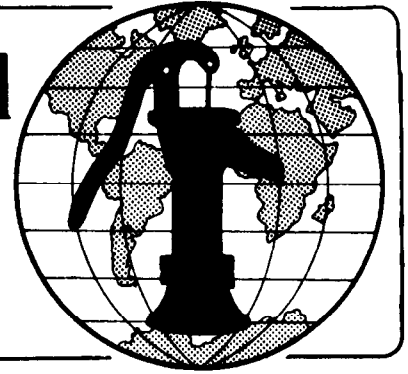# Water for the World

Designing Septic Tanks
Technical Note No. SAN. 2.D.3

Designing a septic tank involves selecting a location for the tank, calculating the tank's capacity and dimensions, and determining the necessary labor, materials, and tools. The products of the design process are (1) a location map, (2) a plan and elevation view of the tank, and (3) a detailed materials list. These items should be given to the construction foreman before construction begins.

This technical note describes how to design a septic tank and arrive at these three end-products. Read the entire technical note before beginning design procedures.

Materials Needed

Measuring tape - To obtain accurate field information for a location map

Ruler - To draw a location map

Location

Locate the septic tank downhill and at least:

15m from the nearest water supply, including the neighbors',
3m from the nearest building,
3m from the property line.

Do not put the septic tank in an area where rainwater or other surface water will flow over or stand on it, or where vehicles will drive over it. When looking for a location for the septic tank, draw a map of the lot showing actual distances from the septic tank to water supplies, dwellings, property lines, vegetation, any other manmade or prominent geographical features, and the proposed (or actual) site of the subsurface absorption system (see "Designing Subsurface Absorption Systems," SAN.2.D.1).

Figure 1 is a sample location map. The actual location map will be needed by the construction foreman prior to and during construction, and will enable him to locate the system properly.
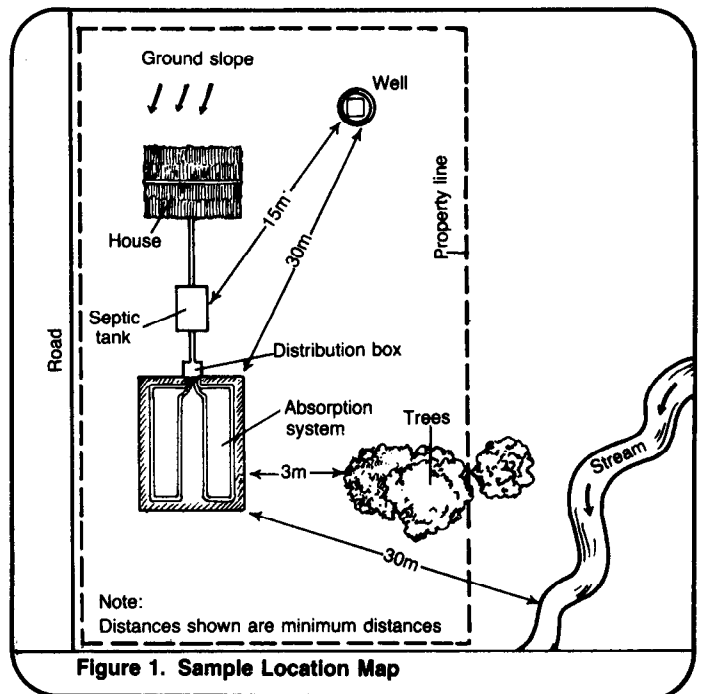

Figure 1. Sample Location Map

General Design Information

Study Figure 2 while following these steps.

