47060309

CALCULATION SHEET

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Project Title EfW CHP FACILITY NORTH YARD, DEVENPORT.
Project Number
Date 25/10/11

Rev
By JML
check by - GNB

It is proposed that stone filled drainage grips are used to discharge surface water run-off from a proposed access road which will serve a energy from waste plant at Devonport.
The purpose of these calculations is to establish if the drainage grips have sufficient capacity to accomodate run-off from the proposed access road.

The proposed location of these drainage grips is shown on drawing PA19A. The maximum impermeable area that drains to one of these grips is $1000 m^2$

To establish run-off rates from the proposed access road the modified Rational Method developed by HR wallingford (kellagher, R. 2004 Drainage of development sites Wallinford limited) has been used.

$$Q(l/s) = C_v \times C_R \times (2.78 \times I \times A)$$

where:

Q is the discharge rate in l/s
C_v is the Volumetric Runoff Coefficient, typically 0.75 unitless coefficient
C_R is the routing factor, a constant 1.3. unitless Coefficient
I is the rate of rainfall given in mm/hr
A is the contributing impermeable area in hectares.

To establish a rainfall intensity for this calculation, the Flood Estimation Handbook (FEH) has been referenced.

Flood Estimation Handbook intensity calculations for design storms are only calibrated for storms greater than 30 minutes in duration. Although it is noted that the time of concentration may be shorter than this, the 30 minute duration storm has been selected, as this will give the highest intensity data.

For this location the average rainfall intensity for the 1 in 100 year event with 30 minute duration, as taken from FEH data is 76.410mm/hr.

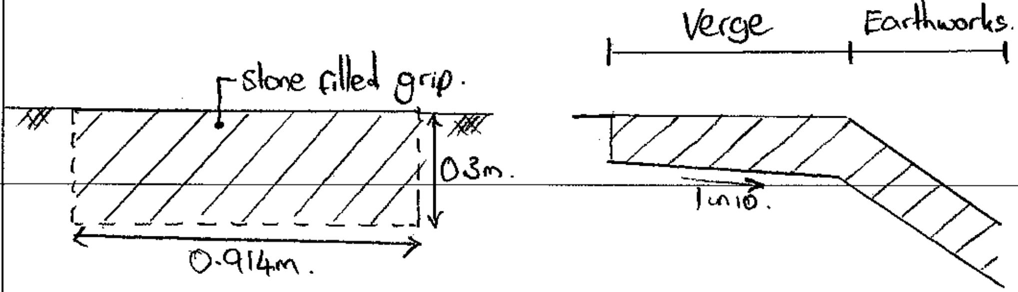
Allowing for a 30% increase due to future climate change, the average intensity is:

$$76.410 \times 1.3 = \underline{99.333\,\text{mm/hr}}.$$

To establish the discharge capacity, and therefore maximum area that a grip can use.

To estimate the flow through the grip, the stone within the grip is assumed to behave as a soil and therefore Darcy's law has been used.

The proposed grip cross-section is shown below, and the minimum longitudinal gradient of the grip base is to be 1:10



Darcy's Law is as follows:

$$\frac{q}{A} = v = ki.$$

where; k = Darcy coefficient of permeability, m/s

i = hydraulic gradient - ratio of head loss over a distance

v = discharge velocity is defined as the quantity of water, q, percolating through a cross-sectional area A in unit time.

Seepage velocity, V_s, is the velocity of water percolating through the voids of the soil.

$$V_s = \frac{q}{A_s} = \frac{V}{n}$$

$$\text{porosity, } n = \frac{\text{volume of voids}}{\text{total volume}}$$

Area of voids $A_s = nA$

Assume:

K = 1 m/s - This is typical for a soil consisting of course gravel (Reference Table 3.3 of 'Soil Mechanics' by G E Barnes).

i = gradient of the grip base = 1/10 = 0.1

n = 0.3 (Assuming 30% voids)

$A_s = 0.3(0.914 \times 0.3) = 0.08226.$

$V = Ki$

$V = 1 \times 0.1$

$V = \underline{0.1 m/s}$.

