Water management in urban areas

Design, Soil & Elaboration

Dr. ir. Frans H.M. van de Ven

25-5-2009

Content

- Introduction
- Accessibility and bearing capacity
- Permeability
- Consolidation
- Filling methods
- Selection of a filling method
- Elaborating on the water assignment

Introduction

- Building site preparation evaluation based on:
  - Development strategy
  - Investment costs
  - Maintenance costs
  - Groundwater management
  - Physical conditions of the site
    - Accessibility and bearing capacity
    - Permeability
    - Consolidation

Accessibility and bearing capacity

Definition

- Accessibility
  Possibility to drive or walk on a terrain
  - Supply and processing of construction material
  - Transport of heavy equipment

- Bearing capacity
  Capacity to absorb loads
  - Foundation pressure of structures, sewer pipes, etc.
  - Bearing of roads
  - Storage of construction material

Accessibility and bearing capacity

Responsibility

- Municipality
  - Only accessibility is required
- Contractor
  - Total quality of the construction site
- Scientific approach
  - Overall quality and cost evaluation

In practice, benefits and costs have different actors

Accessibility and bearing capacity

Requirements

- Accessibility by motorised traffic

  Dependent on equipment type and engine power

  - Tractor — 200 – 300 kN/m2
  - Mobile crane on tyres — 2000 kN/m2
  - Mobile crane on rails with wooden sleepers — 2000 – 5000 kN/m2

- Storage of materials

  Dependent on accessibility of the site, the kind of material and the need to keep the material clean

  - Near the construction roads
  - Bricks, sand, cement — 400 kN/m2
  - Proper cover

- Earth foundation of roads

  - Consolidation
  - Drainage

Accessibility and bearing capacity

Bearing capacity

Dependent on degree of saturation and organic content

Type of soil	Wet	Dry	Note
Slurry-sand	200-600 kN/m^2	400 kN/m^2	Dependent of the density (compaction)
Sandy clay (mature)	50 kN/m^2	400 kN/m^2	
Sandy clay (immature)	50 kN/m^2	-	

Permeability

- Ability to transfer water through the soil
- Strong influence on building site preparation phase
- Can decrease drastically during the construction phase
- Requires extra attention at slurry filled sites

Consolidation

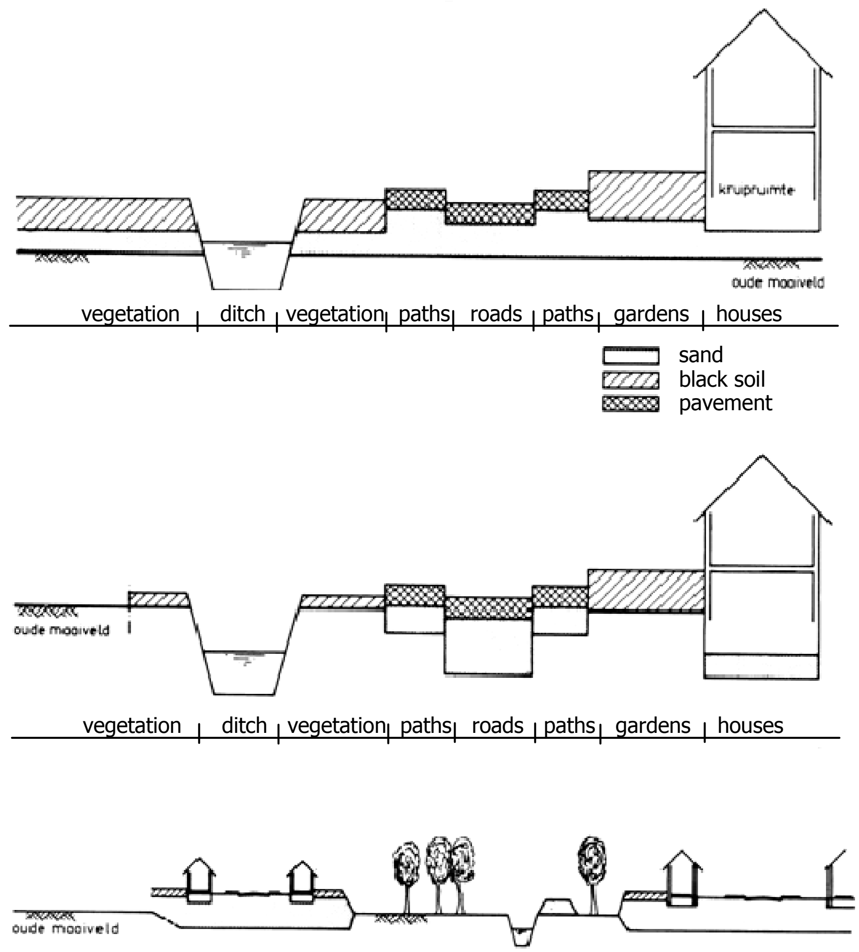
- Subsidence caused by increased loads
  - Raising of the terrain
  - Lowering of the groundwater
  - Enhancing soil characteristics ('grondverbetering')
- Development of the subsidence (Terzaghi)
  - Consolidation is a slow process (> 30 years)
  - Residual subsidence has to be accepted (± 0.1 m)
- Consolidation can be enhanced by vertical drainage

  (very costly)

Filling methods

Variety's

- Integral raise
  - Complete raise of the site with > 0,7 m sand
- Excavation method
  - Filling of sand below pavement and crawlspace
- Other methods
  - Partial filling
  - Filling with EPS



Filling methods

Integral raise

- Sand layer on the entire site
- > 0.5 m sand realises sufficient bearing capacity
- Due to tracks > 0.7 m is applied
- Extra raise to maintain sufficient freeboard and drainage depth
- Minimal soil and sand movement (soil balance)

Filling methods

Excavation method (cunettenmethode)

