

# JM Engineering

## Structural Design Calculations

of

## Gravity Segmental Block Retaining Wall

Kunz Residence  
Osoyoos, BC

For

## South Okanagan Concrete Products

11602 115<sup>th</sup> St.  
Osoyoos, BC V0H 1V5



# JM Engineering

## **SCOPE OF WORK**

Structural design of gravity retaining walls with respect to direct lateral soil loads and traffic loads and equipment dead loads. All methods of analysis are in accordance with NCMA. The following assumptions are to be verified prior to construction.

### **Design Loads**

Soil Type 1	Sand
Soil Friction Angle	28 degrees
Soil Weight	100 pcf
Soil Cohesion	0 pcf
Soil Type 2	Gravel
Soil Friction Angle	36 degrees
Soil Weight	130 pcf
Soil Cohesion	0 pcf
Soil Bearing Capacity	2,000 psf

### **Material**

Block Type	Redi-Rock (28"x46"x18") Redi-Rock (41"x46"x18")
Filter Fabric	US Fabrics US 80NW or equal
Drainpipe	4" ADS Single Wall Drainpipe with Sock

# JM Engineering

## **INSTRUCTIONS TO CLIENT/CONTRACTOR**

During the construction of the retaining wall the client or contractor is required to take photographs of the construction process and provide the photos to the design engineer. The following are items that should be shown in the photos:

1. Preparation of the base gravel
2. Installation of free draining backfill
3. Installation of filter fabric (geo-textile)
4. Placement and compaction of backfill

## Analysis of Redi Rock wall

### Input data

#### Project

Task : Kunz Residence  
 Description : 6.0 Foot Wall  
 Customer : South Okanagon Concrete  
 Date : 4/16/2021  
 Project number : 2021-801

#### Settings

Standard - safety factors

#### Wall analysis

Active earth pressure calculation : Coulomb  
 Passive earth pressure calculation : Caquot-Kerisel  
 Earthquake analysis : Mononobe-Okabe  
 Shape of earth wedge : Calculate as skew  
 Allowable eccentricity : 0.333  
 Internal stability : Standard - straight slip surface  
 Reduction coeff. of contact first block - base : 1.00  
 Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor for overturning :	$SF_o =$	1.50	[-]
Safety factor for sliding resistance :	$SF_s =$	1.50	[-]
Safety factor for bearing capacity :	$SF_b =$	1.50	[-]
Safety factor for sliding along geo-reinforcement :	$SF_{sr} =$	1.50	[-]
Safety factor for geo-reinforcement strength :	$SF_{st} =$	1.50	[-]
Safety factor for pull out resistance of geo-reinf. :	$SF_{po} =$	1.50	[-]
Safety factor for connection strength :	$SF_{con} =$	1.50	[-]

#### Blocks

No.	Description	Height h [in]	Width w [in]	Unit weight $\gamma$ [pcf]
1	Block 28	18.00	28.00	120.00
2	Block 41	18.00	40.50	120.00
3	Block 60	18.00	60.00	130.00
4	Top block 24 straight	18.00	24.00	108.00
5	Planter 41	18.00	40.50	120.00
6	Planter 60	18.00	60.00	112.00
7	Top block 28	18.00	28.00	120.00
8	Top block 41	18.00	40.50	120.00
9	Top block 24 straight garden	18.00	24.00	80.00
10	Block R-5236 HC	36.00	52.00	110.00
11	Block R-7236 HC	36.00	72.00	110.00
12	Block R-9636 HC	36.00	96.00	110.00
13	Block R-41 HC	18.00	40.50	110.00

No.	Description	Min. shear strength $F_{min}$ [lbf/ft]	Max. shear strength $F_{max}$ [lbf/ft]	Friction $f$ [°]
1	Block 28	6061.00	11276.00	44.00
2	Block 41	6061.00	11276.00	44.00
3	Block 60	6061.00	11276.00	44.00
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12	Block R-9636 HC	4550.00	12000.00	44.00
13	Block R-41 HC	5358.00	12906.00	37.00

**Setbacks**

No.	Setback s [in]
1	0.010
2	0.375
3	1.625
4	9.375
5	16.625


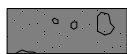
**Geometry**

No. group	Description	Count	Setback s [in]
1	Block 41	1	1.62
2	Block 41	2	1.62
3	Top block 28	1	-

**Base****Geometry**Upper setback  $a_1 = 1.00$  ftLower setback  $a_2 = 1.00$  ftHeight  $h = 1.00$  ftWidth  $b = 5.00$  ft**Material**

Soil creating foundation - Gravel

**Basic soil parameters**

No.	Name	Pattern	$\Phi_{ef}$ [°]	$C_{ef}$ [psf]	$\gamma$ [pcf]	$\gamma_{su}$ [pcf]	$\delta$ [°]
1	Sand		28.00	0.0	100.00	37.50	19.00
2	Gravel		36.00	0.0	130.00	72.50	24.00

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

### Soil parameters

#### Sand

Unit weight :  $\gamma = 100.0$  pcf  
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 28.00^\circ$   
 Cohesion of soil :  $c_{ef} = 0.0$  psf  
 Angle of friction struc.-soil :  $\delta = 19.00^\circ$   
 Saturated unit weight :  $\gamma_{sat} = 100.0$  pcf

#### Gravel

Unit weight :  $\gamma = 130.0$  pcf  
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 36.00^\circ$   
 Cohesion of soil :  $c_{ef} = 0.0$  psf  
 Angle of friction struc.-soil :  $\delta = 24.00^\circ$   
 Saturated unit weight :  $\gamma_{sat} = 135.0$  pcf

### Backfill




Backfill is not considered.

### Geological profile and assigned soils

#### Position information

Terrain elevation = 13.50 ft

#### Geological profile and assigned soils

No.	Thickness of layer t [ft]	Depth z [ft]	Altitude [ft]	Assigned soil	Pattern
1	6.00	0.00 .. 6.00	13.50 .. 7.50	Sand	
2	1.00	6.00 .. 7.00	7.50 .. 6.50	Gravel	
3	-	7.00 .. ∞	6.50 .. -	Sand	

### Terrain profile

Terrain behind the structure is flat.

### Water influence

Ground water table is located below the structure.

### Resistance on front face of the structure

Resistance on front face of the structure: at rest

Soil on front face of the structure - Sand

Soil thickness in front of structure  $h = 1.50$  ft

Terrain in front of structure is flat.

