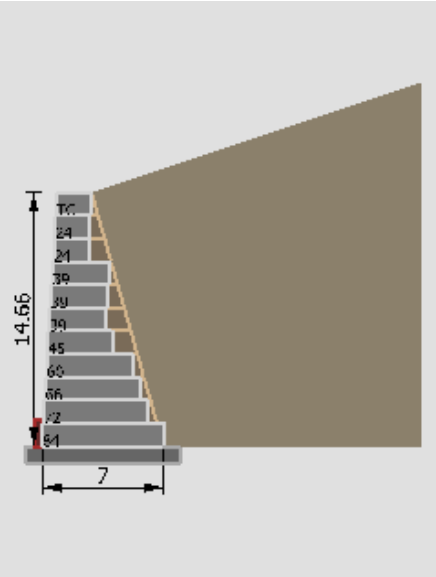
ReCon Walls

ReCon Retaining Walls, Inc version 2.1



Project: New Project
Location: Location
Designer:
Date: 4/4/2011

Section: Section 1
Design Method: AASHTO_LRFD

SOIL PARAMETERS	Phi	coh	Gamma
Retained Soil:	34 deg	0 psf	120 pcf
Foundation Soil:	34 deg	0 psf	120 pcf

Leveling Pad: Crushed Stone Crushed Stone checked

GEOMETRY

Design Height:	14.66 ft	Live Load:	0 psf
Wall Batter/Tilt:	3.58/ 0.00 deg	Live Load Offset:	0.00 ft
Embedment:	1.50 ft	Live Load Width:	0 ft
Leveling Pad Depth:	1.00 ft	Dead Load:	0 psf
Slope Angle:	18 deg	Dead Load Offset:	0 ft
Slope Length:	50 ft	Dead Load Width:	0 ft
Slope Toe Offset:	0 ft	Leveling Pad Width:	8.00 ft

LOAD FACTORS

Load Case:	Str max(d)	Str min(r)	Seis max(sd)	Seis min(sr)	Service(serv)
Dead Load (DC)	1.25	0.90	1.25	0.90	1.00
Dead Load Driving (EH)	1.50	0.90	1.50	0.90	1.00
Vertical Earth load (EV)	1.35	1.00	1.35	1.00	1.00
Live Load (LL, PL, LS)	1.75	0.00	0.50	0.00	1.00

RESISTANCE FACTORS

Resistance Case:	Strength	Seismic	Service
Bearing Resistance(RFbr)	0.55	0.55	1.00
Sliding Soil to Soil(RFsl)	0.90	1.00	1.00

RESULTS

CDR Sliding:	1.26 / 1.40	CDR Bearing:	3981.87
CDR Eccentricity:	L/ 4.33		

Name	Elev.	ka	Pa	Paq	Paqd	- PaC	PaT	FSsl	L/e
TC	13.33	0.295	31	0	0	0	31	3.19	3327.83
24	12.00	0.295	125	0	0	0	125	34.77	25.73
24	10.67	0.295	283	0	0	0	283	15.78	7.68
39	9.33	0.468	797	0	0	0	797	7.76	26.37
39	8.00	0.428	1139	0	0	0	1139	5.43	9.15
39	6.67	0.403	1546	0	0	0	1546	4.07	5.33
45	5.33	0.425	2220	0	0	0	2220	3.08	4.23
60	4.00	0.502	3420	0	0	0	3420	2.42	4.95
66	2.67	0.510	4402	0	0	0	4402	2.05	4.42
72	1.33	0.517	5508	0	0	0	5508	1.78	4.05
84	0.00	0.555	7154	0	0	0	7154	1.26	4.33

Note: Calculations are for Preliminary use only and should
not be used for construction without the review of a qualified professional.
ReCon Retaining Walls, Inc

DESIGN DATA

Load Factors for Design

Load Case	Str_Max	Str_Min	Extreme Max	Extreme Min	Service
Dead Load (DC)	1.25	0.90	1.25	0.90	1.00
Soil Load Driving (EH)	1.50	0.90	1.50	0.90	1.00
Vertical Earth Load (EV)	1.35	1.00	1.35	1.00	1.00
Dead Load Surcharge (ES)	1.50	0.75	1.50	0.75	1.00
Live Load (LL, PL, LS)	1.75	0.00	0.50	0.00	1.00

Resistance Case	Strength	Extreme	Service
Bearing Resistance	0.55	0.55	1.00
Sliding Soil to Soil	0.90	1.00	1.00
Sliding Soil to Reinforcement	1.00	1.00	1.00
Tensile Resistance	0.90	1.20	1.00
Pullout Resistance	0.90	1.20	1.00
Overturning Resistance	0.60	1.00	1.00

MINIMUM DESIGN REQUIREMENTS

Minimum embedment depth — Min_emb = 1.5 ft

INPUT DATA

Geometry

Wall Geometry

Design Height, top of leveling pad to top of grade at tail of base unit	H =14.66 ft
Embedment, measured from top of leveling pad to grade at toe	emb = 1.5 ft
Leveling Pad Depth	LP Thickeness = 1.0 ft
Face Batter, measured from vertical	i = 3.6 deg

Slope Geometry

Slope Angle, measured from horizontal	beta = 18.4 deg
Slope toe offset, measured from toe slope offset	STL_offset = 0.0 ft
Slope Length, measured from back of wall facing	SL_Length = 50.0 ft

NOTE: If the slope toe is offset or the slope breaks within three times the wall height, a Coulomb Trial Wedge method of analysis is used.

