Annexe 5

Sizing pits for pit latrines and determining their infiltration capacity

Calculating the size of pits for latrines, and assessing their infiltration capacity

In this annexe we will look at how we can calculate the size of a pit of a pit latrine, and we present a method for assessing how much liquid could be discharged in the pit.

Materials needed:

- Ruler which allows to measure in mm
- A transparent jar with cover
- A watch which indicates seconds
- Possibly a calculator

Determining the required size of a pit

The liquids in the pit will normally infiltrate into the soil, and excreta and anal cleansing material will decompose over time. What stays behind in the pit are decomposed solids.

To determine what volume a pit will have to be, we have to know how much of these solids (sludge) will accumulate during its period of use. Table E.1 presents estimates on how much solids will accumulate in pits used under different circumstances. These are the sludge accumulation rates.

Table A5.1. Approximate sludge accumulation rates in pit latrines [30]

Anal cleansing material	*Wet pit [a]*	*Dry pit [b]*
Water	40 l/p/y (0.04 m^3/p/y)	60 l/p/y (0.06 m^3/p/y)
Solid material (e.g. stones, corncobs)	60 l/p/y (0.06 m^3/p/y)	90 l/p/y (0.09 m^3/p/y)

[a] : a pit in which the excreta are in the (ground)water
[b] : a pit in which the excreta are not in liquid
l/p/y : litres per person per year
m^3/p/y : cubic metres per person per year

The values presented in table A5.1 are values that can be used when designing a latrine which will be used for several years.

It takes time for the solids to decompose, and the sludge will accumulate at a higher rate over the short term. If a latrine is designed for short term use, the accumulation rates from table E.1 will have to be multiplied by 1½.

The volume of the sludge that will accumulate over the design life (i.e. the total time over which the pit will be used) can be calculated with the formula [(30)]:

$$V_s = R \times P \times N$$

V_s : approximate volume of sludge that will be produced (in m^3)
R : estimated sludge accumulation rate per person (see table E.1 (in $m^3/p/y$))
P : the average number of people using the latrine over the design life
N : the design life of the pit (in years)

A family of 6, who would build a latrine with a dry pit, and who would use water for anal cleansing, would accumulate over a period of 15 years a volume of around (0.06 x 6 x 15) = 5.4 m^3.

Two additional things have to be taken into account when sizing the pit that has to be dug: the pit should be taken out of use when the level of the sludge in the pit has reached 0.5 metres below the slab [(57)], and if the pit needs to be lined, the lining may take an important volume.

Thus, if in our example a rectangular pit would be dug of 1.6 x 1.4 metres, and it would have to be lined from the bottom to the top[1] with blocks 0.1 metres wide, the pit would only have an effective size of around 1.4 x 1.2 metres (we lose the width of the blocks on two sides). The horizontal surface of the pit would be (1.4 m x 1.2 m) = 1.68 m^2. To be able to contain 5.4 m^3 of sludge, the pit would need to be (5.4 m^3/1.68 m^2) = 3.2 metres deep. As the top 0.5 metres of the pit can not be used, the total depth of the pit should be (3.2 m + 0.5 m =) 3.7 metres.

Determining the infiltration capacity of the pit

To avoid that a structure will flow over, the infiltration capacity of the pit needs to be sufficient to allow all the liquid to seep away. The infiltration capacity of a pit depends mainly on the type of the liquid, the surface area which allows infiltration, and the soil type.

The liquid that seeps out of a latrine pit will cause a partial blockage of the pores in the soil. This means that the infiltration capacity of a pit used for excreta will be

[1] Only the top 0.5 metres of a lining should be completely sealed. Below this, the lining should have sufficient openings to allow the liquid to seep into the surrounding soil

much lower than the infiltration capacity of an identical pit used for clean water. The figures we present here take into account this reduced capacity of infiltration of the soil.

The bottom of the pit will most probably clog up and become impermeable. Therefore only the vertical sides of the pit will be used to calculate the infiltration capacity [(30)].