### Settings of the stage of construction

Design situation : permanent

**Verification No. 1****Forces acting on construction**

Name	F <sub>hor</sub> [lbf/ft]	App.Pt. z [ft]	F <sub>vert</sub> [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-2.96	2800.6	2.72	1.000
FF resistance	-59.7	-0.50	0.1	0.50	1.000
Weight - earth wedge	0.0	-1.32	29.5	4.60	1.000
Weight - earth wedge	0.0	-6.43	148.2	3.36	1.000
Active pressure	705.4	-2.44	537.9	4.67	1.000

**Verification of complete wall****Check for overturning stability**Resisting moment  $M_{res} = 10762.6$  lbfft/ftOverturning moment  $M_{ovr} = 1692.4$  lbfft/ft

Safety factor = 6.36 &gt; 1.50

**Wall for overturning is SATISFACTORY****Check for slip**Resisting horizontal force  $H_{res} = 2554.81$  lbf/ftActive horizontal force  $H_{act} = 645.75$  lbf/ft

Safety factor = 3.96 &gt; 1.50

**Wall for slip is SATISFACTORY****Overall check - WALL is SATISFACTORY****Dimensioning No. 1****Forces acting on construction**

Name	F <sub>hor</sub> [lbf/ft]	App.Pt. z [ft]	F <sub>vert</sub> [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-2.71	2150.6	1.78	1.000
Weight - earth wedge	0.0	-5.43	148.2	2.36	1.000
Active pressure	523.6	-2.05	202.1	3.44	1.000

**Verification of block No. 1****Check for overturning stability**Resisting moment  $M_{res} = 4883.0$  lbfft/ftOverturning moment  $M_{ovr} = 1072.5$  lbfft/ft

Safety factor = 4.55 &gt; 1.50

**Joint for overturning stability is SATISFACTORY****Check for slip**Resisting horizontal force  $H_{res} = 1817.00$  lbf/ftActive horizontal force  $H_{act} = 523.63$  lbf/ft

Safety factor = 3.47 &gt; 1.50

**Joint for verification is SATISFACTORY**

**Bearing capacity of foundation soil****Design load acting at the center of footing bottom**

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	-279.2	3516.39	645.75	0.000	703.3

**Service load acting at the center of footing bottom**

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-279.2	3516.39	645.75

**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**

Max. stress at footing bottom  $\sigma = 703.3$  psf

Bearing capacity of foundation soil  $R_d = 2000.0$  psf

Safety factor = 2.84 > 1.50

**Bearing capacity of foundation soil is SATISFACTORY**

**Overall verification - bearing capacity of found. soil is SATISFACTORY**

**Slope stability analysis****Input data****Project****Settings**

Standard - safety factors

**Stability analysis**

Earthquake analysis : Standard

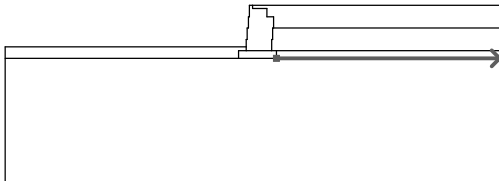
Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor :	$SF_s =$	1.50	[-]


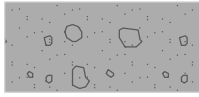


Interface


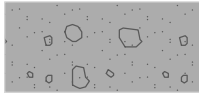
No.	Interface location	Coordinates of interface points [ft]					
		x	z	x	z	x	z
1		0.00	13.50	0.00	13.08	1.92	13.08
		1.92	12.00	2.82	12.00		
2		-32.80	8.00	-0.82	8.00	-0.82	9.00
		-0.69	9.00	-0.69	10.50	-0.55	10.50
		-0.55	12.00	-0.42	12.00	-0.42	13.50
		0.00	13.50	32.80	13.50		
3		-0.82	7.50	2.55	7.50	2.55	9.00
		2.69	9.00	2.69	10.50	2.82	10.50
		2.82	12.00				
4		2.82	10.50	32.80	10.50		
5		-32.80	6.50	-1.82	6.50	-1.82	7.50
		-0.82	7.50	-0.82	8.00		
6		2.55	7.50	3.18	7.50		
7		-1.82	6.50	3.18	6.50	3.18	7.50
		32.80	7.50				

No.	Interface location	Coordinates of interface points [ft]			
		x	z	x	z
8		3.18	6.50	32.80	6.50

## Soil parameters - effective stress state

No.	Name	Pattern	$\phi_{ef}$ [°]	$c_{ef}$ [psf]	$\gamma$ [pcf]
1	Sand		28.00	0.0	100.0
2	Gravel		36.00	0.0	130.0

## Soil parameters - uplift

No.	Name	Pattern	$\gamma_{sat}$ [pcf]	$\gamma_s$ [pcf]	n [-]
1	Sand		100.0		
2	Gravel		135.0		

## Soil parameters

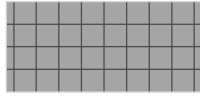
**Sand**

Unit weight :  $\gamma = 100.0$  pcf  
Stress-state : effective  
Angle of internal friction :  $\phi_{ef} = 28.00^\circ$   
Cohesion of soil :  $c_{ef} = 0.0$  psf  
Saturated unit weight :  $\gamma_{sat} = 100.0$  pcf

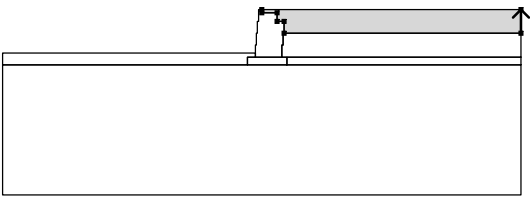

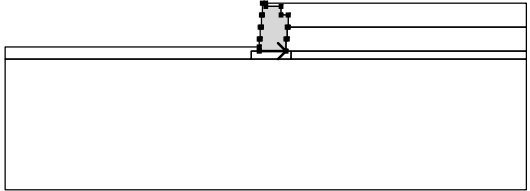
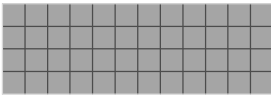
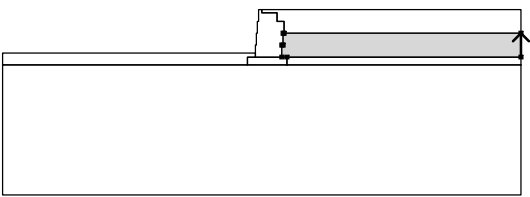

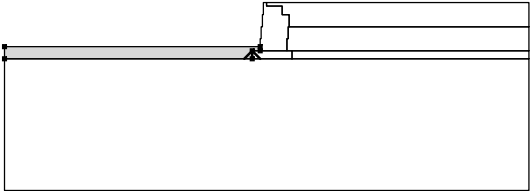

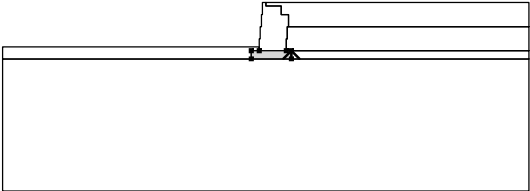
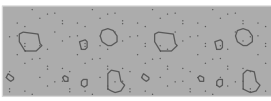
**Gravel**

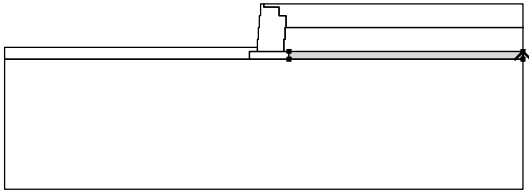
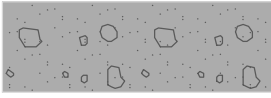
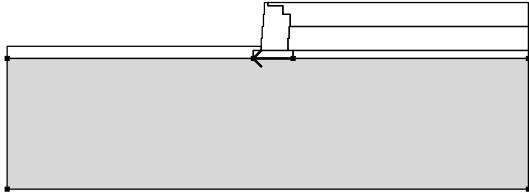

