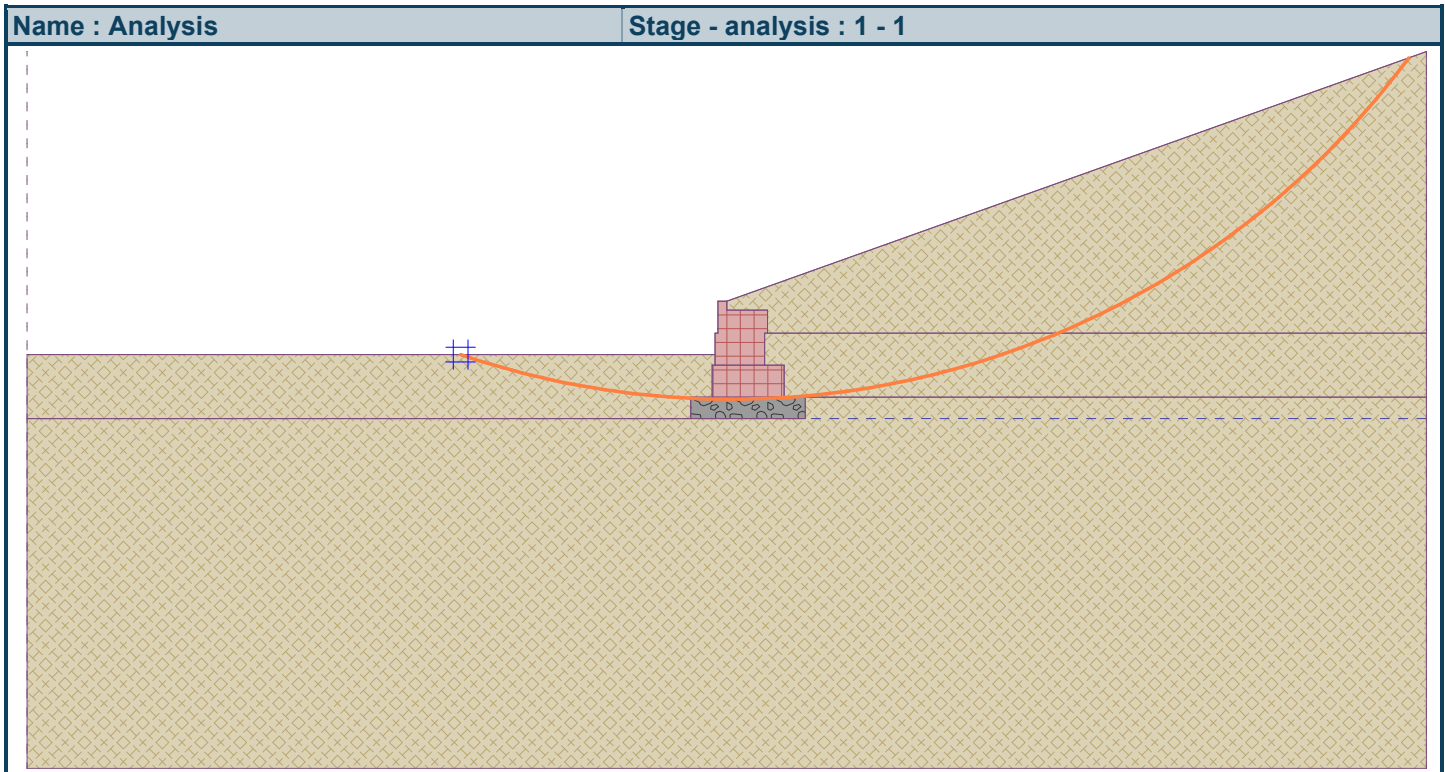
Slope stability analysis**Analysis 1****Circular slip surface**

Slip surface parameters					
Center :	x =	0.21 [ft]	Angles :	α_1 =	-18.71 [°]
	z =	34.94 [ft]		α_2 =	53.48 [°]
Radius :	R =	39.53 [ft]			
The slip surface after optimization.					

Total weight of soil above the slip surface: 24844.0 lbf/ft

The restrictions of points of circular slip surface

Keep the left end point of the slip surface

Slope stability verification (Bishop)Sum of active forces : $F_a = 7694.5$ lbf/ftSum of passive forces : $F_p = 15463.4$ lbf/ftSliding moment : $M_a = 304162.2$ lbfft/ftResisting moment : $M_p = 611269.1$ lbfft/ftFactor of safety = $2.01 \geq 1.50$ **Slope stability ACCEPTABLE**

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio
January 15, 2026 ■ Project No. 25-1213



Design Calculations Section 3: 6.0' Total Height

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Analysis of Redi Rock wall

Input data

Project : COL-EL Riverfront Trail Phase 1
Part : Design 6.0' Section
Customer : EDG
Author : JAD
Date : 1/14/2026
Project number : 25-1213

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : AASHTO - Extensible (straight slip surface)
Reduction coeff. of contact first block - base : 0.80

Geometry

No. group	Description	Count	Setback s [in]
1	Block 41	2	0.13
2	Block 28	1	0.13
3	Top block 28	1	-

Calculation Package

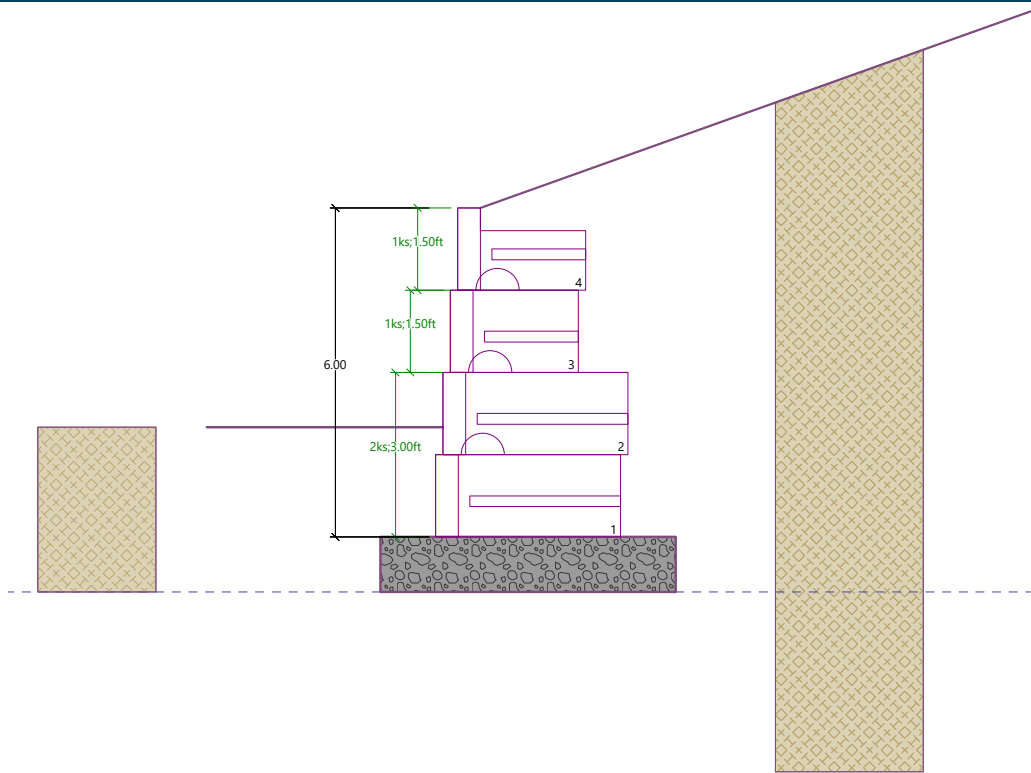
COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Name : Geometry

Stage - analysis : 1 - 0



Base

Geometry

Upper setback $a_1 = 1.00$ ft

Lower setback $a_2 = 1.00$ ft

Height $h = 1.00$ ft

Width $b = 5.38$ ft

Material

12" Granular

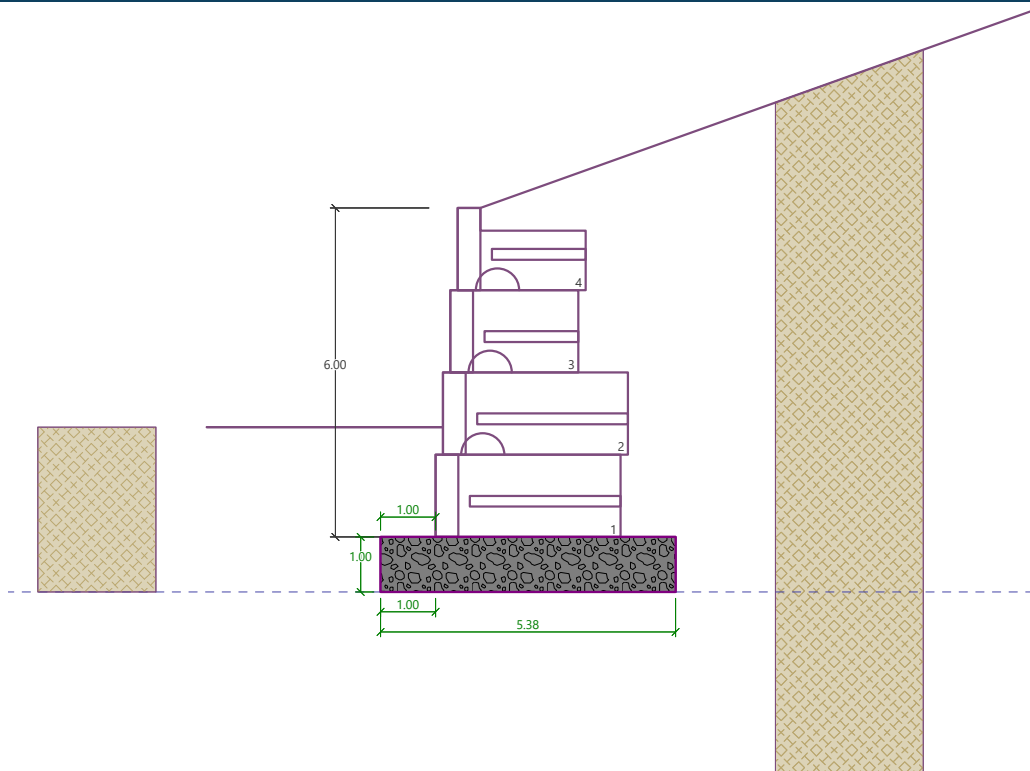
Dry Unit weight $\gamma = 120.00$ pcf

Internal Friction Angle = 34.00°

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Base**Stage - analysis : 1 - 0****Basic soil parameters**

Number	Name	Pattern	Φ_{ef} [°]	C_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Foundation & Retained Soil		32.00	0.0	128.00	76.50	24.00

All soils are considered as cohesionless for at rest pressure analysis.

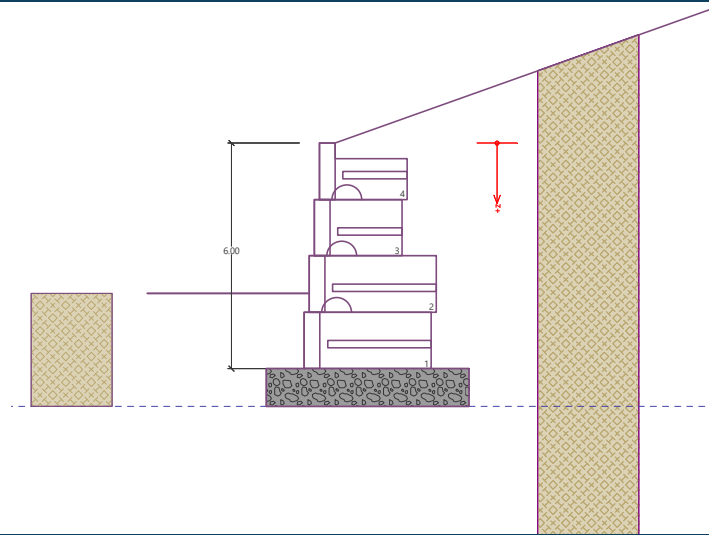
Geological profile and assigned soils

Number	Thickness of layer t [ft]	Depth z [ft]	Assigned soil	Pattern
1	-	0.00 .. ∞	Foundation & Retained Soil	

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Profile and assignment**Stage - analysis : 1 - 0****Terrain profile**

Terrain behind construction has the slope 1: 2.80 (slope angle is 19.65 °).

