SOAKAWAY DESIGN

Dr. Ahmed Ismail

Email: ahmedesmailmarie@gmail.com

Website: ahmedesmail.com and hawktips.com

TABLE OF CONTENTS

1 INTRODUCTION

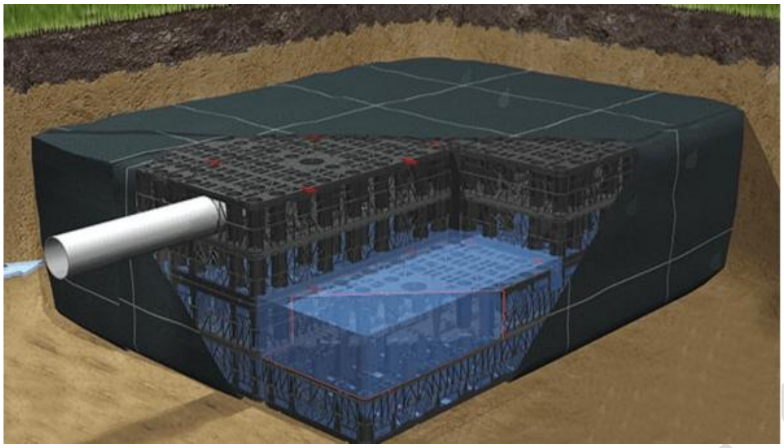
1.1 Usage of Soakaway

Soakaways are used to store the immediate surface water run-off from hard surfaced areas, such as roofs or car parks, and allow for efficient infiltration into the adjacent soil. They discharge their stored water sufficiently quickly to provide the necessary capacity to receive run-off from a subsequent storm.

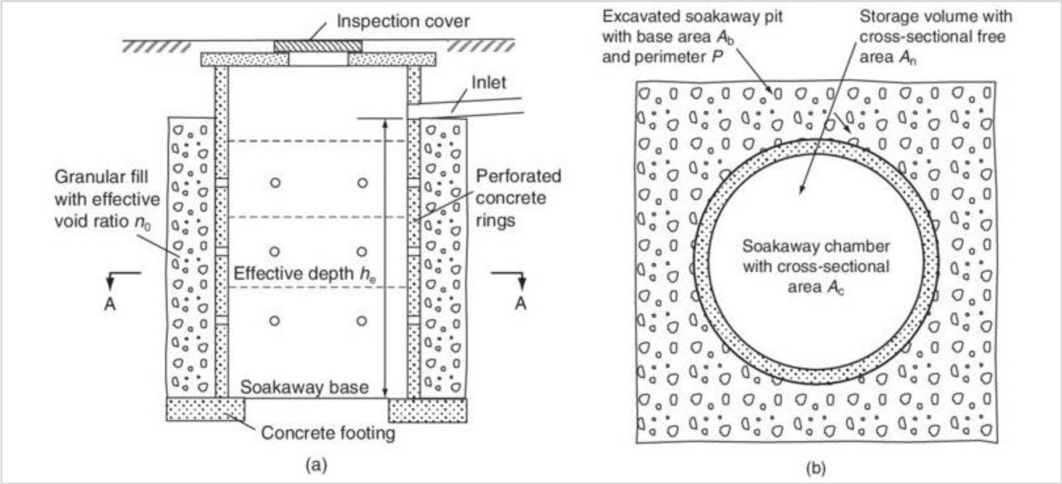
The time taken for discharge depends upon the soakaway shape and size, and the surrounding soil's infiltration characteristics.

1.2 Shape of Soakaway

Soakaways can be square, circular (conventional), or trench excavations.



Square or Rectangular Soakaway



Dr. Ahmed Ismail

Email: ahmedesmailmarie@gmail.com

Website: ahmedesmail.com and hawktips.com

Circular Soakaway

Trench Soakaway

1.3 Media of Soakaway

They can be filled with **rubble**, **Granular (gravel or brickwork)**, **plastic cells**, **perforated pre-cast concrete ring units** or any similar structure that collects rainwater and run-off. The structures are built to allow rainwater to infiltrate directly into the ground. Soakaways can also be deep bored.

perforated pre-cast concrete ring units	plastic cells	gravel or brickwork
		

1.4 Soakaway may not be an appropriate solution:

There are times when a soakaway may not be an appropriate solution,

- ❖ In areas of ground that have low permeability,
- ❖ Where surface water could be contaminated.
- ❖ The maximum seasonal water table should be above the base of the soakaway; contaminants in the ground could be mobilised,
- ❖ In areas of instability.