Unit weight :  $\gamma = 130.0$  pcf  
Stress-state : effective  
Angle of internal friction :  $\phi_{ef} = 36.00^\circ$   
Cohesion of soil :  $c_{ef} = 0.0$  psf  
Saturated unit weight :  $\gamma_{sat} = 135.0$  pcf

**Rigid Bodies**

No.	Name	Sample	$\gamma$ [pcf]
1	Material of structure		120.0

**Assigning and surfaces**

No.	Surface position	Coordinates of surface points [ft]				Assigned soil
		x	z	x	z	
1		32.80	10.50	32.80	13.50	Sand 
		0.00	13.50	0.00	13.08	
		1.92	13.08	1.92	12.00	
		2.82	12.00	2.82	10.50	
2		-0.82	7.50	2.55	7.50	Material of structure 
		2.55	9.00	2.69	9.00	
		2.69	10.50	2.82	10.50	
		2.82	12.00	1.92	12.00	
		1.92	13.08	0.00	13.08	
		0.00	13.50	-0.42	13.50	
		-0.42	12.00	-0.55	12.00	
		-0.55	10.50	-0.69	10.50	
		-0.69	9.00	-0.82	9.00	
-0.82	8.00					
3		32.80	7.50	32.80	10.50	Sand 
		2.82	10.50	2.69	10.50	
		2.69	9.00	2.55	9.00	
		2.55	7.50	3.18	7.50	
4		-1.82	6.50	-1.82	7.50	Sand 
		-0.82	7.50	-0.82	8.00	
		-32.80	8.00	-32.80	6.50	
5		3.18	6.50	3.18	7.50	Gravel 
		2.55	7.50	-0.82	7.50	
		-1.82	7.50	-1.82	6.50	

No.	Surface position	Coordinates of surface points [ft]				Assigned soil
		x	z	x	z	
6		32.80	6.50	32.80	7.50	Gravel 
		3.18	7.50	3.18	6.50	
7		3.18	6.50	-1.82	6.50	Sand 
		-32.80	6.50	-32.80	-9.90	
		32.80	-9.90	32.80	6.50	

**Water**

Water type : No water

**Tensile crack**

Tensile crack not input.

**Earthquake**

Earthquake not included.

**Settings of the stage of construction**

Design situation : permanent

**Results (Stage of construction 1)****Analysis 1****Circular slip surface**

Slip surface parameters						
Center :	x =	-2.37	[ft]	Angles :	$\alpha_1 =$	-41.99 [°]
	z =	14.11	[ft]		$\alpha_2 =$	85.74 [°]
Radius :	R =	8.22	[ft]			
The slip surface after optimization.						

**Slope stability verification (Bishop)**Sum of active forces :  $F_a = 1840.5$  lbf/ftSum of passive forces :  $F_p = 3032.6$  lbf/ftSliding moment :  $M_a = 15129.0$  lbfft/ftResisting moment :  $M_p = 24928.2$  lbfft/ft

Factor of safety = 1.65 &gt; 1.50

**Slope stability ACCEPTABLE**

## Analysis of Redi Rock wall

### Input data

#### Project

Task : Kunz Residence  
 Description : 7.5 Foot Wall  
 Customer : South Okanagon Concrete  
 Date : 4/16/2021  
 Project number : 2021-801

#### Settings

Standard - safety factors

#### Wall analysis

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Safety factor for geo-reinforcement strength :	$SF_{st} =$	1.50	[-]
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### Setbacks

No.	Setback s [in]
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### Geometry

No. group	Description	Count	Setback s [in]
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### Base


#### Geometry

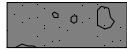
Upper setback  $a_1 = 1.00$  ftLower setback  $a_2 = 1.00$  ftHeight  $h = 1.00$  ftWidth  $b = 5.00$  ft

#### Material

Soil creating foundation - Gravel

#### Basic soil parameters

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2	Gravel		36.00	0.0	130.00	72.50	24.00

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

#### Soil parameters

##### Sand

Unit weight :  $\gamma = 100.0$  pcf  
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 28.00^\circ$   
 Cohesion of soil :  $C_{ef} = 0.0$  psf  
 Angle of friction struc.-soil :  $\delta = 19.00^\circ$   
 Saturated unit weight :  $\gamma_{sat} = 100.0$  pcf

##### Gravel

Unit weight :  $\gamma = 130.0$  pcf  
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 36.00^\circ$   
 Cohesion of soil :  $C_{ef} = 0.0$  psf  
 Angle of friction struc.-soil :  $\delta = 24.00^\circ$   
 Saturated unit weight :  $\gamma_{sat} = 135.0$  pcf

#### Backfill




Backfill is not considered.

#### Geological profile and assigned soils

##### Position information

Terrain elevation = 13.50 ft

##### Geological profile and assigned soils

No.	Thickness of layer t [ft]	Depth z [ft]	Altitude [ft]	Assigned soil	Pattern
1	7.50	0.00 .. 7.50	13.50 .. 6.00	Sand	
2	1.00	7.50 .. 8.50	6.00 .. 5.00	Gravel	
3	-	8.50 .. $\infty$	5.00 .. -	Sand	

#### Terrain profile

Terrain behind the structure is flat.

#### Water influence

Ground water table is located below the structure.

#### Resistance on front face of the structure

Resistance on front face of the structure: at rest

Soil on front face of the structure - Sand

Soil thickness in front of structure  $h = 1.75$  ft

Terrain in front of structure is flat.

**Settings of the stage of construction**

Design situation : permanent

**Verification No. 1****Forces acting on construction**

Name	F <sub>hor</sub> [lbf/ft]	App.Pt. z [ft]	F <sub>vert</sub> [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-3.69	3408.1	2.80	1.000
FF resistance	-81.2	-0.58	0.1	0.50	1.000
Weight - earth wedge	0.0	-1.31	29.2	4.60	1.000
Weight - earth wedge	0.0	-7.93	148.2	3.50	1.000
Active pressure	1033.0	-2.92	697.3	4.70	1.000

**Verification of complete wall****Check for overturning stability**Resisting moment  $M_{res} = 13467.0$  lbfft/ftOverturning moment  $M_{ovr} = 2972.5$  lbfft/ft

Safety factor = 4.53 &gt; 1.50

**Wall for overturning is SATISFACTORY****Check for slip**Resisting horizontal force  $H_{res} = 3111.74$  lbf/ftActive horizontal force  $H_{act} = 951.82$  lbf/ft

Safety factor = 3.27 &gt; 1.50

**Wall for slip is SATISFACTORY****Overall check - WALL is SATISFACTORY****Dimensioning No. 1****Forces acting on construction**

Name	F <sub>hor</sub> [lbf/ft]	App.Pt. z [ft]	F <sub>vert</sub> [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-3.45	2758.1	1.87	1.000
Weight - earth wedge	0.0	-6.93	148.2	2.50	1.000
Active pressure	807.5	-2.54	274.9	3.52	1.000

**Verification of block No. 1****Check for overturning stability**Resisting moment  $M_{res} = 6492.7$  lbfft/ftOverturning moment  $M_{ovr} = 2053.4$  lbfft/ft

Safety factor = 3.16 &gt; 1.50

**Joint for overturning stability is SATISFACTORY****Check for slip**Resisting horizontal force  $H_{res} = 2311.31$  lbf/ftActive horizontal force  $H_{act} = 807.52$  lbf/ft