Water influence

GWT behind the structure lies at a depth of 7.00 ft

GWT in front of the structure lies at a depth of 7.00 ft

Subgrade at the heel is not permeable.

Uplift in foot. bottom due to different pressures is not considered.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Foundation & Retained Soil

Soil thickness in front of structure $h = 3.00$ ft

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : Strength I

Reduction of soil/soil friction angle : reduce to $2/3 \phi$ (AASHTO)**Verification No. 1****Active pressure behind the structure - partial results**

Layer No.	Thickness [ft]	α [°]	ϕ_d [°]	c_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	7.00	13.21	32.00	0.0	128.00	24.00	0.547	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	7.00	896.0	0.0	490.1	390.3	296.4

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Forces acting on construction

Name	F_{hor} [lb/ft]	App.Pt. z [ft]	F_{vert} [lb/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-2.85	2701.3	2.66	0.900	0.900	1.250
Active pressure	1366.1	-2.33	1037.3	4.83	1.500	1.500	1.500
Water pressure	0.0	-7.00	0.0	3.74	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 13995.9$ lbfft/ft

Overturning moment $M_{ovr} = 4781.4$ lbfft/ft

Capacity demand ratio CDR = 2.93

Wall for overturning is SATISFACTORY

Check for slip

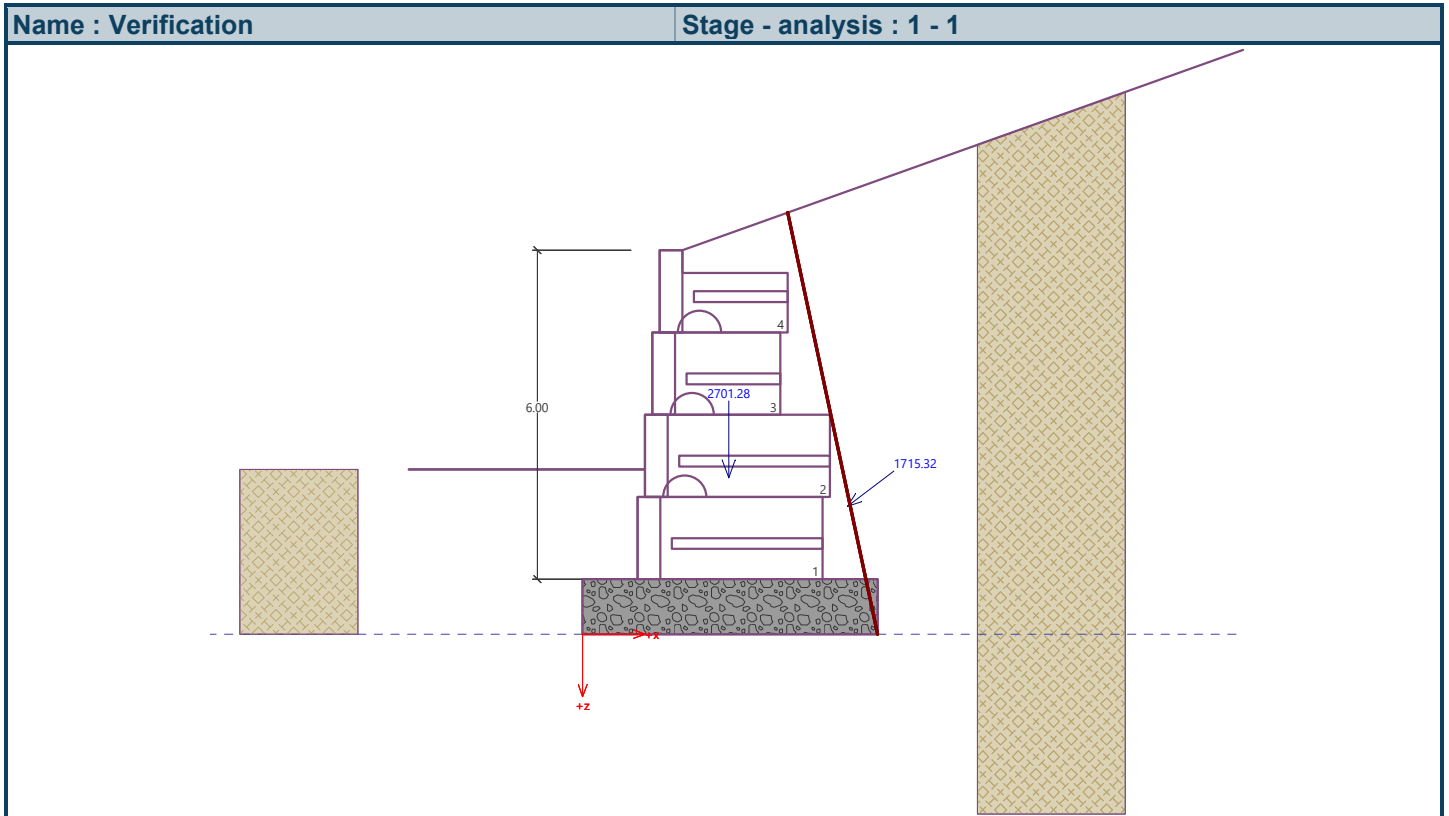
Resisting horizontal force $H_{res} = 2491.44$ lbf/ft

Active horizontal force $H_{act} = 2049.19$ lbf/ft

Capacity demand ratio CDR = 1.22

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

**Dimensioning No. 1****Active pressure behind the structure - partial results**

Layer No.	Thickness [ft]	α [°]	Φ_d [°]	c_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	6.00	6.07	32.00	0.0	128.00	24.00	0.444	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	6.00	768.0	0.0	340.9	295.1	170.8

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overturn.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-2.59	2055.7	1.66	0.900	0.900	1.250
Active pressure	885.2	-2.00	512.5	3.16	1.500	1.500	1.500
Water pressure	0.0	-6.00	0.0	2.74	1.000	1.000	1.000

Verification of most stressed block No. 1**Check for overturning stability**Resisting moment $M_{res} = 5495.0$ lbfft/ftOverturning moment $M_{ovr} = 2655.5$ lbfft/ft

Capacity demand ratio CDR = 2.07

Joint for overturning stability is SATISFACTORY**Check for slip**Resisting horizontal force $H_{res} = 1413.17$ lbf/ftActive horizontal force $H_{act} = 1327.77$ lbf/ft

Capacity demand ratio CDR = 1.06

Joint for verification is SATISFACTORY**Bearing capacity of foundation soil****Design load acting at the center of footing bottom**

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	1535.3	4932.58	2049.19	0.058	1036.8
2	1510.9	3987.13	2049.19	0.070	862.6

Service load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	1035.2	3738.60	1366.12

January 14, 2026 ■ Project No. 25-1213

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force $e = 0.070$

Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil R = 4500.0 psf

Partial factor on bearing capacity $\gamma_{Rv} = 0.55$

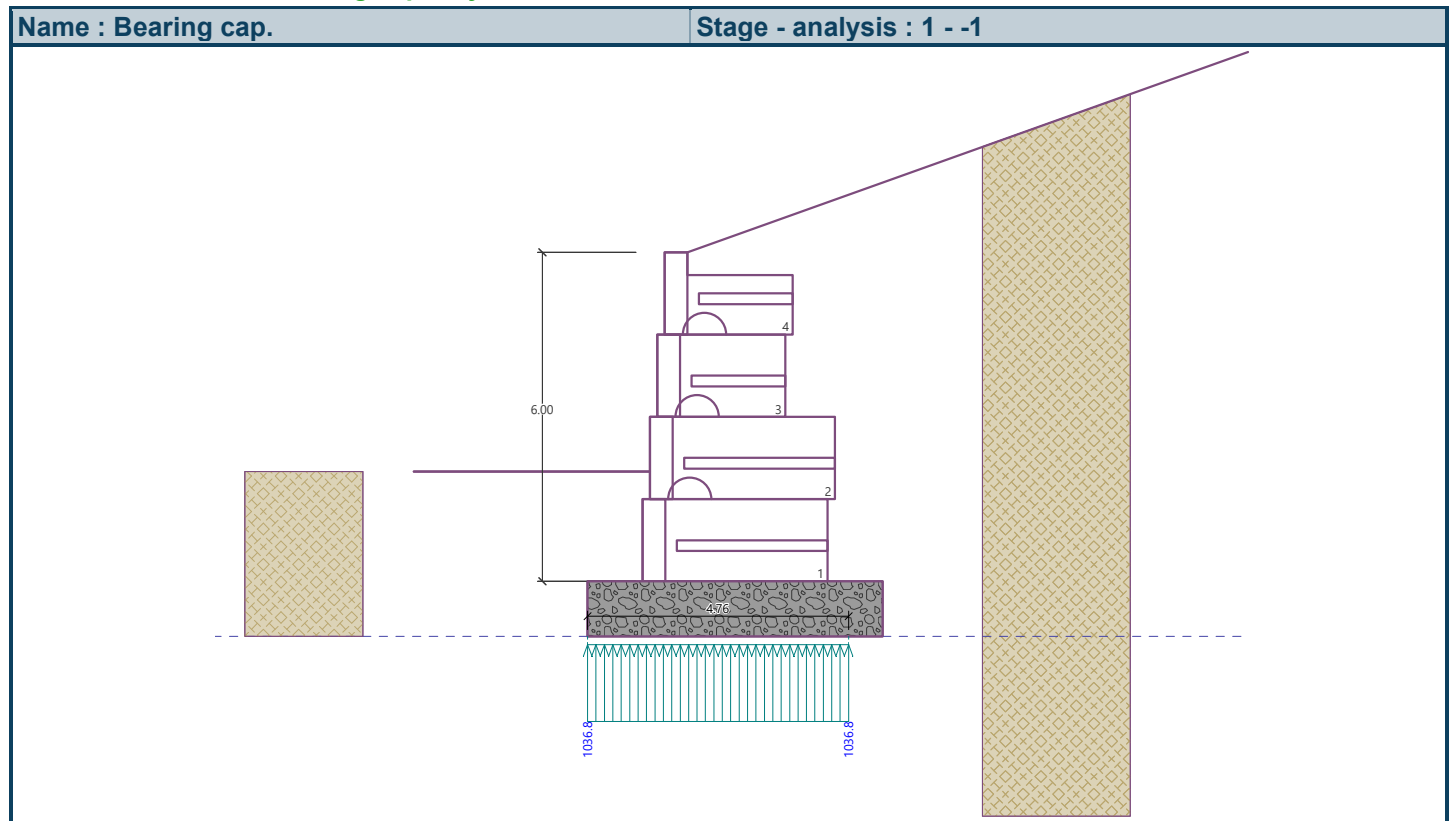
Max. stress at footing bottom $\sigma = 1036.8 \text{ psf}$