1. All sewage from the building to be served should enter the septic tank. This includes both excreta and washwater, but it does not include rainwater, surface water, or subsurface drainage.
2. The septic tank walls may be made of poured reinforced concrete, brick, concrete blocks, or stone masonry. The walls must be watertight. A 25mm thick inside coating of cement plaster, usually applied in two 12mm coats, is needed to make laid-up walls watertight.
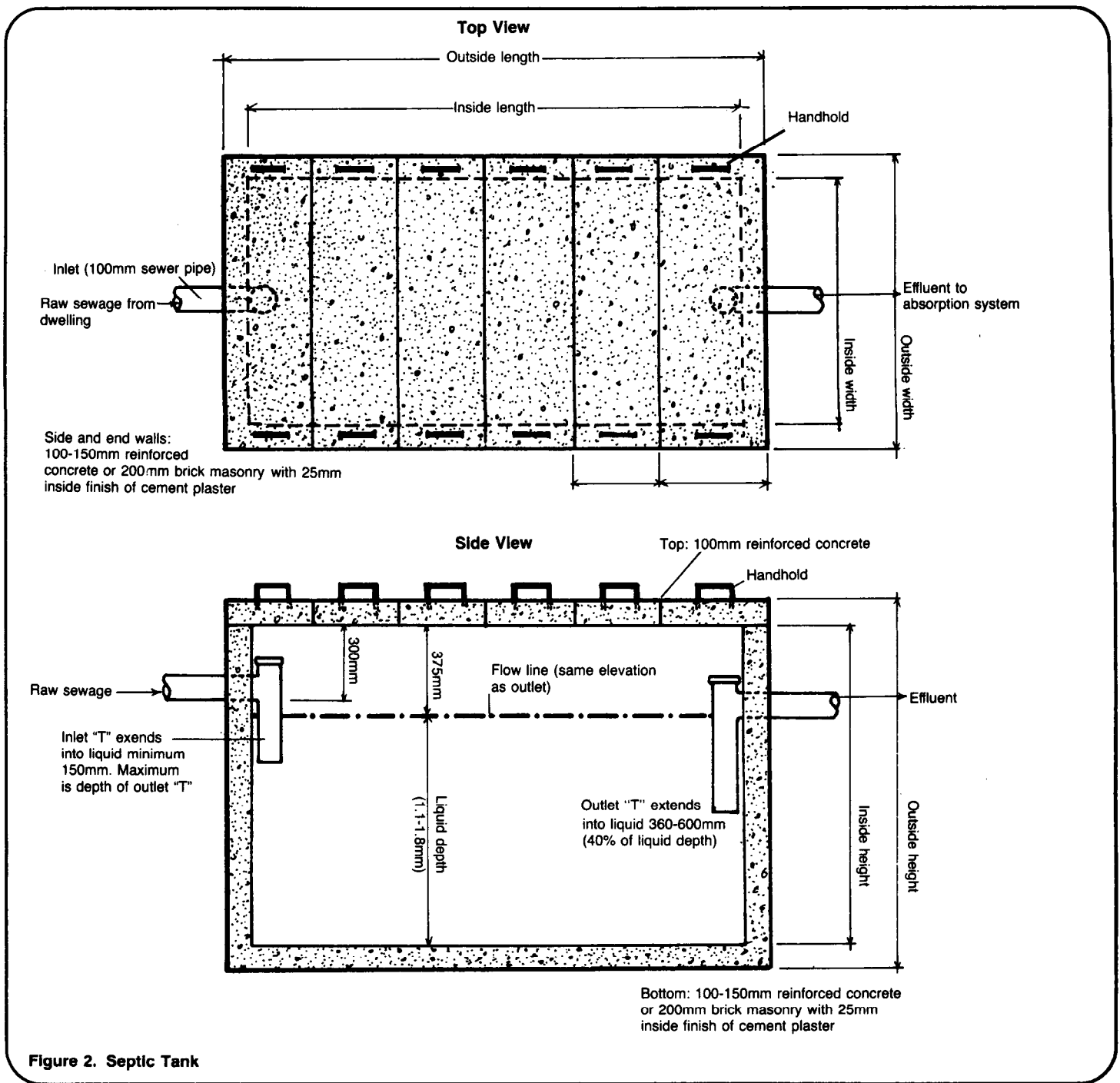
Figure 2. Septic Tank

Top View

Outside length
Inside length
Handhold

Inlet (100mm sewer pipe)