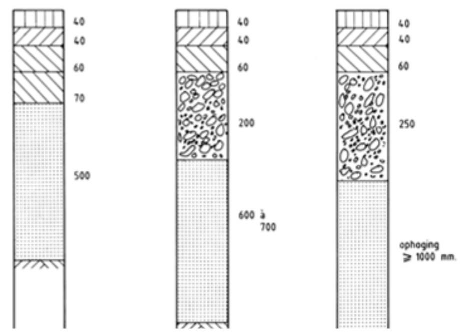
- Soil is excavated out of the road profile and crawlspaces
- Sewer trenches and ditches often filled as well
- Raising of new ground level depends on freeboard
- No consensus on thickness and quality of the fill

	Sandy soils	Clay on firm Underground	Clay on weak Underground
Major roads	0.50	0.60	> 1.00
Residential streets	0.30	0.40	0.60
Parking lots	0.20	0.40	0.60
Bicycle- and pedestrian paths	0.15	0.20	0.30

Filling methods

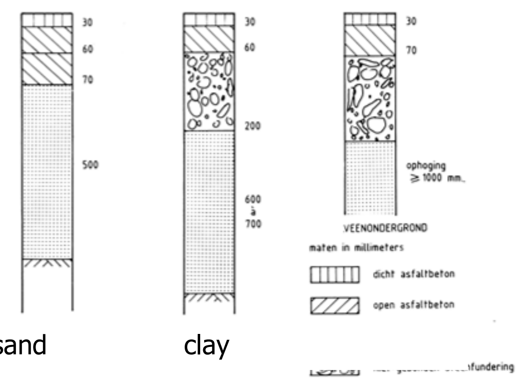
Excavation method (cunettenmethode)

Tertiary roads



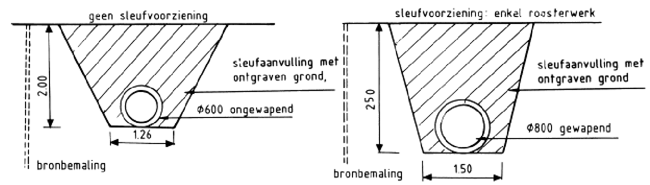
sand clay peat

Secondary roads

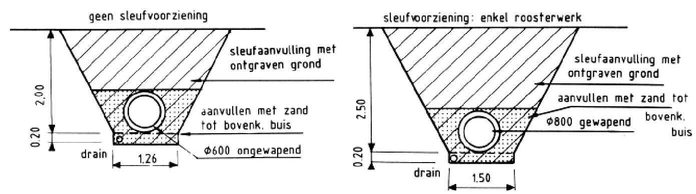


sand clay

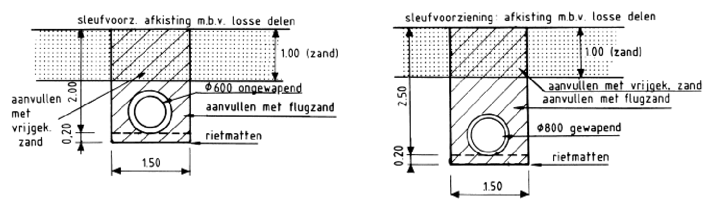
Sewer trenches in sand



Sewer trenches in clay



Sewer trenches in peat



Filling methods

Other methods

- Combinations of integral raising and excavating based on soil characteristics
- Filling with other materials
  - EPS

Selection of a method

Evaluation aspects

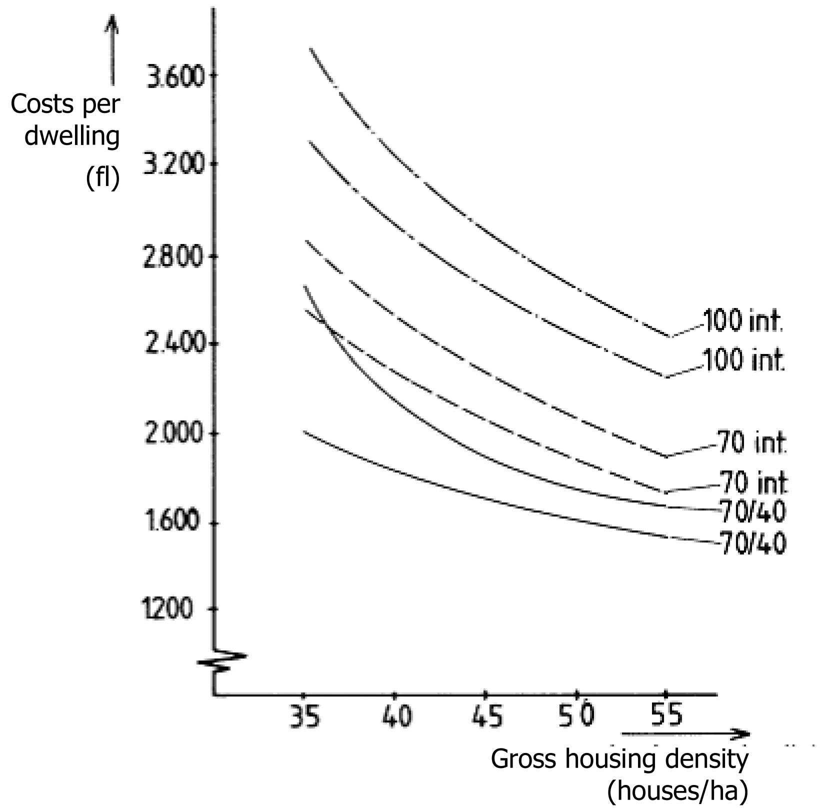
- Development strategy
- Use of sand and topsoil
- Initial conditions
- Construction requirements
- Preparation for habitation
- Maintenance
- Environmental aspects

