AASHTO 98 ASD DESIGN METHOD

MSEW(3.0): Update # 14.6

PROJECT IDENTIFICATION

Title:
Project Number:
Client:
Designer:
Station Number: 단면A (H=4.5)

Description:

[TENAX GEOGRID(H.D.P.E)]

Company's information:

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PROGRAM MODE: DESIGN
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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DESIGN DATA

DESIGN OBJECTIVES

Minimum factor of safety against pullout, Fs-po	1.50
Minimum factor of safety against direct sliding, Fs-sliding	1.50
Maximum allowable eccentricity ratio at each reinforcement level, e/L	0.1667
Minimum factor of safety against compound and overall failure, Fs-comp-static	1.50
Minimum factor of safety against compound and overall failure, Fs-comp-seismic	1.10

Prescribed minimum resistive length to prevent pullout, Le = 1.00 m.
Prescribed minimum normalized length of each layer is: L/Hd = 0.70 --> L = 3.15 m.
Prescribed minimum absolute total length of each layer is: L = 2.50 m.

BEARING CAPACITY

Bearing capacity is controlled by general shear.

Maximum permissible eccentricity ratio (soil), e/L	0.1667
Minimum factor of safety with respect to ultimate bearing capacity (Meyerhof approach)	2.50

Bearing capacity coefficients: Nc = 30.14 N γ= 22.40

SOIL DATA

REINFORCED SOIL

Unit weight, γ	19.0 kN/m^3
Design value of internal angle of friction, ϕ	30.0 deg.

RETAINED SOIL

Unit weight, γ	19.0 kN/m^3
Design value of internal angle of friction, ϕ	30.0 deg.

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	19.0 kN/m^3
Equivalent internal angle of friction, $\phi_{equiv.}$	30.0 deg.
Equivalent cohesion, $c_{equiv.}$	0.0 kPa

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3333 (if batter is less than 10deg., Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ= 60.00deg. (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3333 (if batter is less than 10deg., Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

SEISMICITY

Maximum ground acceleration coefficient, A = 0.154
Design acceleration coefficient in Internal Stability: Kh = Am = 0.200
Design acceleration coefficient in External Stability: Kh_d = 0.099 => Kh = Am = 0.099
(Kh in External Stability is based on allowable displacement, d = 25 mm. using FHWA-NHI-00-043 equation)

Kae (Kh > 0) = 0.3762 Kae (Kh = 0) = 0.3136 Δ Kae = 0.0626

DIRECT SLIDING / ECCENTRICITY

Seismic safety factor is 73.3% of specified static FS for direct sliding.
Maximum allowable eccentricity, e/L, under seismic conditions is: 0.2500

BEARING CAPACITY

Seismic safety factor is 80.0% of specified static FS for bearing capacity.
Maximum allowable eccentricity, e/L, under seismic conditions is: 0.2500

INTERNAL STABILITY

Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.
Seismic factor of safety against pullout, Fs-po, is 73.3% of its specified static value.
Seismic overall factor of safety, Fs-overall, is 66.7% of its specified static value.
The reduction of Fs-overall pertains to geogrid strength and to connection strength for both break and pullout modes of failure.

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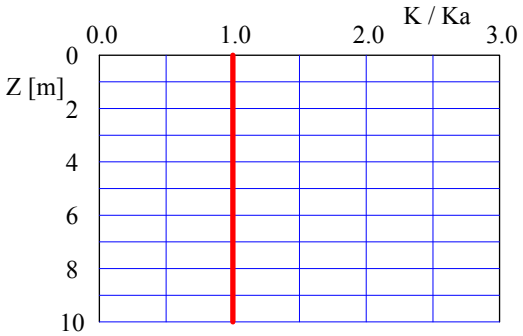
INPUT DATA: Geogrids
(Multiple type reinforcement)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [kN/m]	45.0	60.0	90.0	120.0	160.0
Durability reduction factor, RFd	1.05	1.05	1.05	1.05	1.05
Installation-damage reduction factor, RFid	1.07	1.07	1.07	1.07	1.07
Creep reduction factor, RFc	2.13	2.13	2.13	2.13	2.13
Fs-overall for strength	1.50	1.50	1.50	1.50	1.50
Coverage ratio, Rc	1.000	1.000	1.000	1.000	1.000
Friction angle along geogrid-soil interface, ρ	30.00	30.00	30.00	30.00	30.00
Pullout resistance factor, F*	0.80 tanϕ	0.80 tanϕ	0.80 tanϕ	0.80 tanϕ	0.80 tanϕ
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	0.8

