BHADRAK ENGINEERING SCHOOL & TECHNOLOGY
(BEST), ASURALI, BHADRAK

HYDRAULICS AND IRRIGATION ENGINEERING (Th-02)

(As per the 2019-20 syllabus of the SCTE&VT, Bhubaneswar, Odisha)

FourthSemester

Civil Engg.

Prepared By: *Er. J.J.PUNTIA*

Civil (4th sem)

Theory -2

Hydraulics and irrigation engineering

Chapter-I

HYDROSTATICS

Hydrostatic is that branch of science which relating to fluids at rest or to the pressures they exert or transmit **HydrostaticPressure**.

Fluid:-

Fluid is a substance that continuously deforms (flows) under an applied shear stress. Fluids are a subset of the phase of matter and include liquids, gases, plasmas and, to some extent, plasticsolids. Fluids can be defined as substances which have zero shear modulus or in simpler terms a fluid is a substance which cannot resist any shear force applied toit.

- Fluid is a substance which is capable offlowing
- Conform the shape of the containingvessel
- Deform continuously under application of small shearforce

1.1 PROPERTIES OFFLUID:-

Density:-

Thedensityofafluid,isgenerallydesignatedbytheGreeksymbol$\rho(rho)$isdefinedasthe mass of the fluid over a unit volume of the fluid at standard temperature and pressure. It is expressed in the SI system as kg/m^3.

$$\rho = \lim \frac{\Delta m}{\Delta V} = \frac{dm}{dV}$$

If the fluid is assumed to be uniformly dense the formula may be simplified as:

$$\rho = \frac{m}{V}$$

Example: - setting of fine particles at the bottom of the container.

Specific Weight:-

The specific weight of a fluid is designated by the Greek symbol γ(gamma), and is generally defined as the weight per unit volume of the fluid at standard temperature and pressure. In SI systems the units isN/m^3.

$$\gamma = \rho * g$$

g = local acceleration of gravity and ρ = density

Note: It is customary to use:

$g = 32.174\ ft/s^2 = 9.81\ m/s^2$

$\rho = 1000\ kg/m^3$

Relative Density (Specific Gravity):-

The relative density of any fluid is defined as the ratio of the density of that fluid to the density of the standard fluid. For liquids we take water as a standard fluid with density ρ=1000 kg/m^3. For gases we take air or O_2as a standard fluid with density, ρ=1.293kg/m^3.

Specific volume:-

Specific volume is defined as the volume per unit mass. It is just reciprocal of mass density. It is expressed in m^3/kg.

Viscosity:-

Viscosity (represented by μ, Greek letter mu) is a material property, unique to fluids, that measures the fluid's resistance to flow. Though a property of the fluid, its effect is understood only when the fluid is in motion. When different elements move with different velocities, each element tries to drag its neighboring elements along with it. Thus, shear stress occurs between fluid elements of different velocities.

Viscosity is the property of liquid which destroyed the relative motion between the layers of fluid.

- ❖ It is the internal friction which causes resistance toflow.

❖ Viscosity is the property which control the rate of flow ofliquid

Viscosity is due to two factors-

a) Cohesion between the liquidmolecules.
b) Transfer of momentum between themolecules.

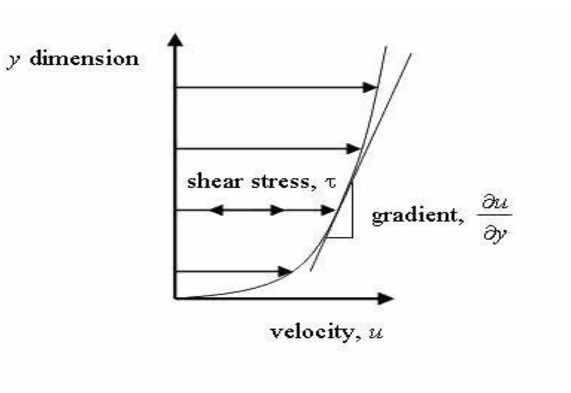


Fig. 1.1

The relationship between the shear stress and the velocity field was that the shear stresses are directly proportional to the velocity gradient. The constant of proportionality is called the coefficient of dynamic viscosity.

$$\tau = \mu \frac{\partial u}{\partial y}$$

UNIT OF VISCOSITY

❖ In mks system unit of viscosity iskgf-sec/m^2
❖ In cgs system unit of viscosity isdyne-sec/cm^2
❖ In S.I system unit of viscosity isNewton-sec/m^2

Kinematic viscosity:-

Another coefficient, known as thekinematic viscosity(ν , Greek nu) is defined as the ratio of dynamic viscosity anddensity.

I.et, $\nu = \frac{\mu}{\rho}$ = viscosity/density

In mks& S.I system unit of kinematic viscosity is $meter^2$/sec

Incgs system unit of kinematic viscosity is stoke.

SURFACETENSION:-

Surface tension is defined as the tensile force acting on the surface of a liquid in contact with a gas or on the surface between two immiscible liquids such that the contact surface behaves like a membrane under tension. The magnitude of this force per unit length of the free surface will have the same value as the surface energy per unit area. It is denoted by Greek letter sigma(σ). In MKS units, it is expressed as kgf/m while in SI unit isN/m.

It is also defined as force per unit length, or of energy per unit area. The two are equivalent—but when referring to energy per unit of area, people use the term surface energy—which is a more general term in the sense that it applies also to solids and not just liquids.

Capillarity:-

Capillarity is defined as a phenomenon of rise or fall of a liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid. The rise of liquid surface is known as capillary rise while the fall of the liquid surface is known as capillary depression. It is expressed in terms of cm or mm of liquid. Its value depends upon the specific weight of the liquid, diameter of the tube and surface tension of theliquid.

1.2 Pressure and its measurement

INTENSITY OFPRESSURE:-

Intensity of pressure is defined as normal force exerted by fluid at any point per unit area. It is also called specific pressure or hydrostatic pressure

P=df/da

- If intensity of pressure is uniform over an area ―A‖ then pressure force exerted by fluid equalto

  MathematicallyF=PA

- If intensity of pressure is not uniform or vary point to point then pressure force exerted by fluid equal to integration of P×A

  Mathematically F=∫PA

- Unit ofpressure

  $1N/m^2$ =1 Pascal

  $1KN/m^2$= 1 kilo Pascal

  Kilo Pascal= 1kpa = 10^3 Pascal

$$1 \text{ bar} = 10^5 \text{ Pascal} = 10^5 \text{ N/m}^2$$

Pascal's law:-

It states that the pressure or intensity of pressure at a point in a static fluid is equal in all direction.

Atmospheric Pressure:-

The atmospheric air exerts a normal pressure upon all surface with which it is in contact and it is called atmospheric pressure. It is also called parametric pressure.

Atmospheric pressure at the sea level is called standard atmospheric pressure.

S.A.P = 101.3 KN/m^2= 101.3 kpa = 10.3m of H_2O

= 760 mm ofHg

=10.3 (millibar)

Gauge pressure:-

It is the pressure which measure with help of pressure measuring device in which atmospheric pressure taken as datum.

The atmospheric pressure on scale is marked as zero.

Absolute pressure:-

Any pressure measure above absolute zero pressure is called absolute pressure.

Vacuum pressure:-

Vacuum pressure is defined as the pressure below the atmospheric pressure.

RELATIONSHIP BETWEEN ABSOLUTE PRESSURE, GAUGE PRESSURE, VACUUM PRESSURE:-

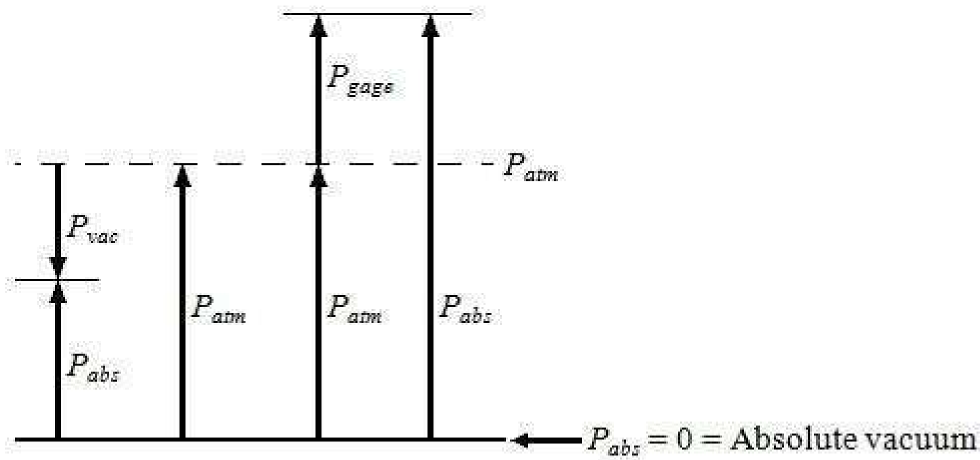


Fig. 1.2

- Equations

$P_{gage} = P_{abs} - P_{atm}$	gauge pressure
$P_{vac} = P_{atm} - P_{abs}$	vacuum pressure
$P_{abs} = P_{atm} + P_{gage}$	absolute pressure

- Nomenclature

P_{abs}	absolute pressure
P_{gage}	gage pressure
P_{vac}	vacuum pressure
P_{atm}	atmospheric pressure

Pressure Head:-

pressure head is the internal energyof a fluiddue to the pressureexerted on its container. It may also be called **static pressure head** or simply **static head** (but not **static head pressure**). It is mathematically expressed as:

$$\psi = \frac{p}{\gamma} = \frac{p}{\rho g}$$

where

ψ is pressure head (Length, typically in units ofm);

p is fluid pressure(forceper unit area, often as Paunits);and
γ is the specific weight(forceper unit volume, typicallyN/m^{3}units) ρ is the densityof the fluid (massper unit volume, typicallykg/m^3)
g isacceleration due to gravity(rate of change of velocity, given inm/s^2)

If intensity of pressure express in terms of height of liquid column, which causes pressure is also called pressure head.

Mathematically, $h= P/w$

Pressure Gauges :-

The pressure of a fluid is measured by the following devices:-

1. manometers
2. mechanicalgauges

Manometers:-Manometers are defined as the devices used for measuring the pressure at a point in a fluid by balancing the column of fluid by the same or another column of the fluid. They are classified as:

a) Simple manometers
b) Differentialmanometer

Mechanical gauges:-mechanical gauges are defined as the devices used for measuring the pressure by balancing the fluid column by the spring or dead weight. The commonly used mechanical gauges are:-

a) Diaphragm pressure gauge
b) Bourdon tube pressuregauge
c) Dead weight pressuregauge
d) Bellows pressuregauge

1.3 PRESSURE EXERTED ON IMMERSEDSURFACE:-

Hydrostatic forces on surfaces:-

Hydrostatic means the study of pressure exerted by a liquid at rest. The direction of such pressure is always perpendicular to the surface to which itacts.

Forces on Submerged Surfaces in Static Fluids

These are the following features of statics fluids:-

Hydrostatic vertical pressure distribution

Pressures at any equal depths in a continuous fluid are equal

Pressure at a point acts equally in all directions (Pascal's law).

Forces from a fluid on a boundary acts at right angles to that boundary.

Fluid pressure on a surface:-

Pressure is defined as force per unit area. If a pressure p acts on a small area δA then the force exerted on that area will be

$F = p\delta A$

TOTAL PRESSURE:-

Total pressure is defined as the force exerted by a static fluid on a surface when the fluid comes in contact with thesurface.

Mathematically **total pressure**,

$P=p_1a_1 + p_2a_2 + p_3a_3$…………

Where,

p_1, p_2, p_3= Intensities of pressure on different strips of the surface, and
a_1, a_2, a_3= Areas of corresponding strips.

The position of an immersed surface may be,

Horizontal
Vertical
Inclined

Total Pressure On A Horizontal Immersed Surface
Consider a plane horizontal surface immersed in a liquid as shown in figure 1.

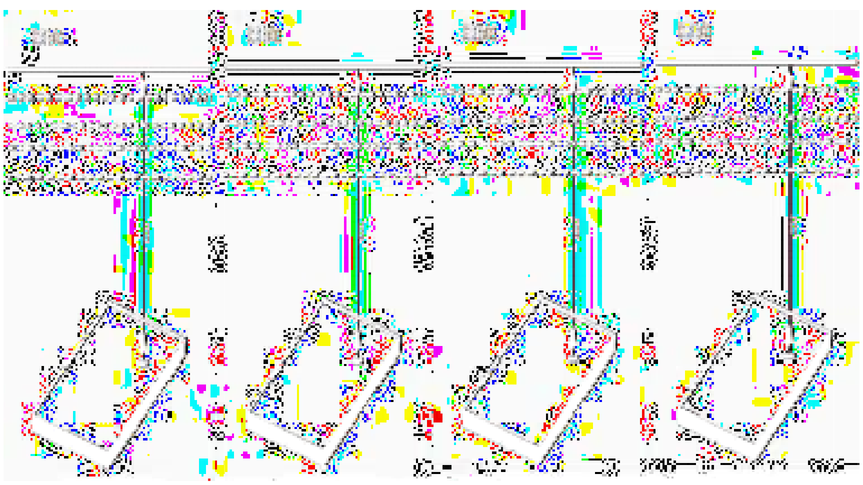


Fig. 1.3

□ □Specific weight of the liquid
A□Area of the immersed surface in in^2
□= Depth of the horizontal surface from the liquid level in meters

We know that the **Total pressure** on thesurface,

P = Weight of the liquid above the immersedsurface

= Specific weight of liquid * Volume of liquid

= Specific weight of liquid * Area of surface * Depth of liquid

= A kN

Total Pressure On A Vertically Immersed Surface

Consider a plane vertical surface immersed in a liquid shown in figure 2.

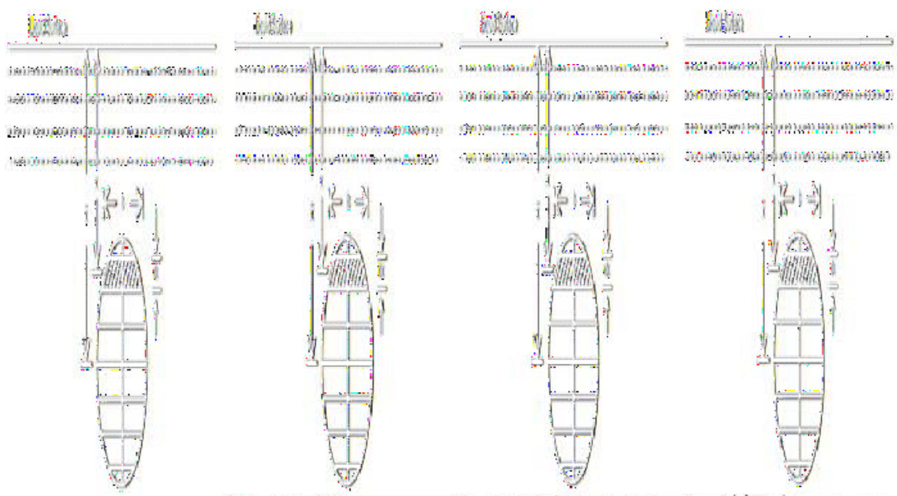


Fig. 1.4

Let the whole immersed surface is divided into a number of small parallel stripes as shown in figure.

Here,

Specific weight of the liquid
A = Total area of the immersed surface
= Depth of the center of gravity of the immersed surface from the liquid surface

Now, consider a strip of thickness dx, width b and at a depth x from the free surface of the liquid.

The intensity of pressure on the strip =

and the area of strip =b.dx

∴ Pressure on the strip = Intensity of pressure * Area = .bd$x$

Now, Total pressure on the surface,

P $wx.bdx$.