Dr. Ahmed Ismail

Email: ahmedesmailmarie@gmail.com

Website: ahmedesmail.com and hawktips.com

2 DESIGN AND CONSTRUCTION CONSIDERATIONS

2.1 General

- ❖ Soakaways can provide a long-term, effective method of disposal of surface water from impermeable areas of several hundred square metres.
- ❖ Long-term maintenance and inspection must be considered during the design and construction process.
- ❖ Risk of pollution to the quality of groundwater must be considered.
  - ➢ Roof surface run-off should not cause damage to groundwater quality and may be discharged directly to soakaways. Those pollutants entering the soakaway from roofs tend to remain in the soakaway, or in its immediate environs, attached to soil particles.
  - ➢ Paved surface run-off for larger trafficked areas should be passed through a suitable form of oil interception device prior to discharge to the soakaway.
- ❖ Maintenance of silt traps, gully pots and interceptors will improve the long-term performance of soakaways.
- ❖ Soakaways should not normally be constructed closer than 5 m to building foundations.

2.2 Sustainable drainage

Sustainable drainage is a departure from the traditional piped approach to draining sites. Sustainable Drainage Systems (SUDS) mimic natural drainage through:

- ❖ Storing run-off rainwater and releasing it slowly (attenuation).
- ❖ Allowing water to soak into the ground (infiltration).
- ❖ Slowly transporting (conveying) water on the surface.
- ❖ Filtering out pollutants.
- ❖ Allowing sediments to settle out by controlling the flow of water.

Soakaways are one of the key technologies for SUDS. They enable stormwater to be dealt with at source rather than being diverted directly into the sewer system; they also satisfy the criteria listed in the bullet points above.

2.3 Cost and performance

The size and complexity of the soakaway largely dictates the costs involved.

- Overall the cost of a soakaway can be described as low/medium compared with conventional drainage.
- Larger soakaways cost more to construct due to:
  - Higher labour costs and the use of more construction materials;
  - Disposal of excavated soil may also be an issue.

Running and maintenance costs are low, with routinely undertaken tasks as follows:

- Removal of sediments and debris from pre-treatment devices (leaf screens, sedimentation chambers, filter strips and swales).
- Cleaning of gutters or filters on downpipes.
- Removal of roots causing blockages.
- Monitoring performance.

Email: ahmedesmailmarie@gmail.com
Website: ahmedesmail.com and hawktips.com

3 DESIGN

3.1 Principles

The design of a soakaway depends on a number of factors including the following:

- Permeability of the ground.
- Groundwater level (preferably undertaken when water levels will be highest, during winter to spring)
- Type of ground
- Contamination
- Space restrictions
- Building foundations (It is not desirable to locate a soakaway close to a building. A minimum distance of 5 m is most often quoted)
- Risk of ground instability and other hazards.

Perforated pre-cast concrete ring unit soakaways should be installed within a square pit, with sides about twice the selected ring unit diameter.

- Granular fill can be separated from the surrounding soil by a suitable geotextile to prevent migration of fine particles into the soakaway.
- The top surface of the granular fill should also be covered with geotextile to prevent the ingress of fill material during and after surface reinstatement.
- Geotextile should not be wrapped around the outside of the ring units as it cannot be cleaned satisfactorily or removed when it has become blocked.

In order to limit any possible alteration to the quality of groundwater, attention should be paid to the source of the run-off water that is to be collected.

- If it is from a paved surface where there is a risk of oil or fuel spillage, a light liquid separator should be provided.
- Domestic drives and paths should not need a light liquid separator, but municipal roads and car parks will require them.