Allowable bearing capacity of foundation soil $R_d = 2475.0$ psf

Capacity demand ratio CDR = 2.4

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY



Slope stability analysis

Analysis 1

Circular slip surface

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

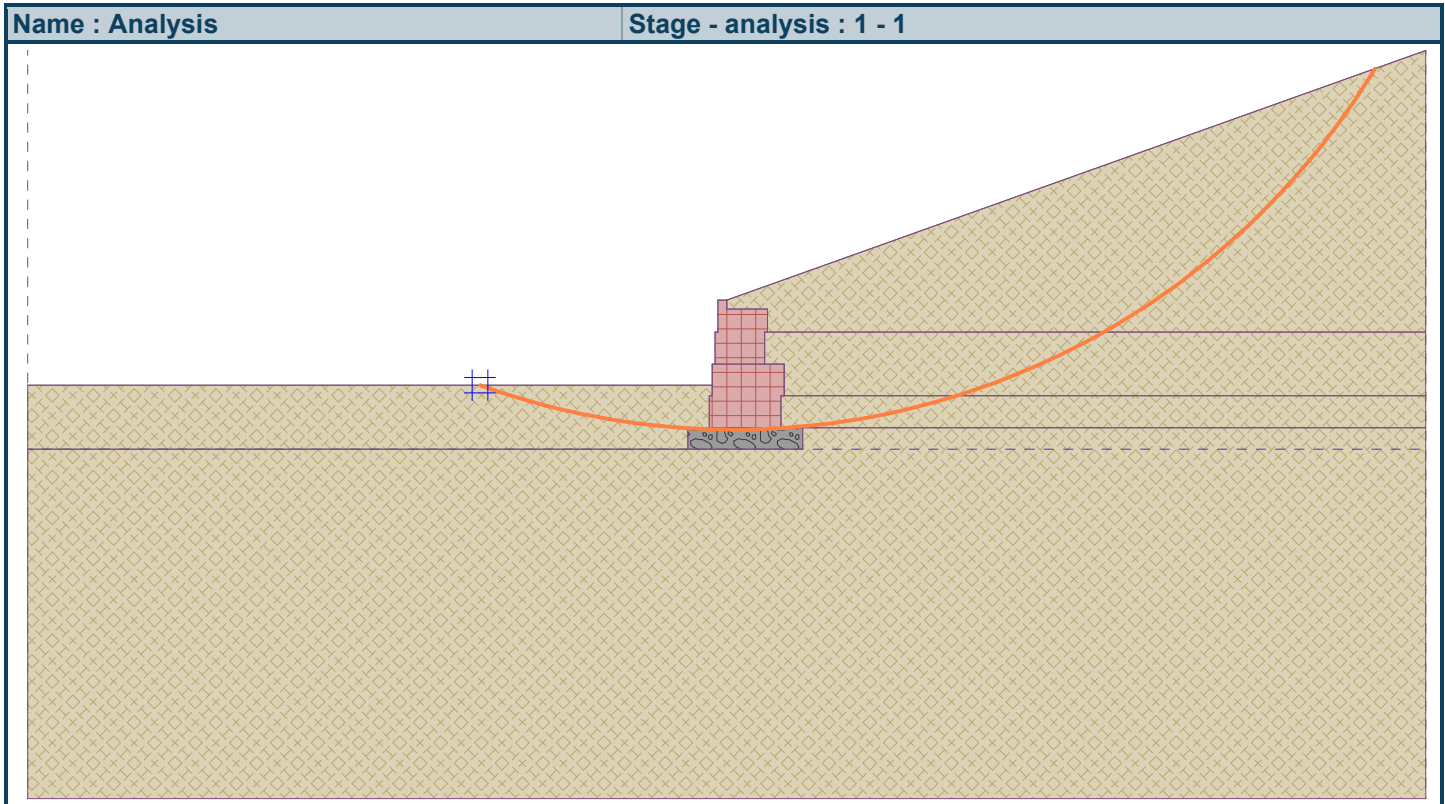


Slip surface parameters					
Center :	x =	0.34 [ft]	Angles :	α_1 =	-19.80 [°]
	z =	29.10 [ft]		α_2 =	58.77 [°]
Radius :	R =	35.18 [ft]			
The slip surface after optimization.					

Total weight of soil above the slip surface: 27912.8 lbf/ft

The restrictions of points of circular slip surface

Keep the left end point of the slip surface

Slope stability verification (Bishop)Sum of active forces : $F_a = 9205.9$ lbf/ftSum of passive forces : $F_p = 17374.3$ lbf/ftSliding moment : $M_a = 323864.9$ lbft/ftResisting moment : $M_p = 611227.1$ lbft/ftFactor of safety = $1.89 \geq 1.50$ **Slope stability ACCEPTABLE**

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio
January 15, 2026 ■ Project No. 25-1213



Design Calculations

Section 4: 7.5' Total Height

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Analysis of Redi Rock wall

Input data

Project : COL-EL Riverfront Trail Phase 1
Part : Design 7.5' Section
Customer : EDG
Author : JAD
Date : 1/14/2026
Project number : 25-1213

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : AASHTO - Extensible (straight slip surface)
Reduction coeff. of contact first block - base : 0.80

Geometry

No. group	Description	Count	Setback s [in]
1	Block 60	2	0.13
2	Block 41	1	0.13
3	Block 28	1	0.13
4	Top block 28	1	-

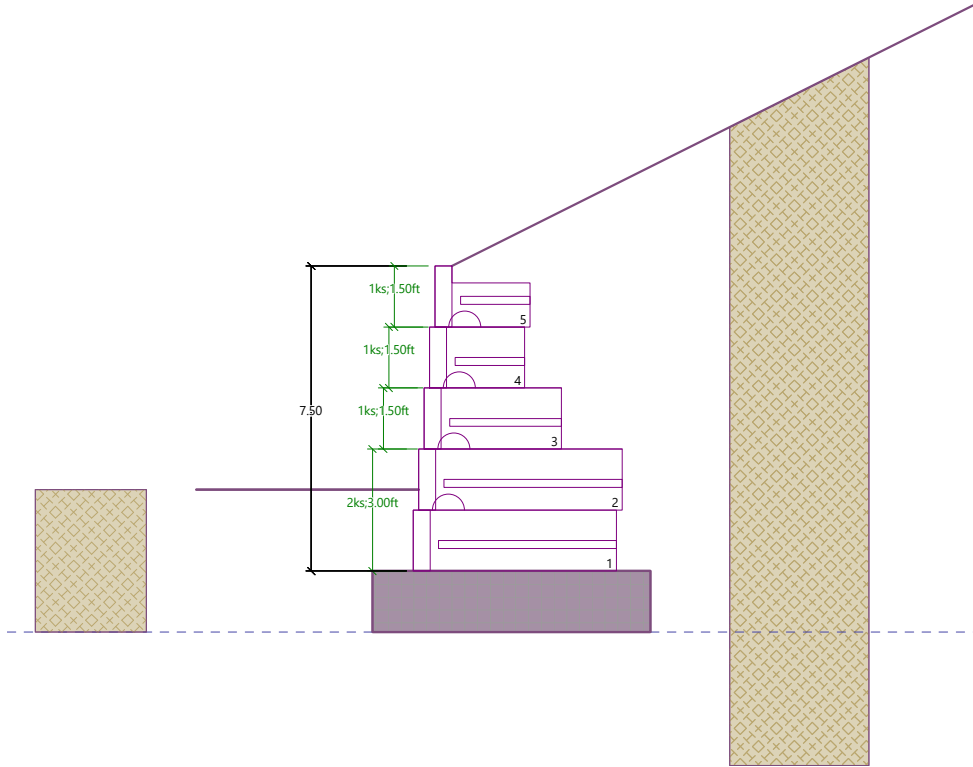
Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Geometry

Stage - analysis : 1 - 0



Base

Geometry

Upper setback $a_1 = 1.00$ ft

Lower setback $a_2 = 1.00$ ft

Height $h = 1.50$ ft

Width $b = 6.83$ ft

Material

6" Concrete over 12" Granular

Concrete self-weight $\gamma = 128.30$ pcf

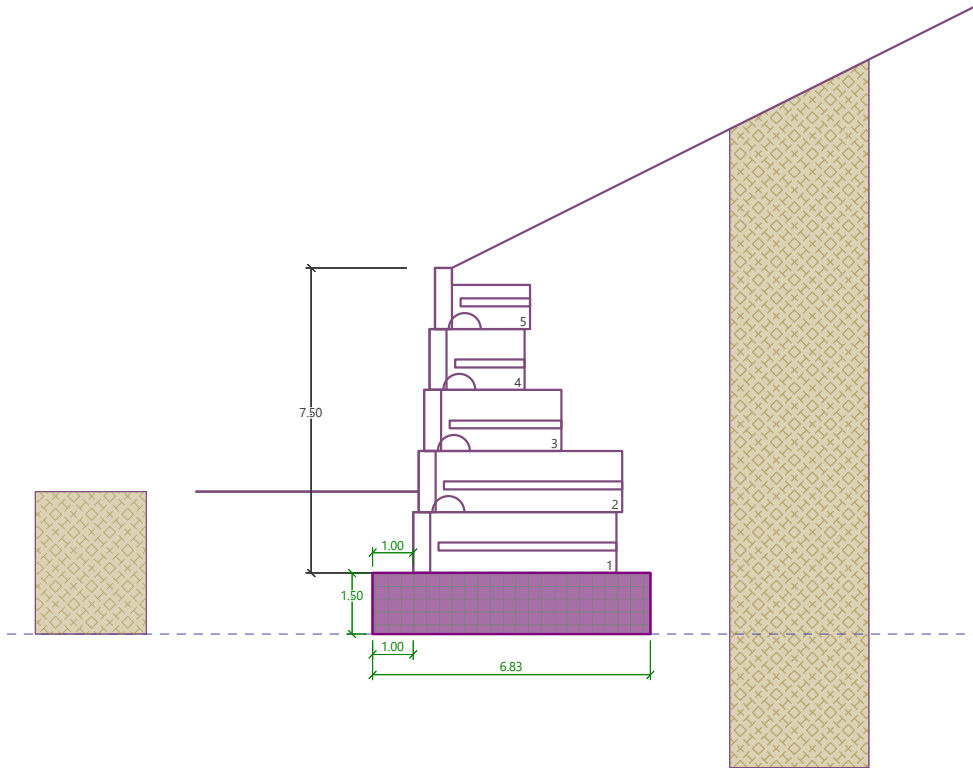
Shear cub (key) capacity = 0.00 lbf/ft

Friction angle concrete-concrete = 29.25 °

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Base**Stage - analysis : 1 - 0****Basic soil parameters**

Number	Name	Pattern	Φ_{ef} [°]	C_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Foundation & Retained Soil		32.00	0.0	128.00	76.50	24.00

All soils are considered as cohesionless for at rest pressure analysis.

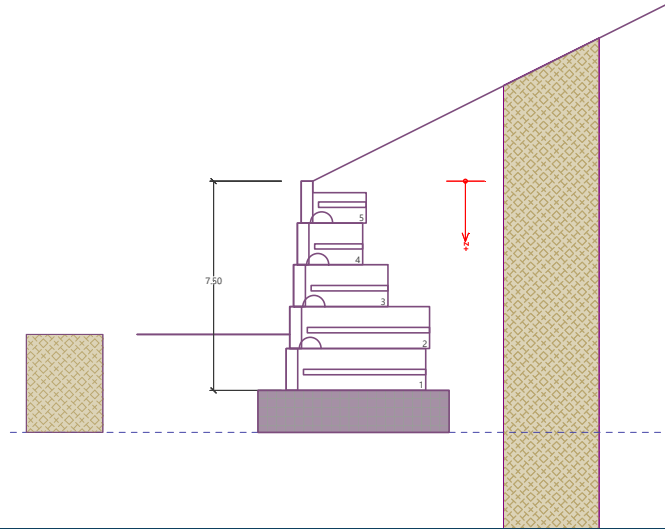
Geological profile and assigned soils

Number	Thickness of layer t [ft]	Depth z [ft]	Assigned soil	Pattern
1	-	0.00 .. ∞	Foundation & Retained Soil	

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Profile and assignment**Stage - analysis : 1 - 0****Terrain profile**

Terrain behind construction has the slope 1: 2.00 (slope angle is 26.57 °).