Note: Z for calculating K/Ka and F* is measured from roadway surface (FHWA-NHI-10-024).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 m	1.00
1 m	1.00
2 m	1.00
3 m	1.00
4 m	1.00
5 m	1.00
6 m	1.00



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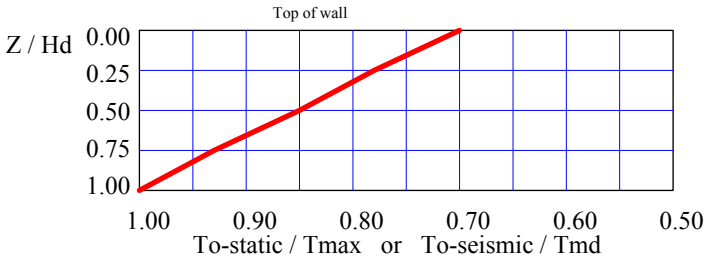
INPUT DATA: Facia and Connection (Design)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 0.47/0.20 m. Horizontal distance to Center of Gravity of block is 0.24 m.
Average unit weight of block is γ_f = 22.00 kN/m^3

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	0.70
0.25	0.78
0.50	0.85
0.75	0.93
1.00	1.00



To-static, To-seismic = connection force, static and superimposed dynamic component, respectively.

Geogrid Type #1			Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRu	(2)	σ	CRu	σ	CRu	σ	CRu	σ	CRu
10.0	0.90		10.0	0.90	10.0	0.90	10.0	0.90	10.0	0.90
200.0	0.90		200.0	0.90	200.0	0.90	200.0	0.90	200.0	0.90

Geogrid Type #1			Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRs	(3)	σ	CRs	σ	CRs	σ	CRs	σ	CRs
10.0	0.90		10.0	0.90	10.0	0.90	10.0	0.90	10.0	0.90
200.0	0.90		200.0	0.90	200.0	0.90	200.0	0.90	200.0	0.90

(1) σ = Confining stress in between stacked blocks [kPa]
(2) CRu = Tult-connection / Tult-geogrid
(3) CRs = Tpo-connection / Tult-geogrid

In seismic analysis, Tc-pullout is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	TT045	TT060	TT090	TT120	TT160
Durability reduction factor, RFd	1.05	1.05	1.05	1.05	1.05
Creep reduction factor, RFc	2.13	2.13	2.13	2.13	2.13
Overall factor of safety: connection break, Fs	1.50	1.50	1.50	1.50	1.50
Overall factor of safety: connection pullout, Fs	1.50	1.50	1.50	1.50	1.50