Safety factor = 2.86 > 1.50

Joint for verification is **SATISFACTORY**

### Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	212.9	4282.95	951.82	0.010	874.0

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	212.9	4282.95	951.82

### Verification of foundation soil

Stress in the footing bottom : rectangle

#### Eccentricity verification

Max. eccentricity of normal force  $e = 0.010$

Maximum allowable eccentricity  $e_{alw} = 0.333$

Eccentricity of the normal force is **SATISFACTORY**

#### Verification of bearing capacity

Max. stress at footing bottom  $\sigma = 874.0$  psf

Bearing capacity of foundation soil  $R_d = 2000.0$  psf

Safety factor = 2.29 > 1.50

Bearing capacity of foundation soil is **SATISFACTORY**

Overall verification - bearing capacity of found. soil is **SATISFACTORY**

### Slope stability analysis

#### Input data

##### Project

##### Settings

Standard - safety factors

##### Stability analysis

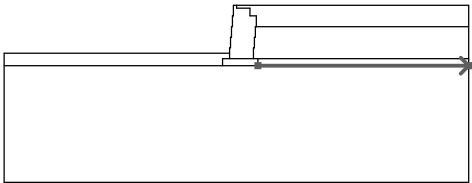
Earthquake analysis : Standard

Verification methodology : Safety factors (ASD)


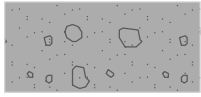
Safety factors			
Permanent design situation			
Safety factor :	$SF_s =$	1.50	[-]

Interface


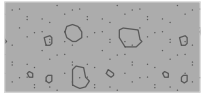
No.	Interface location	Coordinates of interface points [ft]					
		x	z	x	z	x	z
1		0.00	13.50	0.00	13.08	1.92	13.08
		1.92	12.00	2.82	12.00		
2		-32.80	6.75	-0.96	6.75	-0.96	7.50
		-0.82	7.50	-0.82	9.00	-0.69	9.00
		-0.69	10.50	-0.55	10.50	-0.55	12.00
		-0.42	12.00	-0.42	13.50	0.00	13.50
		32.80	13.50				
3		-0.96	6.00	2.42	6.00	2.42	7.50
		2.55	7.50	2.55	9.00	2.69	9.00
		2.69	10.50	2.82	10.50	2.82	12.00
4		2.82	10.50	32.80	10.50		
5		-32.80	5.00	-1.96	5.00	-1.96	6.00
		-0.96	6.00	-0.96	6.75		
6		2.42	6.00	3.04	6.00		
7		-1.96	5.00	3.04	5.00	3.04	6.00
		32.80	6.00				

No.	Interface location	Coordinates of interface points [ft]			
		x	z	x	z
8		3.04	5.00	32.80	5.00

## Soil parameters - effective stress state

No.	Name	Pattern	$\phi_{ef}$ [°]	$c_{ef}$ [psf]	$\gamma$ [pcf]
1	Sand		28.00	0.0	100.0
2	Gravel		36.00	0.0	130.0

## Soil parameters - uplift

No.	Name	Pattern	$\gamma_{sat}$ [pcf]	$\gamma_s$ [pcf]	n [-]
1	Sand		100.0		
2	Gravel		135.0		

## Soil parameters

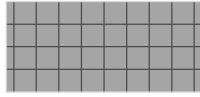
**Sand**

Unit weight :  $\gamma = 100.0$  pcf  
Stress-state : effective  
Angle of internal friction :  $\phi_{ef} = 28.00^\circ$   
Cohesion of soil :  $c_{ef} = 0.0$  psf  
Saturated unit weight :  $\gamma_{sat} = 100.0$  pcf

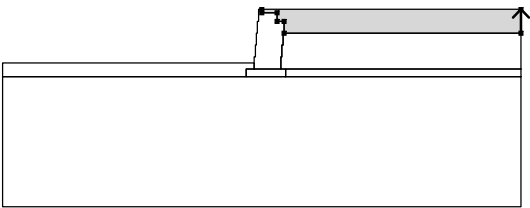

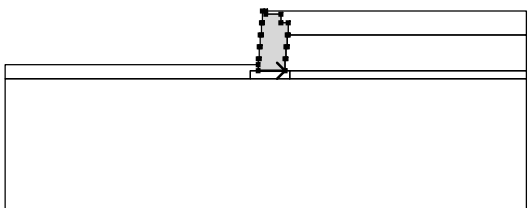
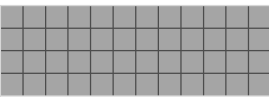
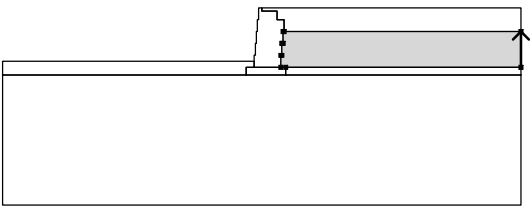

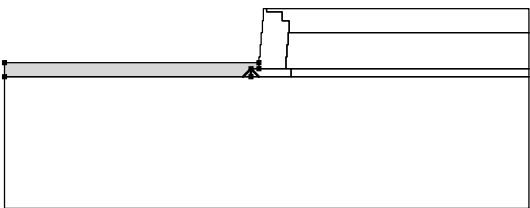

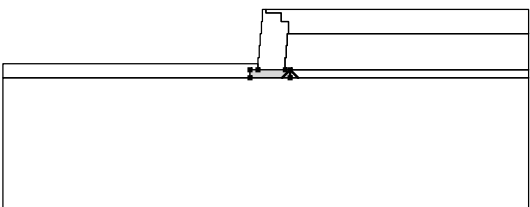
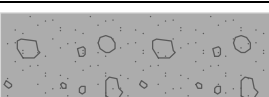
**Gravel**

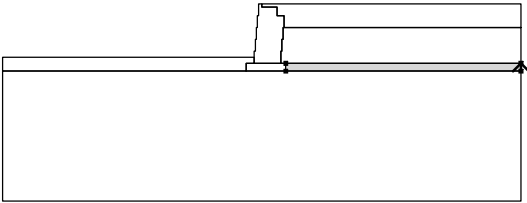
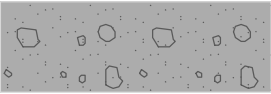
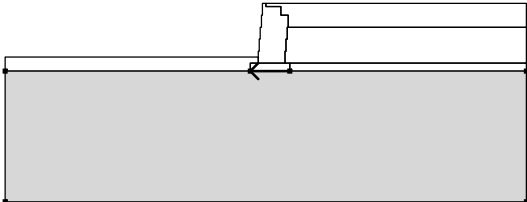

Unit weight :  $\gamma = 130.0$  pcf  
Stress-state : effective  
Angle of internal friction :  $\phi_{ef} = 36.00^\circ$   
Cohesion of soil :  $c_{ef} = 0.0$  psf  
Saturated unit weight :  $\gamma_{sat} = 135.0$  pcf