Water influence

GWT behind the structure lies at a depth of 9.00 ft

GWT in front of the structure lies at a depth of 9.00 ft

Subgrade at the heel is not permeable.

Uplift in foot. bottom due to different pressures is not considered.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Foundation & Retained Soil

Soil thickness in front of structure $h = 3.50$ ft

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : Strength I

Reduction of soil/soil friction angle : reduce to $2/3 \phi$ (AASHTO)**Verification No. 1****Active pressure behind the structure - partial results**

Layer No.	Thickness [ft]	α [°]	ϕ_d [°]	c_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	9.00	18.20	32.00	0.0	128.00	24.00	0.801	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	9.00	1152.0	0.0	922.6	683.5	619.7

Forces acting on construction

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Name	F _{hor} [lb/ft]	App.Pt. z [ft]	F _{vert} [lb/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-3.40	4685.2	3.29	0.900	0.900	1.250
Active pressure	3075.6	-3.00	2788.5	5.84	1.500	1.500	1.500
Water pressure	0.0	-9.00	0.0	3.87	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 38298.2$ lbfft/ft

Overturning moment $M_{ovr} = 13840.2$ lbfft/ft

Capacity demand ratio CDR = 2.77

Wall for overturning is SATISFACTORY

Check for slip

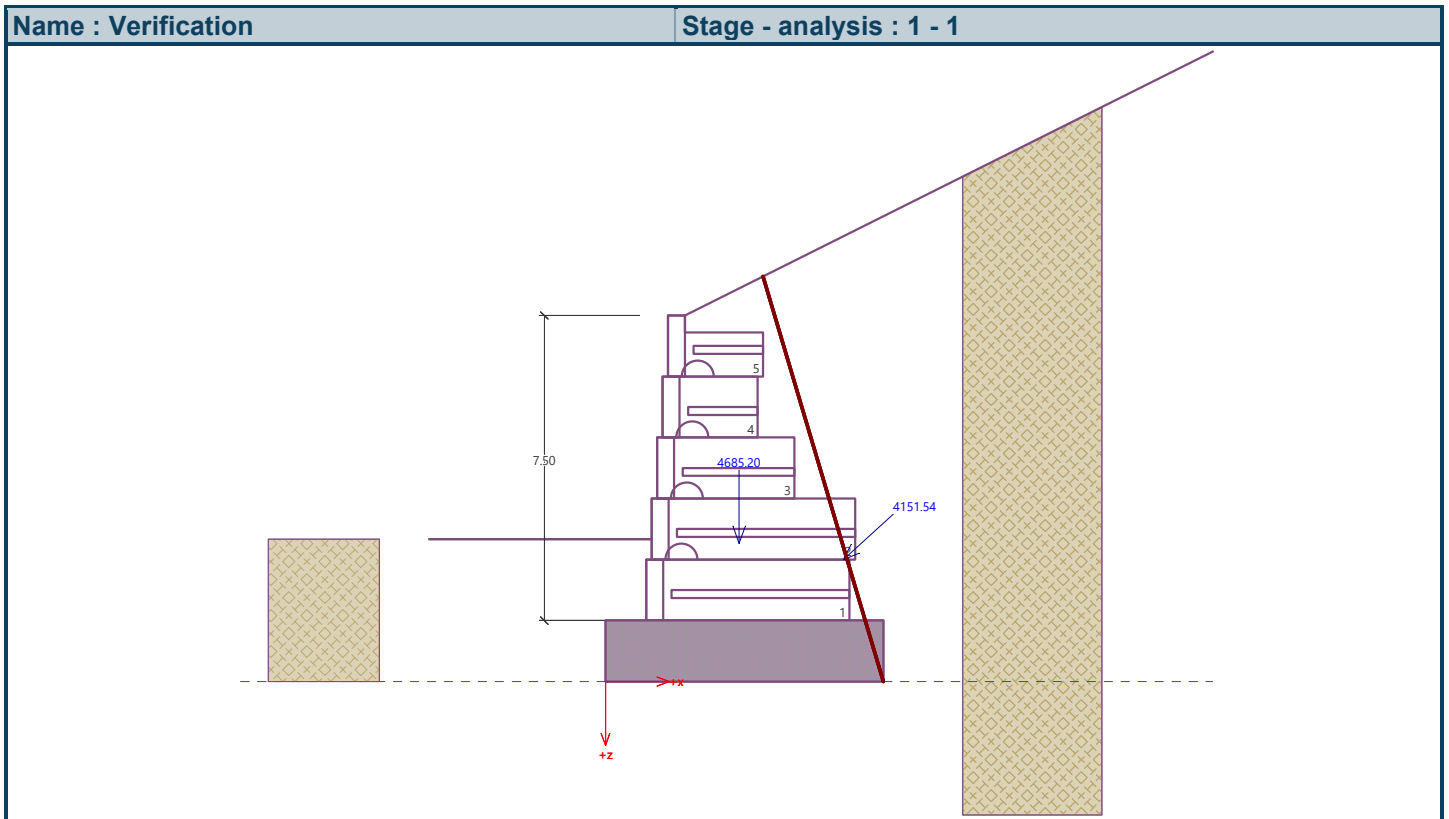
Resisting horizontal force $H_{res} = 5248.58$ lb/ft

Active horizontal force $H_{act} = 4613.40$ lb/ft

Capacity demand ratio CDR = 1.14

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Dimensioning No. 1

Active pressure behind the structure - partial results

Layer No.	Thickness [ft]	α [°]	Φ_d [°]	C_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	7.50	15.84	32.00	0.0	128.00	24.00	0.742	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	7.50	960.0	0.0	712.7	547.2	456.6

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overturn.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-2.93	3370.8	2.24	0.900	0.900	1.250
Active pressure	2052.0	-2.50	1712.4	4.29	1.500	1.500	1.500
Water pressure	0.0	-7.50	0.0	2.87	1.000	1.000	1.000

Verification of most stressed block No. 1

Check for overturning stability

Resisting moment $M_{res} = 17801.3$ lbfft/ft

Overturning moment $M_{ovr} = 7694.9$ lbfft/ft

Capacity demand ratio CDR = 2.31

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 3137.40$ lbf/ft

Active horizontal force $H_{act} = 3077.96$ lbf/ft

Capacity demand ratio CDR = 1.02

Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	4438.3	10039.31	4613.40	0.065	1688.5
2	4226.2	8399.49	4613.40	0.074	1442.3

Service load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	3059.8	7473.74	3075.60

Verification of foundation soil

Stress in the footing bottom : rectangle

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Eccentricity verification

Max. eccentricity of normal force $e = 0.074$

Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 4500.0 \text{ psf}$

Partial factor on bearing capacity $\gamma_{Rv} = 0.55$

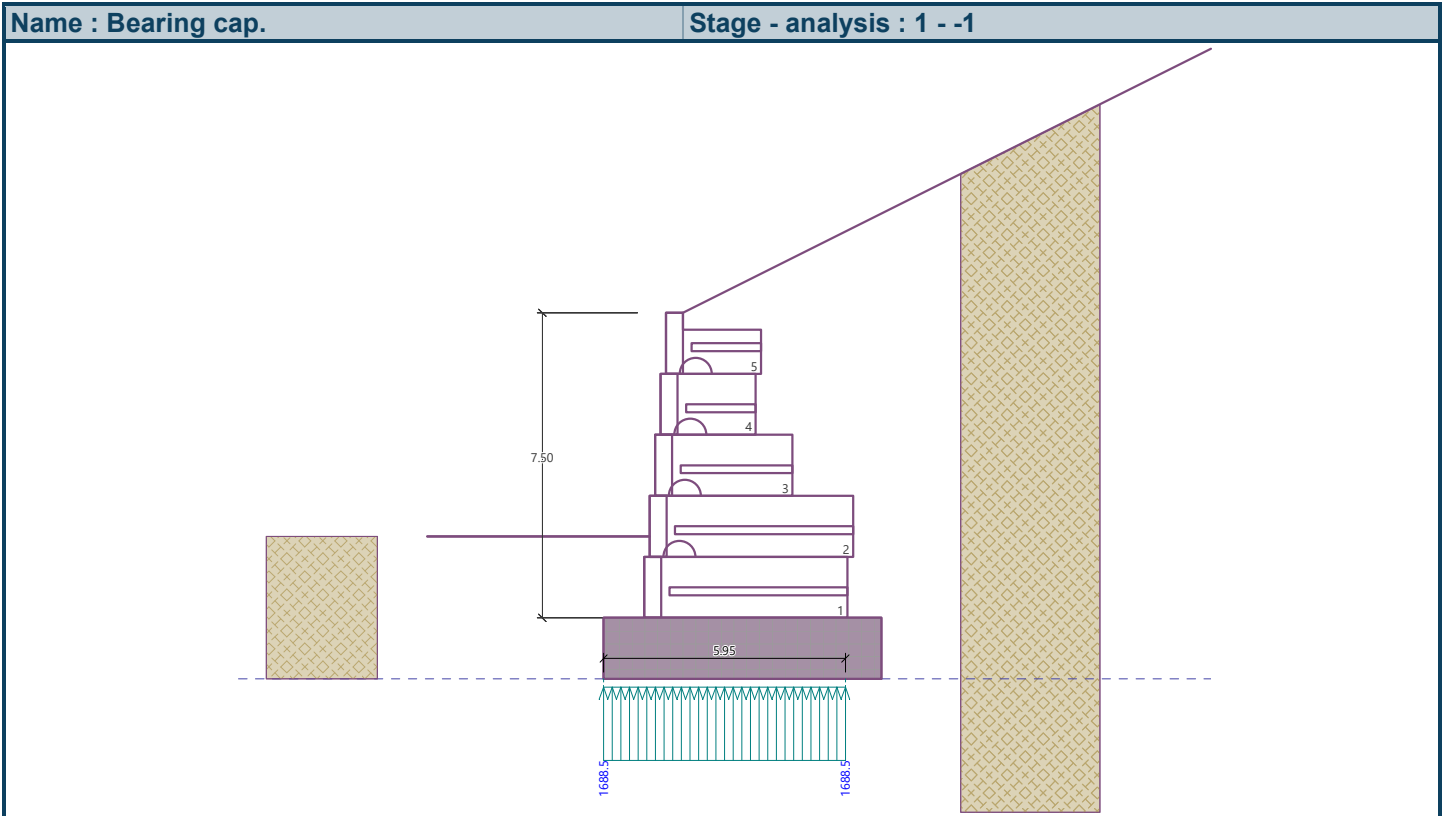
Max. stress at footing bottom $\sigma = 1688.5 \text{ psf}$

Allowable bearing capacity of foundation soil $R_d = 2475.0 \text{ psf}$

Capacity demand ratio $CDR = 1.5$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY



Slope stability analysis

Analysis 1

Circular slip surface

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

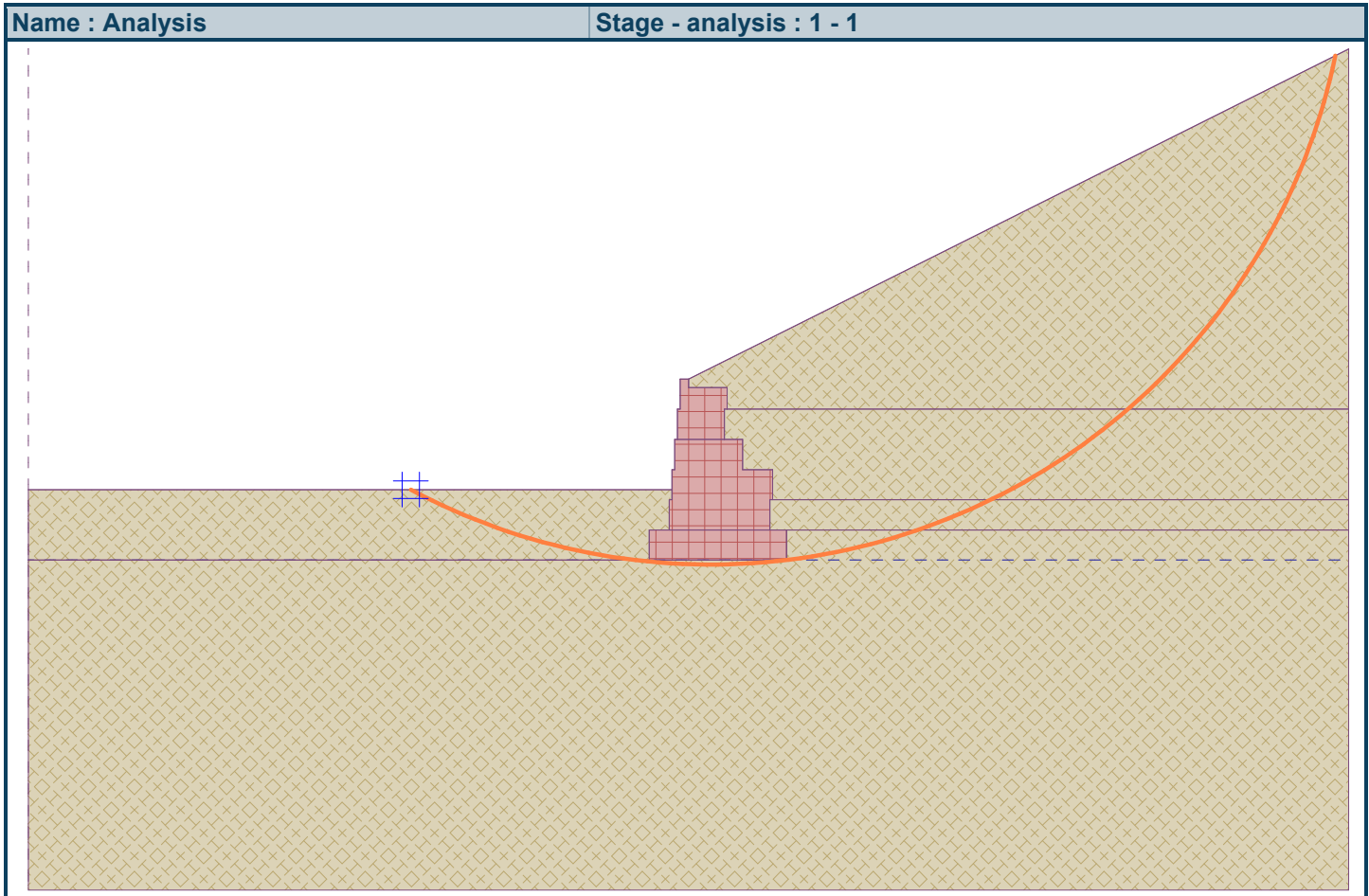


Slip surface parameters					
Center :	x =	1.10 [ft]	Angles :	α_1 =	-28.04 [°]
	z =	22.47 [ft]		α_2 =	78.35 [°]
Radius :	R =	31.69 [ft]			
The slip surface after optimization.					

Total weight of soil above the slip surface: 50388.4 lbf/ft

The restrictions of points of circular slip surface

Keep the left end point of the slip surface

Slope stability verification (Bishop)Sum of active forces : $F_a = 18901.1$ lbf/ftSum of passive forces : $F_p = 31741.2$ lbf/ftSliding moment : $M_a = 598975.3$ lbfft/ftResisting moment : $M_p = 1005877.2$ lbfft/ftFactor of safety = $1.68 \geq 1.50$ **Slope stability ACCEPTABLE**

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio
January 15, 2026 ■ Project No. 25-1213



Design Calculations Section 5: 9.0' Total Height

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Analysis of Redi Rock wall

Input data

Project : COL-EL Riverfront Trail Phase 1
Part : Design 9.0' Section
Customer : EDG
Author : JAD
Date : 1/14/2026
Project number : 25-1213

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : AASHTO - Extensible (straight slip surface)
Reduction coeff. of contact first block - base : 0.80

Geometry

No. group	Description	Count	Setbacks [in]
1	Block R-7236 HC	1	0.27
2	Block R-7236 HC	1	0.27
3	Block 28	1	0.13
4	Top block 28	1	-

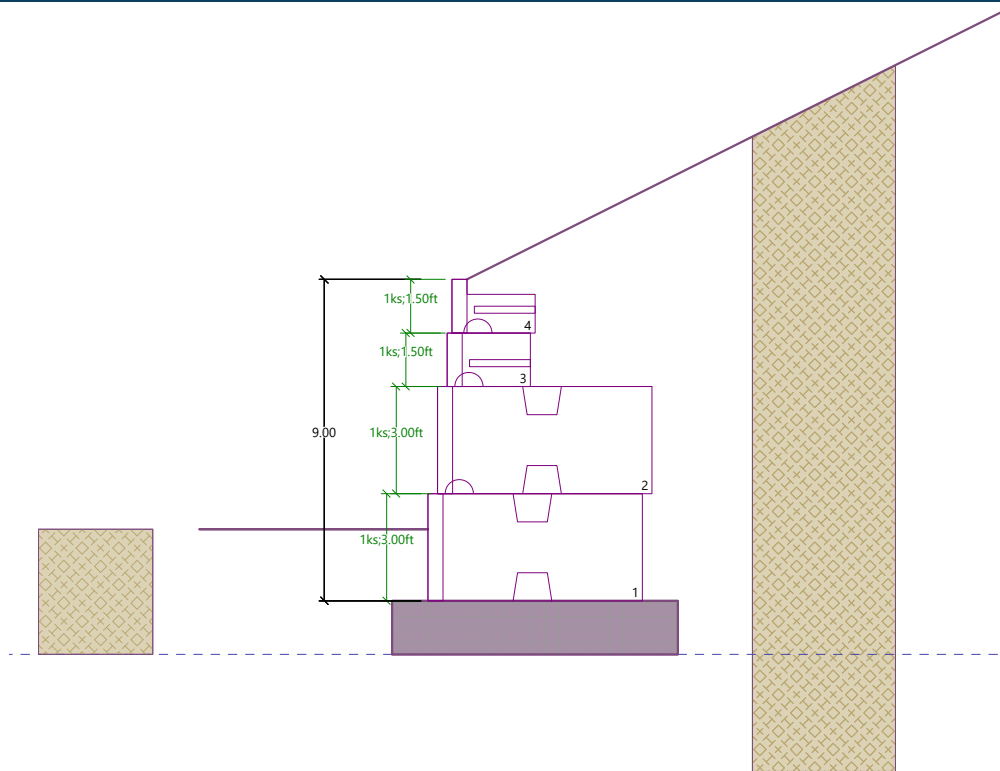
Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Geometry

Stage - analysis : 1 - 0



Base

Geometry

Upper setback $a_1 = 1.00$ ft

Lower setback $a_2 = 1.00$ ft

Height $h = 1.50$ ft

Width $b = 8.00$ ft

Material

6" Concrete over 12" Granular

Concrete self-weight $\gamma = 128.30$ pcf

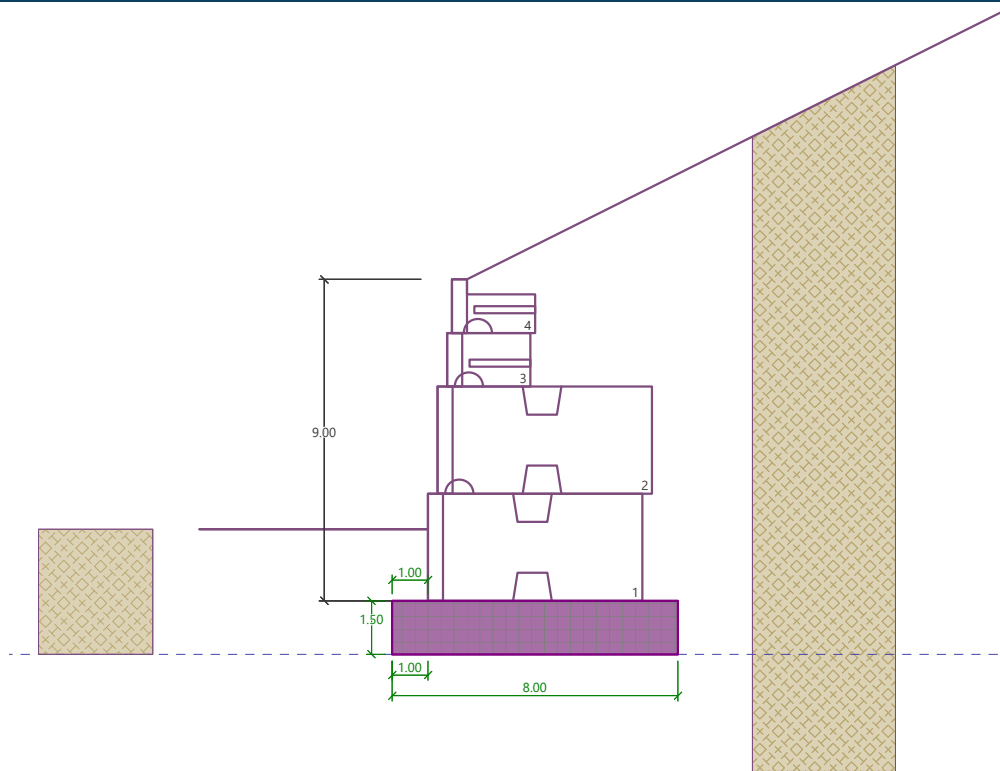
Shear cub (key) capacity = 0.00 lbf/ft

Friction angle concrete-concrete = 29.25 °

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Base**Stage - analysis : 1 - 0****Basic soil parameters**

Number	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Foundation & Retained Soil		32.00	0.0	128.00	70.50	24.00

All soils are considered as cohesionless for at rest pressure analysis.

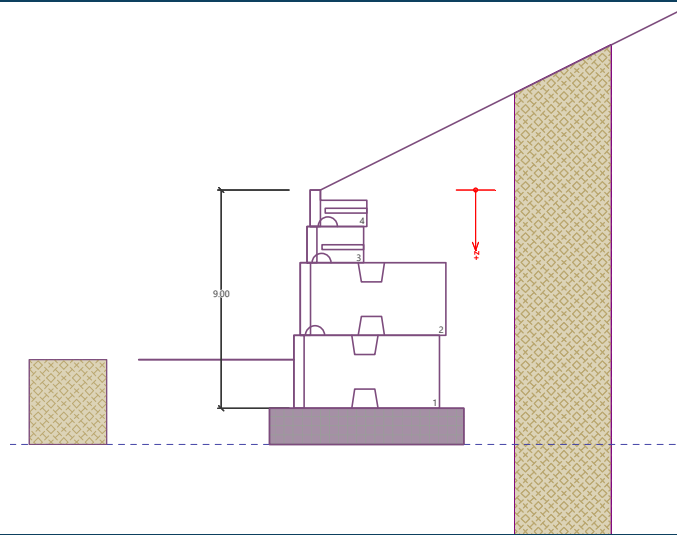
Geological profile and assigned soils

Number	Thickness of layer t [ft]	Depth z [ft]	Assigned soil	Pattern
1	-	0.00 .. ∞	Foundation & Retained Soil	

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Profile and assignment**Stage - analysis : 1 - 0****Terrain profile**

Terrain behind construction has the slope 1: 2.00 (slope angle is 26.57 °).