Surcharge Loading

Live Load, assumed transient loading (e.g. traffic)	LL = 0.0 psf
Live Load Offset, measured from back face of wall	LL_offset = 0.0 ft
Live Load Width, assumed strip loading	LL_width = 0.0 ft
Dead Load, assumed permanent loading (e.g. buildings)	DL = 0.0 psf
Dead Load Offset, measured from back face of wall	DL_offset = 0.0 ft
Dead Load Width, assumed strip loading	DL_width = 0.0 ft

Soil Parameters

Retained Zone

Angle of Internal Friction	phi = 34 deg
Cohesion	coh = 0.0 psf
Moist Unit Weight	gamma = 120 pcf

Foundation

Angle of Internal Friction	phi = 34 deg
Cohesion	coh = 0.0 psf
Moist Unit Weight	gamma = 120 pcf

RETAINING WALL UNITS

STRUCTURAL PROPERTIES:

N is the normal force [or factored normal load] on the base unit

Unit Designation: Top Block

Unit Dimensions:

Height = 1.33 ft
Width = 4.00 ft
Weight = 1493.33 lbs
Depth = 2.00 ft
Density = 140.00 pcf

Unit to Unit Shear
tau = N tan(10.00) + 100.00 ppf

Unit to Leveling Pad Shear
tau = N tan(0.00) + 0.00 ppf

Unit Designation: A-24

Unit Dimensions:

Height = 1.33 ft
Width = 4.00 ft
Weight = 1546.67 lbs
Depth = 2.00 ft
Density = 145.00 pcf

Unit to Unit Shear
tau = N tan(22.00) + 6775.00 ppf

Unit to Leveling Pad Shear
tau = N tan(32.90) + 20.60 ppf

Unit Designation: B-39

Unit Dimensions:

Height = 1.33 ft
Width = 4.00 ft
Weight = 2513.33 lbs
Depth = 3.25 ft
Density = 145.00 pcf

Unit to Unit Shear
tau = N tan(22.00) + 6775.00 ppf

Unit to Leveling Pad Shear
tau = N tan(32.90) + 20.60 ppf

Unit Designation: C-45

Unit Dimensions:

Height = 1.33 ft
Width = 4.00 ft
Weight = 2800.00 lbs
Depth = 3.75 ft
Density = 140.00 pcf

Unit to Unit Shear
tau = N tan(22.00) + 6775.00 ppf

Unit to Leveling Pad Shear
tau = N tan(32.90) + 20.60 ppf

Unit Designation: D-60

Unit Dimensions:

Height = 1.33 ft
Width = 4.00 ft
Weight = 3733.33 lbs
Depth = 5.00 ft
Density = 140.00 pcf

Unit to Unit Shear
tau = N tan(22.00) + 6775.00 ppf

Unit to Leveling Pad Shear
tau = N tan(32.90) + 20.60 ppf

Unit Designation: F-66

Unit Dimensions:

Height = 1.33 ft
Width = 4.00 ft
Weight = 4106.67 lbs
Depth = 5.50 ft
Density = 140.00 pcf

Unit to Unit Shear
tau = N tan(22.00) + 6775.00 ppf

Unit to Leveling Pad Shear
tau = N tan(32.90) + 20.60 ppf

Unit Designation: G-72

Unit Dimensions:

Height = 1.33 ft
Width = 4.00 ft
Weight = 4480.00 lbs
Depth = 6.00 ft
Density = 140.00 pcf

CALCULATION RESULTS

OVERVIEW

ReCon Wall calculates stability assuming the wall is a rigid body. Forces and moments are calculated about the base and the front toe of the wall. The base block width is used in the calculations. The concrete units and granular fill over the blocks are used as resisting forces.

EARTH PRESSURES

The method of analysis uses the Coulomb Earth Pressure equation (below) to calculate active earth pressures. Wall friction is assumed to act at the back of the wall face. The component of earth pressure is assumed to act perpendicular to the boundary surface. The effective delta angle is delta minus the wall batter at the back face (assumed to be vertical).

If the slope breaks within the failure zone, a trial wedge method of analysis is used.