**Rigid Bodies**

No.	Name	Sample	$\gamma$ [pcf]
1	Material of structure		120.0

**Assigning and surfaces**

No.	Surface position	Coordinates of surface points [ft]				Assigned soil
		x	z	x	z	
1		32.80	10.50	32.80	13.50	Sand 
		0.00	13.50	0.00	13.08	
		1.92	13.08	1.92	12.00	
		2.82	12.00	2.82	10.50	
2		-0.96	6.00	2.42	6.00	Material of structure 
		2.42	7.50	2.55	7.50	
		2.55	9.00	2.69	9.00	
		2.69	10.50	2.82	10.50	
		2.82	12.00	1.92	12.00	
		1.92	13.08	0.00	13.08	
		0.00	13.50	-0.42	13.50	
		-0.42	12.00	-0.55	12.00	
		-0.55	10.50	-0.69	10.50	
		-0.69	9.00	-0.82	9.00	
-0.82	7.50	-0.96	7.50			
-0.96	6.75					
3		32.80	6.00	32.80	10.50	Sand 
		2.82	10.50	2.69	10.50	
		2.69	9.00	2.55	9.00	
		2.55	7.50	2.42	7.50	
2.42	6.00	3.04	6.00			
4		-1.96	5.00	-1.96	6.00	Sand 
		-0.96	6.00	-0.96	6.75	
		-32.80	6.75	-32.80	5.00	
5		3.04	5.00	3.04	6.00	Gravel 
		2.42	6.00	-0.96	6.00	
		-1.96	6.00	-1.96	5.00	

No.	Surface position	Coordinates of surface points [ft]				Assigned soil
		x	z	x	z	
6		32.80	5.00	32.80	6.00	Gravel 
		3.04	6.00	3.04	5.00	
7		3.04	5.00	-1.96	5.00	Sand 
		-32.80	5.00	-32.80	-11.40	
		32.80	-11.40	32.80	5.00	

**Water**

Water type : No water

**Tensile crack**

Tensile crack not input.

**Earthquake**

Earthquake not included.

**Settings of the stage of construction**

Design situation : permanent

**Results (Stage of construction 1)****Analysis 1****Circular slip surface**

Slip surface parameters							
Center :	x =	-2.70	[ft]	Angles :	$\alpha_1 =$	-40.25	[°]
	z =	13.97	[ft]		$\alpha_2 =$	87.15	[°]
Radius :	R =	9.46	[ft]				
The slip surface after optimization.							

**Slope stability verification (Bishop)**Sum of active forces :  $F_a = 2542.2$  lbf/ftSum of passive forces :  $F_p = 3992.8$  lbf/ftSliding moment :  $M_a = 24049.6$  lbfft/ftResisting moment :  $M_p = 37772.1$  lbfft/ft

Factor of safety = 1.57 &gt; 1.50

**Slope stability ACCEPTABLE**

## Analysis of Redi Rock wall

### Input data

#### Project

Task : Kunz Residence  
 Description : 9.0 Foot Wall  
 Customer : South Okanagon Concrete  
 Date : 4/16/2021  
 Project number : 2021-801

#### Settings

Standard - safety factors

#### Wall analysis

Active earth pressure calculation : Coulomb  
 Passive earth pressure calculation : Caquot-Kerisel  
 Earthquake analysis : Mononobe-Okabe  
 Shape of earth wedge : Calculate as skew  
 Allowable eccentricity : 0.333  
 Internal stability : Standard - straight slip surface  
 Reduction coeff. of contact first block - base : 1.00  
 Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor for overturning :	$SF_o =$	1.50	[-]
Safety factor for sliding resistance :	$SF_s =$	1.50	[-]
Safety factor for bearing capacity :	$SF_b =$	1.50	[-]
Safety factor for sliding along geo-reinforcement :	$SF_{sr} =$	1.50	[-]
Safety factor for geo-reinforcement strength :	$SF_{st} =$	1.50	[-]
Safety factor for pull out resistance of geo-reinf. :	$SF_{po} =$	1.50	[-]
Safety factor for connection strength :	$SF_{con} =$	1.50	[-]

#### Blocks

No.	Description	Height h [in]	Width w [in]	Unit weight $\gamma$ [pcf]
1	Block 28	18.00	28.00	120.00
2	Block 41	18.00	40.50	120.00
3	Block 60	18.00	60.00	130.00
4	Top block 24 straight	18.00	24.00	108.00
5	Planter 41	18.00	40.50	120.00
6	Planter 60	18.00	60.00	112.00
7	Top block 28	18.00	28.00	120.00
8	Top block 41	18.00	40.50	120.00
9	Top block 24 straight garden	18.00	24.00	80.00
10	Block R-5236 HC	36.00	52.00	110.00
11	Block R-7236 HC	36.00	72.00	110.00
12	Block R-9636 HC	36.00	96.00	110.00
13	Block R-41 HC	18.00	40.50	110.00

No.	Description	Min. shear strength $F_{min}$ [lbf/ft]	Max. shear strength $F_{max}$ [lbf/ft]	Friction $f$ [°]
1	Block 28	6061.00	11276.00	44.00
2	Block 41	6061.00	11276.00	44.00
3	Block 60	6061.00	11276.00	44.00
4	Top block 24 straight	6061.00	11276.00	44.00
5	Planter 41	6061.00	11276.00	44.00
6	Planter 60	6061.00	11276.00	44.00
7	Top block 28	6061.00	11276.00	44.00
8	Top block 41	6061.00	11276.00	44.00
9	Top block 24 straight garden	6061.00	11276.00	44.00
10	Block R-5236 HC	4550.00	12000.00	44.00
11	Block R-7236 HC	4550.00	12000.00	44.00
12	Block R-9636 HC	4550.00	12000.00	44.00
13	Block R-41 HC	5358.00	12906.00	37.00

**Setbacks**

No.	Setback s [in]
1	0.010
2	0.375
3	1.625
4	9.375
5	16.625


**Geometry**

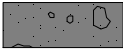
No. group	Description	Count	Setback s [in]
1	Block 41	1	1.62
2	Block 41	1	1.62
3	Block 41	1	1.62
4	Block 41	2	1.62
5	Top block 28	1	-

**Base****Geometry**Upper setback  $a_1 = 1.00$  ftLower setback  $a_2 = 1.00$  ftHeight  $h = 1.00$  ftWidth  $b = 5.00$  ft**Material**

Soil creating foundation - Gravel

**Basic soil parameters**

No.	Name	Pattern	$\Phi_{ef}$ [°]	$C_{ef}$ [psf]	$\gamma$ [pcf]	$\gamma_{su}$ [pcf]	$\delta$ [°]
1	Sand		28.00	0.0	100.00	37.50	19.00

No.	Name	Pattern	$\varphi_{ef}$ [°]	$C_{ef}$ [psf]	$\gamma$ [pcf]	$\gamma_{su}$ [pcf]	$\delta$ [°]
2	Gravel		36.00	0.0	130.00	72.50	24.00

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

### Soil parameters

#### Sand

Unit weight :  $\gamma = 100.0$  pcf  
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 28.00^\circ$   
 Cohesion of soil :  $C_{ef} = 0.0$  psf  
 Angle of friction struc.-soil :  $\delta = 19.00^\circ$   
 Saturated unit weight :  $\gamma_{sat} = 100.0$  pcf

#### Gravel

Unit weight :  $\gamma = 130.0$  pcf  
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 36.00^\circ$   
 Cohesion of soil :  $C_{ef} = 0.0$  psf  
 Angle of friction struc.-soil :  $\delta = 24.00^\circ$   
 Saturated unit weight :  $\gamma_{sat} = 135.0$  pcf

### Backfill

Backfill is not considered.