Multi-criteria analysis

Selection of a method

Direct costs

- Percentage of pavement
- Percentage of open water
- Percentage of vegetation
  (concentrated in lots)



Selection of a method

Indirect costs

- Integral raise
  - Interest loss over the invested capital for building site preparation
  - Interest loss over the acquisition cost of the entire building site
  - Maintenance due to extra subsidence
- Excavation method
  - Limited production during rain
  - Extra transport facilities (steel plates)
  - Extra construction costs of cables and pipes
  - Extra costs of drainage system
  - Maintenance due to unequal subsidence

Selection of a method

Summary

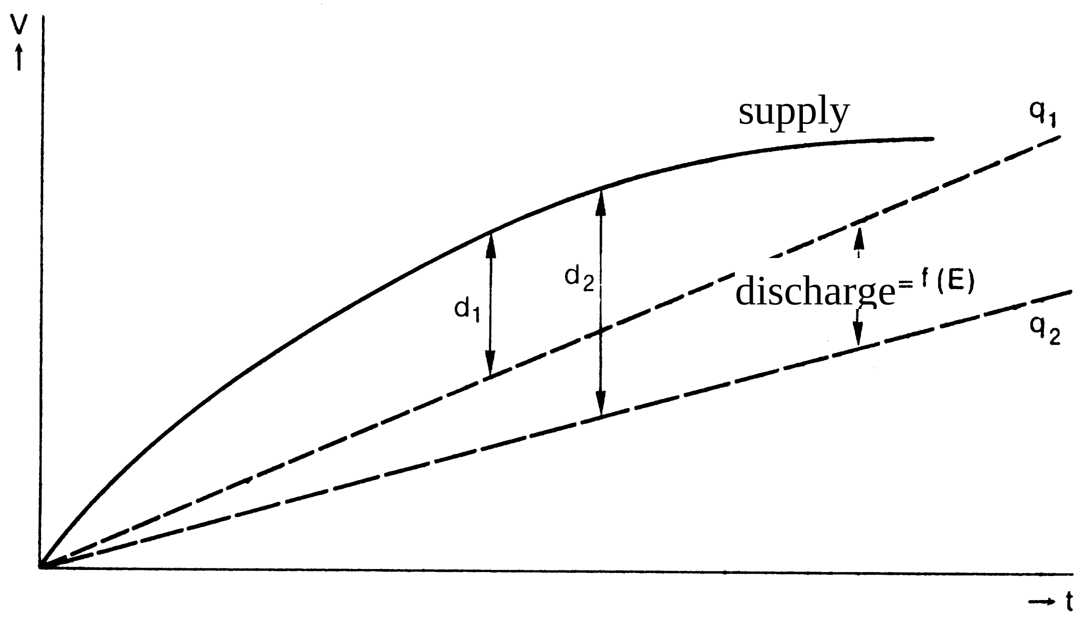
	Integral fill	Cunette method
Planning	+	-
Sand consumption	-	+
Subsidence	-	-
Preparation for construction, earthworks	+	-
Preparation for construction, other work	+	-
Construction of houses	+	-
Preparation for habitation	+	-
Loss of interests	-	+
Saving existing vegetation	-	+/-