Raw sewage from dwelling

Effluent to absorption system

Inside width
Outside width

Side and end walls: 100-150mm reinforced concrete or 200mm brick masonry with 25mm inside finish of cement plaster

Side View

Top: 100mm reinforced concrete
Handhold

300mm
375mm
Flow line (same elevation as outlet)

Raw sewage →

Inlet "T" exends into liquid minimum 150mm. Maximum is depth of outlet "T"

Liquid depth (1.1-1.8mm)

Outlet "T" extends into liquid 360-600mm (40% of liquid depth)

Effluent

Inside height
Outside height

Bottom: 100-150mm reinforced concrete or 200mm brick masonry with 25mm inside finish of cement plaster

Figure 2. Septic Tank

3. The floor of the septic tank should be made of reinforced concrete 100-150mm thick and should rest on a bed of gravel or sand 75mm thick.

4. The tank must have a strong, watertight top, usually made of reinforced concrete. The top should be designed in 300mm wide sections, with each section as long as the septic tank is wide and equipped with a handhold near each end. One or two sections over the outlet end can be removed to inspect the tank. All or most of the sections can be removed to clean the tank.

5. Predesigned, prefabricated tanks may be available. They are made of fiberglass, precast reinforced concrete, or steel. The most important consideration with these tanks is selecting the proper capacity (see next page, "Steps in Design").

6. The recommended liquid depth in the tank is 1.2m, however, it may be as shallow as 1.1m or as deep as 1.8m.

7. The length of the tank is two to three times its width (see Table 1).

8. The bottom of the inlet pipe (the pipe entering the septic tank, not the "T" fitting) is 300mm below the top of the tank. The bottom of the outlet pipe (the pipe leaving the septic tank, not the "T" fitting) is 75mm below the bottom of the inlet pipe, or 375mm below the top of the tank (see Figure 2).

9. The inlet and outlet pipes are fitted with open "T" sewer pipe fittings.

10. The sewer pipe from the source of sewage to the septic tank and from the septic tank to the subsurface absorption field is made of vitrified clay, concrete, special plastic, or other noncorrosive material, and is usually 100mm in diameter.

11. After the tank has been constructed and installed, the space between the septic tank's outside walls and the earth sides of the hole should be carefully filled and the septic tank should be covered with dirt to grade level or above.

Table 1. Suggested Septic Tank Dimensions

Volume liters	Length, inside meters	Width, inside meters	Liquid Depth meters
1100	1.5	0.7	1.1
1500	1.8	0.9	0.9
1900	1.8	0.9	1.2
2800	2.3	1.1	1.2
3800	2.7	1.2	1.2
4700	3.4	1.2	1.2
5700	3.2	1.5	1.2
7600	4.3	1.5	1.2
9500	4.4	1.8	1.2
11000	5.2	1.8	1.2
13000	4.9	1.8	1.5
15000	4.9	2.2	1.5
19000	5.9	2.2	1.5
23000	6.2	2.4	1.5
26000	7.3	2.4	1.5
30000	7.0	2.4	1.8
38000	8.5	2.4	1.8

Steps in Design

Refer to Worksheet A in following these steps. This is only a sample that has been filled out; you will need to prepare one for your use.

1. Determine how much sewage will enter the septic tank during each 24-hour period (see "Estimating Sewage or Washwater Flows," SAN.2.P.2).

2. Determine the desired retention time. It should be a minimum of one day and a maximum of three days. When determining retention time, consider the following:

(a) A longer retention time requires a larger tank, and thus a higher initial cost. However, a larger tank needs to be cleaned less often than a smaller one. Larger tanks also treat the sewage more, which increases the life of the subsurface absorption system.

(b) A shorter retention time requires a smaller tank, and thus reduces the initial cost.

3. Determine the capacity of the tank. Do this by multiplying the daily flow by the retention time (in days). For example:

Suppose that the estimated daily flow of sewage is 1500 liters, and the desired retention time is 2.5 days. The tank capacity is 1500 liters a day times 2.5 days: the tank capacity equals 3800 liters.

