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GABION EARTH RETAINING WALL

EXAMPLE CALCULATIONS

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Contents

1.0 DESIGN STATEMENT

The Design undertaken by Intec Consulting (UK) Ltd includes the following:

(i) Determination of the gabion earth retaining wall design together with details for construction to satisfy soils and loadings as applicable and as provided. The Design of the gabion earth retaining wall works will be in accordance with the relevant Codes and Standards and will satisfy minimum requirements for the design as appropriate

(ii) Should any information not be provided then reasonable assumptions will be made and incorporated in the Design. The Design together with any assumptions will be submitted to the Client in order to establish that the gabion earth retaining wall design and any assumptions and loadings imposed are compatible with the requirements of the site. Intec Consulting (UK) Ltd will accept no liability as a result of the failure to provide information which may have assisted or been of significance in the preparation of the Design.

(iii) Intec Consulting (UK) Ltd will accept no liability as a result of failure to construct the gabion earth retaining wall works and any associated works, which may influence the performance of the gabion earth retaining wall , in accordance with the Design and normally accepted standards, procedures and workmanship.

(iv) Intec Consulting (UK) Ltd are to be notified immediately in the event of any change or variation in the information provided and upon which the Design is based. Intec Consulting (UK) Ltd will accept no liability as a result of failure to notify any such changes or variations.

2.0 DESIGN REFERENCE

1. Information Provided

(i) Drawings

Author:

Drg. No.	Description
-	-

(ii) Other

a) Fine Mesh Metals Ltd gabion basket data ref web site.

2. Standards and Technical Memoranda

• BS 8004: 1986	Foundations
• BS 6031:2009	Earthworks
• BS EN 1997-1:2004	Eurocode 7: Geotechnical design – Part 1: General Rules
• NA to BS EN 1997-1:2004	UK National Annex to Eurocode 7: Geotechnical design – Part 1: General Rules
• BS 8002:2015	Code of practice for earth retaining structures

3. Published Text

- Foundation Design & Construction 6th Edition, M J Tomlinson
- Elements of Soil Mechanics Seventh Edition, G N Smith and Ian G N Smith
- Soil Mechanics SI version, Lambe & Whitman

3.0 DESIGN

A gabion earth retaining wall is subject to design analysis in respect of the following potential failure mechanisms:-

- Sliding
- Overturning
- Foundation bearing

In some situations global stability failure mechanisms i.e. typically circular failure planes in the soil beyond the retaining wall, are also considered.

Assessment of In-situ soils for design.

The design of the gabion earth retaining wall is subject to the determination of appropriate design parameters relative to the specific soil type involved. In order to

enable this determination an assessment is made of the factual data provided via site investigation information.

The design is based upon effective stress conditions.

Soil Type

Ground conditions and in-situ shear strength(s) are generally obtained from ground investigations which include boreholes and in-situ and laboratory testing.

In the case of cohesive soils it is normal practice to limit the value of effective cohesion in design as this characteristic cannot always be guaranteed to be present throughout the service life of the facility and in addition forces to be stabilised are significantly reduced. A practice is to base the design on the effective angle of internal friction only determined from a line on the stress/strain diagram for the material from the origin and tangential to the stress/strain plot i.e. secant effective angle of internal friction.

Selection of design parameters is based upon the following:-

- Ignoring apparent effective cohesion.
- Adopting an effective angle of internal friction that reflects the long term stability of the existing slope (average angle) and incorporating a normally acceptable factor of safety for stability.
- Adopting an effective angle of internal friction that generates critical failure mechanisms that would appear reasonable if not erring on the conservative.

In the absence of ground investigation information and where possible depending upon soil type, assessment of appropriate design parameters is made based upon the soil type and knowledge and experience of the type of material involved.

Ground conditions and criterion associated with the design of the gabion earth retaining wall are summarised as below.

Design Analysis

A gabion earth retaining wall is considered a 'flexible' structure and as such will be subject to some deflection or yield as pressures and forces applied to its rear face develop. The process of this deflection or yield is sufficient to allow retained soils to similarly yield and in so doing develop an 'active' state. Design analysis is thus based on

'active earth pressures' and pressures and forces supported by the gabion earth retaining wall from retained soils so determined.

Lateral earth pressures supported by the gabion dearth retaining wall are a function of such factors as effective retained height, coefficient of 'active earth pressure' as applicable to the specific type of retained soil and any additional loading from any slope and/or other loading i.e. vehicular etc.

Established earth pressure theory as developed by Coulomb(1776) and Rankine(1857) is used the estimate active earth pressures.