For drained areas less than 100 m^2, soakaways can be:

- square or circular pits, either filled with rubble or lined with dry-jointed brickwork, or perforated pre-cast concrete ring units surrounded by suitable granular fill.

For drained areas above 100 m^2, soakaways can be:

- ❖ perforated pre-cast ring units or trench type and not substantially deeper than soakaways that serve small areas:
  - ➢ 3 to 4 m is adequate if ground conditions allow.

There is an increasing number of soakaways that are being built using plastic cells.

- ❖ These are typically lightweight modular water storage cells with a high void ratio.
- ❖ Plastic cells can be used for either attenuation or infiltration of surface water in residential, commercial, industrial and retail applications.
- ❖ Proprietary components such as silt traps, flow control units and adaptors will normally be used as part of these systems.

3.2 Site Investigation and Testing

Site investigation and testing should be carried out prior to design or construction work taking place; this is part of the design process.

The site investigation will be required to assess the following:

- ❖ Water table depth and perched water table presence/depth (based on the worst annual case, ie during April or May). Groundwater levels should be investigated to ensure that the base of the proposed infiltration component is at least 1 m above the maximum anticipated groundwater level.
- ❖ Chemical contamination risks
- ❖ Suitability of strata for soakaway discharges, including permeability.

In the site investigation, boreholes and/or soakage trial pits can be used to determine the ground condition, soil material and presence and depth of groundwater.

3.3 Risk assessment

The information gathered during the site investigation should be used to prepare a risk assessment, which may be required by planning and building development authorities. Issues of interest are chemical contamination, ground failure features and the effects of adjacent development.

- ❖ The soakaway should not connect a contamination source to a groundwater target, ie creating a source-pathway-receptor linkage.

Email: ahmedesmailmarie@gmail.com

Website: ahmedesmail.com and hawktips.com

- ❖ Ground and slope instability, flooding and wash out-induced settlements should be considered.

3.4 Soil infiltration

Site testing for soil infiltration rates should give representative results for the proposed site of the soakaway. This is achieved by the following:

- ❖ Excavating a soakage trial pit of sufficient size to represent a section of the soakaway.
- ❖ Filling the soakage trial pit several times in quick succession while monitoring the rate of seepage.
- ❖ Examining site data to ensure that the area surrounding the soakaway has been assessed for variations in soil conditions, areas of filled land, preferential underground seepage routes, variations in the level of groundwater, and any geotechnical and geological factors likely to affect the long-term percolation and stability.

3.5 Rate test

Field investigations are required to confirm infiltration rates. The procedure recommended in this Digest is to excavate a soakage trial pit to the same depth as anticipated in the full-size soakaway.

- ❖ For run-off from 100 m^2 this will be 1 m to 1.5 m below the invert level of the drain discharging to the soakaway.
- ❖ Overall depths of excavation will be typically 1.5 m to 2.5 m for permeable areas >100 m^2 draining to the soakaway.
- ❖ The soakage trial pit should be 1 m to 3 m long and 0.3 m to 1 m wide. It should have vertical sides trimmed square and, if necessary for stability, should be filled with granular material.

Fill the soakage trial pit and allow it to drain three times to near empty. Each time record the water level and time from filling, at intervals sufficiently close to clearly define water level versus time. The filling of the soakage trial pit should be on the same or consecutive days.

Email: ahmedesmailmarie@gmail.com
Website: ahmedesmail.com and hawktips.com

3.6 Sizing

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

$$I - O = S$$

where:

- I = the inflow from the impermeable area drained to the soakaway
- O = the outflow infiltrating into the soil during rainfall
- S = the required storage in the soakaway to balance temporarily inflow and outflow.