4. Is the type of building the system is being designed for a family dwelling or public building? If it is a family dwelling, go to step 5. If it is a public building, go to step 4a.

4a. Septic tanks for certain types of public buildings, such as schools, stores, and factories, must be large enough to receive sewage when all or most of the sewage flow takes place within a few hours. For such buildings, first determine the normal size of the septic tank (steps 1, 2, and 3). In this example, the flow is 3800 liters a day.

Worksheet A. Steps in Design

1. Sewage flow for 24 hours (from SAM.2.P.3): _1500_ liters/day

2. Retention time: _2.5_ days

3. Tank capacity (step 1 x step 2): _1500_ x _2.5_ = _3800_ liters

4. Type of building served:

   [X] Home. Go to step 5   [X] Public. Go to step 4a

   4a. Normal tank capacity (step 3): _3800_ liters

   4b. Number of hours building in use: _8_ hours

   4c. Size adjustment factor: $\dfrac{24 \text{ hours}}{4b}$ = _3_

   4d. Adjusted size: 4c x 4a = _11400_ liters

5. Inside tank dimensions from Table 1 (using capacity from _step 3_ or step 4d):

   Length: _2.7_ m   Width: _1.2_ m
   Height: _1.2_ (liquid depth) + 0.375m (1.25 feet) = _1.575_ m

6. Thickness (from Table 2):

   Top: _100_ mm   Bottom: _100_ mm   Walls: _100_ mm

7. Outside dimensions (from steps 5 and 6):

   Outside length = inside length + 2 end walls
   = _2.7_ m + _100_ mm + _100_ mm
   = _2.9_ m

   Outside width = inside width + 2 walls
   = _1.2_ m + _100_ mm + _100_ mm
   = _1.4_ m

   Outside height = inside height + top + bottom
   = _1.575_ m + _100_ mm + _100_ mm
   = _1.775_ m

4b. Determine the number of hours when all or most of the sewage flow takes place, for example, 8 hours.

4c. Divide 24 hours by the number of hours from 4b to find the size adjustment factor. Thus $\dfrac{24}{8}$ = 3.

4d. Multiply the size adjustment factor (4c) by the normal size of the tank (4a) to find the required capacity, which is the adjusted size of the tank.

5. Use Table 1 to find the inside tank dimensions. Table 1 shows the liquid depth. The inside height is the liquid depth plus 375mm.

6. Use Table 2 to find the thickness of the top, bottom, and walls.

7. Using the information from Tables 1 and 2, calculate the outside dimensions of the septic tank.

Table 2. Septic Tank Reinforced Concrete Slab Thicknesses

Slab	Tank Capacity		
	3800 liters or less	3800–7600 liters	7600–23000 liters	23000–38000 liters
top	100mm	100mm	250mm	150mm
bottom	100mm	100mm	250mm	150mm
walls	100mm*	150mm	150mm	200mm

*For walls of tanks of 3800 liters or less you may substitute 200mm brick or stone masonry with a 25mm cement plaster inside finish (applied in two 12mm layers).

8. Using the calculations from steps 1 through 7 and the information in Figure 2, prepare a plan view (top, side, and end views) of the septic tank. Figure 3 shows a blank plan

view. Fill in all dimensions ("mm" indicates where a dimension must be filled in), and give the completed plan view to the construction foreman for use in constructing the septic tank.

Materials List

In addition to the location map and the plan view, give the construction foreman a materials list; you should prepare a completed one for the construction foreman. Table 3 shows a sample materials list; you should prepare a completed one for the construction foreman. The list must include number of laborers, types and quantities of materials, and tools necessary to construct the septic tank. This technical note provides some quantities and the means for calculating others. The remaining quantities will have to be determined in the field by the project designer or the construction foreman.

Labor. Labor requirements will depend in part on whether the tank is reinforced concrete, stone masonry, or prefabricated.