Water influence

GWT behind the structure lies at a depth of 10.50 ft

GWT in front of the structure lies at a depth of 10.50 ft

Subgrade at the heel is not permeable.

Uplift in foot. bottom due to different pressures is not considered.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Foundation & Retained Soil

Soil thickness in front of structure $h = 3.50$ ft

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : Strength I

Reduction of soil/soil friction angle : reduce to $2/3 \phi$ (AASHTO)**Verification No. 1****Active pressure behind the structure - partial results**

Layer No.	Thickness [ft]	α [°]	ϕ_d [°]	c_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	10.50	20.83	32.00	0.0	128.00	24.00	0.874	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	10.50	1344.0	0.0	1174.2	832.8	827.7

Forces acting on construction

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Name	F _{hor} [lb/ft]	App.Pt. z [ft]	F _{vert} [lb/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-4.13	6367.1	3.94	0.900	0.900	1.250
Active pressure	4372.1	-3.50	4345.7	6.67	1.500	1.500	1.500
Water pressure	0.0	-10.50	0.0	4.01	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 66019.2$ lbfft/ft

Overturning moment $M_{ovr} = 22953.6$ lbfft/ft

Capacity demand ratio CDR = 2.88

Wall for overturning is SATISFACTORY

Check for slip

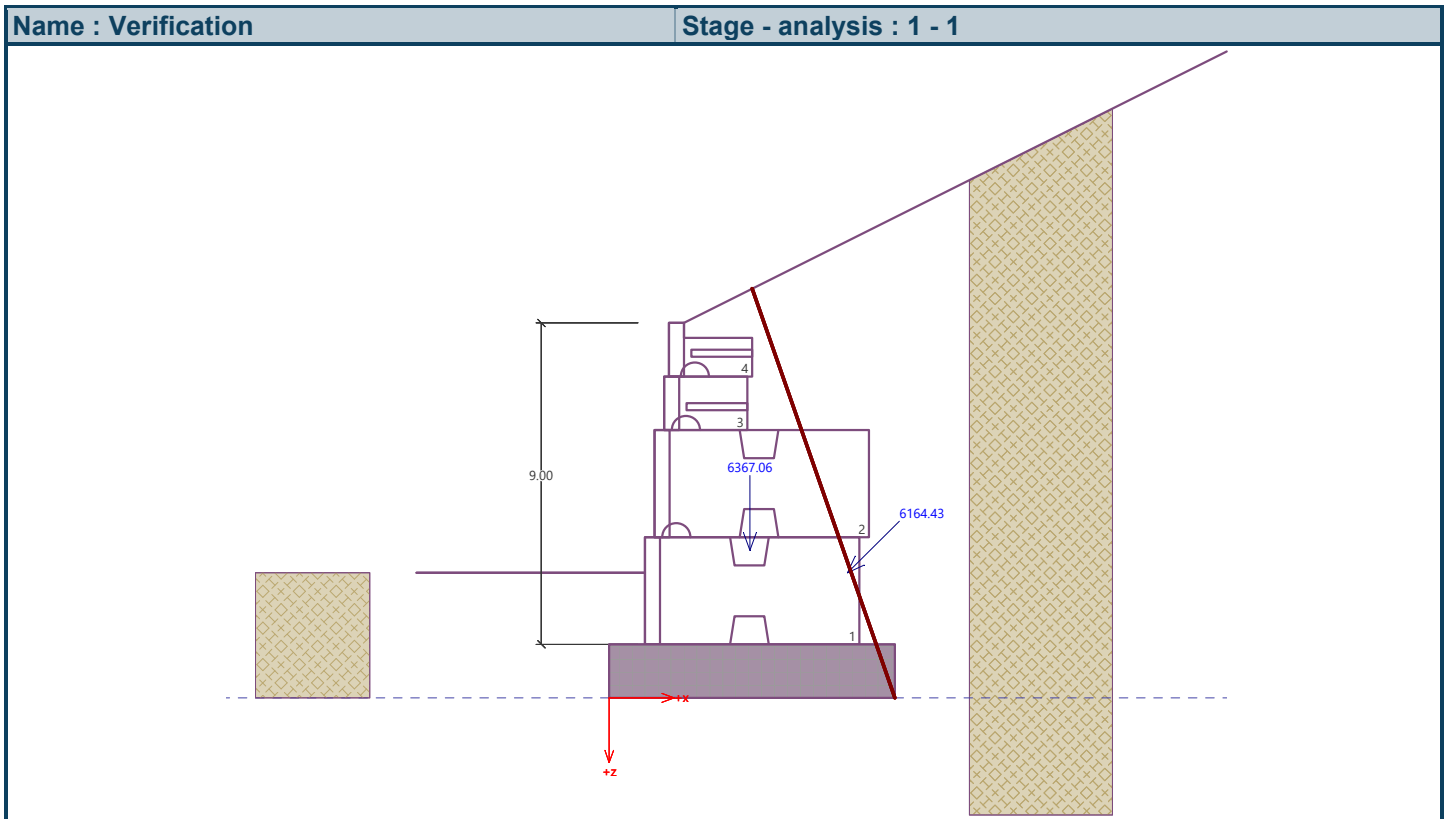
Resisting horizontal force $H_{res} = 7653.94$ lb/ft

Active horizontal force $H_{act} = 6558.16$ lb/ft

Capacity demand ratio CDR = 1.17

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Dimensioning No. 1

Active pressure behind the structure - partial results

Layer No.	Thickness [ft]	α [°]	Φ_d [°]	C_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	9.00	18.40	32.00	0.0	128.00	24.00	0.806	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	9.00	1152.0	0.0	928.7	685.8	626.2

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overturn.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-3.70	4827.5	2.91	0.900	0.900	1.250
Active pressure	3086.1	-3.00	2818.1	5.00	1.500	1.500	1.500
Water pressure	0.0	-9.00	0.0	3.01	1.000	1.000	1.000

Verification of most stressed block No. 1

Check for overturning stability

Resisting moment $M_{res} = 33806.6$ lbfft/ft

Overturning moment $M_{ovr} = 13887.5$ lbfft/ft

Capacity demand ratio CDR = 2.43

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 4800.49$ lbf/ft

Active horizontal force $H_{act} = 4629.18$ lbf/ft

Capacity demand ratio CDR = 1.04

Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	6074.4	14477.34	6558.16	0.052	2021.7
2	5929.8	12248.87	6558.16	0.061	1741.9

Service load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	4118.5	10712.73	4372.11

Verification of foundation soil

Stress in the footing bottom : rectangle

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Eccentricity verification

Max. eccentricity of normal force $e = 0.061$

Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 4500.0$ psf

Partial factor on bearing capacity $\gamma_{Rv} = 0.55$

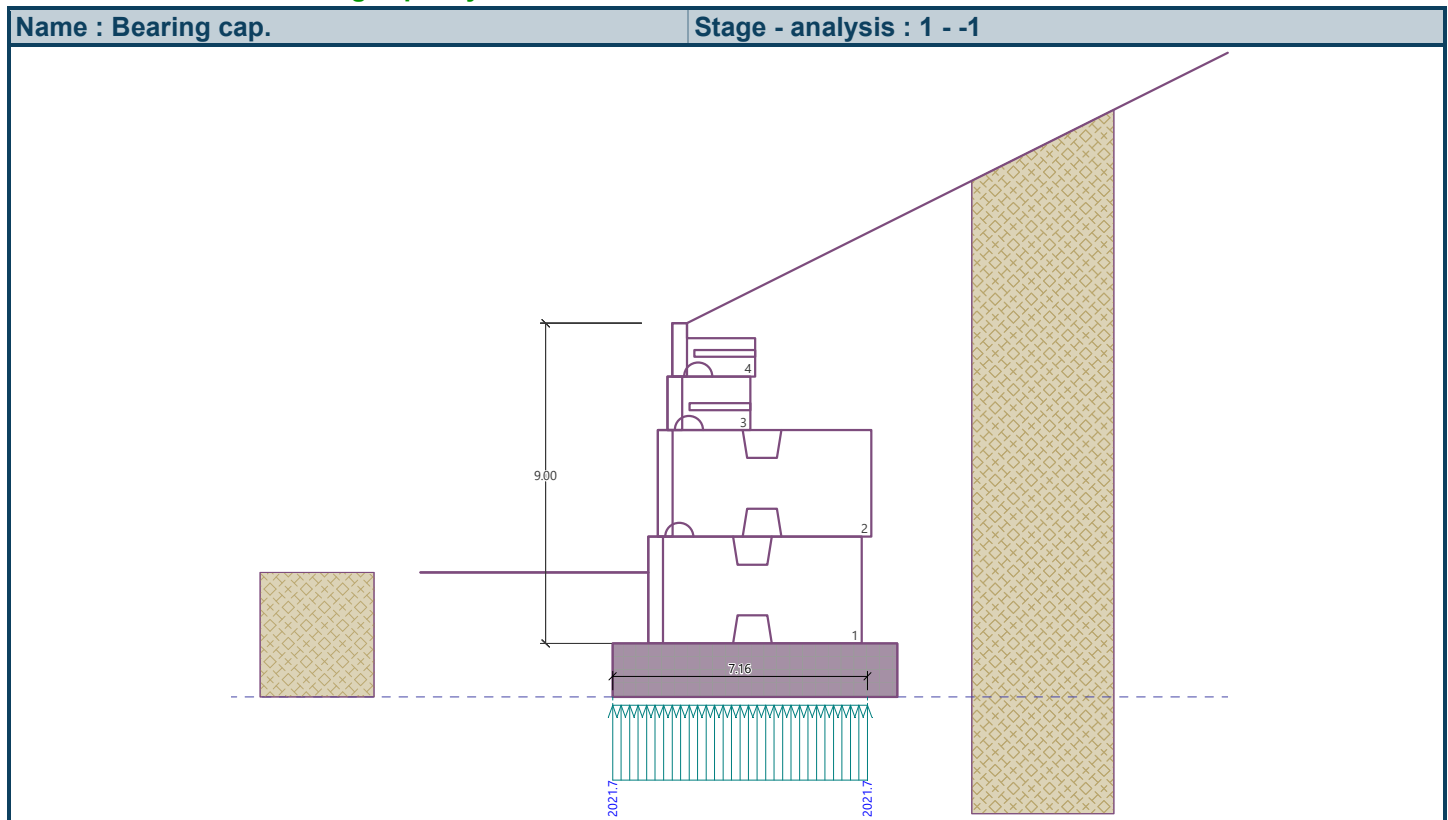
Max. stress at footing bottom $\sigma = 2021.7$ psf

Allowable bearing capacity of foundation soil $R_d = 2475.0$ psf

Capacity demand ratio $CDR = 1.2$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY



Slope stability analysis

Analysis 1

Circular slip surface

Slip surface parameters					
Center :	x =	-1.96 [ft]	Angles :	$\alpha_1 =$	-29.10 [°]
	z =	23.40 [ft]		$\alpha_2 =$	77.75 [°]

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

**Slip surface parameters**

Radius : R = 34.79 [ft]

The slip surface after optimization.

