

Soakaway Calculations

Site address: Single new dwelling adj. 259 High Road, Whaplode, PE12 6TG

Full planning permission has been granted for the erection of a single new residential dwelling under application ref. H23-0607-22, approved 25/08/2022.

Condition 5 of the approval requests details of the proposed soakaway system for the disposal of surface water from the site.

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 Digest 365 – Soakaway Design*.

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

$$I - O = S$$

Where:

I = inflow from the 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 outflow

Inflow to the soakaway (I)

$$I = A \times R$$

Where:

A = the impermeable area drained to the soakaway

R = the total rainfall in a design storm

Calculating 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 $M_{X-D} \text{ min}$ is used to identify the storm, where:

X = the return period (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 return period rainfall total, $M_{5-D} \text{ min}$, for different storm durations, D .

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

Rainfall Ratio r	Rainfall Duration (D)	Z_1 Factor	$M_{5-D} \text{ min}$ 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 Z2 from Table 2 of BRE Digest – Soakaway design 2016.

Rainfall Duration (D)	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 area (A) and Inflow (I)

Impermeable area draining to the soakaway (A) =

64m² (dwelling roof area) + 15m² (garage roof area) = 79m²

$$I = A \times R$$

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

Rainfall Duration (D)	M _{10-D} min Rainfall (m)	Drained Area (A) m ²	Inflow (I) m ³
5	0.0091	79	0.72
10	0.0129	79	1.02
15	0.0157	79	1.24
30	0.0201	79	1.59
60	0.0248	79	1.96
120	0.0298	79	2.35
240	0.0349	79	2.76
360	0.0380	79	3.00
600	0.0418	64	2.67

Outflow from 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 soakage 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

$$\begin{aligned} a_{s50} &= 2 \times (2.0 + W) \times (0.8 \div 2) \\ &= 1.6 + 0.8W \text{ m}^2 \end{aligned}$$

Calculating soil infiltration rate (f)

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

Volume outflowing between 75% & 25% effective depth:

$$\begin{aligned} V_{p75-25} &= 0.6 \times 0.45 \times (0.657 - 0.373) \\ &= 0.10 \text{ m}^3 \end{aligned}$$

Mean surface area through which outflow occurs:

$$\begin{aligned} A_{p50} &= (0.6 \times 0.285 \times 2) + (0.45 \times 0.285 \times 2) + (0.6 \times 0.45) \\ &= 0.87 \text{ m}^2 \end{aligned}$$

Time for the outflow between 75% & 25% effective depth: (Figure 1)

$$\begin{aligned} t_{p75-25} &= 540 - 90 \\ &= 450 \text{ min.} \end{aligned}$$

$$\begin{aligned} f &= \frac{0.10}{0.87 \times 450 \times 60} \\ &= 3.55 \times 10^{-6} \text{ m/s} \end{aligned}$$

$$\text{Outflow (O)} = (1.6 + 0.8W) \times (3.55 \times 10^{-6}) \times (D \times 60) \text{ m}^3$$

Soakaway storage volume (S)

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

$$S = 2.0 \times 0.8 \times W \times 0.95$$

$$= 1.52W \text{ m}^3$$

For satisfactory storage of the M_{10-10} min run-off:

$$I - O = S$$

$$1.02 - (1.6 + 0.8W) \times (3.55 \times 10^{-6}) \times (10 \times 60) = 1.52W$$

$$\text{Required soakaway width (W)} = 0.67\text{m}$$

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

<i>Storm Duration (D – min)</i>	<i>Required Soakaway Width (W – m)</i>
10	0.67
15	0.81
30	1.04
60	1.27
120	1.51
240	1.72
360	1.83
600	1.92

A soakaway 2m long x 0.8m effective depth x 1.92m wide would be suitable, with the critical storm duration being 10 hours for 10-year events.

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

$$t_{s50} = \frac{S \times 0.5}{as50 \times f}$$

$$= \frac{(1.52 \times 1.92) \times 0.5}{(1.6 + [0.8 \times 1.92]) \times (3.55 \times 10^{-6})} \text{ seconds}$$

$$= 36 \text{ hours}$$

Conclusions

BRE Digest 365 – Soakaway Design states that t_{s50} should be less than 24 hours to allow 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 proposed soakaway location, as shown on drawing 1034-4001 is the only feasible location on the site. The area of the soakaway is constrained by the requirement to maintain a distance of 5m from buildings, and the depth by the requirement for the base to remain above the ground water level.

The design calculations show that a soakaway measuring 2.00 x 1.92 x 0.8m and using plastic crates with a 95% void ratio will provide sufficient storage volume for the critical storm duration of 10 hours for 10-year events.

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 the 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 the relatively low soil infiltration rate.

Appendix 1

Soakaway trial pit field data

Elapsed Time (min.)	Depth to Water (m)
0	0.230
1	0.236
2	0.246
3	0.252
6	0.260
9	0.271
12	0.278
18	0.287
24	0.297
30	0.307
60	0.344
90	0.376
120	0.401
180	0.447
240	0.488
300	0.521
360	0.556
420	0.586