$\int w\,x.bdx$

But, $w\int x.bdx$=Moment ofthesurfaceareaabout theliquidlevel = $A\bar{x}$

$\therefore P = wA\bar{x}$

Short questions :

Q. What is capillarity

And : it is define as phenomenon of rise or fall of a liquid surface in a small tube relative to the adjacent general labor of liquid when the tube Is held vertically in the liquid.

Q. State the relation between kinematic and dynamic viscosity.

Ans : kinematic viscosity is the ratio of dynamic viscosity and density of fluid.

Q. Why a ship Float in water but a nail sink.

Ans : ship Float in water but a nail sink because the surface area of sink is much more than nail hence the uplifting buoyancy force act of on the ship surface area is more than nailed.

Long Question :

Q. Calculate the specific weight, density and specific gravity of one litre of a liquid which weight 7N.

Q. A rectangle plate 3m long and 1m wide is immersed vertically in water in such a way that it's 3 m side is parallel to the water surface and is 1m below it. Find total pressure on the plate.

Q. Derivation of total pressure and center of pressure.

Chapter 2:KINEMATICS OF FLUID FLOW

2.1 Basic equation of fluid flow and their application:-

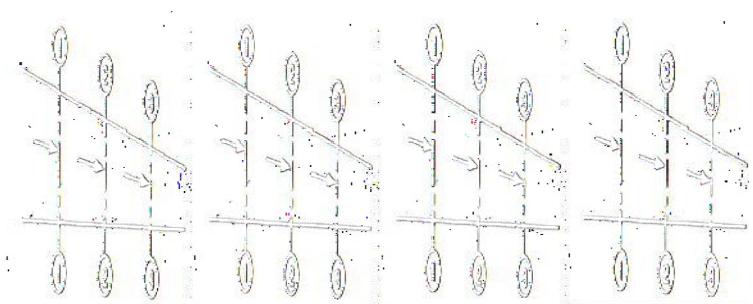
Rate of Discharge

The quantity of a liquid, flowing per second through a section of a pipe or a channel, is known as the rate of discharge or simply discharge. It is generally denoted by Q. Now consider a liquid flowing through apipe.

Let, a = Cross-sectional area of the pipe, and
v = Average velocity of theliquid,
:. Discharge, Q = Area × Average velocity = a.v

Notes: 1. If the area is in $m^2$and velocity in m/s, then the discharge,
$Q = m^2 x\ m/s = m^3/s$ = cumecs
2. Remember that $1m^3$= 1000litres.

Equation of Continuity of a Liquid Flow



If an incompressible liquid is continuously flowing through a pipe or a channel (whose cross-sectional area may or may not be constant) the quantity of liquid passing per second is the same at all sections. This is known as the equation of continuity of a liquid flow. It is the first and fundamental equation offlow.

Fig. 2.8

CONTINUITY OF A LIQUID FLOW

Consider a tapering pipe through which some liquid is flowing as shown in Fig

Let , a_1= Cross-sectional area of the pipe at section 1-1, and
v_1= Velocity of the liquid at section 1-1,
Similarly ,a_2, v_2= Corresponding values at section 2-2,
and a_3, v_3= Corresponding values at section3-3.
We know that the total quantity of liquid passing through section 1-1,

$$Q_1 = a_1.v_1 \quad \text{......(i)}$$

Similarly, total quantity of liquid passing through section 2-2,

$$Q_2 = a_1.v_1 \quad \text{...... (ii)}$$

and total quantity of the liquid passing through section 3-3,

$$Q_3 = a_3 . v_3 \quad \text{.......... (iii)}$$

From the law of conservation of matter, we know that the total quantity of liquid passing through the sections 1-1, 2-2 and 3-3 is the same.Therefore
$Q_1= Q_2= Q_3=$ .... or $a_1.\ v_1= a_2.v_2= a_3.v_3$.......... and so on.

Example : Water is flowing through a pipe of 100 mm diameter with an average velocity 10 m/s. Determine the rate of discharge of the water in litres/s. Also determine the velocity of water
At the other end of the pipe, if the diameter of the pipe is gradually changed to 200 mm.

Solution. Given: $d_1= 100$ mm = 0.1 m; $V_1= 10$ m/s and $d_2= 200$ mm = 0.2 m.
Rate of discharge
We know that the cross-sectional area of the pipe at point 1,

$$a_1= \left(\frac{\pi}{4}\right)x(0.1)^2=7.854x10^{-3}m^2$$

and rate of discharge, $Q = a_1.v_1= (7.854 \text{ x } 10^{-3})\text{x } 10 = 78.54 \text{ X } 10^{-3}m^3/s$
=78.54 litres/s **Ans.**

Velocity of water at the other end of the pipe
We also know that cross-sectional area of the pipe at point 2,

$$a_2=\left(\frac{\pi}{4}\right)x(0.2)^2=31.42x10^{-3}m^2$$

and velocity of water at point 2 ,$v_2= \frac{Q}{a2}= ((78.54 \text{ X } 10^{-3})/(31.42x10^{-3}))$=2.5m/s**Ans.**

Total Energy of a Liquid Particle in Motion:-
The total energy of a liquid, in motion, is the sum of its potential energy, kinetic energy and pressure energy, Mathematically total energy,

$$E = Z + V^2/2g+ \frac{p}{w} \text{ m of Liquid.}$$

Potential Energy of a Liquid Particle in Motion:-
It is energy possessed by a liquid particle by virtue of its position. If a liquid particle is *Z m* above the horizontal datum (arbitrarily chosen), the potential energy of the particle will be *Z* metre-kilogram (briefly written as mkg) per kg of the liquid. The potential head of the liquid, at
point, will be *Z* metres of the liquid.

Kinetic Energy of a Liquid Particle in Motion:-
Itisthe energy, possessed byaliquidparticle, byvirtueofitsmotion or velocity. If a liquid particleisflowingwithameanvelocityofv-metrespersecond;thenthekineticenergyof the

particle will be $V^2/2g$ mkg per kg of the liquid. Velocity head of the liquid, at that velocity, will be $V^2/2g$ metres of theliquid.

Pressure Energy of a Liquid Particle in Motion:-

It is theenergy, possessed by a liquid particle, by virtue of its existing pressure. If a liquid particle is under a pressure ofpkN/m2 (i.e., kPa), then the pressure energy of theparticle- will be $\frac{p}{w}$ mkg per kg of the liquid, where w is thespecific weight of the liquid.Pressure head of the liquid under that pressure will be $\frac{p}{w}$ metres of the liquid.

Bernoulli's Theorem :-

It states, ―For a perfect incompressible liquid, flowing in a continuous stream, the total energy; of a particle remains the same, while the particle moves from one point to another.‖ This statement is based on the assumption that there are no ―losses due to friction in the pipe. Mathematically,

$$Z + V2/2g + \frac{p}{w} = \text{Constant}$$

where

Z = Potential energy,

$V^2/2g$ =Kinetic energy, and

$\frac{p}{w}$ = Pressure energy.

Proof

Consider a perfect incompressible liquid, flowing through a non-uniform pipe as shown in Fig-

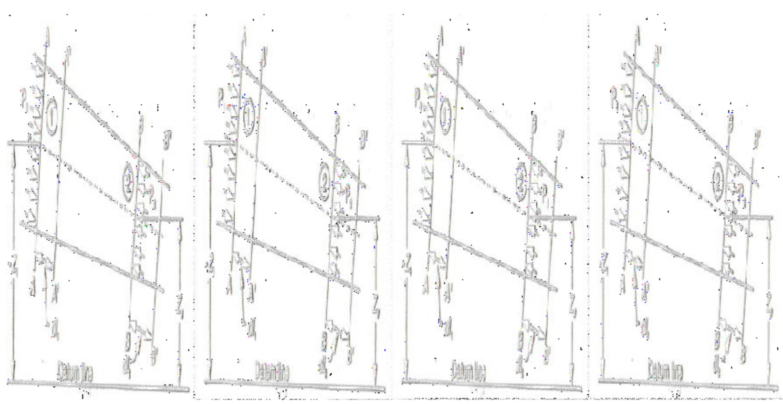


Fig. 2.1

Let us consider two sections AA and BB of the pipe. Now let us assume that the pipe is running full and there is a continuity of flow between the two sections.

Let

Z_1= Height of AA above the datum,

P_1= Pressure at AA,

V_1= Velocity of liquid at AA,

A_1= Cross-sectional area of the pipe at AA, and

Z_2, P_2, V_2, A_2= Corresponding values at BB.

Let the liquid between the two sections AA and BB move to A' A' and B' B' through very small lengths $dl_1$and dl_2as shown in Fig. This movement of the liquid between AA and BB is equivalent to the movement 'of the liquid between AA and A' A' to BB and B' B', the remaining liquid between A' A' and BB being unaffected.

Let W be the weight of the liquid between AA and A' A'. Since the flow is continuous, therefore

$W = wa_1dI_1=wa_2dL_2$

or $a_1 \times dl_1 = \frac{W}{w}$ ...(i)

Similarly $a_2 dl_2 = \frac{W}{w}$

$\therefore a_1 . dL_1 = a_2 dL_2$ ...(ii)

We know that work done by pressure at AA, in moving the liquid to A' A'
= Force x Distance = $P_1 . a_1 . dL_1$
Similarly, work done by pressure at BB, in moving the liquid to B' B'
$= -P_2 a_2 dl_2$
...(Minus sign is taken as the direction of P_2 is opposite to that of P_1)
:. Total work done by the pressure
$= P_1 a1 dl_1 - P_2 a_2 dl_2$
$= P_1 a1 dl_1 - p_{2a} 1 dl_1$ …($a_1 dl_1 = a_2 dl_2$)
$= a_1 . dl_1 (P_1 - P_2) = \frac{W}{w} (P_1 - P_2)$ …($a_1 . dl_1 = \frac{W}{w}$)

Loss of potential energy = $W(Z_1 - Z_2)$
and again in kinetic energy $= W[(V_2^2/2g) - (V_1^2/2g)] = \frac{W}{2g}(v_2^2 - v_1^2)$

We know that loss of potential energy + Work done by pressure
= Gain in kinetic energy

$\therefore W(Z_1 - Z_2) + \frac{W}{w}(P_1 - P_2) = \frac{W}{2g}(v_2^2 - v_1^2)$

$(Z_1 - Z_2) + (p_1/w) - (p_2/w) = v_2^2/2g - v_1^2/2g$

Or $Z_1 + v_1^2/2g + (p_1/w) = Z_2 + v_2^2/2g + (p_2/w)$

which proves the Bernoulli'sequation.

Limitations of Bernoulli's Equation:-

The Bernoulli's theorem or Bernoulli's equation has been derived on certain assumptions, which are rarely possible. Thus the Bernoulli's theorem has the followinglimitations:

TheBernoulli'sequation has been derived under the assumption that the velocity of everyliquidparticle,acrossanycross-sectionofapipe,isuniform.But,inactualpractice, it is not so. The velocity of liquid particle in the centre of a pipe is maximum and gradually decreases towards the walls of the pipe due to the pipe friction. Thus, while using the Bernoulli's equation, only the mean velocity of the liquid should be taken in to account.

1. The Bernoulli's equation has been derived under the assumption that no external force, except the gravity force, is acting on the liquid. But, in actual practice, it is not so. There are always some external forces (such as pipe friction etc.) acting on the liquid, which effect the flow of the liquid. Thus, while using the Bernoulli's equation, all such external forces should be neglected. But, If some energy is supplied to, or, extracted from the flow, the same should also be taken intoaccount.
2. The Bernoulli's equation has been derived, under the assumption that there is. no loss of energy of the liquid particle while flowing. But, in actual practice, -it is rarely so. In a turbulent flow, some kinetic energy is converted into heat energy. And in a viscous flow, some energy is lost due to shear forces. Thus, while using Bernoulli's equation, all such losses should beneglected.
3. If the liquid is flowing in a curved path, the energy due to centrifugal force should also be taken intoaccount.

Example

The diameter of a pipe changes from 200 mm at a section 5 metres-above datum = to 50 mm at a section 3 metres above datum. The pressure of water at first section is 500 kPa. If the velocity of flow at the first section is 1 m/s, determine the intensity of pressure at the second section.

Solution.'Gi~en: d_1= 200 mm = 0.2 m; Z_1= 5 m; d2 = 50 mm = 0.05 m z_2= 3 m; p = 500/ kPa = 500 kN/m2 and V_1= 1mls.

Let

V_2= Velocity of flow at section 2, and

P_2= Pressure at section 2. We know that area of the pipe at section 1$a_1 = \frac{\pi}{4} \times 0.2^2$ =31.42 $\times 10^{-3} m^2$

and area of pipe atsection 2 $a_1 = \frac{\pi}{4} \times 0.05^2$ =1.964 $\times 10^{-3} m^2$

Since the discharge through the pipe is continuous,therefore $a_1 . V_1 = a_2 . V_2 V_2 =$

$\frac{a1 . v1}{a2}$ =[(31.42 $\times 10^{-3}$)$\times 1$]/1.964 $\times 10^{-3}$ =16m/s

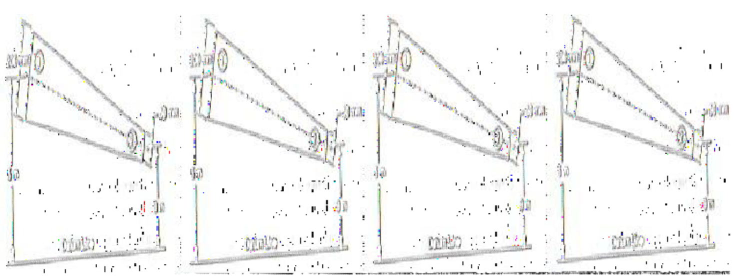


Fig. 2.3

Applying Bernoulli's equation for both the ends of the pipe,

$Z_1 + v_1^2/2g + (p_1/w) = Z_2 + v_2^2/2g + (p_2/w)$

$5+(1)^2/(2 \times 9.81)+500/9.81=3+(16)^2/2X9.81+ \frac{p2}{9.81}$

$P2 = 40 \times 9.81 = 392.4\ kN/m^2 = 392.4\ kPa$ Ans

practical Applications of Bernoulli's Equation

The Bernoulli's theorem or Bernoulli's equation is the basic equation which has the widest applications in Hydraulics and Applied Hydraulics. Since this equation is applied for the derivation

.of many formulae, therefore its clear understanding is very essential. Though the Bernoulli's equation has a number of practical applications.yet in this chapter we shall discuss its applications on the following _hydraulic devices :

1. Venturimeter.
2. Orifice meter.
3. Pitottube.

Venturimeter

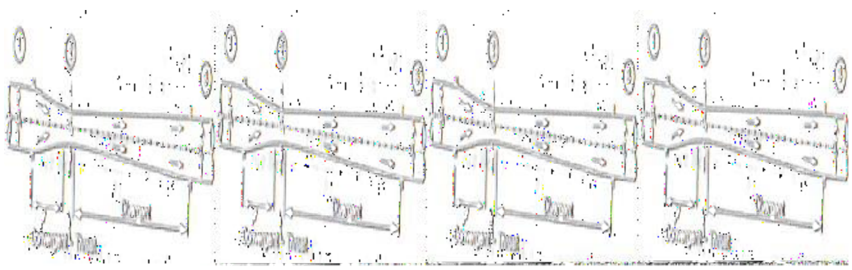


Fig. 2.4

A venturi meter is an apparatus for finding out the discharge of a liquid flowing in a pipe.

A- venture meter, in its simplest form, consists of the following threeparts:

(a) Convergentcone.

(b) Throat.

(c) Divergentcone.

(a) Convergent cone

It is a short pipe which converges from a diameter d_1(diameter of the pipe. in which the venture meter is fitted) to a smaller diameter d_2: The convergent cone is also known as inlet of the venturi meter. The slope of the converging sides is between 1 in 4 or 1 in 5 as shown inFig.