$V_s = \frac{V}{n}$

$V_s = 0.1/0.3$

$V_s = \underline{0.333 m/s}$

$V_s = \frac{q}{A_s}$.

$q = V_s \times A_s$

$q = 0.333 \times 0.08226$

$q = 0.0274 m^3/s$

$= \underline{27.4 l/s}$.

Therefore the discharge capacity through a drainage grip is estimated to be 27.4 l/s.
To calculate the maximum impermeable area that one grip can accomadate, this discharge rate can be used in the modified Rational equation:

$Q = C_v \times C_r \times (2.78 \times I \times A)$

$27.4 = 0.75 \times 1.3 \times (2.78 \times 99.333 \times A)$.

$27.4 = 0.975(276 A)$

$27.4 = 269 A$

$A = 0.1018$ Ha.

$A = 1018 m^2$.

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This area is greater than the maximum area, which is planned to drain to one grip.

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9/11/2011.

Further to the calculations dated 25/10/11, it has been decided that the longitudanal gradient is to be reduced from 1 in 10 to 1 in 20. The purpose of this is to reduce seepage velocity, which will increase the cleansing properties of the grip. To accomodate different impermeable areas, the below calculations are for two grip widths, 0.914m and 1.828 (these represent standard kerb lengths.

5% longitudonal gradient and 0.914m grip width.

$V = ki$ $\quad k = 1\,m/s$

$i = 1/20 = 0.05$

$V = 1 \times 0.05$

$V = 0.05\,m/s$.

$V_s = \frac{V}{n}$ $\quad n = 0.3$

$V_s = \frac{0.05}{0.3}$

$V_s = 0.166\dot{6}\,m/s$.

$V_s = \frac{q}{A_s}$ $\quad A_s = 0.3(0.914 \times 0.3) = 0.08226$

$q = V_s \times A_s$

$q = 0.16666 \times 0.08226$

$q = 0.01371\,m^3/s$

$q = 13.71\,l/s$.

Therefore the discharge capacity of this drainage grip is estimated to be 13.71 l/s.
To calculate the maximum impermeable area that one grip can accomodate, this discharge rate can be used in the modified Rational Equation:

$$Q = C_v \times C_r \times (2.78 \times I \times A)$$
$$13.71 = 0.75 \times 1.3 \times (2.78 \times 99.333 \times A).$$
$$13.71 = 0.975(276A)$$
$$13.71 = 269A$$
$$A = 0.05097\ Ha$$
$$A = \underline{509.7\ m^2}.$$

<u>5% longitudonal gradient and 1.828m grip width.</u>

$V = ki$ $\qquad$ $k = 1\ m/s.$
$i = 1/20 = 0.05.$

$V = 1 \times 0.05$
$V = 0.05\ m/s.$

$V_s = \frac{V}{n}$ $\qquad$ $n = 0.3.$

$V_s = \frac{0.05}{0.3}$

$V_s = 0.1666\dot{6}\ m/s.$

$V_s = \frac{q}{A_s}$ $\qquad$ $A_s = 0.3(1.828 \times 0.3) = 0.16452$

$q = V_s \times A_s$
$q = 0.16666 \times 0.16452$
$q = 0.0274\ m^3/s$
$q = 27.4\ l/s.$

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Therefore the discharge capacity of this drainage grip is estimated to be 27.4 l/s.
To calculate the maximum impermeable area that one grip can accomodate, this discharge rate can be used in the modified Rational Equation:

$$Q = C_v \times C_r \times (2.78 \times I \times A)$$
$$27.4 = 0.75 \times 1.3 (2.78 \times 99.333 \times A)$$
$$27.4 = 0.975 (276A)$$
$$27.4 = 269A$$
$$A = 0.1018 Ha$$
$$\underline{A = 1018 m^2}$$