

Soakaway calculations

Site – Rear 260 Highstreet, Whaplode PE12 6TG, Application No H23-0907-22

Planning permission approval requires details of the soakaway calculations.

In accordance with Approved Document H of the Building Regulations 2010 (2015 Edition), as the impermeable area serving the soakaway is greater in area than 25m² field testing and design has been conducted following the guidance in BRE 365 – Soakaway design.

The test method for sizing the soakaway is based upon the equation of volumes:

$$I - O = S$$

Where:

I = inflow from impermeable area drained to the soakaway

O = Outflow infiltrating to the soil during rainfall

S = the required storage volume of the soakaway to balance inflow and out flow

Inflow to the soakaway (I)

$$I = A \times R$$

Where:

A = the impermeable area to be drained to the soakaway

R = the total rainfall in the design storm

Calculating the Design Rainfall (R)

Values of design rainfall, R, can be determined using Figure 1 and Tables 1 and 2 of BRE digest – Soakaway design 2016, for different storm durations with a 10-Year return period. The notation M_{X-D} min is used to identify the storm where:

X = the return periods (years)

D = the storm duration (min)

From the map shown in Figure 3, the rainfall ratio, r , for the location of the soakaway = 0.42

Using the determined rainfall ratio in Table 1, scale factor Z_1 , can be applied to the calculation of the 5-year period rainfall total, M_{5-D} min, for different storm durations, D.

The basis for this calculation is the 5-year return period rainfall of 60 min duration (M_{5-60} min). This can be taken to be 20mm for all parts of the UK.

Rainfall Ratio r	Rainfall Duration (D)	Z_1 Factor	M_{10-D} Min Rainfall (mm)
0.42	5	0.38	7.60
0.42	10	0.53	10.60
0.42	15	0.64	12.80
0.42	30	0.81	16.20
0.42	60	1.00	20.00
0.42	120	1.20	24.00
0.42	240	1.42	28.40
0.42	360	1.57	31.40
0.42	600	1.74	34.80
0.42	1400	2.16	43.20

Adjustment for 10-year return period

The required 10-year return period rainfalls used in the soakaway design are calculated by interpolating the growth factors Z_2 from Table 2 of the BRE Digest – soakaway design 2016

Rainfall Duration	M_{5-D} min Rainfall (mm)	M10 Growth factor Z_2	M_{10-D} Min Rainfall (mm)
5	7.60	1.2	9.12
10	10.60	1.22	12.93
15	12.80	1.23	15.74
30	16.20	1.24	20.09
60	20.00	1.24	24.80
120	24.00	1.24	29.76
240	28.40	1.23	34.93
360	31.40	1.21	37.99
600	34.80	1.20	41.76
1400	43.20	1.18	50.98

Calculating impermeable are (A) and Inflow (I)

Impermeable are draining to soakaway (A) =

93.3 m² (dwelling roof area)

$$I = A \times R$$

$$= A \times M_{10-x} \text{ min}$$

Rainfall Duration (D)	M _{10-D} min Rainfall (m)	Drained Area (A) m ²	Inflow (I) m ³
5	0.0091	93.3	0.85
10	0.0129	93.3	1.20
15	0.0157	93.3	1.46
30	0.0201	93.3	1.88
60	0.0248	93.3	2.31
120	0.0298	93.3	2.78
240	0.0349	93.3	3.26
360	0.0380	93.3	3.55
600	0.0418	93.3	3.90

Outflow to the soakaway (O)

$$O = a_{s50} \times f \times D$$

Where:

a_{s50} = internal surface area of the soakaway to 50% effective storage depth: this excludes the base area which is assumed to clog with fine particles and become ineffective in the long term.

f = the soil infiltration rate determined in a soakaway trial pit at the site of the soakaway

D = the storm duration

Calculating a_{s50} for a cellular soakaway (95% void ratio)