(b) Throat

It is a small portion of circular pipe in which the diameter $d_2$is kept constant as shown in Fig.

(c) Divergent cone

It is a pipe, which diverges from a diameter $d_2$to a large diameter d_1. The divergent cone is also known as outlet of the venture meter. The length of the divergent cone is about 3 to 4 times than that of the convergent cone as shown inFig.

A little consideration will show that the liquid, while flowing through the venture meter, is accelerated between the sections 1 and 2 (i.e., while flowing through the convergent cone). As a result of the acceleration, the velocity of liquid at section 2 (i.e., at the throat) becomes higher than that at section 1. This increase in velocity results in considerably decreasing the pressure at section 2.1fthe pressure head at the throat falls below the separation head (which is 2.5 metres of water), then there will be a tendency of separation of the liquid flow, In order to avoid the tendency of separation at throat, there is always a fixed ratio of the diameter of throat and the pipe (i.e., dz/dt). This ratio varies from 1/4 to 3/4, but the most suitable value is 1/3 to1/2.

The liquid, while flowing through the venture meter, is decelerated (i.e., retarded) between the sections 2 and 3 (i.e., while flowing through the divergent cone). As a result of this retardation, the velocity of liquid decreases which, consequently, increases the pressure. If the pressure is rapidly recovered, then there is every possibility for the stream of liquid to break away from the walls of the metre due to boundary layer effects. In order to avoid the tendency of breaking away the stream of liquid, the divergent cone is made sufficiently longer. Another reason for making the divergent cone longer is to minimize the frictional losses. Due to these reasons, the divergent cone is 3 to 4 times longer than convergent cone as shown inFig.

Discharge through a Venturi meter

Consider a venture meter through which some liquid is flowing as shown in Fig.

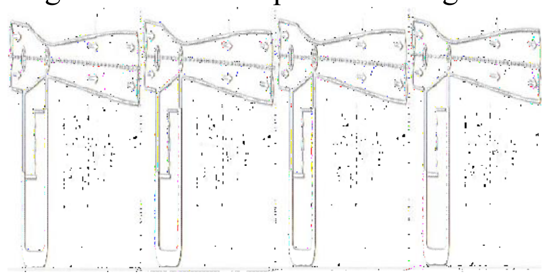


Fig. 2.5

Let

P_1= Pressure at section1,

V_1= Velocity of water at section 1,

Z_1= Datum head at section1,

a_1= Area of the venturi meter at section 1, and

p_2,v_2,z_2,a_2= Corresponding values at section 2.

Applying Bernoulli's equation at sections 1 and 2.i.e

$Z_1+ v_1^2/2g+(p_1/w)=Z_2+v_2^2/2g+(p_2/w)$ .... (1)

Let us pass our datum line through the axis of the venture meter as shown in Fig.

Now $Z_1=0$ and $Z_2=0$

$\therefore\ v_1^2/2g+ (p_1/w)= v_2^2/2g+(p_2/w)$

Or $(p_1/w)-(p_2/w)=v_2^2/2g-v_1^2/2g$ .... (2)

Since the discharge at sections 1 and 2 is continuous, therefore

$V_1=a_2v_2/a_1 (a_1v_1=a_2v_2)$

$V_1^2=a_2^2v_2^2/a_1^2$ .... (3)

Substituting the above value of v_1^2 in equation (2),

$\frac{p1}{w}-\frac{p2}{w}=v_2^2/2g-(a_2^2/a_1^2 X\ v_2^2/2g)$

$=v_2^2/2g(1-a_2^2/a_1^2)=v_2^2/2g[(a_1^2-a_2^2)/a_1^2]$

We know that $\frac{p1}{w}-\frac{p2}{w}$ is the difference between the pressure heads at sections 1 and 2 when the pipe is horizontal, this difference represents the venturi head and is denoted byh.

Or $h=v_2^2/2g[(a_1^2-a_2^2)/a_1^2]$

Or $v_2^2=2gh[a_1^2/(a_1^2-a_2^2)]$

$\therefore\ v_2=\sqrt{2gh}[a_1/\sqrt{(a_1^2-a_2^2)}]$

We know that the discharge through a venture meter,

Q = Coefficient of venturi meter x a_2v_2

$=C.a_2v_2=[Ca_1a_2/\sqrt{(a_1^2-a_2^2)}]\times\sqrt{2gh}$

Example

A venture meter with a 150 mm diameter at inlet and 100 mm at throat is,laid with its axis horizontal and is used for measuring the flow of oil specific gravity O.9. The oil-mercury differential manometer shows a gauge difference of200 mm. Assume coefficient of the metre as O.9 Calculate the discharge in litres perminute.

Solution. Given: d_1= 150 mm = 0.15 m; d_2= 100 mm = 0.1 rn; Specific gravity of oil = 0.9
h = 200 mm = O.2 m of mercury and C =0.98.

We know that the area at inlet,

$a_1=\frac{\pi}{4}\times 0.15^2=17.67\times 10^{-3}m^2$

and the area at throat,

$a_2=\frac{\pi}{4}\times 0.1^2=7.854\ \ 10^{-3}m^2$

We also know that the difference of pressure head,

H=0.2(13.6-0.9/0.9)=2.82 m of oil

and the discharge through the venturi meter,

$Q=[Ca_1a_2/\sqrt{(a_1^2-a_2^2)}]\times\sqrt{2gh}$

$=63.9\ X10^{-3}m^3/s$=63.9lit/s Ans.

0rifice Metre

An orifice metre is used to measure the discharge in a pipe. An orifice metre, in its simplest form, consists of a plate having a sharp edged circular hole known as an orifice. This plate is fixed inside a pipe as shown in Fig. c A mercury manometer is inserted to know the difference

of pressures between the pipe an? the throat (i.e., orifice).

Let

h = Reading of the mercury manometer,

P_1= Pressure at inlet,

V_1= Velocity of liquid at inlet,

a_1= Area of pipe at inlet, and

P_2, v_2, a_2= Correspondingvalues atthe throat.

Fig. 2.6

Now applying Bernoulli's equation for inlet of the pipe and the throat,

$$Z_1 + v_1^2/2g + (p_1/w) = Z_2 + v_2^2/2g + (p_2/w) \qquad \ldots\ldots\ldots(i)$$

$$(p_1/w) - (p_2/w) = v_2^2/2g - v_1^2/2g$$

Or $h = v_2^2/2g - v_1^2/2g = 1/2g(v_2^2 - v_1^2) \qquad \ldots\ldots\ldots(ii)$

Since the discharge is continuous, therefore $a_1.v_1 = a_2 v_2$

$V_1 = a_2/a_1 X\ v_2$ or $v_1^2 = a_2^2/a_1^2 X\ v_2^2$

Substituting the above value of v_1^2 in equation (ii)

$h = 1/2g(v_2^2 - a_2^2/a_1^2 X\ v_2^2) = v_2^2/2g^1\ X\ (1 - a_2^2/a_1^2) = v_2^2/2g[(a_1^2 - a_2^2)/a_1^2]$

$\therefore \quad v_2^2 = 2gh[a_1^2/(a_1^2 - a_2^2)]$ or $v_2 = \sqrt{2gh}[a_1/\sqrt{(a_1^2 - a_2^2)}]$

We know that the discharge,

Q = Coefficient of orifice metre x a_2. v_2

$= [Ca_1a_2/\sqrt{(a_1^2 - a_2^2)}] \times \sqrt{2gh}$

Example. An orifice metre consisting of 100 mm diameter orifice in a 250 mm diameter pipe has coefficient equal to 0•65. The pipe delivers oil (sp. gr. 0•8). The pressure difference on the two sides of the orifice plate is measured by a mercury oil differential inanometer.lfthe differential gauge reads 80 mm of mercury, calculate the rate of flow inlitresls.

Solution. Given: d_2= 100 mm = 0.1 m; d_1= 250 mm = o.25 m; C = 0.65 ; Specific gravity of oil = 0.8 and h = 0.8 m ofmercury.

We know that the area of pipe,

$a_1 = \frac{\pi}{4} \times 0.25^2 = 49.09 \times 10^{-3} m^2$

and area of throat

$a_2 = \frac{\pi}{4} \times 0.1^2 = 7.854 \times 10^{-3} m^2$

We also know that the pressure difference, h = 0.8[(13.6-0.8)/0.8]=12.8 m of oil

and rate of flow,

Q=[Ca_1a_2/ √(a ^{2}-a^2)]× $\sqrt{2gh}$

=82 × 10^{-3} m^3/s=82 lit/s Ans

PitotTube.

A Pitot tube is an instrument to determine the velocity of flow at the required point in a pipe or a stream. In its simplest form, a pitot tube consists of a glass tube bent a through 90° as shown inFig.

The lower end of the tube faces the direction of the flow as shown in Fig. The liquid rises up in the tube due to the pressure exerted by the flowing liquid. By measuring the rise of liquid in the tube, we can find out the velocity of the liquidflow.

Let h = Height of the liquid in the pitot tube above the surface,

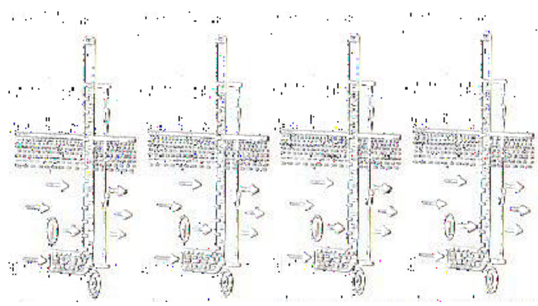


Fig. 2.7

H = Depth of tube in the liquid, and

v=Velocity of theliquid.

Applying Bernoulli's equation forthesections 1 and 2,

$H+v^2/2g=H+h$

…..(z_1=z_2)

h =v^2/2g

∴ v = √2gh

Example .

A pltot tube was inserted in a pipe to measure the velocity of water in it. If (

water rises the tube is 200 mm, find the velocity of water.

Solution. Given: h = 200 mm = 0.2m.

We know thatthe velocity of water in the pipe,

v = √2gh = √(2 x 9.81 x 0.2) = 1.98 m/sAns.

2.2 Flow over Notches and weirs:-

A notch is a device used for measuring the rate of flow of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening.

A weir is a concrete or masonry structure, placed in an open channel over which the flow occurs. It is generally in the form of vertical wall, with a sharp edge at the top, running all the way across the open channel. The notch is of small size while the weir is of a bigger size. The notch is generally made of metallic plate while weir is made of concrete or masonrystructure.

1. Nappe or Vein. The sheet ofwater flowing through a notch or over a weir is called NappeorVein.

2. Crest orSill.The bottom edge ofanotch oratop ofaweir over which the water flows, is known as the sill orcrest.

Types Of Notches :-

The notches are classified as :

According to the shape of theopening:

(a) Rectangular notch,

(b) Triangular notch,

(c) Trapezoidal notch,and

(d) Steppednotch.

2. According to the effect of the sides on the nappe:

(a) Notch with end contraction.

lb)Notch without endcontraction orsuppressed notch e,

Weirs are classified according to the shape of the opening the' shape of the crest, the effect of the sides on the nappe and nature of discharge. The following are important classifications.

Discharge Over A Rectangular Notch Or Weir

The expression for discharge over a rectangular notch or weir is the same.

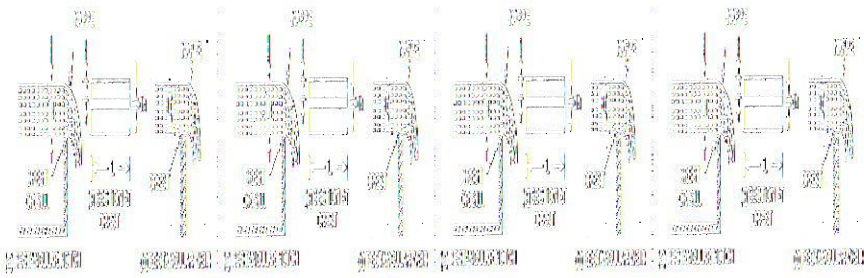


Fig. 2.9

Rectangular notch and 'weir:-

Consider arectangular notch or weir provided in a channel carrying water as shown in Fig

Let H = Head of water overthecrest L = Length of the notch orweir

The total discharge, $Q = \frac{2}{3} \times c_d \times L \times \sqrt{2g}[H]^{3/2}$

Problem - 1

Find the discharge ofwaterflowing overarectangular notch 0/2 In length when the constant head over the notch is 300 mm. Take *cd* =0.60.

Solution. Given:

Length of the notch, L=2.0m

Head over notch, H = 300 m = 0.30 m

C_d=0.06

Discharge$Q = \frac{2}{3} \times c_d \times L \times \sqrt{2g}[H]^{3/2}$

$= \frac{2}{3} \times 0.6 \times 2.0 \times \sqrt{2} \times 9.81 \times [0.30]_{1.5}$ m3/s

= 3.5435 x 0.1643 = 0.582 m3/s. Ans,

Problem2

Determine the height of a rectangular weir of length 6 m to be built across a Rectangular channel. The maximum depth of water on the upstream side of the weir is 1.8m and discharge is 2000 litres/s. Take Cd = 0.6 and neglect endcontractions.

Solution. Given:

Length of weir, L=6m

Depth of water, H1=1.8m

Discharge, Q = 2000 litIs = 2 m3/s

Cd/=0.6

Let H is the height of water above the crest of weir and H2 =height of weir

The discharge over the weir is given by the equation .

$Q=\frac{2}{3}\times C_d \times L \times \sqrt{2g}[H]_{3/2}$

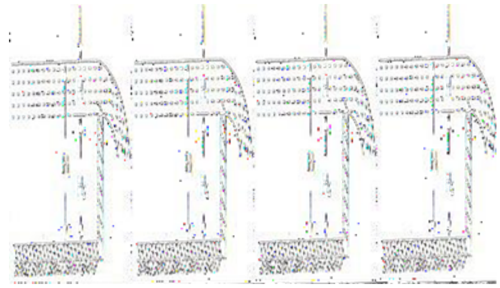


Fig.2.10

$2=\frac{2}{3}\times 0.6 \times 6 \times \sqrt{2}\times 9.81 \times [H]_{3/2}$

$=10.623\ H^{3/2}$

$= H^{3/2}= \frac{2.0}{10.623}$

$H=\left(\frac{2.0}{10.623}\right)^{2/3}=0.328$m

Height of weir, H2 = H1- H

= Depth of water on upstream side - H

= 1.8 - .328 = 1.472 m. Ans.

Discharge OverATriangular Notch OrWeir:-

The expression for the discharge over a triangular notch or weir is the same. It is derived as :

Let H = head of water above the V-notch

θ = angle of notch

Totaldischarge, $Q=\frac{8}{15}\times C_d \times \frac{\tan\theta}{2} \times \sqrt{2g} \times H^{5/2}$

For a right angle V Notch ,if C_d=0.6

$\theta = 90^0$, $\tan\frac{\theta}{2} = 1$

Discharge, $Q=\frac{8}{15}\times 0.6 \times 1 \times \sqrt{2 \times 9.81} \times H^{5/2}$

$=1.417\times H^{5/2}$

Fig.2.11

Problem-1

Find the discharge over a triangular notch of angle 60° when the head over the V-notch is 0.3 m. Assume C_d=0.6.

Solution. Given an Angle of V-notch, e = 60°

Head over notch, H=0.3 m

C_d=0.6

Discharge, Q over a V-notch is given by equation

$$Q=\frac{8}{15}\times C_d\times\frac{\tan\theta}{2}\times\sqrt{2g}\times H^{5/2}$$

$$\frac{8}{15}\times C_d\times\frac{0.6\tan 60}{2}\times\sqrt{2\times 9.81}\times(0.3)^{5/2}$$

= 0.8182 x 0.0493 = 0.040 m3/s. Ans,

Problem-2

Water flows over a rectangular weir 1 m wide at a depth of 150 mm and afterwards passes through a triangular right-angled weir. Taking C_d for the rectangular and triangular weir as 0.62 and 0.59 respectively, find the depth over the triangularweir.