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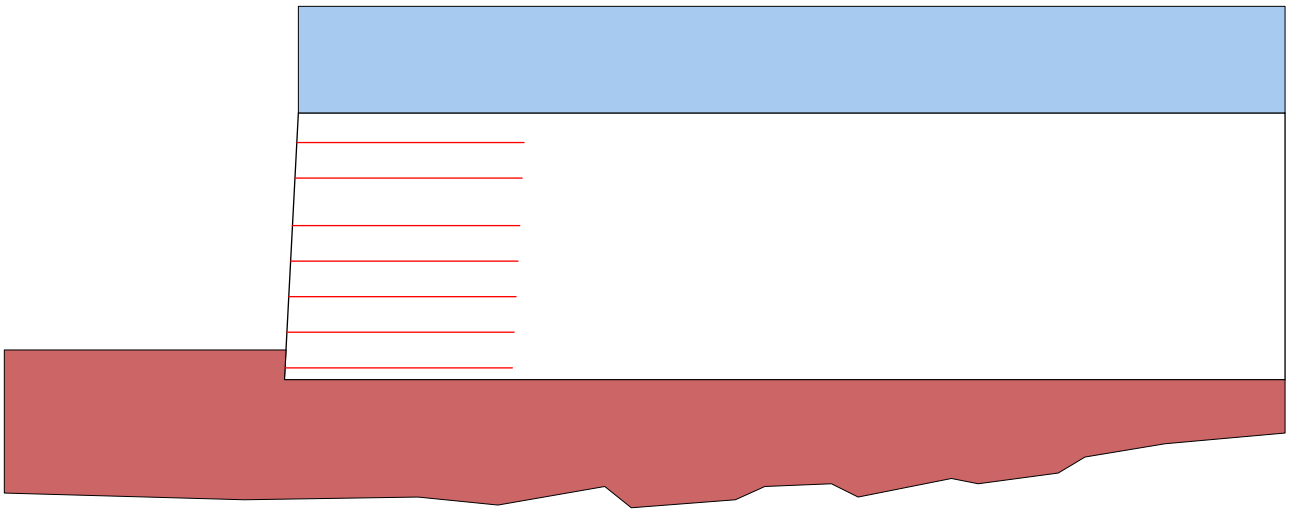
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	4.50	[m]	{ Embedded depth is E = 0.50 m, and height above top of finished bottom grade is H = 4.00 m }
Batter, ω	3.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[m]	Broken back equivalent angle, I = 0.00deg. (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 0.0 [kPa], and live load is 13.0 [kPa]

DESIGNED REINFORCEMENT LAYOUT:



SCALE:

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REINFORCEMENT LAYOUT AND DESIGN CRITERIA

LEGEND:
(1) Connection strength — V Satisfactory
(2) Geogrid strength — X Unsatisfactory
(3) Pullout resistance
(4) Direct sliding
(5) Eccentricity

Bearing capacity: V
Foudation Interface: Direct sliding V Eccentricity V

#	Geogrid Elevation [m]	Length [m]	Type #	(1)	(2)	(3)	(4)	(5)
1	0.20	3.83	2	V	V	V	V	V
2	0.80	3.83	2	V	V	V	V	V
3	1.40	3.83	2	V	V	V	V	V
4	2.00	3.83	1	V	V	V	V	V
5	2.60	3.83	1	V	V	V	V	V
6	3.40	3.83	1	V	V	V	V	V
7	4.00	3.83	1	V	V	V	V	V

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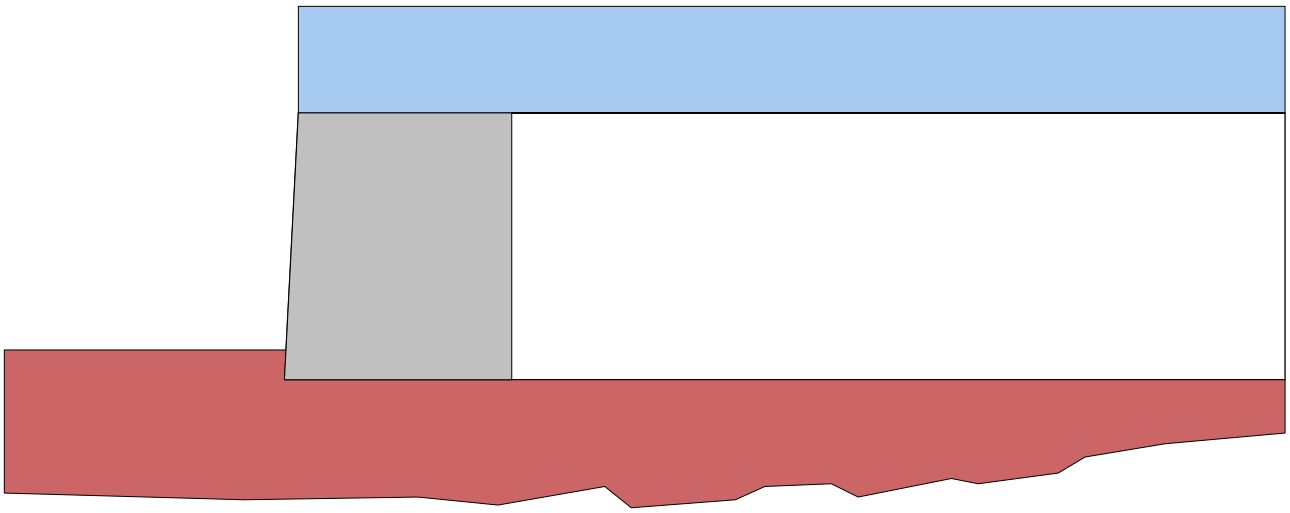
BEARING CAPACITY for DESIGNED LAYOUT

