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COMPARISON BETWEEN THE DRAINAGE CAPACITY OF A GRANULAR DRAIN AND THAT OF INTERDRAIN DRAINAGE GEOCOMPOSITES AS DRAINAGE SYSTEMS IN THE BATTER OF STRUCTURES

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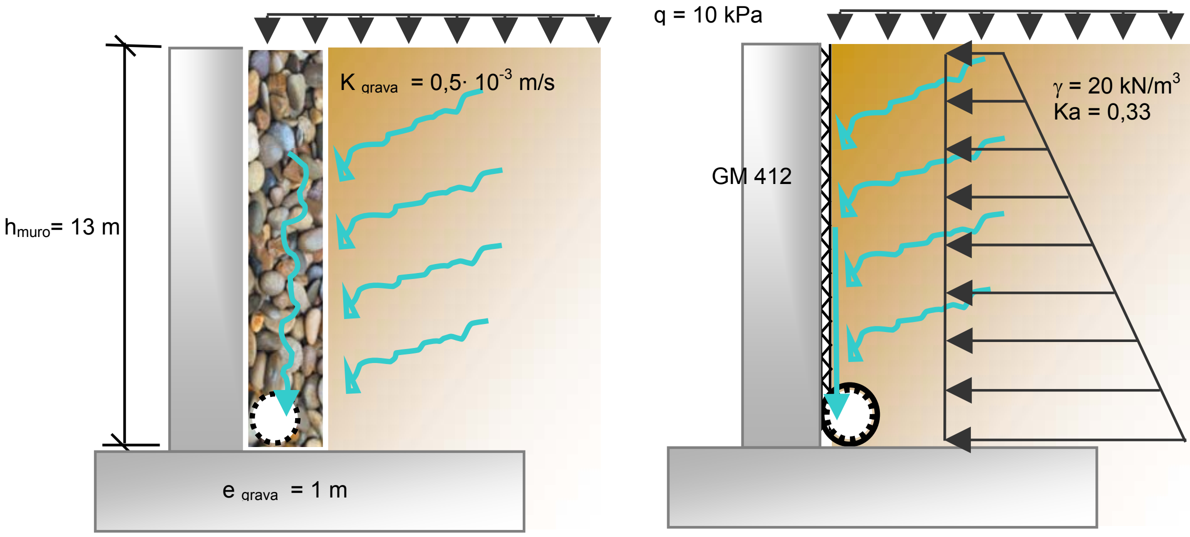
1. DIAGRAM



2. DESCRIPTION OF THE GRANULAR DRAIN FOR STRUCTURAL DRAINAGE:

The granular drain will be 1 m thick and will be worked to a maximum depth of 13 m. Traffic will circulate on top of the earth (additional load = q = 10 kN/m^2). The granular drain will be made up of sandy gravel which will be separated from the earth by a geotexile that will act as a filter. The maximum permeability of the granular/geotextile drain combination is K=0.5·10^{-3}m/s.

3. CALCULATING THE DRAINAGE CAPACITY OF THE GRANULAR DRAIN

The maximum drainage capacity of the granular drain is estimated using Darcy's equation:

$Q = K \cdot A \cdot i$ (m^3/s)
$q = K \cdot e \cdot i$ (m^3/s·m)

Where:

- k = permeability of the granular material = 0.5·10^{-3} m/s
- A = Section of the granular drain (m^2)
- e = Thickness of the granular drain = 1 m
- i = Hydraulic gradient = 1 (the water direction inside the drain is vertical).

$q_{GRAVEL} = K \cdot e \cdot i = 0.5 \cdot 10^{-3} \cdot 1 \cdot 1 = 0.5 \cdot 10^{-3}$ m^2/s **= 0.5 l/m/s**

This calculation is the result of our revised and corrected knowledge. INTERMAS refuses to accept any responsibility deriving from its use in works schemes and provides it purely for information purposes.

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4. CALCULATING THE DRAINAGE CAPACITY OF THE INTERDRAIN GM 412

The drainage capacity of INTERDRAIN can be calculated by using the ISO 12958 Standard (Transmissivity Test) and it depends on the perpendicular pressure on the INTERDRAIN plane and on the hydraulic gradient.

4.1. Calculating the pressure on the drainage geocomposite

The maximum pressure perpendicular to the plane of the drainage geocomposite (due to the earth) at the most unfavourable point (start of the wall) is σ_H.