The area of the pit which allows infiltration is the surface area of the bare soil. An impermeable lining (e.g. bricks, blocks, concrete) hinders infiltration. Only the openings in the lining should therefore be used to determine the surface of the infiltration area.

Liquid infiltrates into the soil because its hydraulic gradient is higher than that of the water in the surrounding soil. Therefore only the surface of the pit above the water table should be used to calculate the infiltration area [(57)].

In other words, the effective infiltration area is all bare soil on the vertical sides of a pit which are above the groundwater table (and below 0.5 metres under the slab).

> In our example the actual size of the pit is 1.4 x 1.2 x 3.7 metres. As the top 0.5 metres of the pit should not be used, the effective depth of the pit is 3.2 metres. The pit will thus have two sides of 1.4 x 3.2 metres, and two sides of 1.2 x 3.2 metres. This gives a total surface area of ((2 x (1.4 x 3.2)) + (2 x (1.2 x 3.2))) = 16.6 m^2. If the blocks are laid in a honeycomb structure which leaves ¼ of the soil exposed, the effective area of infiltration will be (¼ x 16.6 m^2) = 4.2 m^2. As the pit is dry, all this area is used.
>
> (However, if during the wet season there is 1.5 metres of water in the pit, the effective depth of the pit would be (3.2 – 1.5 m) = 1.7 metres. The effective size of the pit would be ((2 x (1.4 x 1.7)) + (2 x (1.2 x 1.7))) = 8.8 m^2, and the area of infiltration (¼ x 8.8 m^2) = 2.2 m^2).

To estimate the potential infiltration capacity of the soil the following method can be used.

A transparent jar is half filled with soil, and topped up to three quarters with water. The jar is shaken vigorously to bring all soil in suspension and to break up all soil (no lumps of soil should be left). The jar is placed on a flat surface and the time taken. A mark is made to where the particles have settled after 25 seconds; this part are stones and sand. A second mark is made after 60 seconds, this part is silt. After 24 hours, clay will have settled out.

If the sample contains sand, silt and clay, three layers will have been identified. An estimate of the percentages of the different categories of particles can be found with the formula:

$$Per_{lay} = \left(\frac{Th_{lay}}{Th_{tot}} \right) \times 100\ \%$$

Per_{lay} : percentage of the specific category of particles
Th_{lay} : thickness of the specific layer (in mm)
Th_{tot} : total thickness of all layers (in mm)

There are four possibilities (adapted from 249,268,281):

Sand	***Silt***	***Clay***	***Infiltration capacity (in litres per m² per day)***
-	-	over 40%	under 10 l/m²/d
-	over 50%	20-40%	around 10 l/m²/d
over 50%	under 50%	under 20%	around 25 l/m²/d
over 90%	-	-	around 33 l/m²/d

- : percentage is unimportant

If we would find in our test a layer of sand of 31 mm, silt 20 mm, and clay 6 mm (total thickness of all layers: 57 mm), than the percentages of the different particles would be: sand ((31/57 mm) x 100%) = 54%; silt ((20/57 mm) x 100%) = 35%; and clay ((6/57 mm) x 100%) = 11%. This would mean that the infiltration capacity of our soil would probably be around 25 $l/m^2/d$.

The infiltration capacity of a pit can be calculated with the formula:

$$Ic_{pit} = A_{pit} \times Ic_{soil}$$

Ic_{pit} : infiltration capacity of the pit (in litres/day)
A_{pit} : effective surface of infiltration of the soil (in m^2)
Ic_{soil} : the infiltration capacity of the soil (in litres/m^2/day)

In the latrine of our example, the pit could deal with a supply of around (4.2 m^2 x 25 $l/m^2/d$) = 105 litres per day. This means that if the local water usage is around 15 litres per person per day, it would be acceptable for the 6 users to dispose of their wastewater in the latrine. If the water supply would be upgraded though, the latrine would probably not be able to cope with the wastewater.