● All tanks: a foreman and at least two workers; additional workers would be helpful, especially in excavating the hole.
● Reinforced concrete tank: at least one worker with some knowledge of or experience with reinforced concrete (mixing and pouring, positioning reinforcing material, and building forms).
● Stone masonry: at least one worker with experience with stone masonry (mixing mortar and laying bricks).

Concrete. When calculating the amounts of cement, sand, gravel, and water needed for concrete, keep the following two points in mind:

● A common mix by volume is one part cement, two parts sand, three parts gravel, and two-thirds of a part water. In percentages of the total amount, this mix is 15 percent cement; 30 percent sand; 45 percent gravel; and 10 percent water.
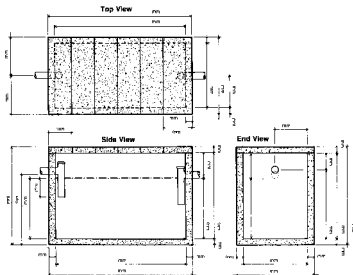● The mixed concrete is about two-thirds the original volume of all the parts.

Figure 3. Technical Drawing of Septic Tank

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Table 3. Sample Materials List

Item	Description	Quantity	Estimated Cost
Labor	Foreman	1	___
	Laborers	2 (at least)	___
	(NOTE: Either the foreman or one of the laborers must have some experience with concrete work.)		
Supplies	Portland cement	0.9m³	___
	Sand, clean, five to 6mm	0.4m³	___
	Gravel, clean, 8-38mm	1.4m³	___
	Water (enough to make a fairly stiff mixture; quantity is a rough estimate)	300 liters	___
	Wire mesh (reinforcing material)	2in²	___
	Sewer pipe 100mm diameter vitrified clay	___m: enough to reach from dwelling to septic tank and from tank to field, plus several sections to be used as extensions to "T" fittings	___
	"T" sewer pipe fittings (for inlet and outlet)	2	___
	Gravel for bedding material	___m: enough to spread under tank to a depth of 75mm	___
	Wooden boards (for building forms)	___	___
	Stones, gummy, or wood (for shoring up sides of hole)	___	___
	Tar or equivalent (for waterproofing top of tank)	___	___
	Nails (for building forms)	___	___
	Handholds (horseshoes or other bent pieces of metal)	18 (2 for each section of top)	___
	Tar, mortar, or oakum (for sealing pipe joints)	___	___
	Other	___	___
Tools	Measuring Tape	1	___
	Shovels	2 (at least; one per worker)	___
	Bucket	1	___
	Container for mixing concrete (or hand mixer)	1	___
	Hoe	1	___
	Trowel	1	___
	Saw	1	___
	Hammer	1	___
	Plumb line (rock and string)	1	___
	Carpenter's level or equivalent (extremely useful, through not essential)		___
	Carpenter's square or equivalent (extremely useful, through not essential)	1	___
	Other		___
		Total Estimated Cost	___

DO NOT USE THE QUANTITIES IN THIS SAMPLE - CALCULATE YOUR OWN

Worksheet B. Calculating Quantities Needed for Concrete

1. Volume of mixed concrete (dimensions from Worksheet A):

   a. top = outside length x outside width x thickness

      = _2.9_ m x _1.4_ m x _0.1_ m = _0.4_ m³

   b. bottom = outside length x outside width x thickness

      = _2.9_ m x _1.4_ m x _0.1_ m = _0.4_ m³

   c. two sides = inside length x inside height x thickness x 2

      = _3.7_ m x _1.575_ m x _0.1_ m x 2 = _0.9_ m³

   d. two ends = inside width x inside height x thickness x 2

      = _1.2_ m x _1.575_ m x _0.1_ m x 2 = _0.4_ m³

   e. total mixed volume = step 1 + 2 + 3 + 4 = _2.1_ m³

2. Unmixed volume = step e x 1.5 = _2.1_ m³ x 1.5 = _3.15_ m³

3. Volume of each material:

   cement: 0.15 x step b = _0.5_ m³   gravel: 0.45 x step b = _1.4_ m³
   sand: 0.30 x step b = _0.9_ m³   water: 0.10 x step b = _0.4_ m³

(NOTES: Quantities of each material may be rounded off to the nearest 1/10th cubic meter.