### Geological profile and assigned soils

#### Position information

Terrain elevation = 13.50 ft

### Geological profile and assigned soils

No.	Thickness of layer t [ft]	Depth z [ft]	Altitude [ft]	Assigned soil	Pattern
1	9.00	0.00 .. 9.00	13.50 .. 4.50	Sand	
2	1.00	9.00 .. 10.00	4.50 .. 3.50	Gravel	
3	-	10.00 .. $\infty$	3.50 .. -	Sand	

### Terrain profile

Terrain behind the structure is flat.

### Water influence

Ground water table is located below the structure.

### Resistance on front face of the structure

Resistance on front face of the structure: at rest

Soil on front face of the structure - Sand

Soil thickness in front of structure  $h = 2.00$  ft

Terrain in front of structure is flat.



**Settings of the stage of construction**

Design situation : permanent

**Verification No. 1****Forces acting on construction**

Name	F <sub>hor</sub> [lbf/ft]	App.Pt. z [ft]	F <sub>vert</sub> [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-4.43	4015.6	2.87	1.000
FF resistance	-106.0	-0.67	0.1	0.50	1.000
Weight - earth wedge	0.0	-1.31	29.0	4.61	1.000
Weight - earth wedge	0.0	-9.43	148.2	3.63	1.000
Active pressure	1423.0	-3.41	872.1	4.72	1.000

**Verification of complete wall****Check for overturning stability**Resisting moment  $M_{res} = 16331.8$  lbfft/ftOverturning moment  $M_{ovr} = 4780.2$  lbfft/ft

Safety factor = 3.42 &gt; 1.50

**Wall for overturning is SATISFACTORY****Check for slip**Resisting horizontal force  $H_{res} = 3679.99$  lbf/ftActive horizontal force  $H_{act} = 1316.91$  lbf/ft

Safety factor = 2.79 &gt; 1.50

**Wall for slip is SATISFACTORY****Overall check - WALL is SATISFACTORY****Dimensioning No. 1****Forces acting on construction**

Name	F <sub>hor</sub> [lbf/ft]	App.Pt. z [ft]	F <sub>vert</sub> [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-4.19	3365.6	1.95	1.000
Weight - earth wedge	0.0	-8.43	148.2	2.63	1.000
Active pressure	1153.8	-3.04	363.2	3.59	1.000

**Verification of block No. 1****Check for overturning stability**Resisting moment  $M_{res} = 8246.6$  lbfft/ftOverturning moment  $M_{ovr} = 3505.5$  lbfft/ft

Safety factor = 2.35 &gt; 1.50

**Joint for overturning stability is SATISFACTORY****Check for slip**Resisting horizontal force  $H_{res} = 2816.80$  lbf/ftActive horizontal force  $H_{act} = 1153.82$  lbf/ft

Safety factor = 2.44 > 1.50

Joint for verification is **SATISFACTORY**

### Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [-]	Stress [psf]
1	1111.1	5065.07	1316.91	0.044	1110.5

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	1111.1	5065.07	1316.91

### Verification of foundation soil

Stress in the footing bottom : rectangle

#### Eccentricity verification

Max. eccentricity of normal force  $e = 0.044$

Maximum allowable eccentricity  $e_{alw} = 0.333$

Eccentricity of the normal force is **SATISFACTORY**

#### Verification of bearing capacity

Max. stress at footing bottom  $\sigma = 1110.5$  psf

Bearing capacity of foundation soil  $R_d = 2000.0$  psf

Safety factor = 1.80 > 1.50

Bearing capacity of foundation soil is **SATISFACTORY**

Overall verification - bearing capacity of found. soil is **SATISFACTORY**

### Slope stability analysis

#### Input data

##### Project

##### Settings

Standard - safety factors

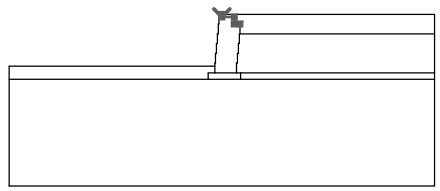
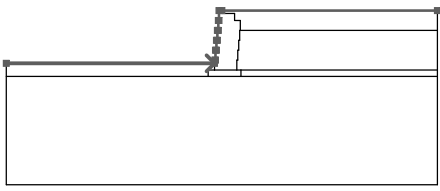
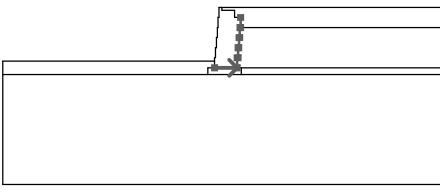
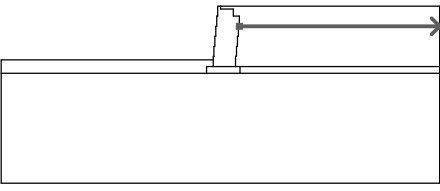
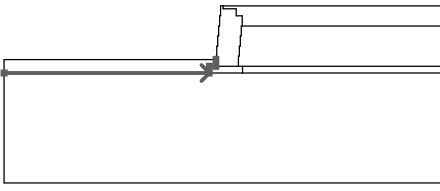
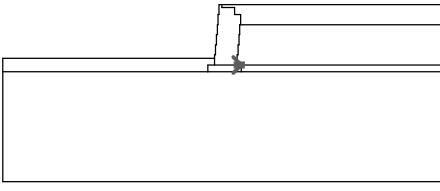
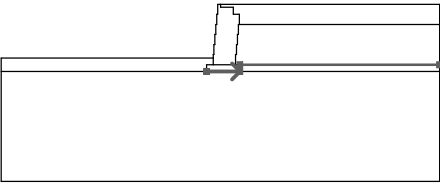
##### Stability analysis

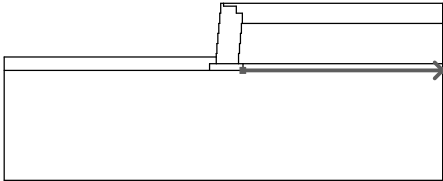
Earthquake analysis : Standard

Verification methodology : Safety factors (ASD)


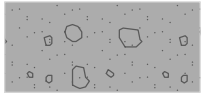
Safety factors			
Permanent design situation			
Safety factor :	$SF_s =$	1.50	[-]

Interface


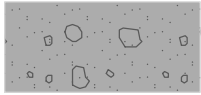
No.	Interface location	Coordinates of interface points [ft]					
		x	z	x	z	x	z
1		0.00	13.50	0.00	13.08	1.92	13.08
		1.92	12.00	2.82	12.00		
2		-32.80	5.50	-1.09	5.50	-1.09	6.00
		-0.96	6.00	-0.96	7.50	-0.82	7.50
		-0.82	9.00	-0.69	9.00	-0.69	10.50
		-0.55	10.50	-0.55	12.00	-0.42	12.00
		-0.42	13.50	0.00	13.50	32.80	13.50
3		-1.09	4.50	2.28	4.50	2.28	6.00
		2.42	6.00	2.42	7.50	2.55	7.50
		2.55	9.00	2.69	9.00	2.69	10.50
		2.82	10.50	2.82	12.00		
4		2.82	10.50	32.80	10.50		
5		-32.80	3.50	-2.09	3.50	-2.09	4.50
		-1.09	4.50	-1.09	5.50		
6		2.28	4.50	2.91	4.50		
7		-2.09	3.50	2.91	3.50	2.91	4.50
		32.80	4.50				