Coulomb's expression for the coefficient of active earth pressure (K_a) is:-

$$K_a = \left\{ \frac{\operatorname{cosec}\psi \sin(\psi - \phi)}{\sqrt{\sin(\psi + \delta)} + \sqrt{\dfrac{\sin(\phi + \delta)\sin(\phi - \beta)}{\sin(\psi - \beta)}}} \right\}^2$$

where

ψ = angle of back of wall to the horizontal
δ = angle of wall friction
β = angle of inclination of surface of retained soil to the horizontal
ϕ = angle of friction of retained soil (see Fig. 6.6).

(3)

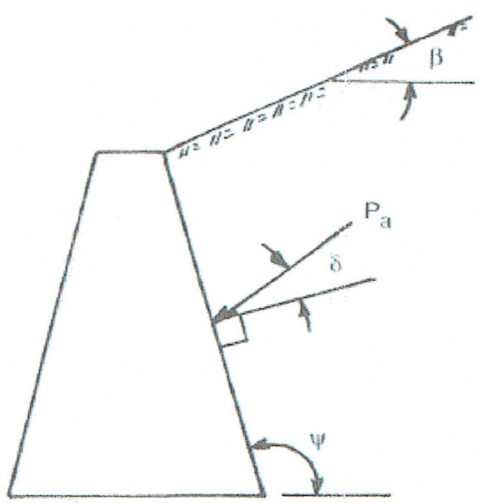

Fig. 6.6 Symbols used in Coulomb's formula.

(3)

For walls with a stepped faces, the analysis incorporates a 'virtual' face.

4.0 DESIGN EXAMPLE

This is an example calculation for a 4.0m high gabion earth retaining wall based on the standard designs listed on the Fine Mesh Metals Ltd website. The retaining wall sits on 200mm of compacted well graded granular material e.g. hardcore, in total 500mm embedment below finished ground level. The soil type is clay that exhibits typical characteristics. Behind the wall well graded granular backfill is compacted up to a safe temporary excavated face typically at 45 degrees. This retaining wall has a plain non stepped face sloped back at 6 degrees. The wall is subject to additional loading from ground sloping to the top of the wall at 5 degrees and the weight of car parking.

5.0 DESIGN SUMMARY

Soil Parameters and data taken for the design of the proposed gabion earth retaining wall are as follows:-

Effective design height: 4.0m

Retained soil:

Type: Well graded granular fill as crushed rock or similar approved, maximum particle size 40mm, compacted in layers not exceeding 150mm to form a dense stable mass.

Effective cohesion (c') = 0 kPa

Effective angle of internal friction (ϕ'_{pk}) = 41^0 (Typical)

Unit weight (Y) = 20 kN/m^3 (Typical)

Foundation soil:

Type: Minimum firm CLAY (I_p not greater than 23%)

Effective cohesion (c') = 0 kPa

Effective angle of internal friction (ϕ'_{pk}) = 25^0 (Typical)

Unit weight (Y) = 20 kN/m^3 (Typical)

Allowable bearing capacity $q_{allow.}$ = 250 kPa(assessed)

Surcharge loading:

Slope: 5 degrees.

Imposed UDL: 2.5 kN/m^2 (car parking)

6.0 DESIGN DRAWINGS

Drawing No.	Description
-	-

7.0 CALCULATIONS

See Over

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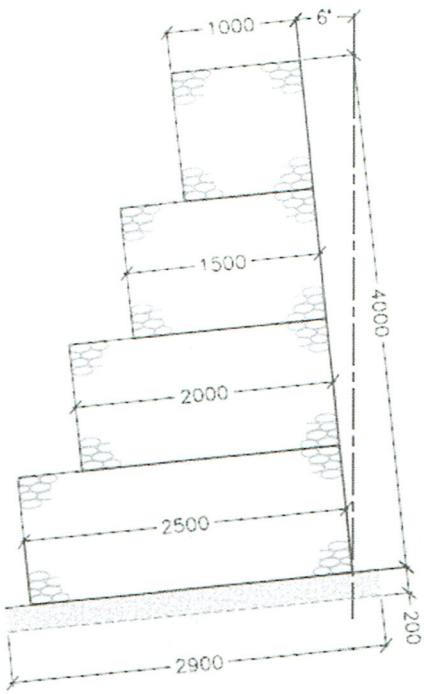
CALCULATIONS FOR:	BY:	DATE:	REV.:	BY:	CHKD:
GABION EARTH RETAINING WALLS DESIGN EXAMPLE	IRP	Ap'l.18			
	CHKD:	DATE:			

UDL surcharge 2.5 kN/m2



Wall ht.
4 m

DESIGN TO EC7

Partial Factors	Combination SLS	1	2
Retained soil Yϕ :	1	1	1.25
Retained soil YG :	1	1.35	1
Surcharge YQ:	1	1.5	1.3
Bearing YR;v :	1	1	1
Sliding YR;h :	1	1	1