$\sigma_V = \cdot[\gamma \cdot h + q]$ (vertical pressure) ; $\sigma_H = k_a \cdot \sigma_v = k_a \cdot [\gamma \cdot h + q]$ (normal pressure)

Where:

- h = maximum depth =13 m
- δ = angle of friction of the soil = 30º
- q = additional vertical overload = 10 kN/m^2 = 10 kPa
- k_a = active thrust coefficient of the earth = $k_a = \frac{1 - \sin\delta}{1 + \sin\delta} = 0.33$
- γ = density of the ground = 20 kN/m^3

$\sigma_H = k_a \cdot \sigma_v = k_a \cdot [\gamma \cdot h + q] = 0.33 \cdot [(20 \cdot 13) + 10] = 90$ kN/m^2 = 90 kPa

A conservative pressure value will be considered of: **σ_H = 100 kPa**

4.2. Calculating the hydraulic gradient (i)

The water direction inside INTERDRAIN is vertical, so the hydraulic gradient is **i = 1**

4.3. Drainage capacity of INTERDRAIN GM 412

The GM 412 drainage geocomposite must drain more than 0.5 l/ms.

The drainage capacity of INTERDRAIN GM 412 is:

$q_{GM\,412}$ (i=1, σ = 100 kPa) = 1 l/m·s (ISO 12958, hard/hard)

5. CALCULATING THE SAFETY FACTOR

The safety factor of the drainage geocomposite compared with the granular drain is:

S.F. = $q_{GM\,412} / q_{GRAVEL}$ = 1.00 / 0.5 = **2**

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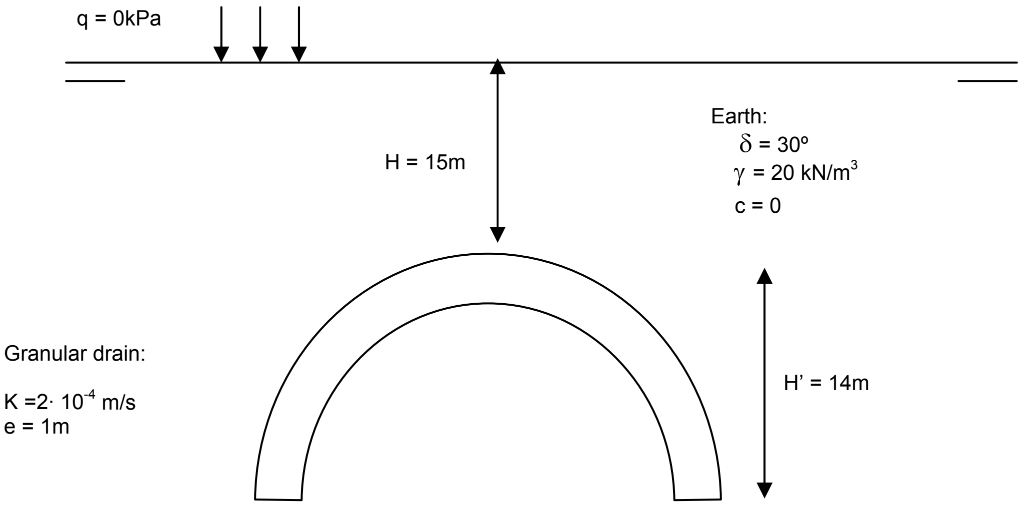
EXAMPLE 2: COMPARISON BETWEEN THE DRAINAGE CAPACITY OF A GRANULAR DRAIN AND INTERDRAIN GMFL4 GEOCOMPOSITE IN DRAINING A FALSE TUNNEL

1. DIAGRAM



2. DESCRIPTION OF THE GRANULAR DRAIN FOR STRUCTURAL DRAINAGE

The granular drain will be 1 m thick and will work at a variable depth of between 15 m (at the key of the vault) and 29 m (at the bottom of the vault). The drainage layer will be made up of a drainage material and filter made up of sands and gravels which will be separated from the structure by a protective geotextile and from the earth by a geotextile filter and protector. The permeability of the system (material and geotextile) is estimated at $K=2\cdot10^{-4}$m/s.