No.	Interface location	Coordinates of interface points [ft]			
		x	z	x	z
8		2.91	3.50	32.80	3.50

## Soil parameters - effective stress state

No.	Name	Pattern	$\phi_{ef}$ [°]	$c_{ef}$ [psf]	$\gamma$ [pcf]
1	Sand		28.00	0.0	100.0
2	Gravel		36.00	0.0	130.0

## Soil parameters - uplift

No.	Name	Pattern	$\gamma_{sat}$ [pcf]	$\gamma_s$ [pcf]	n [-]
1	Sand		100.0		
2	Gravel		135.0		

## Soil parameters

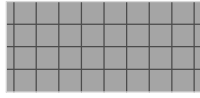
**Sand**

Unit weight :  $\gamma = 100.0$  pcf  
Stress-state : effective  
Angle of internal friction :  $\phi_{ef} = 28.00^\circ$   
Cohesion of soil :  $c_{ef} = 0.0$  psf  
Saturated unit weight :  $\gamma_{sat} = 100.0$  pcf

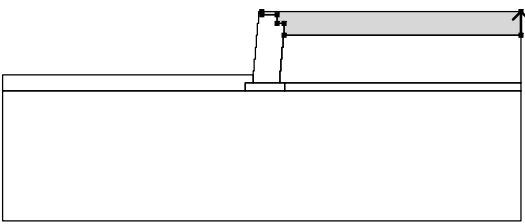

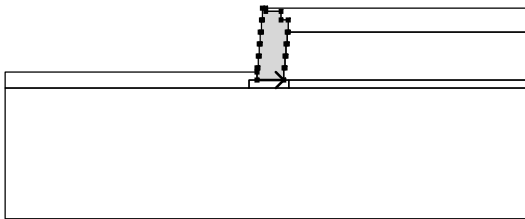
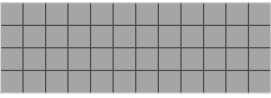
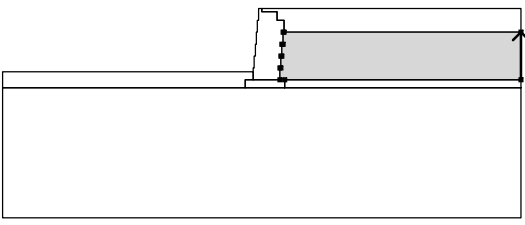

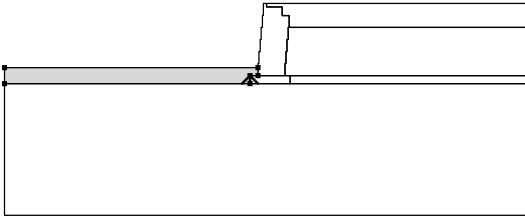

**Gravel**

Unit weight :  $\gamma = 130.0$  pcf  
Stress-state : effective  
Angle of internal friction :  $\phi_{ef} = 36.00^\circ$   
Cohesion of soil :  $c_{ef} = 0.0$  psf  
Saturated unit weight :  $\gamma_{sat} = 135.0$  pcf

**Rigid Bodies**

No.	Name	Sample	$\gamma$ [pcf]
1	Material of structure		120.0

**Assigning and surfaces**

No.	Surface position	Coordinates of surface points [ft]				Assigned soil
		x	z	x	z	
1		32.80	10.50	32.80	13.50	Sand 
		0.00	13.50	0.00	13.08	
		1.92	13.08	1.92	12.00	
		2.82	12.00	2.82	10.50	
2		-1.09	4.50	2.28	4.50	Material of structure 
		2.28	6.00	2.42	6.00	
		2.42	7.50	2.55	7.50	
		2.55	9.00	2.69	9.00	
		2.69	10.50	2.82	10.50	
		2.82	12.00	1.92	12.00	
		1.92	13.08	0.00	13.08	
		0.00	13.50	-0.42	13.50	
		-0.42	12.00	-0.55	12.00	
		-0.55	10.50	-0.69	10.50	
		-0.69	9.00	-0.82	9.00	
		-0.82	7.50	-0.96	7.50	
		-0.96	6.00	-1.09	6.00	
-1.09	5.50					
3		32.80	4.50	32.80	10.50	Sand 
		2.82	10.50	2.69	10.50	
		2.69	9.00	2.55	9.00	
		2.55	7.50	2.42	7.50	
		2.42	6.00	2.28	6.00	
		2.28	4.50	2.91	4.50	
4		-2.09	3.50	-2.09	4.50	Sand 
		-1.09	4.50	-1.09	5.50	
		-32.80	5.50	-32.80	3.50	

No.	Surface position	Coordinates of surface points [ft]				Assigned soil
		x	z	x	z	
5		2.91	3.50	2.91	4.50	Gravel 
		2.28	4.50	-1.09	4.50	
		-2.09	4.50	-2.09	3.50	
6		32.80	3.50	32.80	4.50	Gravel 
		2.91	4.50	2.91	3.50	
7		2.91	3.50	-2.09	3.50	Sand 
		-32.80	3.50	-32.80	-12.90	
		32.80	-12.90	32.80	3.50	

**Water**

Water type : No water

**Tensile crack**

Tensile crack not input.

**Earthquake**

Earthquake not included.

**Settings of the stage of construction**

Design situation : permanent

**Results (Stage of construction 1)****Analysis 1****Circular slip surface**

Slip surface parameters							
Center :	x =	-3.23	[ft]	Angles :	$\alpha_1 =$	-39.82	[°]
	z =	13.81	[ft]		$\alpha_2 =$	88.36	[°]
Radius :	R =	10.82	[ft]				
The slip surface after optimization.							

**Slope stability verification (Bishop)**Sum of active forces :  $F_a = 3386.5$  lbf/ft

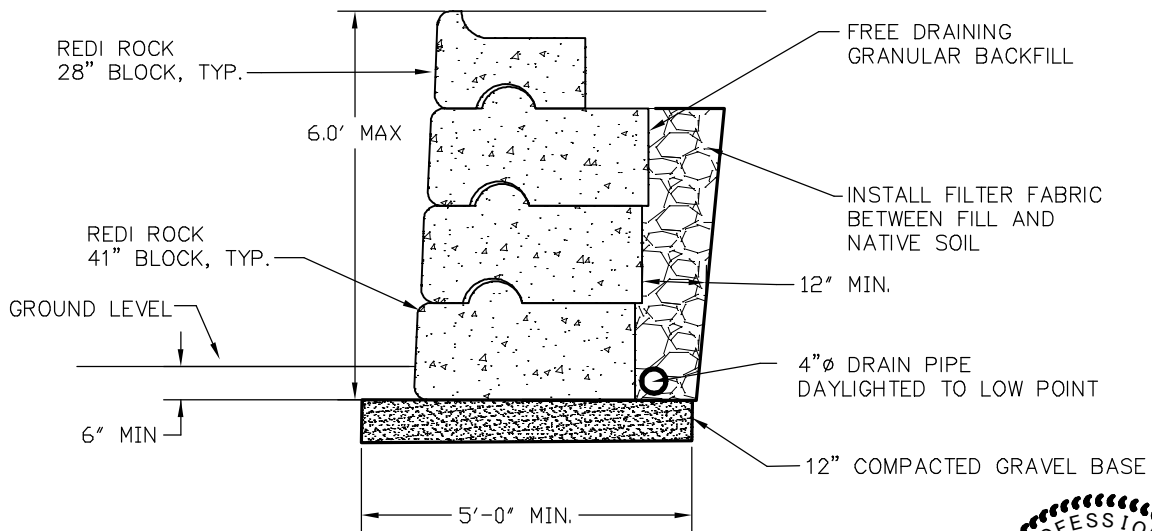
Sum of passive forces :  $F_p = 5153.5$  lbf/ft