3.6.1 Inflow to the Soakaway

$$Q = \frac{CIA}{360}$$

where:

- Q = maximum rate of runoff (m^3/s)
- C = runoff coefficient (refer to Table 1)
- I = rainfall intensity with a duration equal to the time of concentration (mm/hr) (For Dubai refer to Table 2Table 1)
- A = drainage area (ha)

Table 1: Rational Method Runoff Coefficients for Urban Watersheds (FHWA, 2001)

Type of Drainage Area	Runoff Coefficient
Business	
Downtown areas	0.70 - 0.95
Neighbourhood areas	0.50 - 0.70
Residential	
Single-family areas	0.30 - 0.50
Multi-units, detached	0.40 - 0.60
Multi-units, attached	0.60 - 0.75
Suburban	0.25 - 0.40
Apartment dwelling areas	0.50 - 0.70

Email: ahmedesmailmarie@gmail.com

Website: ahmedesmail.com and hawktips.com

Industrial	
Light areas	0.50 - 0.80
Heavy areas	0.60 - 0.90
Parks, cemeteries	0.10 - 0.25
Playgrounds	0.20 - 0.40
Railroad yards	0.20 - 0.40
Railroad yards	0.20 - 0.40
Unimproved areas	0.10 - 0.30
Lawns	
Sandy soil, flat, 2%	0.05 - 0.10
Sandy soil, average, 2-7%	0.10 - 0.15
Sandy soil, steep, 7%	0.15 - 0.20
Heavy soil, flat, 2%	0.13 - 0.17
Heavy soil, average, 2-7%	0.18 - 0.22
Heavy soil, steep, 7%	0.25 - 0.35
Streets	
Asphaltic	0.70 - 0.95
Concrete	0.80 - 0.95
Brick	0.70 - 0.85
Drives and walks	0.75 - 0.85
Roofs	0.75 - 0.95

Table 2: Dubai IDF values including the Estimated, Upper Limit and Mean values

Return Period (years)	Intensity (mm/h) in different durations														
	1min	5min	10min	15min	20min	30min	45min	60min	90min	2h	3h	4h	5h	6h	12h	24h
2	84.32	59.60	41.74	32.09	25.71	18.62	13.77	11.27	8.19	6.63	5.12	4.12	3.43	3.00	1.89	1.04
	118.14	85.63	60.34	46.48	37.58	27.41	20.46	16.39	11.79	9.48	7.21	5.80	4.86	4.29	2.82	1.60
	101.23	72.62	51.04	39.29	31.65	23.02	17.12	13.83	9.99	8.06	6.17	4.96	4.15	3.65	2.36	1.32
5	126.78	92.28	65.10	50.16	40.61	29.66	22.17	17.70	12.72	10.21	7.74	6.23	5.22	4.61	3.05	1.75
	178.72	132.25	93.67	72.25	58.84	43.17	32.45	25.55	18.25	14.59	10.95	8.80	7.41	6.59	4.47	2.61
	152.75	112.27	79.39	61.21	49.73	36.42	27.31	21.63	15.49	12.40	9.35	7.52	6.32	5.60	3.76	2.18
10	154.90	113.92	80.57	62.12	50.48	36.98	27.73	21.95	15.71	12.58	9.48	7.62	6.40	5.68	3.82	2.22
	221.54	165.20	117.22	90.47	73.87	54.30	40.92	32.03	22.80	18.20	13.59	10.92	9.21	8.21	5.64	3.33
	188.22	139.56	98.90	76.30	62.18	45.64	34.33	26.99	19.26	15.39	11.54	9.27	7.81	6.95	4.73	2.78
20	181.87	134.68	95.40	73.59	59.95	43.99	33.07	26.03	18.58	14.86	11.14	8.96	7.54	6.70	4.56	2.67
	263.40	197.42	140.25	108.28	88.57	65.19	49.21	38.36	27.26	21.73	16.18	13.00	10.97	9.80	6.79	4.02
	222.64	166.05	117.83	90.94	74.26	54.59	41.14	32.20	22.92	18.30	13.66	10.98	9.26	8.25	5.68	3.35