EXTERNAL EARTH PRESSURES

Effective Delta angle (3/4 retained phi)	delta = 30.0 deg
Coefficient of active earth pressure	ka = 0.555
External failure plane	rho = 55 deg
Effective Face Angle from horizontal	Face Alpha =74.14 deg

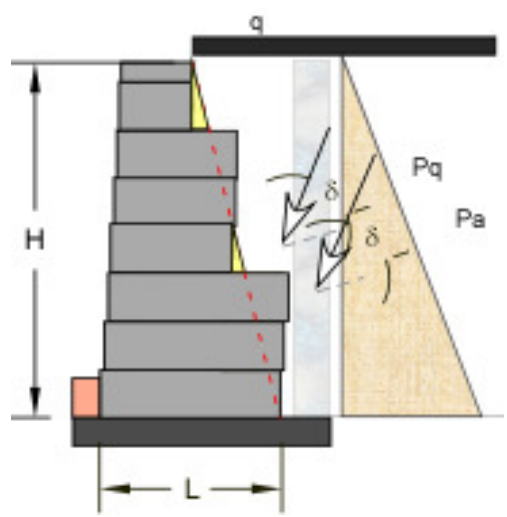
$$Ka := \frac{\cos(\phi_i + i)^2}{\cos(i)^2 \cdot \cos(\delta_i - i)\left(1 + \sqrt{\frac{\sin(\phi_i + \delta_i)\cdot\sin(\phi_i - \beta)}{\cos(\delta_i - i)\cdot\cos(i + \beta)}}\right)^2}$$

FORCES AND MOMENTS

ReCon Wall resolves all the geometry into simple geometric shapes to make checking easier. All x and y coordinates are referenced to a zero point at the front toe. The wall image can be exported to CAD for a more detailed output.

Name	Force (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	8118	--	2.60	--	--	21147
Face Soil(W2)	1080	--	4.24	--	--	4579
Pa_h	--	4982	--	4.89	24345	--
Pa_v	5134	--	5.61	--	--	28811
Sum V / H	14333	4982		Sum Mom	24345	54537

Note: liveloads and liveload moments are not included in SumV or Mr as live loads are not included as resisting forces.



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BASE SLIDING

Sliding at the base is checked at the block to leveling pad interface between the base block and the leveling pad. Sliding is also checked between the leveling pad and the foundation soils.

Forces Resisting sliding = W1(DCr) + W2(EVr) + Pav(EHd) + Pqv(LLd)	N =16088 ppf
Resisting force at pad = (N tan(slope) + intercept) x RFsl	Rf1 =9386
where Wu is the base block width	
Friction angle is the lesser of the leveling pad and Fnd	phi =34.00 deg
N1 includes N + leveling pad	N1 = 17063 ppf
Resisting force at fnd = ((N1) tan(phi) + cL) * RFsl + + PPp * RFbr	Rf2 = 10464
where LP = lvl pad thickness * 130 pcf * Wu + lvl pad thickness/2	
Driving force is the horizontal component of	
Pah(EHd) + Pqh(LLd)	Df =7473
CDR = Rf / Df	CDR =1.26 / 1.40

ECCENTRICITY ABOUT THE TOE

Eccentricity at the base is checked by assuming rotation about the front toe by the block mass, soil retained on the blocks or soil within the reinforced zone. Allowable overturning can be defined by eccentricity (e/L).

Moments resisting overturning =	
M1(DCr) + M2(EVr) + MPav(EHd) + MPq(LLd)	Mr =66828 ft-lbs
Moments causing overturning = MPah(EHd) + MPq(LLd)	Mo =36517 ft-lbs
e = L/2 - (SumMr - SumMo)/SumV	
e =7/2 - (30310) /16088	e =1.62
	L/e = 4.33

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant force away from the centroid of mass. This measure is an indication of the overturning of the mass. In rigid concrete structures, the limit to eccentricity is L/6 (the middle third of the base). In rigid structures the pressure distribution at the base is trapezoidal meaning a high pressure on the toe and possibly lifting at the tail. The L/6 prevents the possibility of lifting at the tail. ReCon Wall uses an allowable eccentricity of L/4 per the AASHTO LRFD guidelines. Eccentricity is still used as a guide to design in some design methods.

ReCon Wall calculates two eccentricities:

1) Maximum eccentricity (overturning) where it uses the maximum driving forces combined with the minimum resisting forces (see overturning).

2) Maximum bearing where it uses the maximum driving forces combined with the maximum resisting forces (see below).

Calculation of Eccentricity for maximum bearing

Moments resisting = M1(DCd) + M2(EVd) + MPav(EHd) + MPq(LLd)	Mr =75832 ft-lbs
Moments driving = MPah(EHd) + MPq(LLd)	Mo =36517 ft-lbs

e = L/2 - (SumMr - SumMo)/SumV

e = 7.0/2 - (39315) /19308 e =1.464

Calculation of Bearing Pressures

Qult = (c*Nc + q*Nq + 0.5*gamma*(B')*Ng) * RFbrg

where:

Nc = 42.16

Nq = 29.44

Ng = 41.06

c = 0.00 psf

q = 300.00 psf

B' = B - 2e + lvl pad thickness = 5.07 ft

Calculate Ultimate Bearing, Qult	Qult =11731.28 psf
Applied Bearing Pressures	(SumV + lvl Pad)/B' = 3981.87 psf
Calculated CDR for bearing	Qult/sigma = 2.95