RETAINED SOIL PARAMETERS

Eff.ve angle of int'l friction : 41 degrees
Unit weight : 20 kN/m2

SURCHARGE

Slope : 5 degrees
Top set back : 1 m
UDL : 2.5 kPa

DESIGN COMBINATION SLS

φ'_{des} : 41 degrees
γ_{des} : 20 kN/m^3

Equiv. rear of wall angle : 75 degrees
Face element angle 96 degrees
Equiv. face angle 96 degress *(Applicable to stepped face)*

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DESIGN EXAMPLE	CHKD:	DATE:			

EXTERNAL STABILITY (/m run) **DESIGN SECTION** 1

Restoring Forces/Moments

Component	Base (m)	Top (m)	hw (m)	Unit wt (kN/m3)	W (kN)	La (m)	Mts @ o. (kNm)
Wall	2.5	1	4	14	98	1.0781	105.656

Disturbing Forces/Moments

Component	δ (°)	Ka	Hr (m)	Pa (kN)
Retained soil	41	0.377	4.261	68.459
UDL surcharge				4.0163

Overturning @ o

Resistance to overturning > Overturning Moment(PaHLa)

232.2 > 49.67

Resistance to overturning greater than overturning moment - design satisfied

Sliding

Effective angle of internal friction (charc.)
for foundation soils = 25 degrees

φ'_{des} = 25

Resistance to sliding > Sliding Force (PaH)

85.53 > 34.025

Resistance to sliding greater than sliding force - design satisfied

Foundation bearing pressures

Position of resultant e = 0.1197 < B/6 = 0.416667

Foundation pressures toe = 83.139 kPa
heel = 46.025 kPa

Position of resultant within the middle third of the foundation - design satisfied

Foundation pressures less than allowable foundation pressure - design satisfied

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GABION EARTH RETAINING WALLS	BY:	Ap'l.18			
DESIGN EXAMPLE	CHKD:	DATE:			

DESIGN COMBINATION 1

φ'_{des} : 41 degrees
Y_{des} : 27 kN/m^3

EXTERNAL STABILITY (/m run)

DESIGN SECTION 1

Restoring Forces/Moments

Component	Base (m)	Top (m)	hw (m)	Unit wt (kN/m3)	W (kN)	La (m)	Mts @ o. (kNm)
Wall	2.5	1	4	14	98	1.0781	105.656

Disturbing Forces/Moments

Component	δ (°)	Ka	Hr (m)	Pa (kN)
Retained soil	41	0.377	4.261	92.42
UDL surcharge				6.0244

Overturning @ o

Resistance to overturning > Overturning Moment (PaHLa)

277.4 > 67.657

Resistance to overturning greater than overturning moment - design satisfied

Sliding

Effective angle of internal friction (charc.)
for foundation soils = 25 degrees
φ'_{des} = 25

Resistance to sliding > Sliding Force (PaH)

96.22 > 46.217

Resistance to sliding greater than sliding force - design satisfied

Foundation bearing pressures

Position of resultant e = 0.1127 < B/6 = 0.416667

Foundation pressures toe = 93.701 kPa
heel = 53.806 kPa

Position of resultant within the middle third of the foundation - design satisfied

Foundation pressures less than allowable foundation pressure - design satisfied

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DESIGN EXAMPLE	IRP	Ap'l.18			
	CHKD:	DATE:			

DESIGN COMBINATION 2

φ'_{des} : 34.82 degrees
γ_{des} : 20 kN/m^3

EXTERNAL STABILITY (/m run)

DESIGN SECTION 1

Restoring Forces/Moments

Component	Base (m)	Top (m)	hw (m)	Unit wt (kN/m3)	W (kN)	La (m)	Mts @ o. (kNm)
Wall	2.5	1	4	14	98	1.0781	105.656

Disturbing Forces/Moments

Component	δ (°)	Ka	Hr (m)	Pa (kN)
Retained soil	34.82	0.427	4.261	77.538
UDL surcharge				5.9136

Overturning @ o

Resistance to overturning > Overturning Moment (PaHLa)

241.9 > 68.954

Resistance to overturning greater than overturning moment - design satisfied

Sliding

Effective angle of internal friction (charc.)
for foundation soils = 25 degrees

φ'_{des} = 25

Resistance to sliding > PaH

87.88 > 46.883

Resistance to sliding greater than sliding force - design satisfied

Foundation bearing pressures

Position of resultant e = 0.2115 < B/6 = 0.416667

Foundation pressures toe = 100.41 kPa
heel = 32.791 kPa

Position of resultant within the middle third of the foundation - design satisfied

Foundation pressures less than allowable foundation pressure - design satisfied