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Ultimate bearing capacity, q-ult	680.3	614.7	[kPa]
Meyerhof stress, s_v	114.01	126.2	[kPa]
Eccentricity, e	0.32	0.47	[m]
Eccentricity, e/L	0.083	0.123	
Fs calculated	5.97	4.87	
Base length	3.83	3.83	[m]



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0 2 4 6 [m]

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DIRECT SLIDING for DESIGNED LAYOUT (for GEOGRID reinforcements)

Specified Fs-static = 1.500 and Fs-seismic = 1.099

Along reinforced and foundation soils interface: Fs-static = 2.193 and Fs-seismic = 1.703

#	Geogrid Elevation [m]	Geogrid Length [m]	Fs Static	Fs Seismic	Geogrid Type #	Product name
1	0.20	3.83	2.274	1.770	2	TT060
2	0.80	3.83	2.554	2.004	2	TT060
3	1.40	3.83	2.909	2.308	2	TT060
4	2.00	3.83	3.374	2.715	1	TT045
5	2.60	3.83	4.010	3.292	1	TT045
6	3.40	3.83	5.339	4.574	1	TT045
7	4.00	3.83	7.082	6.436	1	TT045

ECCENTRICITY for DESIGNED LAYOUT

At interface with foundation: e/L static = 0.0998, e/L seismic = 0.1459; Overturning: Fs-static = 4.48, Fs-seismic = 3.20

#	Geogrid Elevation [m]	Geogrid Length [m]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.20	3.83	0.0919	0.1339	2	TT060
2	0.80	3.83	0.0700	0.1010	2	TT060
3	1.40	3.83	0.0512	0.0728	2	TT060
4	2.00	3.83	0.0353	0.0493	1	TT045
5	2.60	3.83	0.0223	0.0304	1	TT045
6	3.40	3.83	0.0095	0.0122	1	TT045
7	4.00	3.83	0.0031	0.0037	1	TT045

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [m]	Tavailable [kN/m]	Tmax [kN/m]	Tmd [kN/m]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic	Product name
1	0.20	25.1	15.6	3.9	1.500	1.605	1.001	1.436	TT060
2	0.80	25.1	16.7	3.6	1.500	1.505	1.001	1.367	TT060
3	1.40	25.1	14.4	3.2	1.500	1.744	1.001	1.577	TT060
4	2.00	18.8	12.1	2.9	1.500	1.554	1.001	1.396	TT045
5	2.60	18.8	11.2	2.6	1.500	1.674	1.001	1.511	TT045
6	3.40	18.8	8.1	2.1	1.500	2.312	1.001	2.058	TT045
7	4.00	18.8	5.5	1.8	1.500	3.423	1.001	2.964	TT045