   Volumes of water may be converted to liquid measure as follows: cubic meters times 1000 equals liters.

   The volume of water depends in part on the wetness of the sand, and need not be measured so much as added by "feel"; that is, enough water is needed to make a fairly stiff mix.

   Cement is generally ordered "by the sack." Since the standard volume of a sack varies from region to region, determine the volume per sack from the supplier of cement, then divided the volume of cement required by the volume per sack to determine how many sacks to order. If the number is a fraction, round up to the next whole number.
   <u>volume required ÷ volume per sack = number of sacks.</u>)

To calculate the quantities of cement, sand, gravel, and water, follow these steps:

1. Determine the required volume of mixed concrete within the wooden forms for the top, bottom, two sides, and two ends of the frame.
2. Divide the total volume by two-thirds (or multiply by 1.5) to find the unmixed volume.

3. Multiply the pre-mixed volume by each of the percentages (or decimal equivalent: .15, .30, .45, .10) to determine the approximate quantity of cement, sand, gravel, and water required. The quantities are only approximate because the finished volume depends on the wetness of sand, the size of gravel, and so on.

For example, suppose the septic tank has a capacity of 3800 liters. First, calculate the dimensions of the tank as in Worksheet A. Then proceed with steps (1), (2), (3) above using a form like Worksheet B for the calculations. This worksheet is only a sample that has been filled out; you will need to prepare one for your use.

1. The volume of the top is the outside length times the outside width times the thickness. The outside dimensions are used because the top must span the inside dimensions plus the thicknesses of the walls.

The volume of the bottom is the same as the volume for the top.

The volume of the two side walls is the inside length times the inside height times the thickness times two.

The volume of the end walls is the inside width times the inside height times the thickness times two.

The total mixed volume is the sum of all these volumes, in this example $2.1m^3$.

2. Multiply the mixed volume by 1.5 to determine the unmixed volume. In this example, the unmixed volume is $3.15m^3$.

3. Multiply the unmixed volume by each percentage to find the quantity of each material. In this example, the quantities are:

cement $0.5m^3$
sand $0.9m^3$
gravel $1.4m^3$
water $0.3m^3$ (300 liters)

Reinforcing material. If the reinforcing material is chain-link fencing or wire mesh, the quantity will be approximately equal to the combined surface area of each slab. Add the area of the top plus the area of the bottom plus the area of the two sides plus the area of the two ends. The area of the top is the outside length times the outside width; the area of the two ends is the inside width times the inside height times two (see Worksheet B).

If the reinforcing material is steel bars, sketch each slab (see Figure 4), draw in the bars using the criteria given in Figure 4, and count the bars. Remember, a separate quantity is needed for each length of bar.