	190.43	141.26	100.11	77.23	62.95	46.21	34.76	27.32	19.49	15.58	11.67	9.38	7.90	7.03	4.79	2.81
25	276.78	207.71	147.61	113.97	93.27	68.67	51.85	40.39	28.69	22.86	17.00	13.66	11.53	10.31	7.15	4.25
	233.61	174.49	123.86	95.60	78.11	57.44	43.31	67.71	24.09	19.22	28.67	11.52	9.72	8.67	5.97	3.53
	216.78	161.54	114.61	88.45	72.21	53.07	39.98	31.31	22.30	17.80	13.30	10.69	9.01	8.03	5.51	3.25
50	318.19	239.57	170.39	131.59	107.80	79.44	60.05	46.65	33.10	26.35	19.56	15.71	13.27	11.88	8.28	4.94
	267.49	200.56	142.50	110.02	90.01	66.26	50.02	38.98	27.70	22.08	16.43	13.20	11.14	9.96	6.90	4.10
	242.94	181.67	129.00	99.58	81.39	59.87	45.16	35.27	25.08	20.01	14.91	11.98	10.11	9.02	6.23	3.68
100	359.49	271.35	193.11	149.16	122.30	90.18	68.22	52.90	37.49	29.84	22.11	17.76	15.01	13.45	9.41	5.62
	301.22	226.51	161.06	124.37	101.85	75.03	56.69	44.09	31.29	24.93	18.51	14.87	12.56	11.24	7.82	4.65

3.6.2 Outflow from the Soakaway

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

where:

- ❖ a_{s50} = the 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.

3.6.3 Required storage volume in the soakaway, S

Storage must be equal to, or greater than, inflow minus outflow, defined above in sections 3.6.1 and 3.6.2, and is the required effective volume available between the base of the soakaway and the invert of the drain discharging to the soakaway.

<u>There are four steps in the design procedure:</u>

1. Carry out a site investigation to determine the soil infiltration rate;
2. Decide on a construction type (eg filled pit in square, circular or trench form, or concrete ring units with granular surround);

Dr. Ahmed Ismail

Email: ahmedesmailmarie@gmail.com

Website: ahmedesmail.com and hawktips.com

3. Calculate required storage volume, S, from inflow minus outflow for a range of durations of 10-year design storms to determine the maximum storage predicted for the type of soakaway (or as per the design manual);
4. Review the design to ensure its overall suitability considering space requirements, site layout and time for emptying.

$$O = W * L * d * (V\%)$$

Where:

- ❖ W = Width of the soakaway;
- ❖ L = Length of the soakaway;
- ❖ D = Depth of the soakaway (Soakaway height); (Trench soakaway depths should generally be between 1 and 2 m. (According to SuDS)
- ❖ V% = Void ratio of fill material (voids volume/total volume) According to SuDS Manual, the void ratio of the different types of media as the following table:

Material	Porosity, v
Geocellular systems	0.90 - 0.95
Uniform gravel	0.30 - 0.40
graded sand or gravel	0.20 - 0.30

For Example: A perforated concrete ring soakaway may be installed in a square or rectangular plan excavation and the gap between the rings and the soil filled with clean stone. Under these circumstances an effective porosity, v', applies.

$$v' = \frac{\pi(r')^2 + v(WL - \pi(r')^2)}{WL}$$

where

- ❖ r' = radius of the ring sections (m)
- ❖ W = width of the excavation (m)
- ❖ L = length of the excavation (m)

3.6.4 Time of Emptying of Soakaway

The infiltration component should discharge from full to half‐full within a reasonable time so that the risk of it not being able to manage a subsequent rainfall event is minimized. It is usual to specify that half emptying occurs within 24 hours (or as per the design manual).

Check on time of emptying half storage volume, t_{s50}:

$$t_{s50} = \frac{S \ * 0.50}{a_{s50} \ * f}$$

<u>As Per Dubai Municipality, The following criteria shall be considered for sizing of Modern Plastic Soakaways:</u>

Parameter	Design Criteria
Design with overflow arrangement ARI	10-year
Design without overflow arrangement ARI	25-year
Emptying time at low level	5 days
Emptying time at high level	2-3 weeks

It shall be noted that the emptying time for the higher level is approximate. Actual emptying time may vary depending on the infiltration rate or outlet sizing based on the lower level emptying time.

4 REFERENCES

- BRE (1991) Soakaway design, BRE Digest 365.
- CIRIA SuDS Manual 2015

Dr. Ahmed Ismail

Email: ahmedesmailmarie@gmail.com

Website: ahmedesmail.com and hawktips.com