Elaborating on the water assignment

- Step 1: Surface water
- Step 2: Water quality
- Step 3: Groundwater

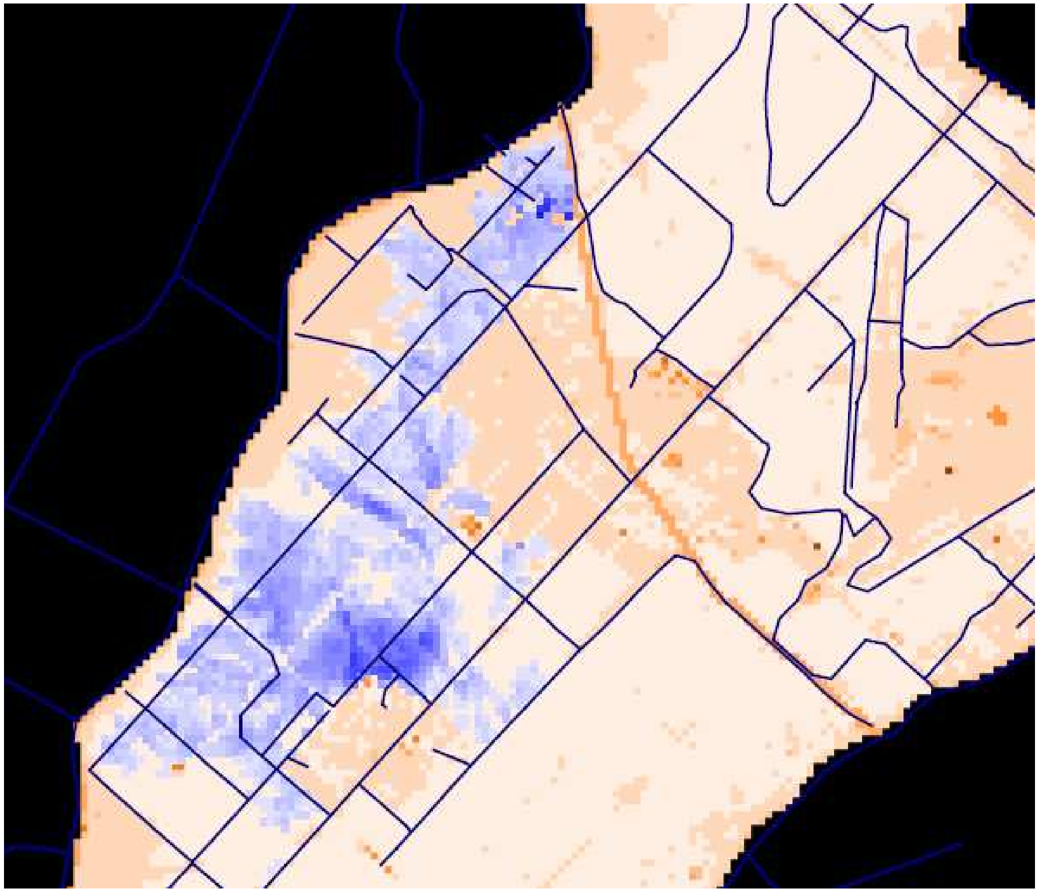
1.d. Determine required storage

Storage



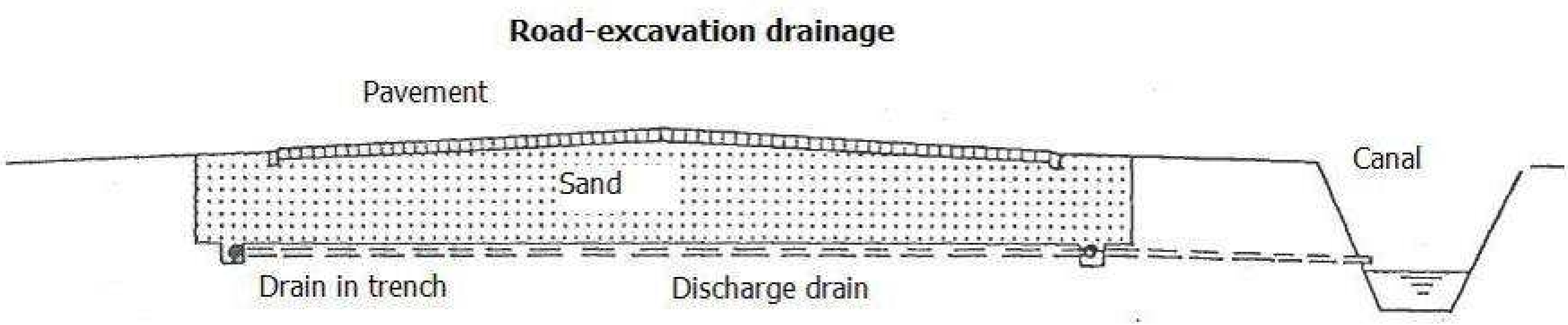
1.d. Determine required storage

Hydrological model (sobek)