Total weight of soil above the slip surface: 57528.6 lbf/ft

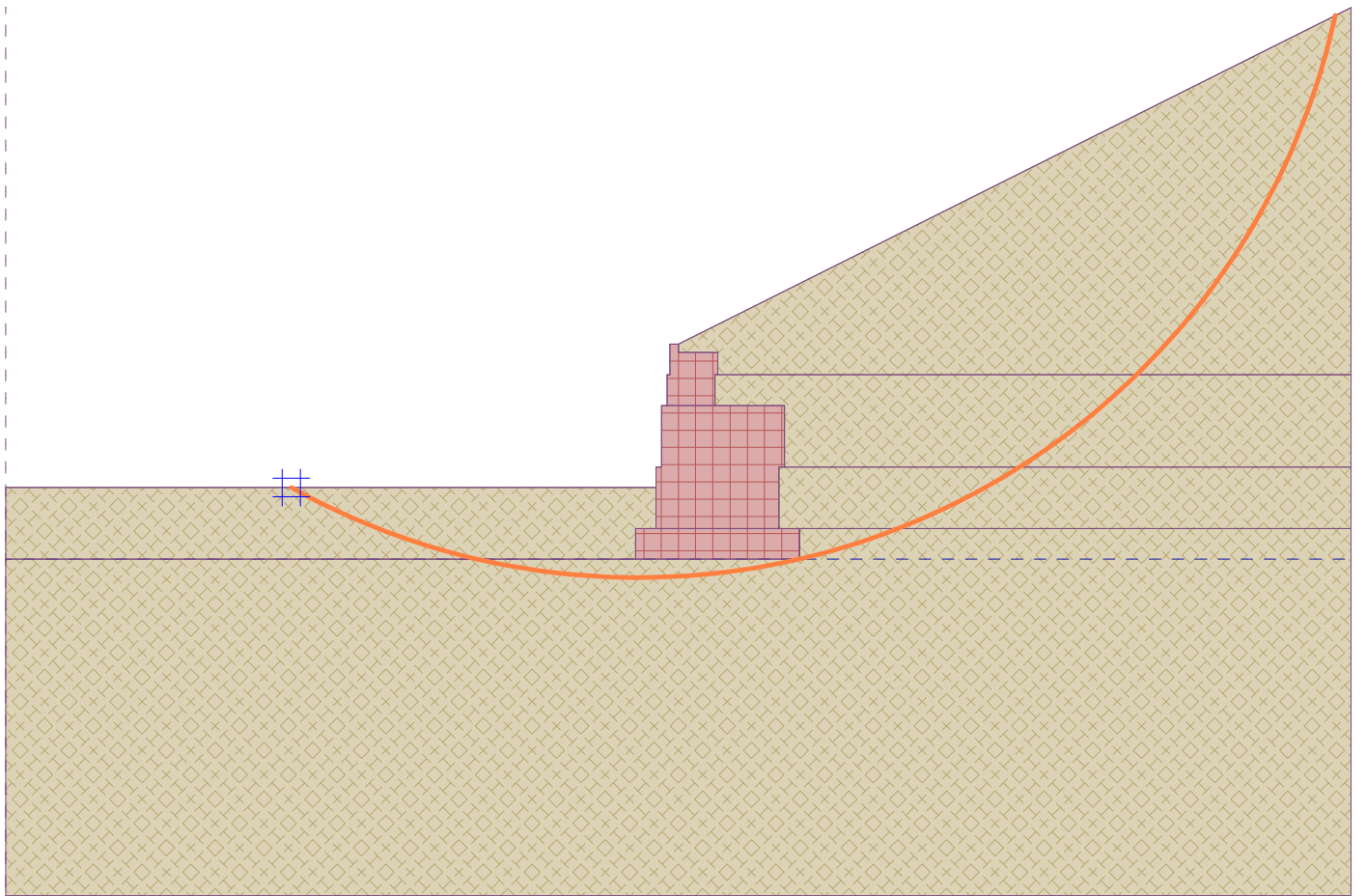
The restrictions of points of circular slip surface

Keep the left end point of the slip surface

Slope stability verification (Bishop)Sum of active forces : $F_a = 22020.4$ lbf/ftSum of passive forces : $F_p = 35785.5$ lbf/ftSliding moment : $M_a = 766088.5$ lbfft/ftResisting moment : $M_p = 1244978.3$ lbfft/ftFactor of safety = $1.63 \geq 1.50$ **Slope stability ACCEPTABLE**

Name : Analysis

Stage - analysis : 1 - 1



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio
January 15, 2026 ■ Project No. 25-1213



Design Calculations Section 6: 10.5' Total Height

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Analysis of Redi Rock wall

Input data

Project : COL-EL Riverfront Trail Phase 1
Part : Design 10.5' Section
Customer : EDG
Author : JAD
Date : 1/14/2026
Project number : 25-1213

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : AASHTO - Extensible (straight slip surface)
Reduction coeff. of contact first block - base : 0.80

Geometry

No. group	Description	Count	Setbacks [in]
1	Block R-9636 HC	1	0.27
2	Block R-5236 HC	1	0.27
3	Block 41	1	0.13
4	Block 28	1	0.13
5	Top block 28	1	-

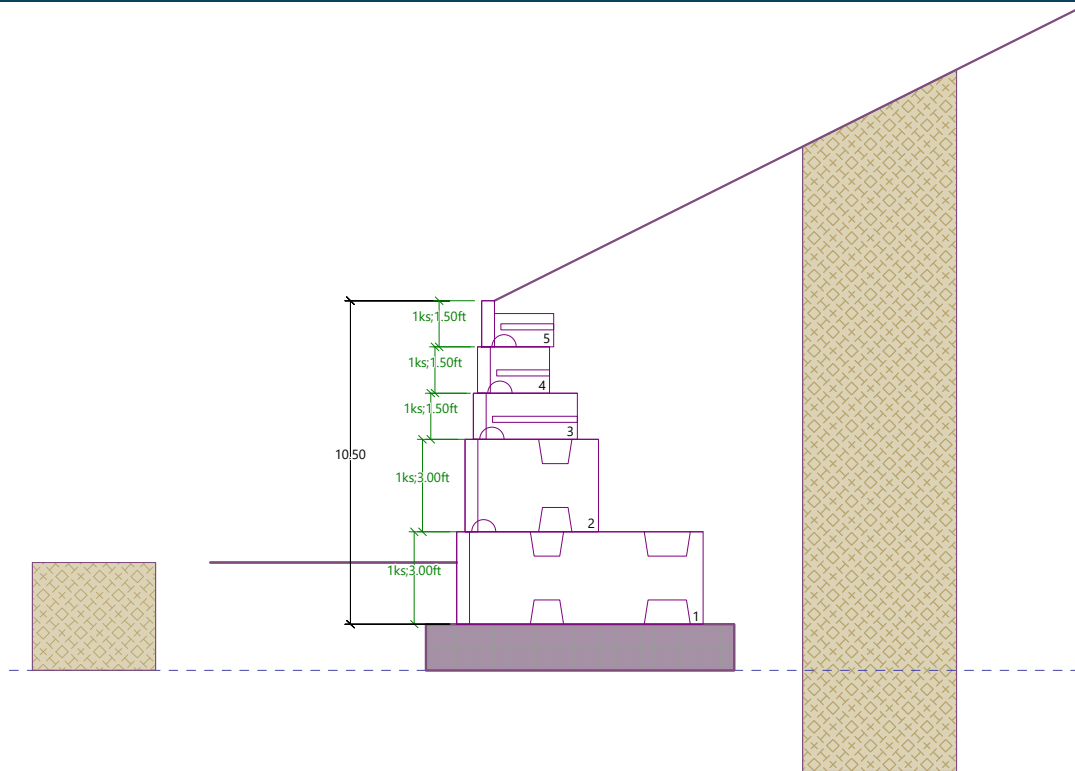
Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Geometry

Stage - analysis : 1 - 0



Base

Geometry

Upper setback $a_1 = 1.00$ ft

Lower setback $a_2 = 1.00$ ft

Height $h = 1.50$ ft

Width $b = 10.00$ ft

Material

6" Concrete over 12" Granular

Concrete self-weight $\gamma = 128.30$ pcf

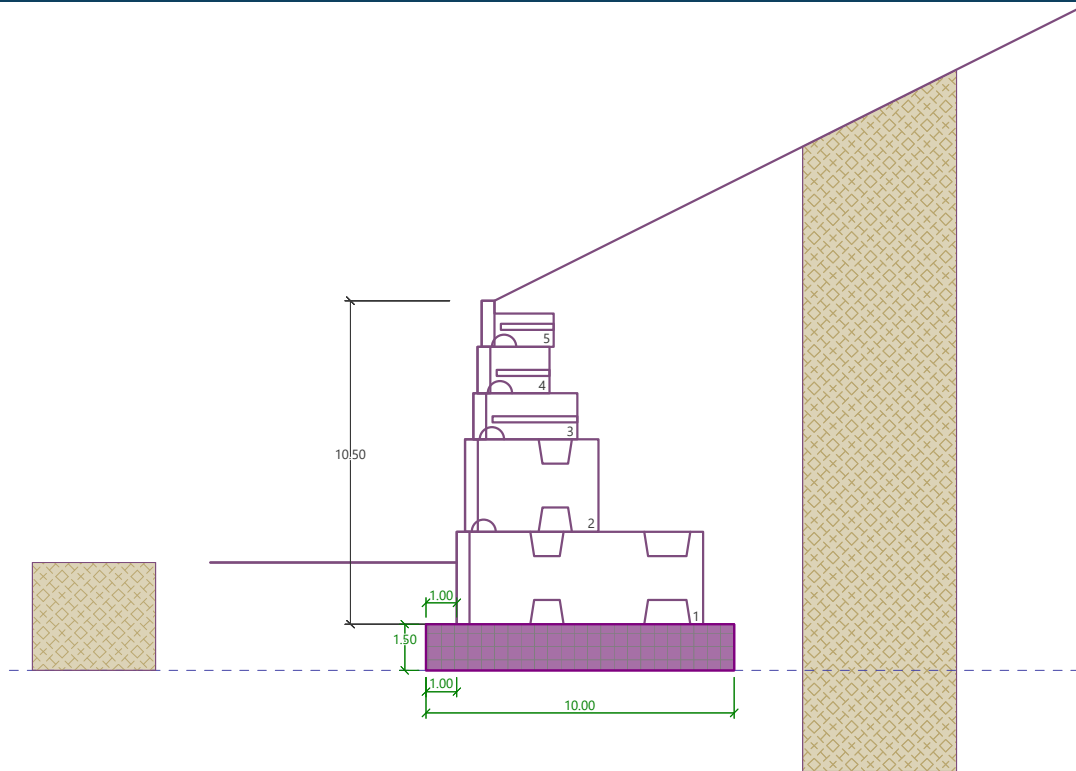
Shear cub (key) capacity = 0.00 lbf/ft

Friction angle concrete-concrete = 29.25 °

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Base**Stage - analysis : 1 - 0****Basic soil parameters**

Number	Name	Pattern	Φ_{ef} [°]	C_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Foundation & Retained Soil		32.00	0.0	128.00	76.50	24.00

All soils are considered as cohesionless for at rest pressure analysis.

