

Lecture Notes

Subsurface Drainage – Design of Subsurface Drainage – Pipe Materials

1. Introduction to Subsurface Drainage

Subsurface drainage refers to the removal of excess water from the root zone of the soil profile through a network of buried pipes or drains. Its primary objective is to maintain an optimal soil moisture balance that promotes plant growth while preventing waterlogging and salinization (Hillel, 2004; Schwab et al., 1993).

Key purposes include:

- Lowering high water tables.
- Preventing salinity and alkalinity buildup.
- Improving soil aeration and root respiration.
- Enhancing crop yield and soil workability.

2. Fundamentals of Subsurface Drainage Design

2.1 Drainage System Types

- Random drainage system: Suitable for irregularly spaced wet areas.
- Herringbone drainage system: Laterals enter the main at an angle from both sides.
- Gridiron system: Parallel laterals enter a main at right angles—common in uniform soils.

2.2 Key Design Parameters

- Drain Spacing (S): Distance between adjacent drains.
- Drain Depth (d): Vertical distance from the soil surface to the drain.
- Soil Hydraulic Conductivity (K): Soil's ability to transmit water (expressed in m/day).
- Drainage Coefficient (q): Amount of water to be removed (mm/day).

Basic Design Equation (Hooghoudt's Equation):

$$q = (8 K d (D - d)) / S^2$$

Where:

q = drainage rate,

K = hydraulic conductivity,

d = depth of the drains,

D = depth to the impermeable layer,

S = drain spacing.

2.3 Factors Affecting Design

- Soil texture and structure.
- Crop tolerance to waterlogging.
- Climatic conditions (rainfall, evapotranspiration).
- Topography and land slope.

3. Concepts and Mechanisms

3.1 Water Movement Towards Drains

Driven by gravity flow and capillary action. Water from saturated zones flows towards the drains following Darcy's Law:

$$Q = K \times A \times (dh/dl)$$

Where Q is the flow rate, A is the cross-sectional area, and dh/dl is the hydraulic gradient.

3.2 Soil-Water-Plant Relationships

Field Capacity and Permanent Wilting Point define the moisture thresholds for plant growth. Subsurface drainage ensures the water table remains below the root zone, avoiding hypoxic stress to roots.

4. Pipe Materials for Subsurface Drainage

4.1 Common Pipe Materials

- Clay Tiles: Traditional material, brittle but long-lasting if undisturbed.
- Concrete Pipes: Strong, durable, susceptible to chemical corrosion.
- Corrugated Plastic Pipes (PVC, HDPE): Lightweight, flexible, resistant to chemicals, and easy to install.
- Smooth Plastic Pipes: Used for mains where high flow rates are expected.

4.2 Selection Criteria

- Soil chemistry compatibility.
- Load-bearing capacity.
- Ease of installation and maintenance.
- Cost-effectiveness.
- Life expectancy (plastic pipes typically >50 years).

4.3 Filter Materials

Gravel envelopes, sand filters, and geotextiles prevent soil particles from entering the pipe and clogging the drainage system.

5. Applications

- Agricultural lands: Boosting crop yield by preventing waterlogging.
- Urban green spaces: Preventing soil saturation in parks and sports fields.
- Reclamation of salt-affected lands.
- Civil engineering: Foundation drainage to stabilize structures.

6. Case Study: Subsurface Drainage in Haryana, India

Location: Karnal District, Haryana.

Problem: Waterlogging and secondary salinity affecting wheat-rice cropping system.

Solution: Subsurface drainage with PVC corrugated pipes at 2.0 m depth, spaced at 40 m.

Outcome:

- Increased wheat yield from 2.5 to 4.5 t/ha.
- Reduced water table depth.
- Salinity levels declined over 3 years.

7. Conclusion

Subsurface drainage is a vital land improvement technique that optimizes root zone conditions by maintaining the water table at safe levels. Designing an effective system requires understanding soil-water interactions, selecting appropriate pipe materials, and considering economic and environmental factors.

References

- Brady, N. C., & Weil, R. R. (2002). The Nature and Properties of Soils. Pearson.
- Hillel, D. (1998). Environmental Soil Physics. Academic Press.
- Hillel, D. (2004). Introduction to Environmental Soil Physics. Academic Press.
- Ritzema, H. P. (1994). Drainage Principles and Applications. ILRI Publication 16.
- Schwab, G. O., Fangmeier, D. D., Elliot, W. J., & Frevert, R. K. (1993). Soil and Water Conservation Engineering. John Wiley & Sons.
- Singh, R., & Sharma, D. P. (2003). Impact assessment of subsurface drainage in Haryana. Agricultural Water Management, 60(3), 197-213.
- Skaggs, R. W., & van Schilfgaarde, J. (1999). Agricultural Drainage. ASA, CSSA, SSSA.
- USDA Natural Resources Conservation Service. (2001). Drainage of Agricultural Land.