Figure 4. Steel Rod Placement in Reinforced Concrete Slab
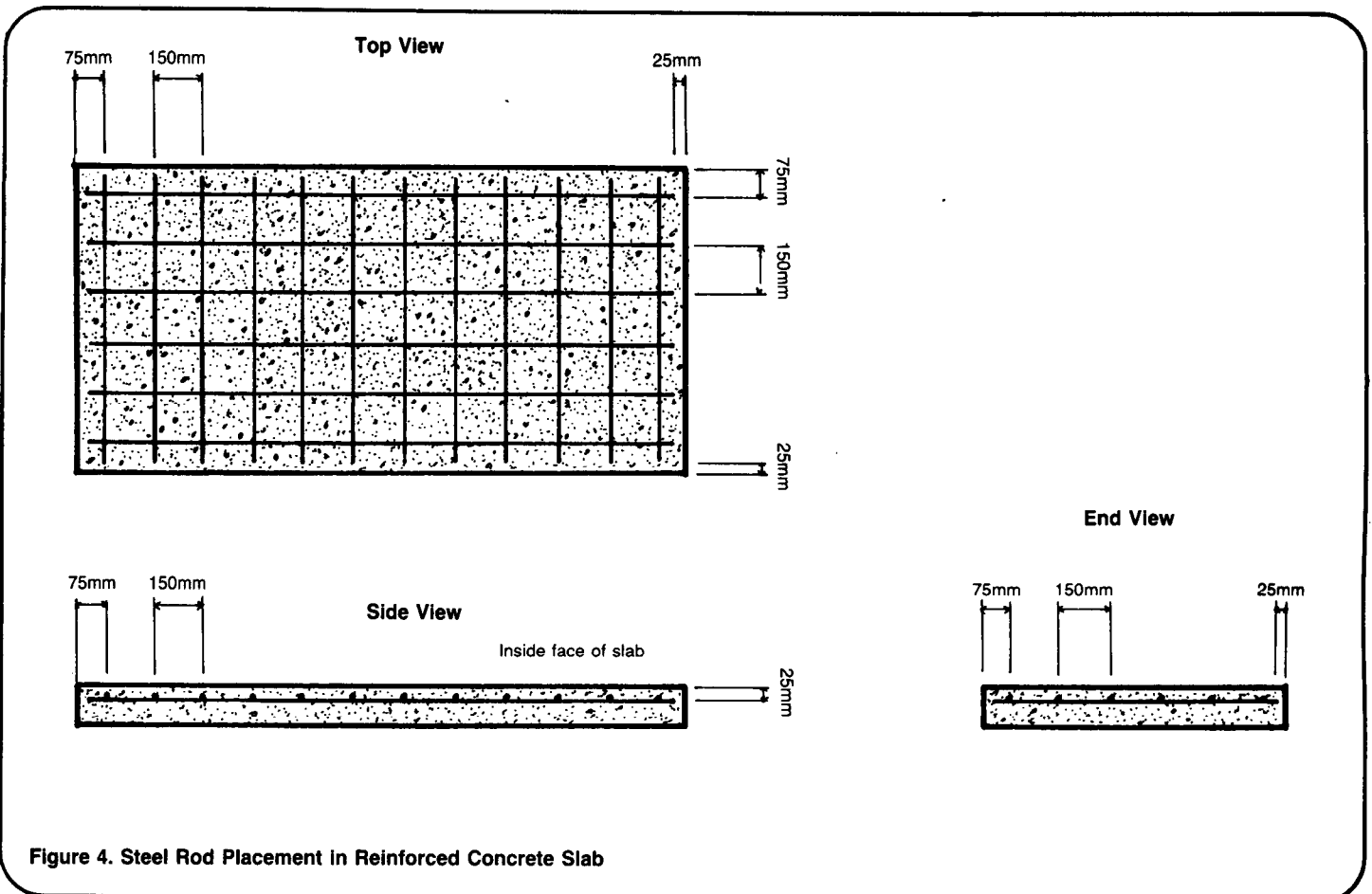
Sewer pipe. The pipe must be of noncorrosive, durable material such as cast-iron soil pipe, vitrified clay, concrete, bituminized fiber, asbestos cement, or plastic. The trench line for the pipe should be as straight as possible from the dwelling to the septic tank and from the tank to the absorption field. Avoid bends. Plan the pipe line so that it falls evenly and smoothly from the dwelling to the tank with a slope of from 1 in 50 to 1 in 100, and from the tank to the field with a slope of 1 in 100. Figure 5 shows the slope of these pipes. The total length of pipe needed will be the distance along the trench line from the dwelling to the tank and from the tank to the absorption field (see "Designing Subsurface Absorption Systems," SAN.2.D.1). Sewer pipe is generally 100mm in diameter.

When labor requirements, materials, (including concrete mix, reinforcing materials, and sewer pipe), and tools have been decided, prepare a materials list and give it to the construction foreman.

Important Considerations

1. The location of the septic tank is vital. (Review section on location.) Provide the construction foreman with a map similar to Figure 1, showing actual distances from the septic tank to dwellings, water supplies, roads, and other man-made or prominent features.