Solution. Given:

For rectangular weir. Length= L = 1 m

Depth of water, H = 150mm=0.15m

C_d=0.62

For triangularweir.

θ = 90°

C_d=0.59

Let depth overtriangularweir =H_1

The discharge over the rectangular weir IS given by equation

$$Q=\frac{2}{3}\times C_d\times L\times\sqrt{2g}[H]^{3/2}$$

$$=\frac{2}{3}\times 0.62\times 1.0\times\sqrt{2\times 9.81}\times(0.15)^{3/2}$$

=0.10635 m^3/s

The same discharge passes through the triangular right-angled weir. But discharge. Q. is given by theequation

$$Q=\frac{8}{15}\times C_d\times\frac{\tan\theta}{2}\times\sqrt{2g}\times H^{5/2}$$

$$0.10635=\frac{8}{15}\times 0.59\times\frac{\tan 90}{2}\times\sqrt{2g}\times H_1^{5/2} \qquad \{\theta = 90^0 \text{ and } H=H_1\}$$

$$=\frac{8}{15}\times 0.59\times 1\times 4.429\times H_1^{5/2}$$

$$=1.3936\, H_1^{5/2}$$

$$H_1^{5/2}=\frac{0.10635}{1.3936}=0.07631$$

$H_1=(0.07631)^{0.4}$=0.3572m ,Ans

Discharge OverATrapezoidal Notch OrWeir:-

A trapezoidal notch or weir is a combination of a rectangular and triangular notch or weir. Thus the total discharge will be equal to the sum of discharge through a rectangular weir or notch and discharge through a triangular notch orweir.

Let H = Height of water over the notch

L = Length of the crest of thenotch

C_{d1}= Co-efficient or discharge. for rectangular portion ABCD of Fig.

C_{d2}= Co-efficient of discharge for triangular portion [FAD and BCE]

The-discharge through rectangular portion ABCD is given by

or $$Q_1=\frac{2}{3}\times C_{d1}\times L\times\sqrt{2g}\times H^{3/2}$$

The discharge through twotriangular notches FDA and BCE is equal to the discharge through a single triangular notch of angle e and it is given by equation

$$Q_2=\frac{2}{3}\times C_{d2}\times\frac{\tan\theta}{2}\times\sqrt{2g}\times H_{5/2}$$

Discharge through trapezoidal notch or weir FDCEF = Q_1+Q_2

$$=\frac{2}{3}\times C_{d1}L\sqrt{2g}\times H^{3/2}+\frac{8}{15}C_{d2}\times\frac{\tan\theta}{2}\times\sqrt{2g}\times H_{5/2}$$

Problem -1 Find the discharge through a trapezoidal notch which is 1 m wide at the tapand 0.40 m at the bottom and is 30 cm in height. The head of water On the notch is 20 cm.Assume $C_d$for rectangular portion = 0.62 while for triangular portion =0.60.

Solution. Given:

Topwidth AE=1m

Basewidth, CD=L=0.4m

Head ofwater, H=0.20m

For rectangular portion, C_{d1}=0.62

From ΔABC ,we have

$$\frac{\tan\theta}{2}=\frac{AB}{BC}=\frac{\frac{AE-CD}{2}}{H}$$

$$=\frac{\frac{1.0-0.4}{2}}{0.3}=\frac{\frac{0.6}{2}}{0.3}=\frac{0.3}{0.3}=1$$

Fig.2.12

Discharge through trapezoidal notch is given by equation

$$Q=\frac{2}{3}C_{d1}\times L\times\sqrt{2g}\times H^{3/2}+\frac{8}{15}C_{d2}\times\frac{\tan\theta}{2\sqrt{2g}}\times H^{5/2}$$

$$=\frac{2}{3}\times 0.62\times 0.4\times\sqrt{2\times 9.81}\times(0.2)^{3/2}+\frac{8}{15}\times 60\times 1\times\sqrt{2\times 9.81}\times(0.2)^{5/2}$$

$= 0.06549 + 0.02535 = 0.09084\ m^3/s = 90.84$ litres/s. Ans

Discharge Over A Stepped Notch:-

A stepped notch isacombination of rectangular notches. The discharge through 'stepped notch is equal to the sum of the discharges' through the different rectangular notches.

Consider a stepped notch as shown in Fig.

Let H_1= Height of water above the crest of notch(1).

L_1= Length of notch 1 ,

H_2, L_2 and H_3, L_3 arecorresponding values for notches 2 and 3 respectively.

C_d=Co-efficient of discharge for allnotches

Total discharge $Q=Q_1+Q_2+Q_3$

Fig. 2.12

$$Q=\frac{2}{3}\times C_d\times L_1\times\sqrt{2g}[H_1^{3/2}-H_2^{3/2}]+\frac{2}{3}\times C_d\times L_2\times\sqrt{2g}[H_2^{3/2}-H_3^{3/2}]+\frac{2}{3}C_d\times L_3\times\sqrt{2g}\times H_3^{3/2}$$

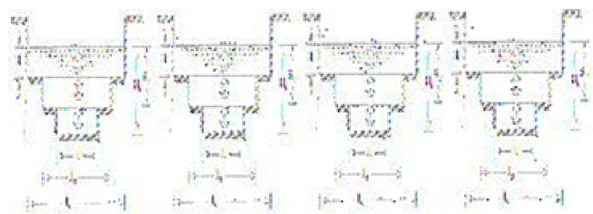


Fig.2.13

Problem

Fig. 1 shows a stepped notch. Find the discharge through the notch if Cd for all section = 0.62.

Solution. Given:

L_1= 40 cm, L_2= 80 cm,

L_3= 120cm

H_1= 50 + 30 + 15 = 95 crn,

H_2=80 cm,H_3=50 cm,

C_d=0.62

Total Discharge

,$Q=Q_1+Q_2+Q_3$ where

$$Q_1=\frac{2}{3}\times C_d\times L_1\times\sqrt{2g}[H_1^{3/2}-H_2^{3/2}]$$

$$=\frac{2}{3}\times 0.62\times 40\times\sqrt{2\times 981}\times[95^{3/2}-80^{3/2}]$$

$=154067 cm^3/s$ =154.067 lit/s

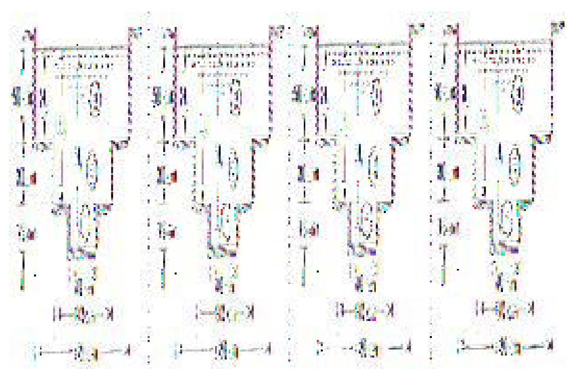


Fig. 2.14

$Q_2 = \frac{2}{3} \times C_d \times L_2 \times \sqrt{2g}\,[H_2^{3/2} - H_3^{3/2}]$

$= \frac{2}{3} \times 0.62 \times 80 \times \sqrt{2 \times 981} \times [80^{3/2} - 50^{3/2}]$

$= 530141\ cm^3/s$

$= 530.144$ lit/s

$Q_3 = \frac{2}{3} C_d \times L_3 \times \sqrt{2g} \times H_3^{3/2}$

$= \frac{2}{3} \times 0.62 \times 120 \times \sqrt{2 \times 981} \times 50^{3/2}$

$= 776771\ cm^3/s$

$= 776.771$ lit/s

$\therefore\ Q = Q_1 + Q_2 + Q_3$

$= 154.067 + 530.144 + 776.771$

$= 1460.98$ lit/sAns.

Types of Weirs :-

Though there arenumerous types of weirs, yet the followingareimportant from the subject point of view:

1. Narrow-crested weirs,
2. Broad-crested weirs,

3. Sharp-crested weirs,
4: Ogee weirs, and
5. Submerged or drownedweirs.

Discharge over a Narrow-crested Weir :-

The weirs are generally classified according to the width of their crests into two types. i.e. narrow-crested weirs and broad crested weirs.

Let b = Width of the crest of the weir, and
H = Height of water above the weir crest.

If 2b is less than H,the weir is called a narrow-crested weir. But if 2b is more than H .it is called a broad-crestedweir.
A narrow-crested weir is hydraulically similar to an ordinary weir or to a rectangular weir .Thus, the same formula for discharge over a narrow-crested weir holds good, which we derived from an ordinary weir.

$$Q = \frac{2}{3} X C_d . L \sqrt{2g} \times H^{3/2}$$

Where, Q = Discharge over the weir,

Cd = Coefficient of discharge,

L = Length of the weir,and

H = Height of water level above the crest of the weir.

Example A narrow-crested weir of 10metres long is discharging water under a constant head of 400 mm. Find discharge over the weir in litres. Assume coefficient of discharge as0.623.

Solution. Given: L = 10 m; H= 400 mm = 0.4 m and C_d= 0.623.
We know that the discharge over theweir,

$$Q = \frac{2}{3} X C_d . L \sqrt{2g} \times H^{3/2}$$

$$= \frac{2}{3} x 0.623 x 10 \sqrt{(2 \times 9.81)} (0.4)^{3/2}$$

$$= 46.55 \ m^2/s = 4655 \ lit/s$$

Discharge overaBroad-crested Weir:-

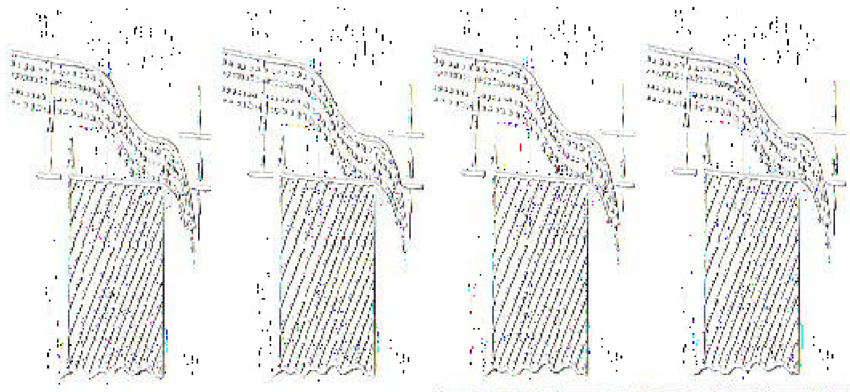


Fig. 2.15

Broad-crested weir

Consider abroad-crested weir as shown in Fig. Let A and B be the upstream and downstream ends of theweir.

Let H = Head of water on the upstream side of the weir (i.e., at A),

h = Head of water on the downstream side of the weir (i.e., at B),

v = Velocity of the water on the downstream side of theweir (i.e., at B),

C_d= Coefficient of discharge,

andL = Length of theweir.

$$\mathbf{Q = 1.71 C_d . L \times H^{3/2}}$$

Example A broad-crested weir 20 m long is discharging water from a reservoir in to channel. What will be the discharge over the weir, if the head of water on the upstream and downstream sides is 1m and 0.5 m respectively? Take coefficient of discharge for the flow as 0.6 .

Solution. Given: L = 20 m; H = 1 m; h = 0.5 m and C_d= 0.6.

We know that the discharge over the weir,

$Q = C_d \times L.h\sqrt{2g(H-h)}$

$= 0.6 \times 2.0 \times 0.5 \times \sqrt{2 \times 9.81(1-0.5)}\ m^3/s$

$= 6 \times 3.13 = 18.8\ m^3/s$ **Ans.**

Discharge over a Sharp-crested Weir :-

It is a special type of weir, having a sharp-crest as shown in Fig. The water flowing over the crest comes in contact with the crest -line and then springs up from the crest and falls as a trajectory as shown inFig.

In a sharp-crested weir, the thickness of the weir is

kept less than half of the height of water on the weir.i.e.,

$$b<(H/2)$$

where , b = Thickness of the weir,

and H = Height of water, above the crest of theweir.

The discharge equation, for a sharp crested weir, remains the same as that of a rectangular weir.i.e.,

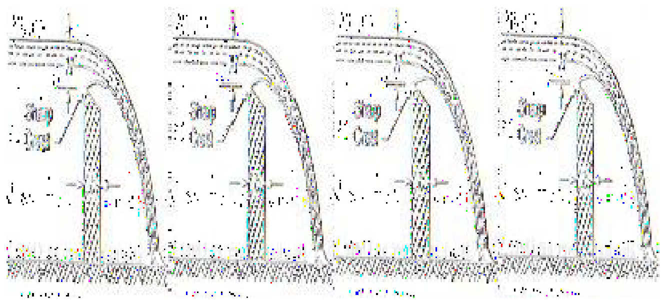


Fig. 2.16

Sharp-crested weir:-

$$Q= \frac{2}{3} X\ C_d.L\sqrt{2g}x\ H^{3/2}$$

Where, C_d= Coefficient of discharge, and
L = Length of sharp-crestedweir

Example In a laboratory experiment, water flows over a sharp-crested weir 200 mm long under a constant head of 75mm. Find the discharge over the weir in litres/s, if C_d=0.6.

Solution. Given: L = 200 mm = 0.2 m; H = 75 mm = 0.075 m and C_d=0.6.

We know that the discharge over the weir,

$$Q = \frac{2}{3}XC_d.L \sqrt{2g} \text{ x } H^{3/2}$$

$$= \frac{2}{3} \times 0.6 \times 0.2 \times \sqrt{2 \times 9.81} \times (0.075)_{3/2}$$

$$=0.0073 \text{ m}^3\text{/s} = 7.3 \text{ litres/s.}$$ **Ans.**

Discharge over an Ogee Weir:-

It is a special type of weir, generally, used as a spillway of a dam as shown in Fig.
, The crest of an agee weir slightly rises up from the point A ,(i.e., crest ofthe sharp-crested weir) and after reaching the maximum riseof 0.115 H (where H is the height of a water above the point A) falls in a parabolic form as shown inFig.

The discharge equation for an ogee weir remainsthesame asthat ofarectangular weir. i.e.,

$Q = \frac{2}{3} X C_d.L \sqrt{2g} \text{ x } H^{3/2}$

Where C_d= Co-efficient of discharge and

L= Length of an ogee weir

Fig. 2.17

Example

An ogee weir 4 metres long has 500 mm head of water. Find the discharge over the weir, if C_d =0.62.

Solution. Given: L = 4 m; H = 500 mm = 0.5 m and C_d= 0.62.

We know that the discharge over the weir,

$Q = \frac{2}{3} X C_d.L \sqrt{2g} \text{ x } H^{3/2}$

$= \frac{2}{3} X 0.62 X 4 \sqrt{2 X 9.81} X (0.5)^{3/2} m^3/s$

$= 7.323 \text{ x } 0.354 = 2.59 \ m^3/s = 2590$ litres/s Ans

Discharge overaSubmerged or Drowned Weir:-

When the water level on the downstream side of a weir is above the top surface of weir, it is known a submerged or drowned weir as shown in Fig

The total discharge, over such a weir, is found out by splitting up the height of water, above the sill of the weir, into two portions as discussedbelow:

Let H_1= Height of water on the upstream side of the weir, and

H_2=height of water on the downstream side of the weir.