Sliding moment :  $M_a = 36641.8$  lbfft/ft

Resisting moment :  $M_p = 55760.7$  lbfft/ft

Factor of safety =  $1.52 > 1.50$

**Slope stability ACCEPTABLE**



*J.E. McKervery*  
4/16/2021

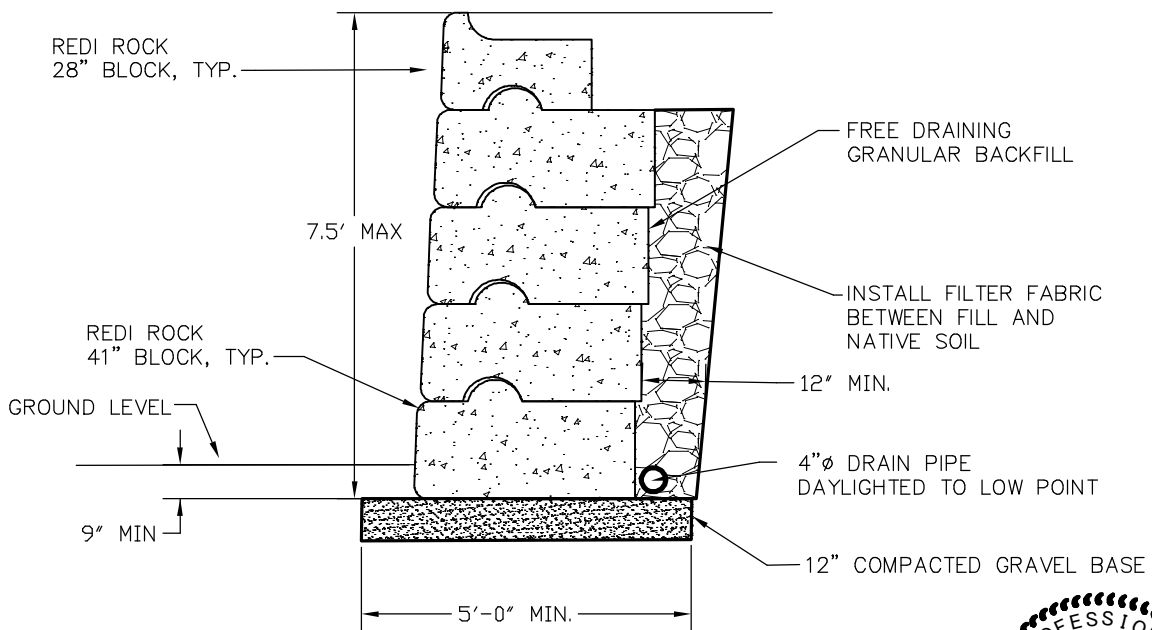
# JM ENGINEERING

2706 N. BLUE RAVEN LANE  
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(509) 455-8760 / CELL (509) 953-9771

KUNZ RESIDENCE  
OSOYOOS, BC  
6.0' SECTION

JOB #: 21-801  
DATE: APRIL 2021





*J.E. McKervey*  
4/16/2021

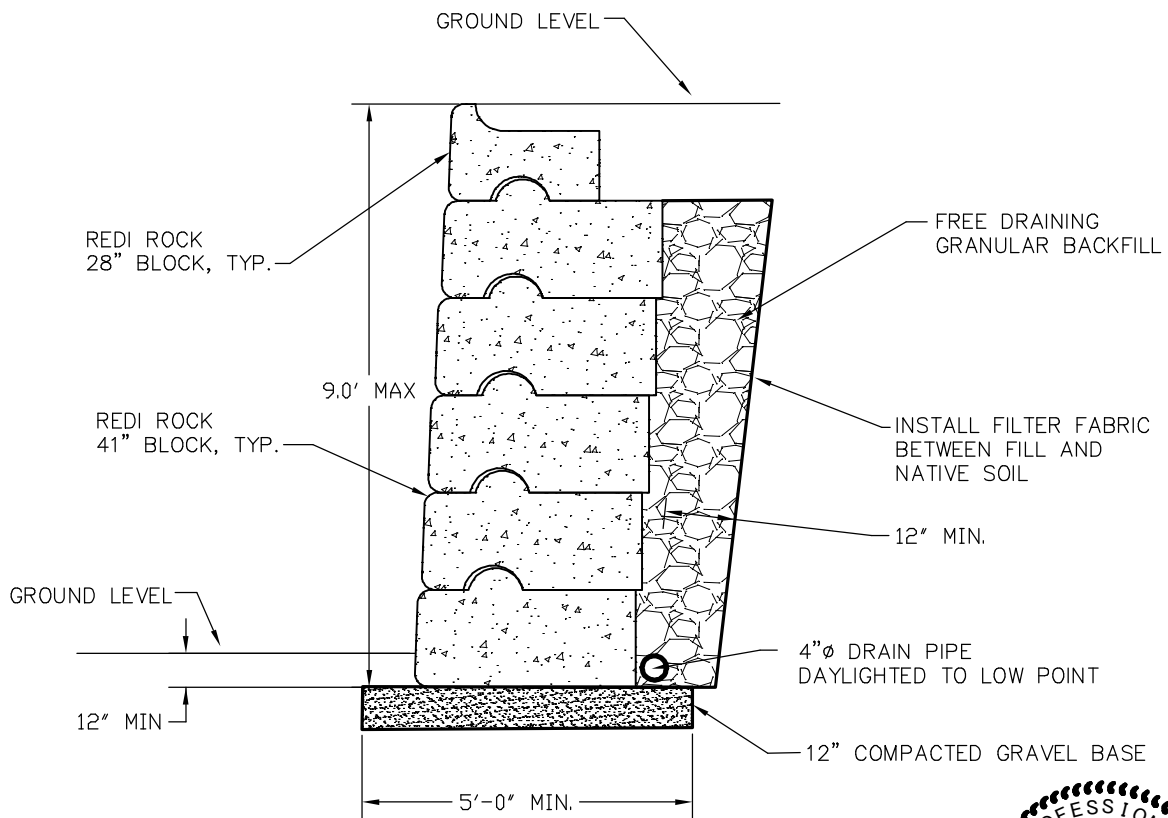
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(509) 455-8760 / CELL (509) 953-9771

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OSOYOOS, BC

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7.5' SECTION



*J.E. McKervery*  
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2706 N. BLUE RAVEN LANE  
SPOKANE, WASHINGTON 99224  
(509) 455-8760 / CELL (509) 953-9771

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