2.0m long x 0.8m effective depth x W m wide

$$a_{s50} = 2 \times (2.0 + W) \times (0.8/2)$$

$$= 1.6 + 0.8W \text{ m}^2$$

Calculating soil infiltration rate (f)

$$f = \frac{V_{p75-25}}{A_{p50} \times t_{p75-25}} \quad \text{Using soakaway trial pit data: (Appendix 1)}$$

Volume outflowing between 75% and 25% effective depth:

$$\begin{aligned} V_{p75-25} &= 0.6 \times 0.45 \times (0.60 - 0.35) \\ &= 0.07 \text{ m}^3 \end{aligned}$$

Mean surface area through which outflows occurs:

$$\begin{aligned} A_{p50} &= (0.6 \times 0.3 \times 2) + (0.45 \times 0.3 \times 2) + (0.6 \times 0.45) \\ &= 0.9 \text{ m}^2 \end{aligned}$$

Time for the outflow between 75% and 25% effective depth: (figure)

$$T_{p75-25} = 300 - 21$$

$$= 299 \text{ min}$$

$$f = \frac{0.07}{0.90 \times 299 \times 60}$$

$$= 4.18 \times 10^{-6} \text{ m/s}$$

$$\text{Outflow (O)} = (1.6 + 0.8W) \times (4.18 \times 10^{-6}) \times (D \times 60) \text{ m}^3$$

Soakaway Storage Volume (S)

Calculating Effective volume of soakaway with 95% free volume (S)

$$\begin{aligned} S &= 2.0 \times 0.8 \times W \times 0.95 \\ &= 1.52 W \text{ m}^3 \end{aligned}$$

For Satisfactory storage of the M10-10 min run off:

$$I - O = S$$

$$1.20 - (1.6 + 0.8W) \times (4.18 \times 10^{-6}) \times (10 \times 60) = 1.52W$$

Required soakaway width (W) = 0.75m

The calculation is repeated for the range of M10-D min storms and the results summarised below.

Storm Duration (D – min)	Required Soakaway Width (W – m)
10	0.75
15	0.90
30	1.11
60	1.47
120	1.77
240	2.14

A soakaway 2m long x 0.8m effective depth and 1.47m wide would be suitable, with the critical storm duration being 1 hour for 10-year events

Check on time emptying half storage volume (t_{s50})

$$t_{s50} = \frac{S \times 0.5}{as50 \times f}$$
$$= \frac{(1.52 \times 1.75) \times 0.5}{+ [0.8 \times 1.75] \times (4.18 \times 10^{-6})}$$
$$= 29 \text{ hours}$$

Conclusions

BRE Digest – Soakaway Design States that t_{s50} should be less than 24 hours for additional inflow from subsequent storms.

Various other soakaway sizes and layouts have been considered; while offering greater storage capacity they have no impact on the t_{s50} calculation as this is primarily governed by the soil infiltration rate (f)

The design calculations show that a soakaway measuring 2.0 x 1.47 x 0.8m using plastic crates with a 95% void will provide sufficient storage volume for critical duration of 1 hour for 10-year event

However, the size of the soakaway should be increased to 2.00 x 2.00 x 1.2m to provide the following benefits

- The size is brought in line with that of commercially available soakaway crates.
- The storage volume is increased while maintaining the required distance from buildings, remaining above ground water level and maintaining adequate cover above the soakaway to ground level.
- The increased storage volume provides attenuation capability for subsequent inflow, mitigating against relatively low soil infiltration rate.

Appendix 1

Elapsed Time (min)	Depth of water (M)			
	Day 1	Day 2	Day3	Average
0	0.200	0.2	0.2	0.200
5	0.260	0.255	0.260	0.258
10	0.300	0.295	0.295	0.297
15	0.330	0.325	0.325	0.327
20	0.350	0.340	0.345	0.345
30	0.380	0.360	0.370	0.370
40	0.400	0.390	0.395	0.395
60	0.430	0.425	0.430	0.428
80	0.450	0.445	0.445	0.447
120	0.485	0.465	0.470	0.473
180	0.525	0.515	0.520	0.520
240	0.565	0.550	0.555	0.557
300	0.600	0.585	0.595	0.593
360	0.630	0.610	0.620	0.620