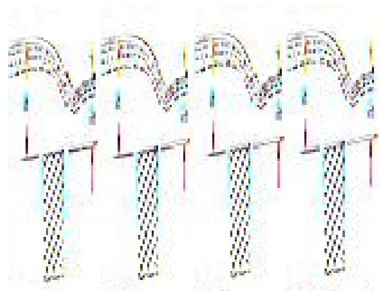


Fig. 2.18

The discharge over the upper portion may be considered as a free discharge under a head of water equal to ($H_1 - H_2$). And the discharge over the lower portion may be considered as a submerged discharge under a head of H_2. Thus discharge over the free portion (i.e., upper portion),

$$Q1 = \frac{2}{3} X Cd.L \sqrt{2g}\ x(H1-H2)^{3/2}$$

Submerged weir :-

and the discharge over the submerged (i.e., lower portion),

$Q_2 = C_d.\ L.\ H_2.\sqrt{2g(H_1 - H_2)}$

:.Totaldischarge, $Q = Q_1 + Q_2$

Example A submerged sharp crested weir 0.8 metre high stands clear across a channel having vertical sides and a width of 3 meters. The depth of water in the channel of approach is 1.2 meter. And 10 meters downstream from the weir, the depth of water is 1 meter. Determine the discharge over the weir in liters per second. Take $C_d$as 0.6.

Solution. Given: L = 3 m and Cd = 0.6.

From the geometry of the weir, we find that the depth

of water on the upstream side,

H_1= 1.25 - 0.8 = 0.45 m and depth of water on the downstream side,

H_2= 1 - 0.8 = 0.2 m

We know that the discharge over the free portion of the weir

$$Q_1 = \frac{2}{3} X Cd.L \sqrt{2g}\ x(H1-H2)^{3/2}$$

$$= \frac{2}{3} \times 0.6 \times 3 \times \left(\sqrt{2 \times 9.81}\right)(0.45 - 0.20)_{3/2}$$

$= 5.315 \times 0.125 = 0.664\ m^3/s = 664$liters/s ... (i)

and discharge over the submerged portion of the weir,

$Q_2 = C_d.\ L.\ H_2.\sqrt{2g(H_1 - H_2)}$

$= 0.6 \times 3 \times 0.2 \sqrt{2 \times 9.81(0.45 - 0.2)}\ m^3/s$

$= 0.36 \times 2.215 = 0.797\ m^3/s = 797$liters/s ...(ii)

:. Total discharge: $Q = Q_1 + Q_2 = 664 + 797 = 1461$liters/ s **Ans.**

2.3 Types of flow through the pipe :

Uniform flow:
.It is Defined as the type of flow in which the velocity at any given time does not change with respect to space.

Non uniform flow:
. It is defined as that type of flow in which the velocity at any given time changes wrt space.

Laminar flow:
. Laminar flow is defined as that type of flow in which the fluid particles move along well defined path or streamline And all the streamline are are straight and parallel. this type of flow also called Viscos flow .

Turbulent flow:
. it is the type of flow in which the fluid particles move in a jig Jag way .the Eddies are formed due to high energy .

Steady flow:
. it is defined as that type of flow in which the fluid characteristics like velocity ,pressure , density etc at a point do not change with time

Unsteady flow:

.it is the type of flow in which the velocity pressure ,density, at a point change with respect to time.

Reynoldnumber :

.it is defined as the ratio of of inertia force of a flowing fluid And the viscous force of the fluid.

It's application :

. it is applied for determination of laminar and turbulent flow .

.If the Reynolds number is less than 2000 the flow is called laminar flow .

. If the Reynolds number is more than 4000 it is called turbulent flow.

. If the Reynolds number Lies Between 2000 and 4000 the pro maybe lamina or turbulent.

2.4 losses of head of a liquid flowing through pipe :

Different types of major and minor losses:

A .Losses due to Frictional loss in pipe

4fLV^2

Hf= ----------------------

d 2g

Hf= loss of head due to ffriction

L= length of the pipe

V= Velocity of flow

d=Diameter of pipe

B . Losses due to sudden enlargement

(V1 - V2)^2

He= ------------------

2g

V1, V2= velocity of flow at section 1 and 2

g = specific gravity

C .loss of head due to sudden contraction

V^2

Hc= --------------* 0.375

2g

Total energy line :

. It is define as the line which gives the sum of pressure head ,datum head And kinetic head of afollowing fluid in a pipe with respect to some reference line. it is also defined as the line which is obtained by joining the top of all vertical units coordinates showing the sum of pressure head and kinetic head from the centre of the pipe.

Hydraulic gradient line:

. it is the defined as the line which gives the sum of pressure head And datum head Of a flowing fluid in a pipe with respect to some reference line or it is the line which is obtained by joining the top of all verticalordinates showing the pressure head of the flowing fluid in a pipe From the centre of the pipe .

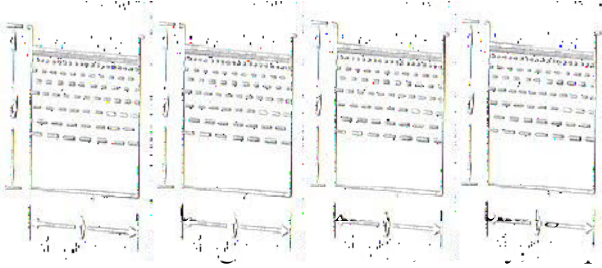
2.5 flow through the open channels:

Types of channel section :

.Rectangular

. Trapezoidal

.circular



rough a Channel of Rectangular Section :-

rovided in channels except in rocky soils where the faces of rocks can stand vertically. Though a rectangular section is notof much practical importance, yet we shall discuss it for its theoretical importanceonly.

Consider a channel of rectangular section as shown in Fig.
Let

b = Breadth of the channel, and
d = Depth of thechannel.
A= b X d
Discharge Q = A x v=AC mi
m=A/P
=d/2

Fig. 2.20

Hence, for maximum discharge or maximum velocity, these two conditions (i.e., b = 2d and m = d/2) should be used for solving the problems of channels of rectangularcross-sections.

Example

Arectangular channel hasacross-section of 8 square metres. Find its size and discharge through the most economical section, if bed slope is 1 in 1000. Take C =55.

Solution. Given: A = 8 m2

i= 1/1000 = 0.001 and C = 55.
Size of the channel
Let
b = Breadth of the channel, andd
= Depth of the channel.
We know that for the most economical rectangular section,
b =2d
:. Area (A) 8=b X d= 2d X d =$2d^2$
= b=2 m

And b=2d=2 X 2= 4 m

Discharge through the channel

We also know that for the most economical rectangular section, hydraulic mean depth,

m=d/2=2/2=1 m

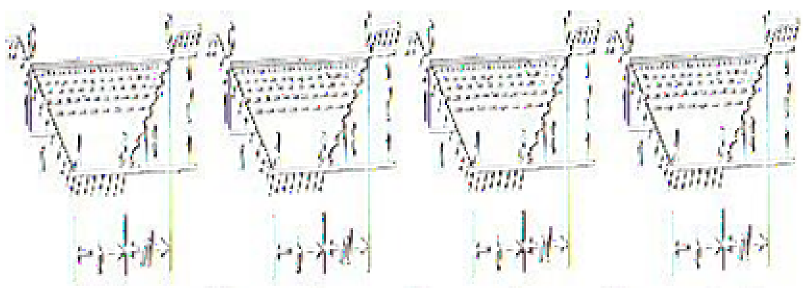
and the discharge through the channel,
Q=AC mi= 8x55 1 X 0.001m^3/s

= 440 x 0.0316 = 13.9 m^3/s , Ans.

Condition for Maximum Discharge through a Channel ofTrapezoidal Section :-

A trapezoidal section is always provided in the earthen channels. The side slopes, in a channel of trapezoidal cross-section are provided, so that the soil can stand safely. Generally, the side slope in a particular soil is decided after conducting experiments on that soil. In a soft soil, flatter sideslopes should be provided whereas in a harder one, steeper side slopes may be provided.

consider a channel of trapezoidal cross- section ABCD as shown in FIg.



Let

b = Breadth of the channel at the bottom,

d = Depth of the channeland

$\frac{1}{n}$=side slope (i.e., 1 vertical to n horizontal)

Hence, for maximum discharge or maximum velocity these two (i.e., b +2nd/2 = d $\sqrt{n2 + 1}$ and m = d/2) should be used for solving problems on channelsof Trapezoidalcross-sections.

Example.

Amosteconomical trapezoidal channel hasanareaofflow 3.5 m^{2}discharge in the channel, when running 1 metre deep. Take C = 60 and bed slope 1 in800.

Solution. Given: A = 3.5 m2 ; d = 1 m; C = 60 and i = 1/800.

We know that for the most economical trapezoidal channel the hydraulic mean depth

m = d/2 = 0.5m

and discharge in the channel,

Q=A.C. = 5.25 m^3/sAns.

Example.

A trapezoidal channel having side slopes of 1 : 1 and bed slope of 1 in 1200 is required to carry a discharge of 1800 m^3/min. Find the dimensions of the channel for cross-section. Take Chezy's constant as50.

Solution.

Given side slope (n)=1

(i.e. 1 vertical to n horizontal),

i= 1/1200 ,Q= 180m^3/min = 3m^3/sec

and C = 50

Let b=breadth of the channel of its bottom and d= depth of the water flow.

We know that for minimum cross section the channel should be most economical and for economical trapezoidal section half of the top width is equal to the slopping side. i.e.

b +2nd/2=d $\sqrt{n2 + 1}$ or b

= 0.828d

Area A = d X (b + nd) = 1.828d^2

We know that in the case of a most economical trapezoidal section the hydraulic mean depth m=d/2

And discharge through the channel(Q)=A.C.

=1.866$d^{5/2}$

$d^{5/2}$ =3/1.866 =1.608

Or d = 1.21 m

b = 0.828 d = 0.828 X 1.21 = 1 m ANS

Condition for Maximum Velocity through a Channel of Circular Section :-

Consider a channel 'of circular section, discharging water undertheatmospheric pressure shown inFig.

Let r = Radius of thechannel,

h = Depth of water in the channel, and

2 = Total angle (in radians) subtended at the centre by the water

From the geometry of the figure, we find that the wetted perimeter of thechannels,

P= 2 ...(i)

and area of the section, through which the water is flowing,

$A= r^2 - \frac{r2 \sin 2\theta}{2} = r^2(- \frac{\sin 2\theta}{2})$ …(ii)

We know that the velocity of flow in an open channel,

Q= A.C.

We know that the velocity of flow in an open channel , v= C

Problem: Find the maximum velocity of water in a circular channel of 500 mm radius, if the bed slope is 1 in 400. Take manning's constant as50.

Solution:-
Given d= 500mm = 0.5m or r = 0.5/2 = 0.25m, i=1/400 and M= 50
Let**2** = total angle (in radian) subtended by the water surface at the centre of thechannel.

Now we know that for maximum velocity , the angle subtended by the water surface at the centre of the channel.

2 $= 257^0 30'$or $= 128.75^0 = 128.75 X \frac{\pi}{180}$=2.247rad

Area of flow, **A** $=r^2(\quad - \frac{\sin 2\theta}{2})$ =
$171 m^2$And perimeter P=2r =1.124m

hydraulic mean depth m= A/P = 0.171/1.124 =0.152m

And velocity of water v= $MXm^{2/3}Xi^{1/2}$=0.71m/s

Chezy'sFormula :-

I = Length of the channel,

A = Area of flow,

v = Velocity of water,

p = Wetted perimeter of the cross-section, m=

f = Frictional resistance per unit area at unit velocity, and

i = Uniform slope in thebed.

m= $\frac{A}{P}$ ……..(known as hydraulic mean depth or hydraulic radious)

∴ Discharge Q= AXv=AC $\sqrt{mi}$

Example.
A rectangular channel is 1. 5 metres deep and 6 metres wide. Find the discharge through channel, when it runs full. Take slope of the bed as 1 in 900 and Chezy's constant as 50.
Solution. Given: d = 1.5 m; b = 6 m; i = 1/900 and C = 50.

We know that the area of thechannel,

A = b.d = 6 x 1.5 = 9 m^2

Andwettedperimeter, D = b + 2d = 6 + (2 x 1.5) = 9m

:. Hydraulic mean depth, m = $\frac{A}{P}$= 1 m and the discharge through thechannel,

$Q=AC\sqrt{mi}=9x50\sqrt{}(1 X1/900)= 15m^3/s$ Ans

Manning equation :-

Manning, after carrying out a series of experiments, deduced the following relation for the value of C in Chezy's formula fordischarge:

$C=\frac{1}{N}\times m_{1/6}$

where N is the Kutter's constant

Now we see that the velocity,

$v=C\sqrt{mi}=M X m^{2/3}X$

$i^{1/2}$where

M =1/N and is known as Manning's constant.

Now the discharge,

Q = Area x Velocity = $A x 1/N x m^2 xi^{1/2}$

$= A x M x m^{2/3} x i^{1/2}$

Example

An earthen channel with a 3 m wide base and side slopes 1 : 1 carries water with a depth of 1 m. The bed slope is 1in 1600. Estimate the discharge. Take value of N in Manning's formula as0.04.

Solution.

Given: b = 3 m; Side slopes = 1 : 1; d =1m; i = 1/1600 and N = 0.04.

We know that the area offlow,

$A = \frac{1}{2} x (3 + 5) x1 = 4m^2$

and wetted perimeter,

$P = 3+2X \sqrt{(1)^2+(1)^2} = 5.83m$

$\therefore$ hydraulic mean depth m = A/P=4/5.83=0.686 m

We know that the discharge through the channel

$Q = \text{Area x Velocity} = A \times 1/N \times m^{2/3} x i^{1/2}$

$= 4 X 1/0.04 X 0.686^{2/3} X (1/1600)^{1/2}$

$=1.945 m^3/s$ Ans

Best Economical sections :-

A channel, which gives maximum discharge for a given cross-sectional area and bed slope is called a channel of most economical cross-section. Or in other words, it is a channel which involves least excavation for a designed amount of discharge. A channel of most economical cross-section is, sometimes: also defined as a channel which has a minimum wetted perimeter; so that there is a minimum resistance to flow and thus resulting in a maximum discharge. From the abovedefinitions,

it is obvious that while deriving the condition for a channel of most economical cross-section, the cross-sectional area is assumed tobe constant. The relation between depth and breadth of the section is found out to give the maximumdischarge.

The conditions for maximum discharge for the following sections will be dealt with in the succeeding pages:

1. Rectangular section,
2. Trapezoidal section,and
3. Circularsection.

Short questions

Q. What is notch

Ans. A notch is a device used for measuring the rate of flow of a liquid through a small channel Or a tank.

Q. Write the continuity equation for a fluid flowing through a pipe.

Ans.

$$A1V1 = A2V2$$

V= velocity of the fluid through respective section.

A= area of the section

Q. Define steady and unsteady flow

Ans. It is defined as that type of flow in which the fluid character like velocity, pressure, density etc at a point do not change with time.

Q. Name the various losses of head of a liquid flowing through pipes.

Ans. Mainly losses of head of a liquid flowing through pipe are minor losses, friction losses, total head losses, pressure losses.

Long questions :

Q. What are the classification of notches and weirs.

Q. What are the difference between total energy line and hydraulic gradient line

Q. A rectangular weir has a discharge of 0.24cum/sec when head of water is 800mm. Find the length of the weir. Assume Cd=0.6

Q. Find the slope of the bed of a rectangular channel of width 5m when depth of water is 2m and rate of flow is given as 20 cum/ sec. Take chezy'sConst C=50

Chapter-III

PUMPS

Introduction :

The hydraulic machine which convert the mechanical energy in to hydraulic energy are called pumps.

3.1 type:

There are two type of pumps

1. Centrifugal pumps
2. Reciprocating pump

3.2 CentrifugalPumps:-

Basic principles :

The hydraulic machines which convert the mechanical energy to hydraulic energy are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted, into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugalpump.