RESULTS for PULLOUT

Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Geogrid Elevation [m]	Coverage Ratio	Tmax [kN/m]	Tmd [kN/m]	Le [m] (see NOTE)	La [m]	Avail.Static Pullout, Pr [kN/m]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [kN/m]	Specified Seismic Fs	Actual Seismic Fs
1	0.20	1.000	15.63	3.90	3.73	0.10	223.2	1.500	14.283	178.5	1.099	9.145
2	0.80	1.000	16.66	3.57	3.41	0.42	177.3	1.500	10.643	141.8	1.099	7.012
3	1.40	1.000	14.38	3.24	3.10	0.73	134.8	1.500	9.377	107.9	1.099	6.122
4	2.00	1.000	12.10	2.91	2.78	1.05	97.7	1.500	8.074	78.2	1.099	5.206
5	2.60	1.000	11.24	2.58	2.47	1.36	65.8	1.500	5.860	52.7	1.099	3.812
6	3.40	1.000	8.13	2.14	2.05	1.78	31.6	1.500	3.889	25.3	1.099	2.463
7	4.00	1.000	5.49	1.81	1.73	2.10	12.2	1.500	2.214	9.7	1.099	1.332

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RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [m]	Connection force, To [kN/m]	Reduction factor for connection break, CRu	Reduction factor for connection pullout, CRs	Available connection strength, Tc-break criterion [kN/m]	Available connection strength, Tc-pullout criterion [kN/m]	Available Geogrid strength, Tavailable [kN/m]	Fs-overall connection break		Fs-overall connection pullout		Fs-overall Geogrid strength		Product name
								Specified	Actual	Specified	Actual	Specified	Actual	
1	0.20	15.4	0.90	0.90	24.1	54.0	25.1	1.50	1.56	1.50	3.50	1.50	1.62	TT060
2	0.80	15.8	0.90	0.90	24.1	54.0	25.1	1.50	1.53	1.50	3.41	1.50	1.58	TT060
3	1.40	13.1	0.90	0.90	24.1	54.0	25.1	1.50	1.84	1.50	4.12	1.50	1.92	TT060
4	2.00	10.5	0.90	0.90	18.1	40.5	18.8	1.50	1.72	1.50	3.86	1.50	1.79	TT045
5	2.60	9.3	0.90	0.90	18.1	40.5	18.8	1.50	1.95	1.50	4.35	1.50	2.02	TT045
6	3.40	6.3	0.90	0.90	18.1	40.5	18.8	1.50	2.86	1.50	6.40	1.50	2.97	TT045
7	4.00	4.0	0.90	0.90	18.1	40.5	18.8	1.50	4.48	1.50	10.02	1.50	4.65	TT045

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Geogrid Elevation [m]	Connection force, To [kN/m]	Reduction factor for connection break, CRu	Reduction factor for connection pullout, CRs	Available connection strength, Tc-break criterion [kN/m]	Available connection strength, Tc-pullout criterion [kN/m]	Available Geogrid strength, Tavailable [kN/m]	Fs-overall connection break		Fs-overall connection pullout		Fs-overall Geogrid strength		Product name
								Specified	Actual	Specified	Actual	Specified	Actual	
1	0.20	19.3	0.90	0.72	24.1	43.2	25.1	1.00	1.40	1.00	2.24	1.00	1.45	TT060
2	0.80	19.2	0.90	0.72	24.1	43.2	25.1	1.00	1.39	1.00	2.25	1.00	1.44	TT060
3	1.40	16.0	0.90	0.72	24.1	43.2	25.1	1.00	1.67	1.00	2.69	1.00	1.73	TT060
4	2.00	13.0	0.90	0.72	18.1	32.4	18.8	1.00	1.55	1.00	2.49	1.00	1.61	TT045
5	2.60	11.4	0.90	0.72	18.1	32.4	18.8	1.00	1.76	1.00	2.83	1.00	1.82	TT045
6	3.40	8.0	0.90	0.72	18.1	32.4	18.8	1.00	2.55	1.00	4.05	1.00	2.64	TT045
7	4.00	5.4	0.90	0.72	18.1	32.4	18.8	1.00	3.88	1.00	6.03	1.00	4.03	TT045

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