3. CALCULATION OF THE DRAINAGE CAPACITY OF THE GRANULAR DRAIN

The maximum drainage capacity of the granular drain is estimated using Darcy's equation:

$Q_{GRAVELS} = K \cdot A \cdot i$ (m^3/s)
$q_{GRAVELS} = K \cdot e \cdot i$ ($m^3/s\cdot m$)

Where:

- K = Permeability of the granular material = $2 \cdot 10^{-4}$m/s
- A = Section of the granular drain (m^2)
- e = thickness of the granular drain = 1 m
- i = hydraulic gradient

3.1 Drainage capacity of the drainage material at the key of the vault

i = = 0.1 (the water direction inside the drain is horizontal)

$q_{GRAVEL\ KEY} = K\cdot e\cdot i = 2\cdot10^{-4}\cdot1\cdot0.1 = 2\cdot10^{-5} m^2/s$ = **0.02 l/m·s**

3.2. Drainage capacity of the drainage material at the bottom of the vault

i = 1 (the water direction inside the drain is vertical)

$q_{GRAVEL\ BOTTOM} = K\cdot e\cdot i = 2\cdot10^{-4}\cdot1\cdot1 = 2\cdot10^{-4}\ m^2/s$ = **0.2 l/m·s**

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4. CALCULATING THE DRAINAGE CAPACITY OF INTERDRAIN GMFL4

The INTERDRAIN drainage capacity can be calculated by using the ISO 12958 Standard (Transmissivity Test) and it depends on the perpendicular pressure on the plane and on the hydraulic gradient.

4.1. Calculating the pressure on the drainage geocomposite

The maximum pressure on the drainage geocomposite caused in the 2 situations will be calculated below:

$\sigma_V = \cdot[\gamma \cdot h + q]$ (vertical pressure) ; $\sigma_H = k_a \cdot \sigma_v = k_a \cdot [\gamma \cdot h + q]$ (normal pressure)

- γ = density of the ground = 20 kN/m^3
- h = depth
- q = additional vertical load = 0
- δ = Friction angle with the ground = 30º
- k_a = active thrust coefficient = $k_a = \dfrac{1-\sin\delta}{1+\sin\delta} = 0.33$

4.1.1. Pressure at the key of the vault

h = H = 15 m
$\sigma_V = [\gamma \cdot H] = 20 \cdot 15 = 300$ kN/m^2 = **300 kPa**

4.1.1. Pressure at the bottom of the vault

h = H + H' = 15 + 14 = 29 m
$\sigma_H = k_a \cdot \sigma_v = k_a \cdot [\gamma \cdot h] = 0.33 \cdot 20 \cdot 29 =$ **191 kPa** (a conservative value of 200 kPa will be considered)

4.2. Calculating the hydraulic gradient (i)

- VAULT KEY: **i = 0.1** (horizontal water direction)
- VAULT BOTTOM: **i = 1** (vertical water direction)

4.3. Drainage capacity of INTERDRAIN GMFL4

The geocomposite has to drain more than:

$q_{\text{GMFL 4 KEY}}$ (i=0.1 ; σ = 300 kPa) > 0.02 l/m·s
$q_{\text{GMFL 4 BOTTOM}}$ (i=1 ; σ = 200 kPa) > 0.2l /m·s

The GMFL drainage geocomposite has a drainage capacity of:

- q: $_{\text{GMFL 4}}$ (i=0.1, σ = 200 kPa) = 0.07 (ISO 12958, hard/hard))
- $q_{\text{GMFL 4}}$ (i=0.1, σ = 400 kPa) = 0.04 (ISO 12958, hard/hard)
- **$q_{\text{GMFL 4}}$ (i=0.1, σ = 300 kPa) = 0.05** (Linear interpolation, hard/hard)
- **$q_{\text{GMFL 4}}$ (i= 1 σ = 200 kPa) = 0.35** (ISO 12958, hard/hard)

5. CALCULATING THE SAFETY FACTOR

Finally, the safety factor of the drainage geocomposite compared with the granular drain is:

KEY: **S.F.** = $q_{\text{GMFL 4 KEY}} / q_{\text{GRAVEL KEY}}$ = 0.05 / 0.02 = **2.5**

BOTTOM: **S.F.** = $q_{\text{GMFL 4 BOTTOM}} / q_{\text{GRAVEL BOTTOM}}$ = 0.35 / 0.2 = **1.75**

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