The centrifugal pump works on the principle of forced vortex flow which means that when a certain mass of liquid is rotated by an external torque, the rise in pressure head of the rotating liquid takes place. The rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of the liquid at that point (i.e. , rise in pressure head= $\frac{v^2}{2g}$ or $\frac{\omega^2 r^2}{2g}$) . Thus at the outlet of the impeller, where radius is more , the rise in pressure head will be more & the liquid will be more & the liquid will be discharged at the outlet with a high pressure head. Due to this high pressure head, the liquid can be lifted to a high level.

Operation Of Centrifugal Pump:-

The followings are the main parts of a centrifugal pump:

1. Impeller
2. Casing
3. Suction pipe with a foot valve & astrainer
4. DeliveryPipe

All the main parts of the centrifugal pump are shown in Fig 19.1

1. **Impeller**: The rotating part of a centrifugal pump is called _impeller‘. It consists of a series of backward curved vanes. The impeller is mounted on a shaft which is connected to the shaft of an electricmotor.

2. **Casing:** The casing of a centrifugal pump is similar to the casing of a reaction turbine. It is an air-tight passage surrounding the impeller & is designed in such a way that the kinetic energyofthewaterdischargedattheoutletoftheimpellerisconvertedintopressureenergy

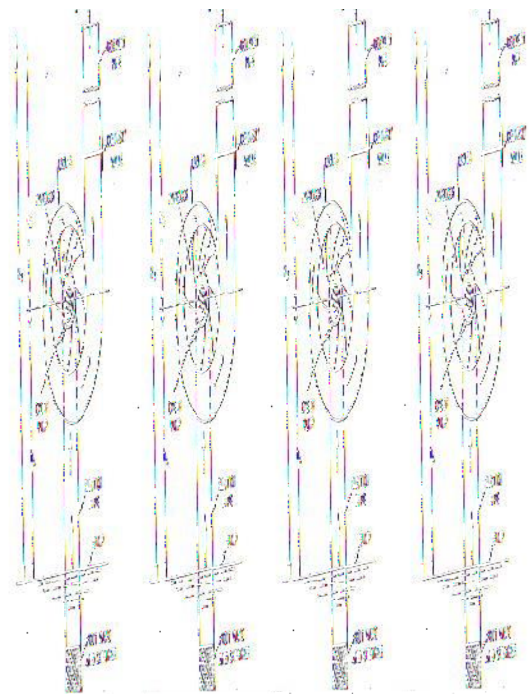
before the water leaves the casing & enters the delivery pipe. The following three types of the casings are commonlyadopted:

a. Volute **casing** as shown inFig.19.1

b. Vortex casing as shown inFig.19.2(a)

c. Casing with guide blades as shown inFig.19.2(b)

a) Volute casing as shown in Fig.3.1the Volute casing, which is surrounding the impeller. It is of spiral type in which area of flow increases gradually. The increase in area of flow decrease velocity of flow. Decrease in velocity increases the pressure of water flowing through casing. it has been observed that in case of volute casing, the efficiency of pump increases.



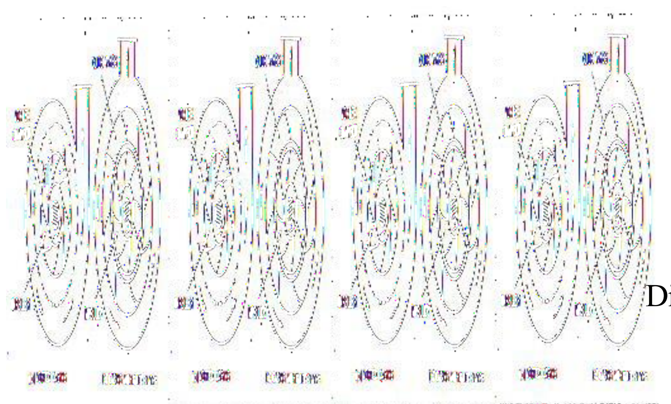
Main parts of a centrifugal pump

Fig. 3.1

b) Vortex casing. if a circular chamber is introduced between the casing and impeller as shown in fig.3.1,the casing is known as vortex casing .by introducing the circular chamber, loss of energy due to formation of eddies is reduced to a considerable extent. thus efficiency of pump is more than the efficiency when only volute casing isprovided.

c) **Casing with guide blades**. This casing is shown in fig.3.1 in which the impeller is surrounded by a series of guide blades mounted on a ring which is known as diffuser. the guide vanes are designed in which a way that the water from the impeller enters the guide vanes without stock. Also the area of guide vanes increases, thus reducing the velocity of flow through guide vanes and consequently increasing the pressure of water. the water from guide vanes then passes through the surrounding casing which is in most of cases concentric with the impeller as shown infig.3.1.

3. **suction pipe with foot-valve and a strainer:** A pipe whose one end is connected to the inlet of pump andotherend dips into water in a sump is known as suction pipe. A foot valve which is a non-return valve or one –way type valve is fitted at lower end of suction pipe. Foot valve opens only in upward direction. A strainer is also fitted at lower end of suctionpipe.



Different type of casing

4. **Delivery pipe:** a pipe whose one end is connected to outlet of pump and other end delivers water at a required height is known as deliverypipe.

Discharge :

$$Q = \pi * D1 * B1 * Vf1 = \pi * D2 * B2 * Vf2$$

B1 and B2 = Width of impeller at inlet and outlet

Vf1 & Vf2 = velocity of flow at inlet and out let

Horse power :

Efficiencies of a centrifugal pump: Efficiencies of a centrifugal pump: In case of a centrifugal pump , the power is transmitted from the shaft of the electric motor to the shaft of the pump & then to the impeller. From the impeller, the power is given to the water. Thus power is decreasing from the shaft of the pump to the impeller & then to the water. The following are the important efficiencies of a centrifugal pump:

a. Manometricefficiencies η_{man}

b. Mechanical efficiencies η_m

c. Overall efficiencies η_o

a) **Manometric Efficiencies η_{man} :** The ratio of the manometric head to the head imparted by the impeller to the water is known as manometric efficiency. It is written as

$\eta_{max} = $ Manometric head / Head imparted by impeller to water

$$= \frac{H_m}{\frac{V_{w2}u_2}{g}} = \frac{gH_m}{V_{w2}u_2} \ldots\ldots\ldots\ldots\ldots$$

The impeller at the impeller of the pump is more than the power given to the water at outlet of the pump. The ratio of the power given to water at outlet of the pump to the power available at the impeller, is known as manometricefficiency.

The power given to water at outlet of the pump= $\frac{WH_m}{1000} kW$

The power at the impeller = $\frac{\text{Work done by impeller per second}}{1000} kW$

$$= \frac{W}{g} \times \frac{V_{w2}u_2}{1000} kW$$

$$\eta_{max} = \frac{\frac{WH_m}{1000}}{\frac{W}{g} \times \frac{V_{w2}u_2}{1000}} = \frac{gH_m}{V_{w2} \times u_2}$$

b) **Mechanicalefficiencies:-**

The power at the shaft of the centrifugal pump is more than the power available at the impeller of the pump . The ratio of the power available at the impeller to the power at the shaft of the centrifugal pump is known as mechanical efficiency. It is writtenas

$\eta_m =$ Power at the impeller / Power at the shaft

The power at the impeller in kW=Work done by impeller per second/10000

$$= \frac{W}{g} \times \frac{V_{w2} u_2}{1000}$$

$$\eta_m = \frac{\left(\dfrac{W}{g} \times \dfrac{V_{w2} u_2}{1000} \right)}{S.P.} \text{...............}$$

Where S.P.= Shaft Power

Overall efficiencies η_o

It is defined as the ratio of power output of the pump to the power input to the pump .
The power output of the pump inkW

$$= \frac{\text{Weight of water lifted} * H_m}{1000} = \frac{WH_m}{1000}$$

Power input to the pump =Power supplied by the electric motor

= S.P. of the pump

$$\eta_o = \frac{\left(\dfrac{WH_m}{1000} \right)}{S.P.} \text{................}$$

$$\eta_o = \eta_{man} \times \eta_m \text{....................}$$

Problem 3.1: The internal & external diameters of the impeller of a centrifugal pump are 200mm & 400mm respectively. The pump is running at 1200 r.p.m. The vane angles of the impeller at inlet & outlet are 20^0 & 30^0 respectively. The water enters the impeller radially & velocity of flow is constant. Determine the velocity of flow per metresec.

Solution: Internal Dia. Of impeller,=D_1=200mm=0.20m

External Dia. Of impeller

,=D_2=400mm=0.40m Speed N=1200r.p.m

Vane angle at inlet ,$\theta = 20^0$

Vane angle at outlet, $\phi = 30^0$

Waterentersradiallymeans, $\alpha = 90^0$ and $V_{w1} = 0$

Velocity of flow , =$V_{f1} = V_{f2}$

Tangential velocity of impeller at inlet & outlet are,

$$u_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times .20 \times 1200}{60} = 12.56 m/s$$

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times .40 \times 1200}{60} = 25.13 m/s$$

From inlet velocity triangle,

$$\tan \theta = \frac{V_{f1}}{u_1} = \frac{V_{f2}}{12.56}$$

$$V_{f1} = 12.56 \tan \theta = 12.56 \times \tan 20 = 4.57 m/s$$

$$V_{f2} = V_{f1} = 4.57 m/s$$

Problem 3.2: A centrifugal pump delivers water against a net head of 14.5 metres& a design speed of 1000r.p.m .The values are back to an angle of 30^0 with the periphery. The impeller diameter is 300mm & outlet width 50mm. Determine the discharge of the pump if manometric efficiency is 95%.

Solution: Net head, $H_{m=}$14.5m

Speed, N =1000r.p.m

Vane angle at outlet, $\phi = 30^0$

Impeller diameter means the diameter of the impeller at outlet

Diameter, $D_2 = 300mm = 0.30m$

Outlet width, $B_2 = 50mm = 0.05m$

Manometricefficiency, $\eta_{man} =$ 95%=0.95

Tangential velocity of impelleratoutlet, $u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times .30 \times 1000}{60} = 15.70 m/s$

Now using equation

$$\eta_{max} = \frac{gH_m}{V_{w2}u_2}$$

$$0.95 = \frac{9.81 \times 14.5}{V_{w2} \times 15.70}$$

$$V_{w2} = \frac{0.95 \times 14.5}{0.95 \times 15.70} = 9.54\,m/s$$

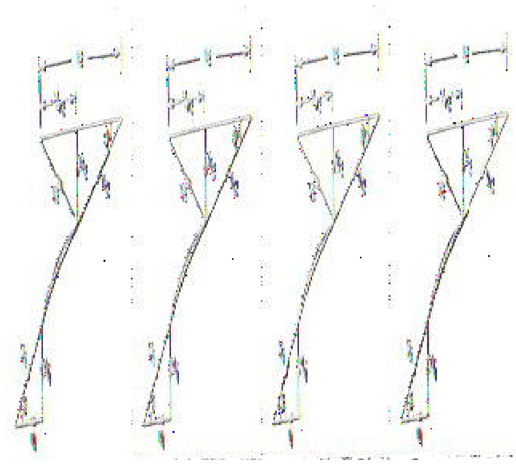


Fig. 3.3

Refer to fig(3.3). From outlet velocity triangle, we have

$$\tan\beta = \frac{V_{f2}}{(u_2 - V_{w2})}$$

$$\tan 30^0 = \frac{V_{f2}}{(15.70 - 9.54)} = \frac{V_{f2}}{6.16}$$

$$V_{f2} = 6.16 \times \tan 30^0 = 3.556\,m/s$$

$$Discharge\; Q = \pi \times D_2 \times B_2 \times V_{f2}$$

$$= \pi \times 0.30 \times 0.05 \times 3.556\,m^3/s = 0.1675\,m^3/s$$

3.3 ReciprocatingPump:-

Introduction:-

We have defined the pumps as the hydraulic machines which convert the mechanical energy to hydraulic energy which is mainly in the form of pressure energy. If the mechanical energy is converted into hydraulic energy (or pressure energy) by sucking the liquid into a cylinder in which a piston is reciprocating (moving backwards and forwards), which exerts the thrust on the liquid & increases its hydraulic energy (pressure energy), the pump is known as reciprocating pump.

Type of reciprocating pumps:

The reciprocating pumps may be classified as:

According to the water being in contact with one side or both sides of the piston, and

According to the number of cylindersprovided

If the water is in contact with one side of the piston, the pump is known as single-acting. On the other hand,

If the water is in contact with both sides of the piston, the pump is called double –acting. Hence, classification according to the contact of water is:

Single-actingpump

Double –actingpump

According to the number of cylinder provided, the pumps are classified as:

Single cylinderpump

Double cylinderpump

Triple cylinderpump

Operation of a reciprocating pump:-

The following are the main parts of a reciprocating pump as shown in fig (3.4)

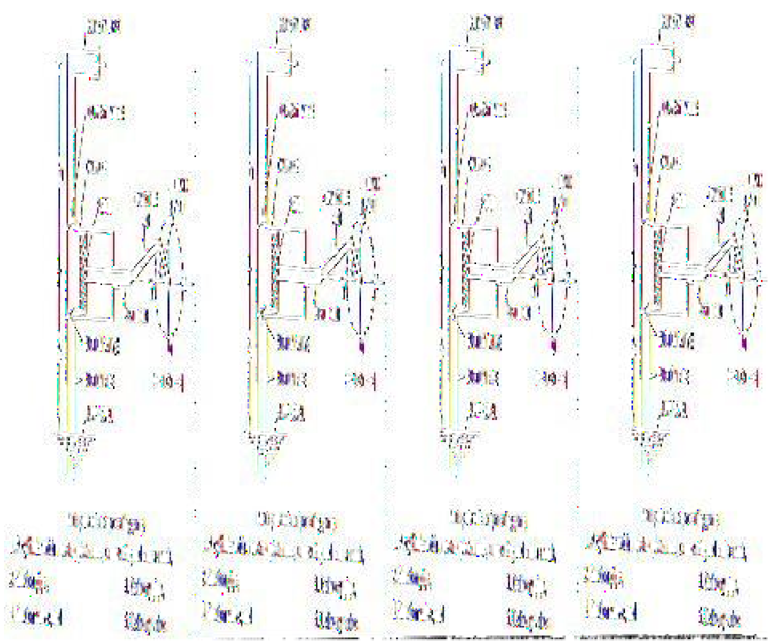


Fig. 3.4

<u>Discharge through a Reciprocating Pump:</u>Consider a single acting reciprocating pump as shown in fig ().

Let D= dia. Of the cylinder

A= C/s area of the piston or cylinder

$= \frac{\pi}{4} D^2$

r= Radius of crank

N=r.p.m of the crank

L=Length of the stroke=2*r

h_s= height of the axis of the cylinder from water surface in sump

h_d= Height of the delivery outlet above the cylinder axis (also called delivery head)

Volume of water delivered in one revolution or discharge of water in one revolution

= Area * Length of stroke = A*L

Number of revolution per second, $= \frac{N}{60}$

Discharge of the pump per second , Q= Discharge in one direction × No. of revolution per second

$$= A \times L \times \frac{N}{60} = \frac{ALN}{60}$$

……………………………….

Wt. of water delivered per second, $W = \rho g Q = \frac{\rho g A L N}{60}$

Horse power :

$$P = \frac{2 * \text{row} * g * ALN * (Hs + Hd)}{60000}$$

Hs = Height of the axis the cylinder from water surface in sump.
HD = Height of delivery out let above the cylinder axis.