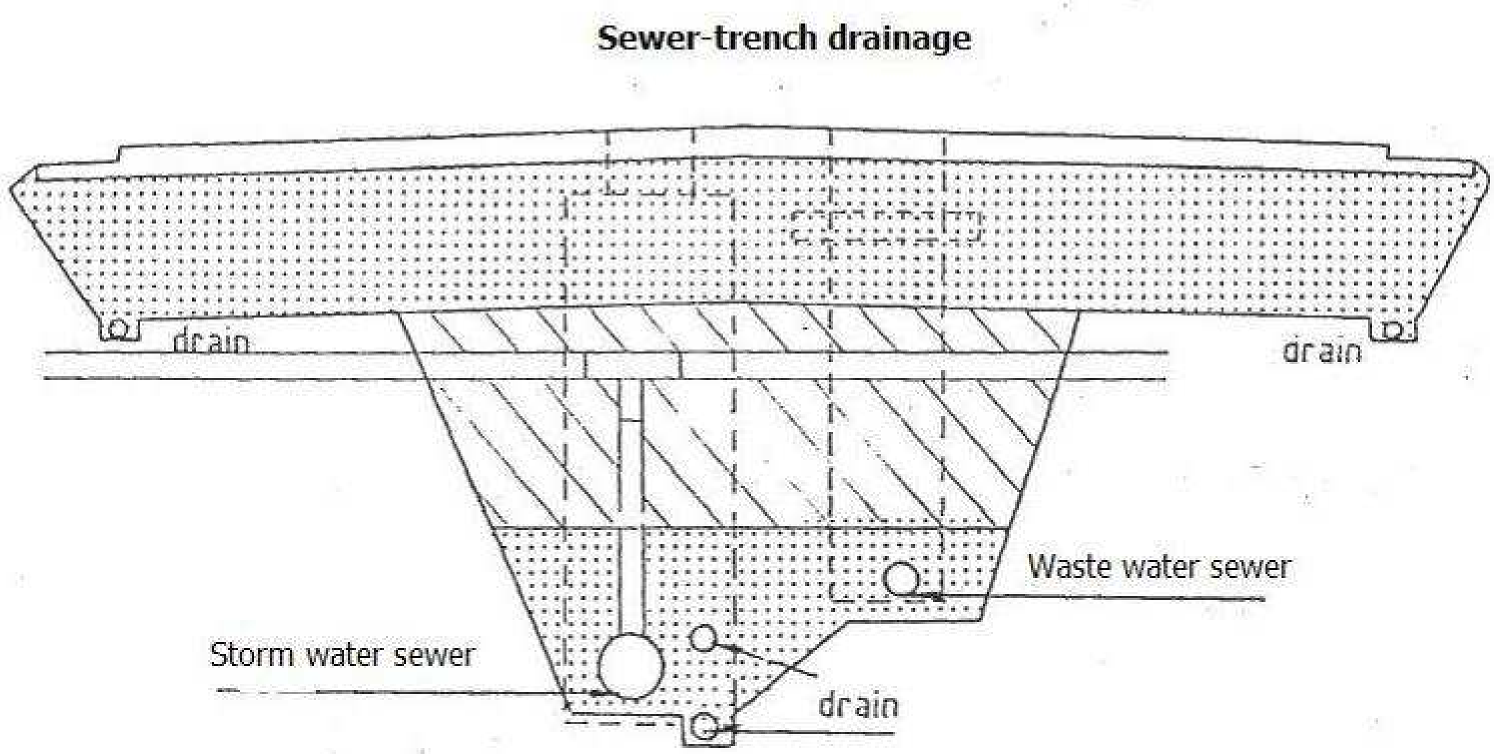
3.b. Type of drainage system

Public



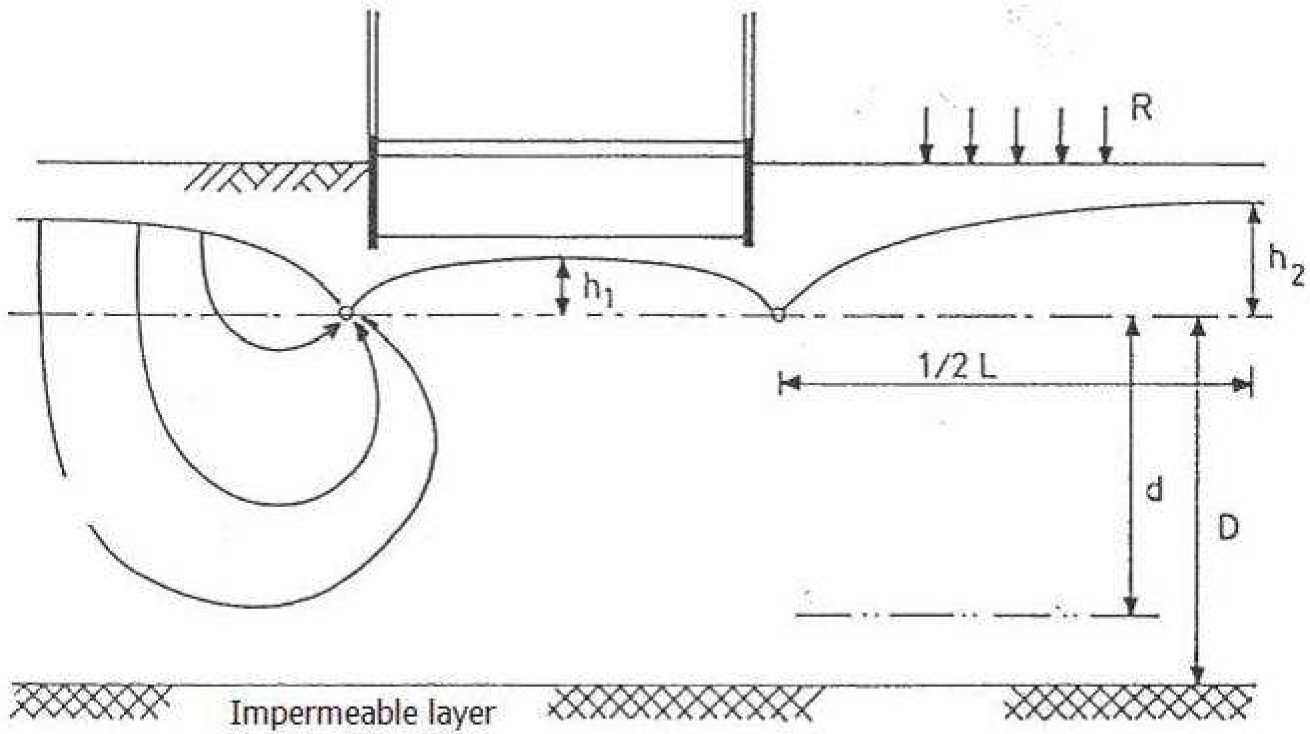
3.b. Type of drainage system

Public



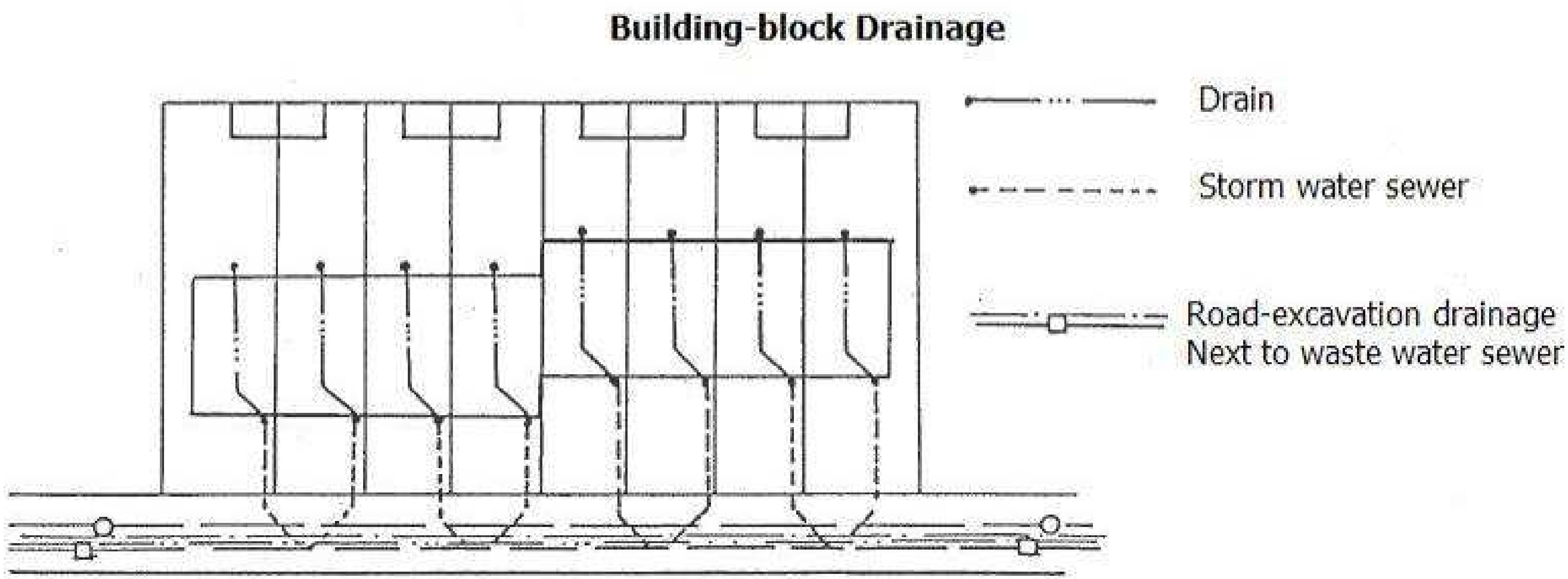
3.b. Type of drainage system

Ground water current near a building

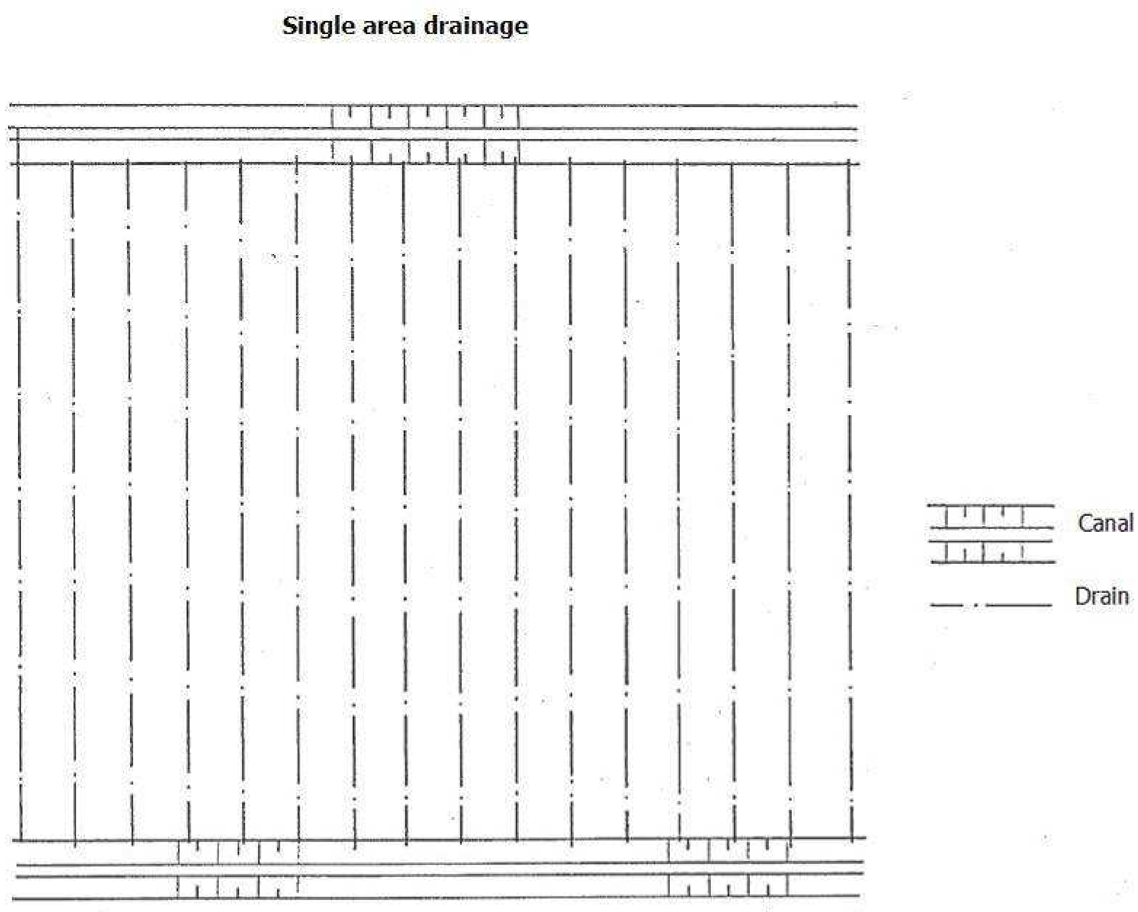


3.b. Type of drainage system

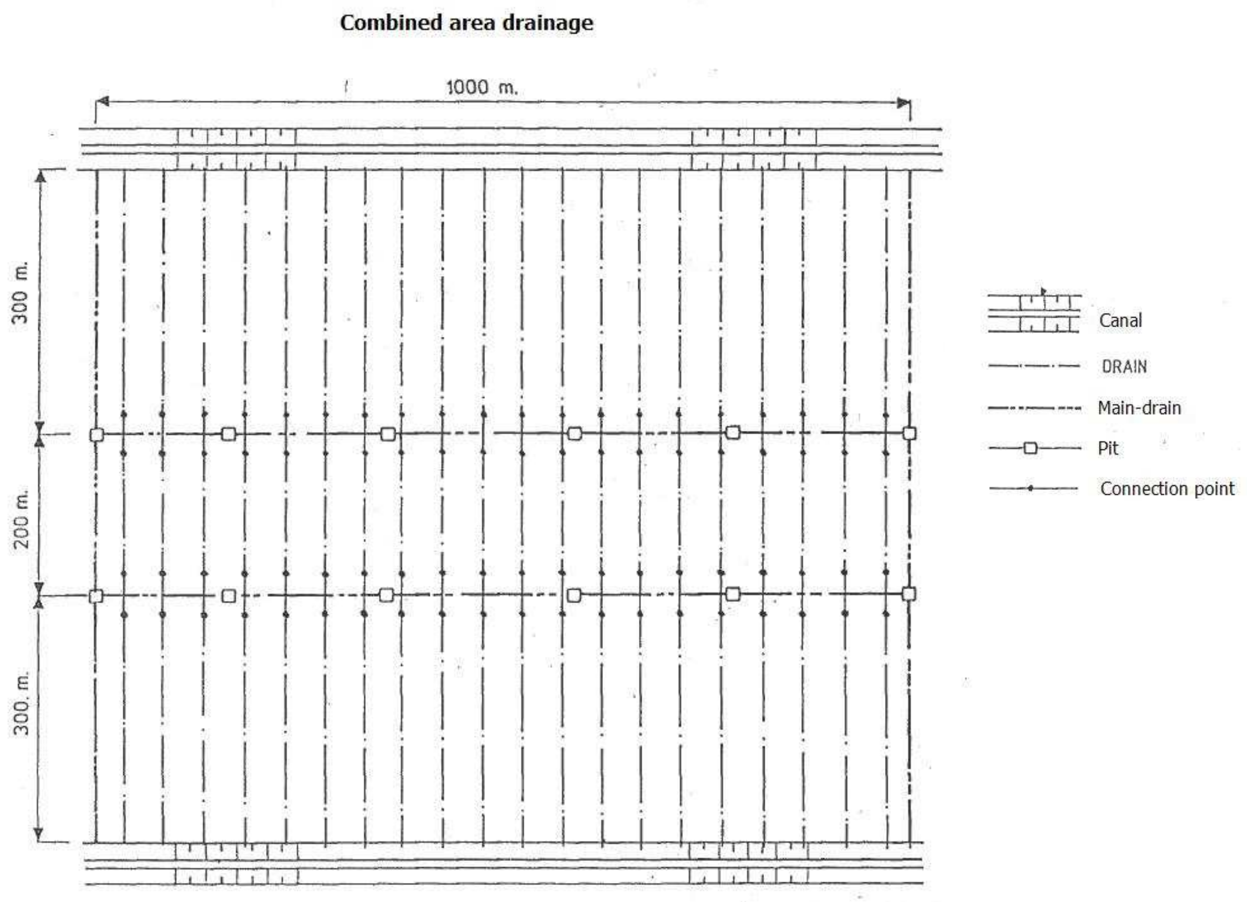
Private