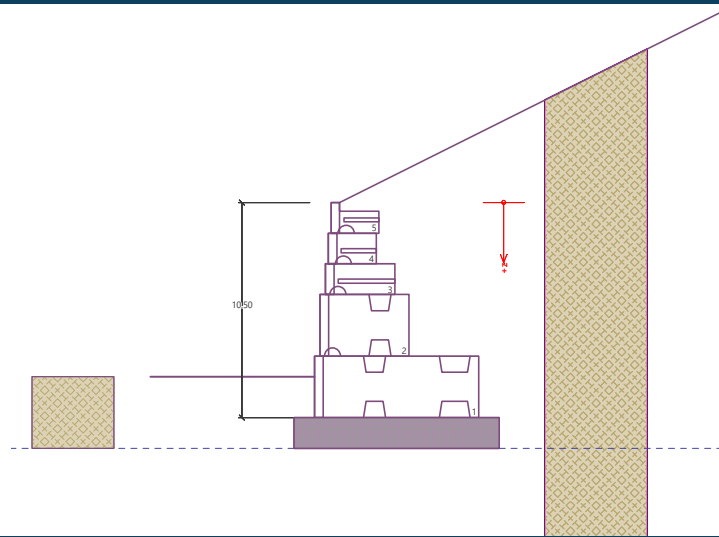
Geological profile and assigned soils

Number	Thickness of layer t [ft]	Depth z [ft]	Assigned soil	Pattern
1	-	0.00 .. ∞	Foundation & Retained Soil	

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Name : Profile and assignment**Stage - analysis : 1 - 0****Terrain profile**

Terrain behind construction has the slope 1: 2.00 (slope angle is 26.57 °).

Water influence

GWT behind the structure lies at a depth of 12.00 ft

GWT in front of the structure lies at a depth of 12.00 ft

Subgrade at the heel is not permeable.

Uplift in foot. bottom due to different pressures is not considered.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Foundation & Retained Soil

Soil thickness in front of structure $h = 3.50$ ft

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : Strength I

Reduction of soil/soil friction angle : reduce to $2/3 \phi$ (AASHTO)**Verification No. 1****Active pressure behind the structure - partial results**

Layer No.	Thickness [ft]	α [°]	ϕ_d [°]	c_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	12.00	26.03	32.00	0.0	128.00	24.00	1.047	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	12.00	1536.0	0.0	1536.0	986.8	1177.1

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Forces acting on construction

Name	F_{hor} [lb/ft]	App.Pt. z [ft]	F_{vert} [lb/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-4.22	7481.3	4.32	0.900	0.900	1.250
Active pressure	5920.7	-4.00	7062.6	8.05	1.500	1.500	1.500
Water pressure	0.0	-12.00	0.0	4.14	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 114366.4$ lbfft/ft

Overturning moment $M_{ovr} = 35524.2$ lbfft/ft

Capacity demand ratio CDR = 3.22

Wall for overturning is SATISFACTORY

Check for slip

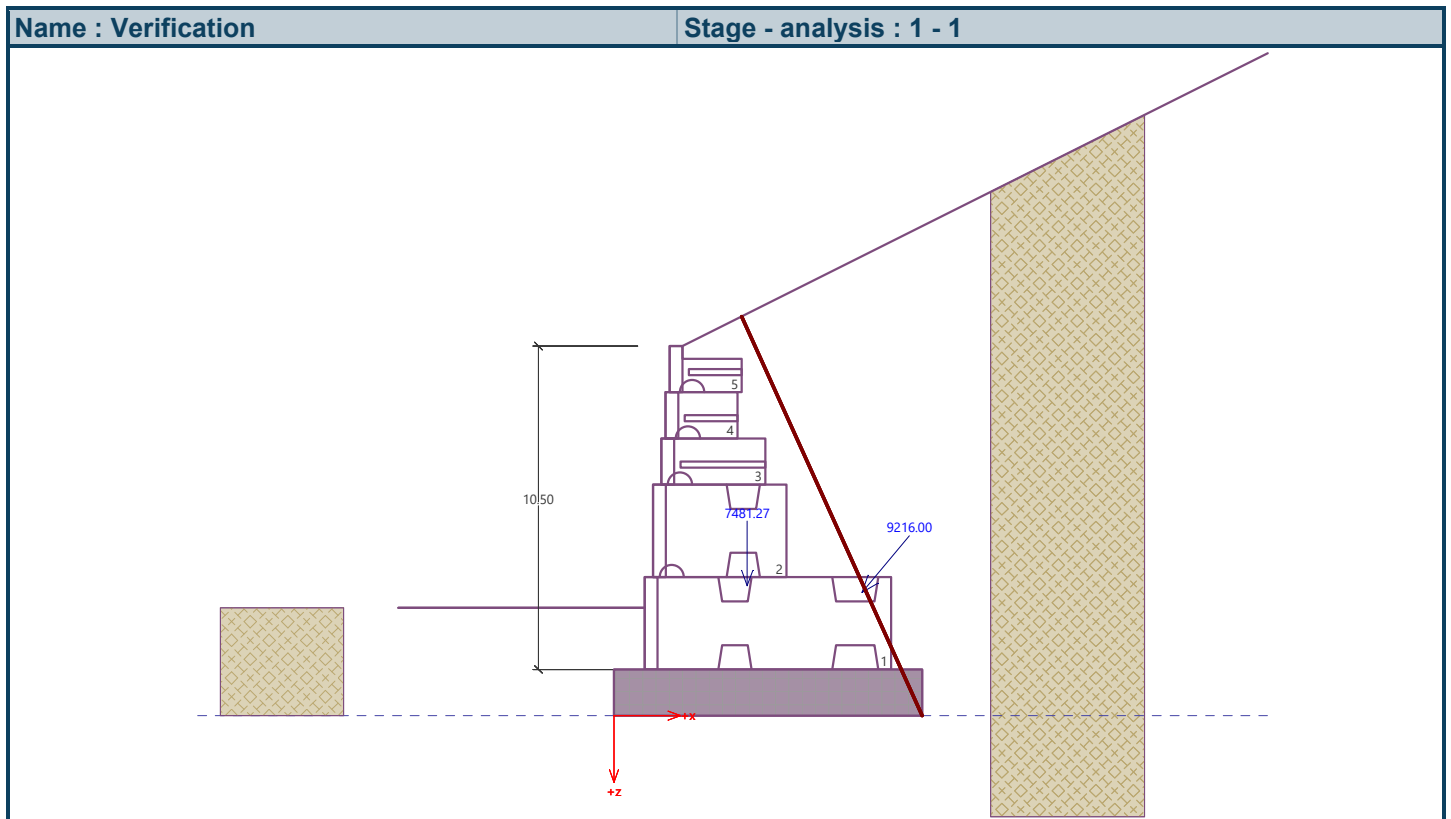
Resisting horizontal force $H_{res} = 10827.11$ lbf/ft

Active horizontal force $H_{act} = 8881.06$ lbf/ft

Capacity demand ratio CDR = 1.22

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Dimensioning No. 1

Active pressure behind the structure - partial results

Layer No.	Thickness [ft]	α [°]	Φ_d [°]	C_d [psf]	γ [pcf]	δ_d [°]	K_a	Comment
1	10.50	24.84	32.00	0.0	128.00	24.00	1.003	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	10.50	1344.0	0.0	1344.0	884.7	1011.8

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overturn.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-3.92	5556.8	3.09	0.900	0.900	1.250
Active pressure	4644.4	-3.50	5311.9	6.38	1.500	1.500	1.500
Water pressure	0.0	-10.50	0.0	3.14	1.000	1.000	1.000

Verification of most stressed block No. 1

Check for overturning stability

Resisting moment $M_{res} = 66294.5$ lbfft/ft

Overturning moment $M_{ovr} = 24383.2$ lbfft/ft

Capacity demand ratio CDR = 2.72

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 7262.97$ lbf/ft

Active horizontal force $H_{act} = 6966.63$ lbf/ft

Capacity demand ratio CDR = 1.04

Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	9560.7	19945.44	8881.06	0.048	2206.0
2	7792.8	17327.00	8881.06	0.045	1904.0

Service load acting at the center of footing bottom

Number	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	7215.7	14543.84	5920.70

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force $e = 0.048$

Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 4500.0$ psf

Partial factor on bearing capacity $\gamma_{Rv} = 0.55$

Max. stress at footing bottom $\sigma = 2206.0$ psf

Allowable bearing capacity of foundation soil $R_d = 2475.0$ psf

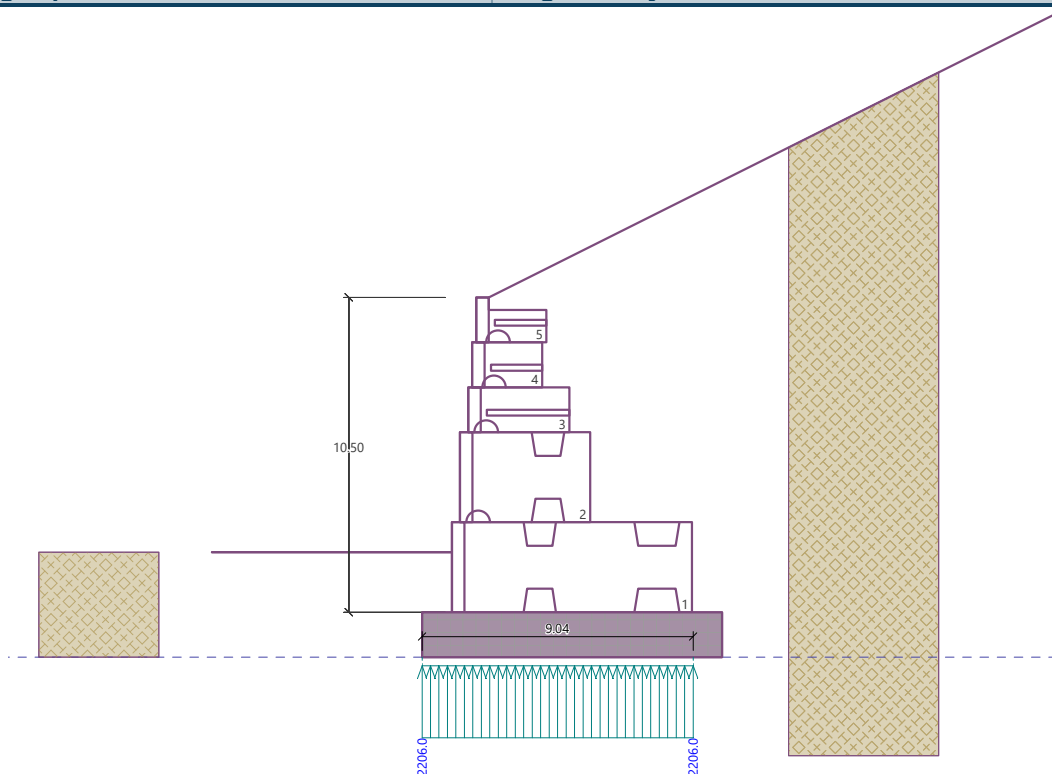
Capacity demand ratio $CDR = 1.1$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap.

Stage - analysis : 1 - -1



Slope stability analysis

Analysis 1

Circular slip surface

Calculation Package

COL-EL Riverfront Trail Ph. 1.1 ■ East Liverpool, Ohio

January 14, 2026 ■ Project No. 25-1213



Slip surface parameters					
Center :	x =	-1.77 [ft]	Angles :	α_1 =	-30.97 [°]
	z =	20.68 [ft]		α_2 =	82.04 [°]
Radius :	R =	34.03 [ft]			
The slip surface after optimization.					

Total weight of soil above the slip surface: 66077.1 lbf/ft

The restrictions of points of circular slip surface

Keep the left end point of the slip surface

Slope stability verification (Bishop)Sum of active forces : $F_a = 25478.0$ lbf/ftSum of passive forces : $F_p = 41095.2$ lbf/ftSliding moment : $M_a = 867017.5$ lbfft/ftResisting moment : $M_p = 1398468.5$ lbfft/ftFactor of safety = $1.61 \geq 1.50$ **Slope stability ACCEPTABLE**