Efficiency :

$$\text{Efficiency} = \frac{wQ\,(His + HD)}{\text{Power given to the shaft}}$$

Q= discharges
w= specific weight
Hs = suction head
HD = Delivery head

Short questions

Q. Define static head and manometric head for centrifugal pump
Ans.

Hs = hs + hd
Hs = static head
hs= sunction Head and
hd=delivery head

Q. State the main parts of a centrifugal pump.
Ans.

- Impeller
- Casing
- Suction pipe
- Deliver pipe

Q. What is centrifugal pump
Ans. The hydraulic machine which converts the mechanical energy into pressure energy by means of centrifugal force is called centrifugal pump .

Q. What is The function of reciprocating pump.

Ans. If the mechanical energy is converted in to hydraulic energy by sucking the liquid in to a cylinder in which a piston is reciprocating which exert the thrust on the liquid and increase it's hydraulic energy the pump is called reciprocating pump.

Long question :

Q. Explain various parts of centrifugal pump with a neat sketches.

Q. A centrifugal pump with a power of 16kw delivers 160 lit of a water at a total head of 7.5 m what is the over all efficiency of a pump.

Q. What are the efficiency of a centrifugal pump. Write down their Formula.

Q. a reciprocating pump Have the internal and external diameter of the impeller of a centrifugal pump are 200mm and 400mm respectively. The pump is running at 1200rpm. The vane angle of impeller at inlet and outlet are 20 30 degree. The water enter the impeller radialy and velocity of flow is constant. Determine the work done by the impeller per unit weight of water.

PART - B

Irrigation engineering

HYDROLOGY - 1

Introduction

The science of studying the different form of water available above the earth surface or below the earth surface is known as hydrology .

1.1 Hydrology Cycle

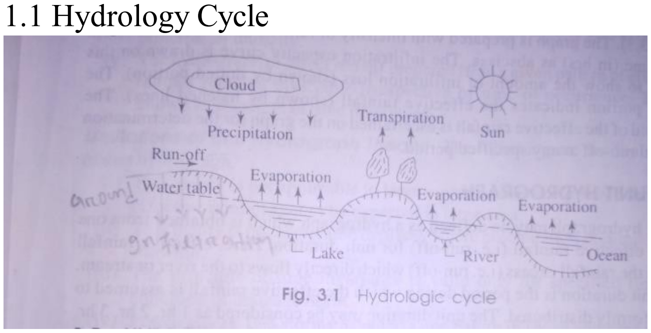


Fig. 3.1 Hydrologic cycle

The water of the universe always changes from one state to other under the effect of the sun.The water from the surface sources like lakes, rivers, ocean etc. Convert to vapour by evaporation due to solar heat. The vapour goes on accumulating continuously in the atmosphere. Thus clouds are formed.These clouds again cause the precipitation (i.e rain fall) .some of the vapour is converted to ice at the peak of the mountains.The ice again melts is summer and flow as rivers to meet the sea or ocean. These processes of evaporation,precipitationandmeltingoficegooncontinuouslylikeanendlesschainandthusa balance is maintained in the atmosphere. This phenomenon is known as hydrologist cycle.

1.2 RAIN FALL

Type of rainfall or (precipitation) :

Cyclonicprecipitation

Frontalprecipitation

Nonfrontalprecipitation

Convectiveprecipitation

Orographicprecipitation

Cyclonicprecipitation

This type of precipitation is caused by the difference of pressure within the air mass on the surface of the earth.if low pressure is generated at some place the warm moist air from surrounding area rushes to the zone of low pressure with violent force. The warm moist air risesupwithwhirlingmotionandgetcondensedathigheraltitudeandultimatelyheavyrainfall occurs. (a). Frontal precipitation

WhenthemovingwarmmoistairmassisObstructedbythezoneofcoldairmass,thewarm moist air rises up to higher altitude where it gets condensed and heavy rain fall occurs thisis known as frontal precipitation.

(b). Non Frontal Precipitation

When the warm moist air mass rushes to the zone of low pressure from the surrounding area, a pocket is formed and the warm moist air rises up like a chimney towards higher altitude. At higher altitude this air mass gets condensed and heavy rainfall occurs. This is known as non frontal precipitation.

Convectiveprecipitation

In tropical countries when on a particular hot day the ground surface gets heated unequally, the warm air is lifted to high altitude and the cooler air takes its place with high velocity. Thus the warm moist air mass is condensed at the high altitude causing heavy rainfall. This is known as convective precipitates.

Orographicprecipitation

The moving warm moist air when obstructed by some mountain rises up to a high altitude. It thengetscondensedandprecipitationoccurs.Thisisknownasorographicprecipitation.

INTENSITY OF RAINFALL :

Intensityrainfallisdefinedastheratioofthetotalamountofrainfallingduringagivenperiod to the duration of the period it is expressed in depth units per unit time , usually as (mm / hr)

HYETOGRAPH :

The graphical representation of rainfall and run-off is known as hyetograph.

Thegraphispreparedwithintensityofrainfall(cm/hr)asordinateandtime(hr)asabscissa. Theinfiltrationloss(dottedportion).theupperportionindicatestheeffectiverainfall(hatched

lines).Thecentroidoftheeffectiverainfallisascertainedonthegraphforthedeterminationof

totalrunoffatanyspecificperiod.

1.3 ESTIMATIONOFRAINFALL/MeasurementofRainfallByRainGauge

Inordertoestimatetheeffectsofprecipitationitisnecessarytomeasuretheprecipitation,and

tofindoutit'sdistributionatvariousplacesontheearth.Allformsofprecipitationaremeasuredasthev erticaldepthsofwaterthatwouldaccumulateon

alevelsurface,iftheentireprecipitationremainedwhereitfell.Thetotalamountof precipitation

falling on earth in a giv

Rain gauge :

.Theinstrumentwhichisusedtomeasuretheamountofrainfallisknownasraingauge.
Type:

Non-recordingType

Recordingtype

Non-recording type:

. Simonsraingauge is known as non recording Type raingauge which is most commonly used. A

funnel with brass rim is placed on the top of the bottle. The rainfall is recorded at every 24 HR.
Recording type:

.theamountOfrainfallisautomaticallyrecordedongraphpaperbysomemechanicaldevice.

. It is Three type (a) weighing bucket

Tippingbucket

floattype

1.4 Catchmentarea:
thecatchmentareaofarivermeanstheareafromwherethesurfacerunoff

flows to that river through the tributaries, stream, springs, etc

Run-off:
whenitrainssomeportionofrainwaterinfiltratesintotothesoilsomeisintercepted

byvegetationsomeevaporatesandtheremainingportionflowsoverthegroundsurfacetojoin

therivers,streams,lakesetcthisportionofwaterwhichflowsoverthegroundsurfaceisknown

as surface run off.
Estimation of flood discharge by Dickens formula :

Q= C * A'3/4

Q=Discharge

A=Catchment area

C= Const

RyvesFormula :

Q=C * A'2/3

Short questions with answers :

Q. Define hydrology

Ans : the science of study the different form of water available above the earth surface or below the earth surface is known as hydrology. Q. Define catchment area

Ans : a catchment area of a river means the area from where the surface run off flows to that river through streams, springs, etc is known as catchment area

Q. Define evaporation

Ans : it is the proces of change in the state of water from liquid or solid to vapour due to the

transfer of heat energy is known as evaporation

Long question:

Q.Whatishydrologycycleanddescribeit's.Q.Whataretheformularequiredinestimationof flooddischarge

Chapter- 2
Requirement of crop water

Definitionofirrigation: theprocessofartificialapplicationofwatertothesoilforthegrowofagriculturalcropsistermedasirrigation.

Necessity :

. Insufficient rainfall .

. Uneven distribution of rainfall.

. Improvement of perenniacrops .
. Development of agriculture in desert area
.

Benefits of irrigation :

. yield of crop

. Protection from famine

. Improvement of cash crops

. Prosperity of farmer

. Source of revenue.

. Navigation

. Hydroelectric power generation

. Water supply

. Development of fishery

Types of irrigation :

a. Surface irrigation
b. Subsurface irrigation

Surface irrigation:

. Flowirrigation

. Liftirrigation

Flow irrigation :

. Perennial irrigation

. Flood irrigation

Subsurface irrigation:

. Natural subsurface irrigation

. artificial subsurface irrigation

2.2 Crop season:

.Theperioddduringwhichsomeparticulartypesofcropcanbegrowneveryyearonthesame landisknownascropseason.

This is two type

Kharifseason

Rabiseason

2.3 duty:

. The duty of water is defined as number of hectares that can be irrigated by constant supply of water at the rate of Onecumecthrough out the base period.

.it is denoted by D

.it is expressed in hectares /cumec

Delta, duty and base period their relationship :

D = duty of water in hectares /cumec B = base in days

= delta in m

Onecomecofwaterflowingcontinuouslyfor Bdaysgivesadepthofwater over an areaDhectares.

1 cumec for Bdaysgives over Dhectares

1 cumec for 1daysgives over D /Bhectares

1 cumec for 1 day =D/B* hectares.meter --------------(1)

1 cumec day = 1*24*60*60

= 86400cubicm---------------(2)

= 8.64 hectares.metre

From 1 and 2

D/B* =8.64

= 8.64*B/D

Overlapallowance:

.Sometimesacroponeseasonmayoverlapthenextcropseasonbyafewdaysmorewhichit requires to mature. During this period of overlapping the irrigation water is to be supplied simultaneouslytothecropsofboththeseasons.Duetotheextrademandofwaterduringthis period the discharge of the canal has to be increased. So for the purpose of canal design a provisionshouldbemadeforthisextrademand.Thisprovisionistermedasoverlapallowance. This is expressed inpercentage.

Kharifcrops :

.The crop sown in the very beginning of monsoon and harvested at the end of autumn. The major kharif crops are rice, millet, jute etc

Rabi crops :

.The crops are sown in the very beginning of winter and harvested at the end of spring. The major Rabi crops are wheat, gram, mustard, onion etc

2.4 gross command area:

.Thewholeareaenclosedbetweenanimaginaryboundarylinewhichcanbeincludedinan irrigationprojectforsupplyingwatertoagriculturallandbythenetworkofcanalisknownas GCA

Culturable command area :

.Thetotalareawithinanirrigationprojectwherethecultivationcanbedoneandcropscanbe growisknownasculturablecommandarea.

Intensity of irrigation :

.The total culturable command area may not be cultivated at the same time in a year due to various reason. Some area may remain vacant every year. Again various crops may be cultivated in the cultivated land for a particular crop to the total culturable command area. It is expressed as percentage.

Irrigable area :

.thetotalirrigableareaisthemaximumareawhichcouldbeirrigatedinthereferenceyearusing theequipmentandthequantityofwaternormallyavailableontheagriculturalholding.

Time factor :

.Theratioofthenumberofdaysthecanalhasactuallybeenkeptopentothenumberofdays thecanalwasdesignedtoremainopenduringthebaseperiodisknownastimefactor.

Crop ratio :

.It is defined as the ratio of the areas of the two main crop season, e. g. Kharif and rabi

short questions with answers :

Q. Define Kor period.

Ans. The period during which kor watering is done is known as Kor period.

Q. Express cumec days.

Ans.1cumecdays=1cubicm/sec. *24*60*60

= 24*60*60/10000

= 8.64 hectares.Metre

Q. Write the relation between duty, delta, base.

Ans. Delta = 8.64*B/D

Where

D= duty Hector /cumec B= base period in day
Delta = delta in cm

Long question :

Q. Write down the necessity of irrigation.

Q. Write down the benefits of irrigation.

*

Chapter -3
Flow
irrigation

Introduction:theirrigationsysteminwhichthewaterflowsunderGravityfromthesourcetothe agriculturallandisknownasflowirrigation.thistypeofirrigationispopularnowadaysbecause avastareacanbeirrigatedunderthissystem.

3.1 Canal irrigation:

. Irrigation canals are the main waterways that brings irrigation water from a water source to the areas to be irrigated . They can be lined with concrete, brick, stone to prevent seepage and erosion

Types of canal :

A . Based on purpose

Based on nature ofsupply

Based ondischarge

Based onalignment

Based on purpose:

Irrigationcanal

Navigationcanal

Powercanal

Feedercanal

Based on nature of supply:

Inundationcanal

Perennialcanal

Based on discharge:

Maincanal

Branchcanals

Distributorycanal

Fieldcanals

Based on alignment:

Ridge/watershedcanal

Contourcanal

Side slopecanal

Losses of water in canal :

. Water may be lost by seepage, leakage.the canal water tries to seep in to the soil .more overs the canal are exposed to the atmosphere at the surface .

. The losses in irrigation canals are mainly

Evaporation losses, absorption losses, Percolation losses, transpiration losses.

3.2 perennial irrigation:

Inthissystemaweirorabarrageisconstructedacrosstheperennialrivertorisethewaterlevel ontheupstreamsideoradamisconstructedtoformastoragereservoir.Thenmaincanalisconstantedon eitherorboththebankoftheriver.

It is two type

Direct irrigationsystem

Storage irrigationsystem

3.3 Different components of irrigation canals and their functions:

canalbank

Berm

hydraulicgradient

Counterberm

Freebody

Sideslope

Serviceroad

Dowel

Borrowpit

Spoilbank

Landwidth

3.4 sketches of different canal crosssections.

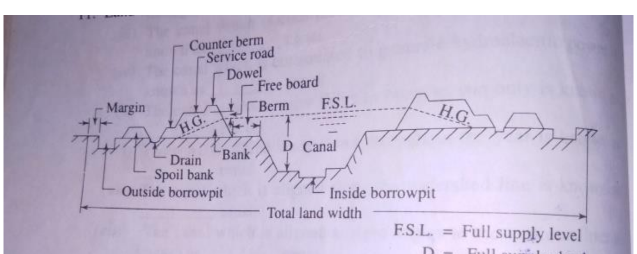


Fig. 6.1 Canal section

3.5 classification of canals according to their alignment:

Depending upon the alignment the canals are designated

Ridge or watershedcanal

Contourcanal

Side slopecanal

Ridge canal :

The canal which is aligned along the ridge line is known as ridge canal.

Contour canal:

Thecanalwhichisalignedapproximatelyparalleltothecontourlinesisknownascontourcanal.

Side slope canal:

Thecanalwhichisalignedapproximatelyatrightanglestothecontourlinesisknownasside slope.

Various types of canal lining :

The following are the different types of linings which are generally recommended according to the various site condition

Cement concretelining

Pre cast concretelining

Cement mortarlining

Lime concretelining

Bricklining

Boulderlining

Shot Cretelining

Asphaltlining

Claylining

Soilcementlining

Advantage of canal lining:

Itreducesthelossofwaterduetoseepageandhencethedutyisenhanced.

It controls the water logging and hence the bad effects of water-logging areeliminated.

Itprovidessmoothsurfaceandhencethevelocityofflowcanbeincreased.

Duetotheincreasedvelocitythedischargecapacityofacanalisalsoincreased.

Duetotheincreasedvelocitytheevaporationlossalsobereduced.

Disadvantages :

Theinitialcostofthecanalliningisveryhigh.Soitmaketheprojectveryexpensivewith respect to theoutput.
Itinvolvesmuchdifficultiesforrepairingthedamagedsectionoflining.

Ittakestoomuchtimetocompletetheprojectwork.

Itbecomesdifficult,iftheoutletsarerequiredtobeshiftedornewoutletsarerequiredtobeprovided,becauset hedismantlingofthelinedsectionisdifficult.

Short questions with answers :

Q. Define gunitng .

Ans. In canal lining cement mortar is directly applied on the sub grade by an equipment know as cement gun.
.Themortaristermedasshotcreteandliningisknownasshortcretelining.Theprocessisalso known asgunting.

Q. What are the object of canal lining.

Ans. To control seepage

. To prevent water logging

. To increased the capacity of canal.

. To control the growth of weeds.

Q. Define flow irrigation.

Ans.Theirrigationsysteminwhichthewaterflowsundergravityfromthesourcetothe agriculturallandisknownastheflowirrigation.