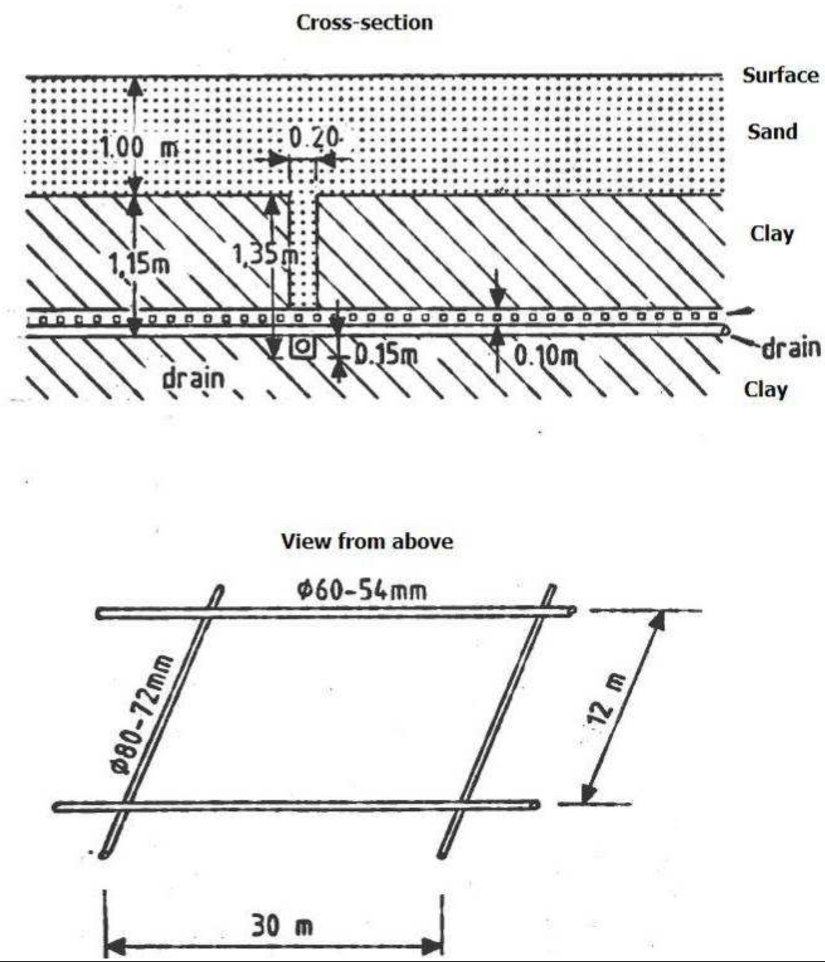
3.c. Lay-out of system



3.c. Lay-out of system

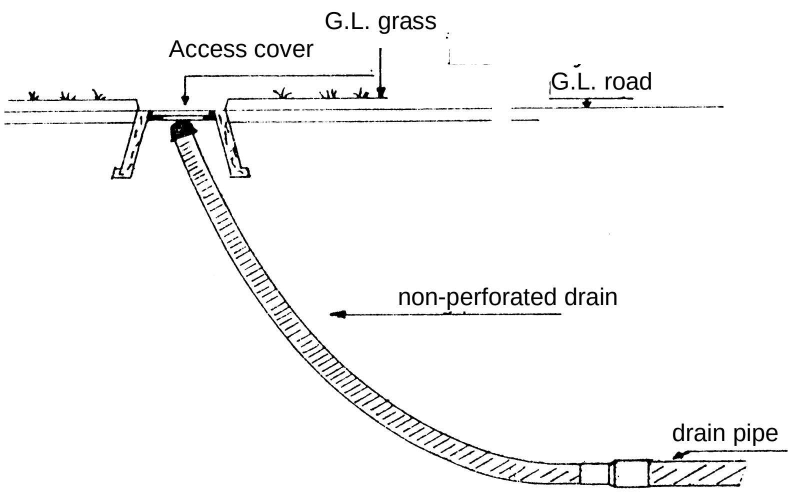


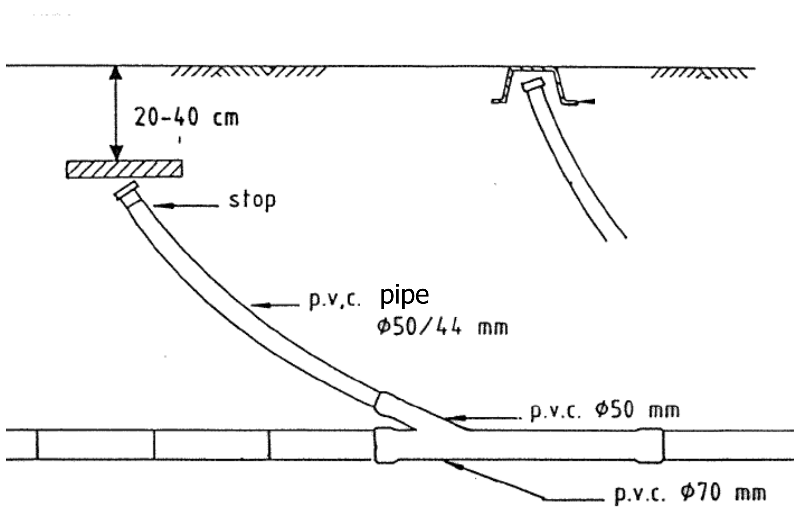
3.c. Lay-out of system



3.c. Lay-out of system

Maintenance

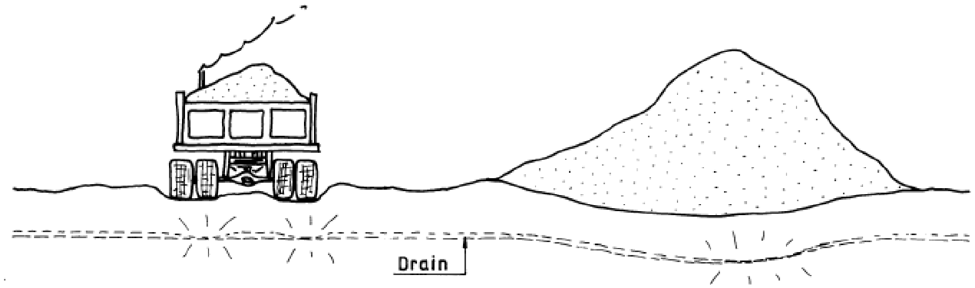




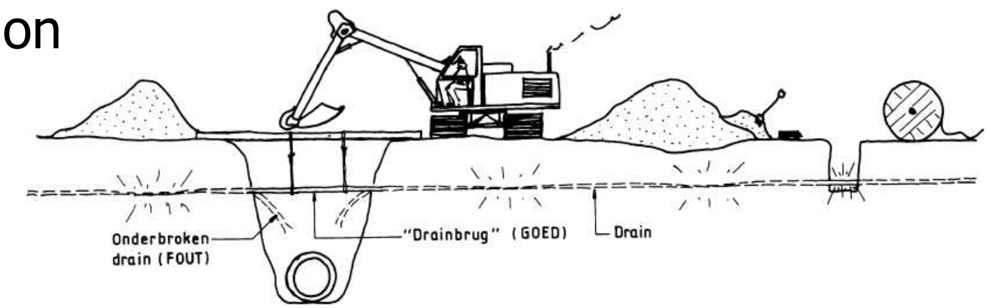
3.d. Type of drainage tubes

Threats

- During construction



- Maintenance during habitation

