Chapter 39: Duty and Delta

Introduction

In irrigation engineering, *Duty* and *Delta* are fundamental concepts that establish the relationship between the amount of water supplied and the area of land irrigated. These parameters form the foundation of irrigation planning, design of canal systems, and efficient water management in agricultural practices. Understanding them is critical for civil engineers dealing with water resources, especially in designing irrigation systems that aim to minimize water loss and maximize agricultural productivity.

39.1 Delta (Δ)

Definition:

Delta (Δ) is the total depth of water (in centimetres or meters) required by a crop during the entire period of its base period, from sowing to harvesting.

Mathematical Expression:

$$\Delta = \text{Depth of water required during base period}$$

- **Unit:** Usually expressed in **cm** or **meters**.
- **Importance:** Determines the total water requirement for a given crop.

Factors Affecting Delta:

- Type of crop (e.g., rice requires more water than wheat).
- Climate (evaporation and rainfall patterns).
- Soil type (infiltration and percolation capacity).
- Method of irrigation (flood, sprinkler, drip, etc.).

Typical Delta Values:

Crop	Base Period (days)	Delta (cm)
Wheat	120	40-50
Rice	135	120-140

Crop	Base Period (days)	Delta (cm)
Sugarcane	360	120-180
Cotton	200	70-85

39.2 Duty (D)

Definition:

Duty (D) is the area of land that can be irrigated with a unit discharge of water flowing continuously during the entire base period of a crop.

Mathematical Expression:

$$D = \frac{A}{Q}$$

Where:

- D = Duty (hectares/cumec)
- A = Area irrigated (hectares)
- Q = Discharge (cumec or cubic metre per second)

Units:

- Commonly expressed in **hectares/cumec** (i.e., hectare per cubic metre per second).

Types of Duty:

1. **Gross Duty**: Refers to water measured at the head of the canal system.
2. **Net Duty**: Refers to water available at the field level after losses in conveyance.

39.3 Relationship Between Duty and Delta

The relationship between **Duty (D)** and **Delta (Δ)** is essential in irrigation planning and is expressed as:

$$\Delta = \frac{8.64 \times B}{D}$$

Where:

- Δ = Delta in metres
- B = Base period in days
- D = Duty in hectares/cumec
- 8.64 = Constant (derived from converting discharge to depth over area)

Derivation:

Let 1 cumec of water run for B days. Volume = $1 \times 86400 \times B$ cubic metres If this irrigates D hectares, the depth of water =

$$\Delta = \frac{86400 \times B}{D \times 10^4} = \frac{8.64 \times B}{D}$$

39.4 Significance of Duty and Delta

- Helps in **canal design** and determining **discharge capacity**.
- Essential for **crop water budgeting**.
- Important in deciding the **water allowance** to farmers.
- Key to **efficient water management** and **minimizing losses**.
- Helps in evaluating the **efficiency of an irrigation system**.

39.5 Factors Affecting Duty

1. **Type of Soil**: Sandy soil increases percolation losses—lower duty.
2. **Type of Crop**: High water-demand crops (e.g., rice) reduce duty.
3. **Climate Conditions**: Hot and dry weather increases evapotranspiration.
4. **Irrigation Practices**: Better field management can improve duty.
5. **Topography**: Uneven terrain may result in poor water distribution.
6. **Canal Losses**: Seepage and evaporation lower effective duty.

39.6 Methods to Improve Duty

- **Lining of canals** to reduce seepage losses.
- **Rotational water supply** or *warabandi system* to ensure equitable use.
- **Use of modern irrigation methods** like drip and sprinkler.
- **Land leveling** for uniform water distribution.
- **Good drainage** to avoid waterlogging and salinity.

39.7 Practical Application and Example

Example: An irrigation canal has a discharge of 10 cumecs and irrigates 20,000 hectares of land. Calculate the duty.

$$D = \frac{A}{Q} = \frac{20000}{10} = 2000 \text{ hectares/cumec}$$

Now, if the base period is 120 days, find the delta:

$$\Delta = \frac{8.64 \times 120}{2000} = 0.5184 \text{ m or } 51.84 \text{ cm}$$

This tells us that each hectare receives 51.84 cm of water during the crop period.

39.8 Delta for Different Crops (Empirical Values)

Crop	Base Period (days)	Duty (hectare/cumec)	Delta (cm)
Rice	120	875	118.5
Wheat	120	1350	76.8
Sugarcane	270	750	310.3
Cotton	200	1125	153.6
Vegetables	100	800	108

39.9 Canal Design Based on Duty

When designing irrigation canals:

- Use **maximum delta** and **minimum duty** to ensure adequacy.
- Factor in **peak water demand**.
- Use **historical cropping patterns** and **soil-water data**.

The canal capacity must be sufficient to supply the **delta** over the base period to the designed command area, ensuring **irrigation efficiency**.