2. The entire system must be designed so that sewage moves by gravity flow from the building, through the septic tank, and to the subsurface absorption system. As Figure 5 indicates:

(a) The septic tank inlet must be lower than the sewer line;
(b) The septic tank outlet must be lower than the inlet, usually 75mm lower;
(c) The distribution box, if there is one, must be lower than the septic tank outlet;
(d) The subsurface absorption system must be lower than the distribution box.

All of these elevations must be checked both on a drawing and in the field prior to and during construction. (see "Designing Subsurface Absorption Systems," SAN.2.D.1).

Give the construction foreman a location map and plan view of the septic tank containing all necessary dimensions and a detailed materials list with quantities of all materials needed.
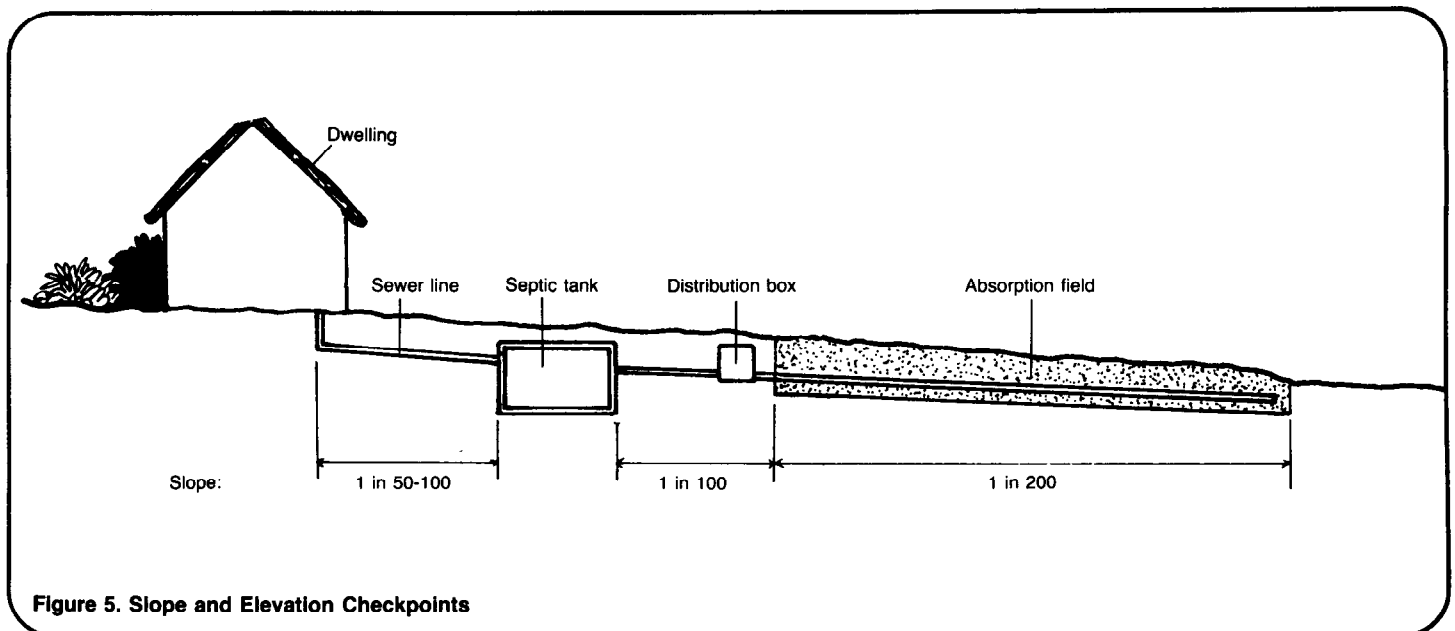

Figure 5. Slope and Elevation Checkpoints

Dwelling

Sewer line   Septic tank   Distribution box   Absorption field

Slope: 1 in 50-100   1 in 100   1 in 200