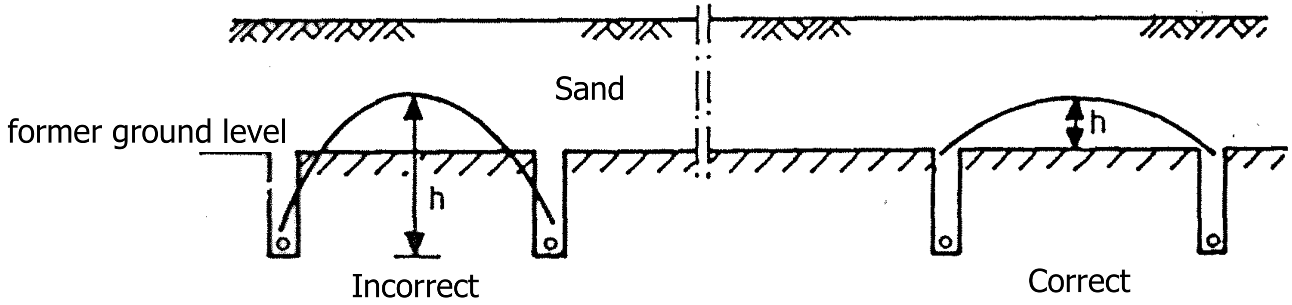


3.d. Type of drainage tubes

Reducing risks

- Drains in coarse aggregate profile
- Soil characteristics enhancement with coarse aggregate
- Stiff PE drains instead of flexible PVC drains

Computations according to the top of the profile!



3.d. Type of drainage tubes

Dimensioning of the drains

1. Available pipe diameters
2. Minimum diameter (>50 mm)
3. Hydraulic capacity

- Flexible corrugated PVC drains

  Maximum area to be drained (Dekker and Ven)

$$A = l.L = 2.27\,.10^7\, q_d^{-1} d_e^3 \left(\frac{h}{L}\right)^{2/3}$$

l	drain distance [m]
L	drain length [m]
q_d	design discharge [m/d]
h	available pressure head [m]
d_e	effective diameter [m] $= 1.04 \cdot D_i - 0.008$
D_i	inside diameter

- PE drains of IT sewer

  Energy losses (Colebrook)