Long questions :

Q. What are the types of canal and describe based an alignment.

Q. Sketch the cross section of canal and describe various term including in.

Q. What are the types of canal lining and describe it.

Q. What are the advantages and disadvantages of canal lining.

*

Chapter -4

Water logging and drainage

Introduction :

.Inagriculturalland,whenthesoilporeswithintherootzoneofthecropsgetsaturatedwiththe subsoilwater,theaircirculationwithinthesoilporesgetstotallystopped.Thisphenomenonis termed as waterlogging.

4.1 causes of water logging:

The following are the main causes of water logging.

Overirrigation

Seepage fromcanals

Inadequate surface drainage
4.obstructioninnaturalwatercourse
5. Obstructioninsubsoildrainage
6. nature ofsoil
Incorrect method ofcuktivation

Seepage fromreservoir

Poor irrigationmanagement

Excessive rainfall

Effect of water logging :

The following are the effects of water logging :

Salinization onsoil:

.Duetowaterloggingthedissolvedsaltslikesodiumcarbonate,sodiumchlorideandsodium sulphatecometothesurfaceofthesoilwhenthewaterevaporatesfromthesurfacethesalts aredepositedthere.thisprocessisknownassalinizationofsoil.

Lack of aeration:

. The crops require some nutrients for their growth which are supplied by some bacteria or microorganisms by breaking the complex nitrogenous compounds into simple compounds whichareconsumedbytheplantsfortheirgrowth.Butthebacteriarequiresoxygenfortheir lifeandactivity.whentheaerationinthesoilisstoppedbywaterloggingthesebacteriacannot survivewithoutoxygenandthefertilityofthelandislostquizresultsintroductionofinreduction ofyield.

Fall of soil temperature:

.Duetowaterloggingthesoiltemperatureislowered.atlowtemperatureofthesoiltheactivity ofthebacteriabecomesveryslowandconsequentlytheplantsdonotgettherequisiteamount offoodintime.thus,growthoftheplantsishamperedandtheyieldalsoisreduced.

Grow of weeds and aquatic plants:

.DuetowaterloggingtheagriculturallandisconvertedtoMarshylandandtheweedsand aquaticplantsaregrowinplenty.theseplantsconsumethesoilfoodinadvanceandthusthe crops aredestroyed.

Diseases of crops:

. Due to low temperature and poor aeration,

the crops get some diseases which may destroy the crops or reduce the yield .

Difficulty in cultivation:

. In water logged area it is very difficult to carry out the operation of cultivation such as tilling ,ploughing, etc.

Restrictions of root growth:

.WhenthewatertableRisesneartorootzonethesoilgetssaturated.thegrowthoftherootsis confinedonlytothetoplayerofthesoil.sothecropscannotbeematureproperlyandtheyield is reduced.

4.2 prevention and remedies:

The following measure may be taken to control water logging.

Preventionofpercolationfromcanal:

.Theirrigationcanalsshouldbelinedwithimperviostopreventthepercolationofwater throughthebedandbanksofthecanals.Thusthewaterloggingmaybeprevented.

Prevention of percolation from reservoirs:

.Duringconstructionofdam,thegeologicalsurveyshouldbeconductedonthereservoirbasin todetectthezoneofpermeableformationthroughwhichwatermaypercolate.

Controlofintensityofirrigation:

.Theintensityofirrigationmaycausewaterloggingsoitshouldbecontrolledinaplannedway sothatthereisnopossibilityofwaterlogginginaparticulararea.

Economical use of water:

. If the water is used economically, then it may control the water logging and the yield of crops may be high. So special training is required to be given to the cultivators to realise the benefits of economical use of water.

Fixing of crop patrern:

.Soilsurveyshouldbeconductedtofixthecroppattern.Thecropshavinghighrateof evapotranspirationshouldberecommendedfortheareasusceptibletowaterlogging.

Providing drainage system:

.Suitabledrainagesystemshouldbeprovidedinthelowlyingareassothatrainwaterdoesnot standforlongdays.networkofsubsurfacedrainsareprovidedwhichareconnectedtothethe surfacedrains.

Improvement of natural drainage:

.Sometimesthenaturaldrainagemaybecompletelysilteduporobstractedbyweeds,aquatic plants ,e t c . the affected section of the drainage should be improved bye excavating and cleaning theobstructions.

Pumping of ground water:

.NumberofopenWellsfortubeWellsareconstructedinthewaterlockedareaandtheground water is pumped out until the water table goes down to Safe level .the lifted groundwater may beutilisedforirrigationormaybedischargedtotheriveroranywatercourse.

Construction of sump well:

.Sumpwellsmaybeconstructedwithinthewaterloggedareaandtheyhelptocollectthe surfacewater.thewaterfromthesumpWellsmaybepumpedtotheirrigablelandsormaybe discharged to anyriver.

Short questions with answers :

Q. What is water logging

Ans. In agricultural land when the soil porous with in in the route zone of the crops get saturatedwiththesubsoilwatertheaircirculationwithinthesoilporousGatestotallystopped this process is called water logging.

Q. What is salinization of soil

Ans.Duetowaterloggingthedissolvedlikesodiumcarbonate,sodiumsulphate,sodium chloridecometothesurfaceofthesoil.whenthewaterevaporatethesoilareare deposited therethisprocessisknownissalinizationofsoil

Long questions :

Q. Describe briefly causes, effect, control of water logging.

*

Chapter - 5

Diversion headworks

and

regulatory structures

Introduction :

.Thewaterflowsthroughtheirrigationcanalundertheforceofgravity.showtheelevationof theheadofthecanalmostbehigherthanthecommandareaoftheirrigationproject.nowto formastoragereserveortowriterisethewaterlevelattheheadofthecanal,somestructures areconstructedwhichareknownasCanalheadworks.

5.1 necessity and objectives of diversion head works:

The following are the objects of diversion of head works

Toraisethewaterlevelattheheadofthecanal.

ToFormastoragebyconstructingdykesonboththebanksoftheriversothatwateris available throughout theyear.
Tocontroltheentryofsiltintothecanalandtocontrolthedepositionofsiltattheheadofthe canal.
Tocontrolthefluctuationofwaterlevelintheriverduringdifferentseasons.

Weir :

. Dharmali the water Label of any perennial river is such that it cannot be diverted to the irrigationcanalthebadLabelofthecanalmaybehigherthantheexistingwaterleveloftheriver insuchcaseayrisconstructedacrosstherivertowritethewaterlabelfromH1toH2thenthe watercanbeeasilydivertedtotheKanaKanakennelKarnalcanalthesurpluswaterpasses overthecrestoftheohyeahsometimeadjusttableshuttersareprovidedontheChristtowrite thewaterlevelTuSomrequiredhiheightnecessarybuttheseshuttersaredroppeddownduring thefraudforfloodfloodtheweathermaybeconstructedwithmachineryforconcrete.

Barrage :

. When the water level on the up stream side of the weir is required to be raised to different level at different time then the Barrage is constructed .practically a Barrage is an arrangement of adjustable Gates aur shutters at different tires over the weir.the water level can be adjusted at H1 ,H2 ,H3 e t c.

5.2 general layout :

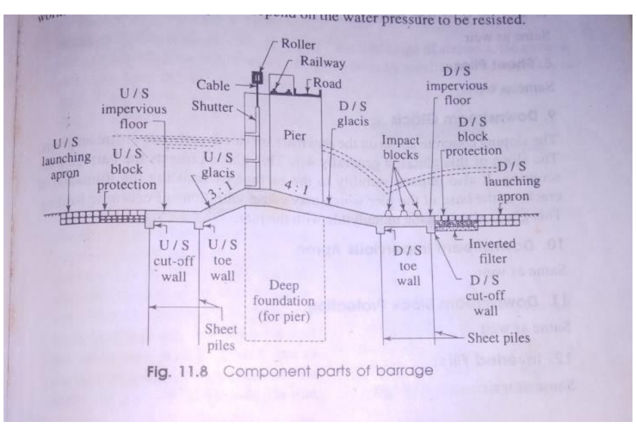


Fig. 11.8 Component parts of barrage

function of different parts of barrage:

The following are the different part of the barrage are

.Barrage piers

.adjustable gates

.upstream glacis

.downstreamglacis

Barragepiers:

. These are the main component parts of the Barrage. depending on the width of the river, the length of the Barrage is ascertained. The total length is then divided into a number of components by constructing piers.each component is known as a b a y .the piers are constructed over the deep Foundation like well Foundation or pneumatic caisson Foundation .ontheupstreamsideofthepiers,theadjustableGatesorshuttersareprovidedatdifferent Tiers according to the water level desired to be raised from time to time. the shutter are operatedfromthecabinbythecableswhichpassthroughtherollersorpulleys.beamsandslab areconstructedoverthepairstoallowthelayingofRailwaylinesandtheroadroads.

Adjustable gates:

. The gates or shutters are made of steel plates welded on the fabricated Steel frame work .the thickness of the plates depends on the water pressure to be e resisted. each shutter consists of rollers on both sides which can be moved with in the grooves in the piers. rubber bearing are provided at the bottom and the edges of the shutter to prevent the the leakage of water .the shutters are suspended by Cable at both ends .the cables passes through the rollers or pulley and are connected to the operating mechanism in the oven cabin .the shutters may be raised or lower from the cabin according to the requirement.

Upstream glacis:

.Thesloping concreteapronontheupstreamsideiscalledupstreamGlacis.theslopeofthe glacisisgenerally3:1.thisisprovidedtoprotectthebaseoftheBarragefromscouring.onthe topoftheBarragetherailwaylineandroadscancausevibrationonthepiersandanyeccentric loadmayleadtocrackonthebestofyourspiers.duetotheformationofcracksthesubsoil watermaygetentrytothefoundationwhichmayendangerthestabilityofthestructure.Sothe slopingglacisismadeMonolythicwiththepier
for the stability of the Barrage.

Downstreamglacis:

.theslopingconcreteapronothedownstreamsiteiscalleddownstreamglacial.theslopeof this glacis is generally 4:1 .this glacis protects the Barrage from scouring. it also imparts stabilitytothebarragebyresistingtheformationofcracksatthebaseofthepierwhichmay causevibrationsoreccentricloading.thisglacisalsoismadeMonolythicwiththepier.

5.3 silting and scouring:

. Irrigation canals normally get silted during their course of flow .whenever the flow velocity in the channel reduce the silt carried by the water in suspension gets deposited on the bed and sides of the canal .the silt is deposited reduce the effective Canal cross section and the carrring capacity of the channel . in order to prevent too much of silt deposition irrigation channels ,must be properly designed so age to ensure a velocity which neither causes any silting nor scoring in the channel.

5.4 Function of regulatory structures:

.Astructurewhichisconstructedattheheadofthecanaltoregulateflowofwaterisknownas Canalheadregulator.itconsistsofanumberofpierswhichdividethetotalwidthofthecanal intoanumberofspanswhichareknownasbays.thepiersconsistsofanumbertiersonwhich theadjustableGatesareplaced.thegatesareoperatedfromthetopbysuitablemechanical deviceaplatformisprovidedonthetopofthepiersforthefacilityofoperatingtheGates .againsomepiersareconstructedonthedownstreamsideofthecanalheadsupportthe roadway.

Short questions with answer:

Q.Definediversionheadwork

Ans.WhenaweirorBarrageisconstructedacrosstheprincipalrivertotheriseofwatertable andtodivertthewatertothecanalthenitisknownasdiversionheadwork.

Q. Define scoring and slice

Ans.TheScoringslicearetheopeningprovidedatthebaseoftheairaurBridgedidopeningare providedwithadjustablegetnormallythegatesarekeptclosed.

.the suspended silt goes on depositing in front of the canal head regulator.

.whenthesiltdepositionbecomeapplicablethegatesareopenandthedepositedsiltisloosing withanmountaingonaboat.

Q. Define bay

Ans.Whenthenumberofpiersareconstructedatthewidthofthecanaltodivertedof compartmenteachcompartmentiscalledasBay.

Long questions :

Q. Write down the component parts of weir and Barrage with net sketches .

Q. What are objective of diversion head work .

Q. What is the canal head regulator .

*

Chapter -6 Cross drainagework

Introduction :

.inanirrigationprojectwhenthenetworkofmaincanal,branchcanal,distributioncanal,etcare providedthenthesecanalmayhavetocrossthenaturaldrainagelikeriver,streams,Ballardetc atdifferentpointswithinthecommandareaoftheproject.Thecrossingofthecanalwithsuch obstaclescannotbeavoided.Sosuitablestructuresmustbeconstructedatthecrossingpoint for the easy flow of water of the canal and drainage in the respective directions. These structuresareknownascrossdrainageworks.

6.1 function and necessity of cross drainage work:

Thewatershe'dcanalsdonotcrossnaturaldrainages.butinactualorientationofthecanal network,thisidealconditionmaynotbeavailableandtheobstacleslikenaturaldrainagemay be present across the canal .so the cross drainage work must be provided for running the irrigationsystem.

Thecrossingpointthewaterofthecanalandthedrainagegetintermixedsoforthesmooth runningofthecanalwithitsdesigndischargethecrossdrainageworksarerequired.

TheSiteconditionofthecrossingpointmaybesuchthatwithoutanysuitablestructurethe waterofthecanalandDrainagecannotbedivertedtotheirnaturaldirections.sothecross drainageworksmostbeprovidedtomaintaintheirnaturaldirectionofflow.

conceptofeachwithhelpofneatsketch:

Aqueduct :

.TheaqueductisjustlikeabridgewhereaCanalistakenoverthedecksupportedbypiers insteadofaroadorRailway.generallythecanalisintheshapeofarectangularthroughwhich isconstructedwithreinforcedcementconcrete.sometimethetroughmaybetrapezoidal section.aninspectionroadisprovidedalongthesideofthethrough.thebedandbanksofthe drainagebelowthethroughisprotectedbyBoulderpitchingwithcementgrouting.thesection oftheTroughIsdesignedaccordingtothefullsupplydischargeofthecanal.afreeBoardof about0.50metreshouldbeprovidedtheheightandsectionofpiersaredesignedaccording tothehighestlevelandvelocityofaflowofthedrainage.thepiersmaybeofbrick masonry,stonemasonryorreinforcedcementconcrete.heredeepFoundationisnotnecessary forthepiers.theconcreteFoundationmaybeDonebyprovidingthedeathofaFoundation accordingtotheavailabilityofhardsoil.

Siphon aqueduct :

.Thesiphonaqueductthebedofthedrainageisdepressedbelowthebottomlevelofthecanal troughbyprovidingslopingapronbothsidesofthecrossing.theslopingapronmaybeMay beconstructedbystonepitchingarecementconcrete.thesectionofthedrainagebelowthe canalthroughisconstructedwithcementconcreteintheformoftunnel.thistunnelactasa Siphon. Cut off walls are provided on the upstream and down streams side of the apron to preventscoringteachingshouldbeprovidedonthehopstreamanddownstreamoftheCutoff walls.TheOthercomponentlikecanalthrough,piers,inspectionRoad,etcshouldbedesignedaccor dingtothemethodadoptedincaseofaqueduct.

Supper passage :

.Thesuperpassageisjustoppositeoftheaqueduct.inthiscasethebedlevelofthedrainage is Above The fully supply level of the canal. The drainage is taken through a rectangular or trapezoidal trough of channel which is constructed on the deck supported by p i e r s .the sectionofthedrainagetroughdependsontheHighflooddischarge.afreeboardofabout1.5 metre should be provided for safety. the trough should be constructed of reinforced cement concrete.thebedandbanksofthecanalbelowthedrainagethroughshouldbeprotectedbuy Boulderpitchingorliningwithconcreteslab.thefoundationofthepierswillbesameasinthe case ofadequates.

Level crossing:

. The level crossing is an arrangement provided t o regulate the flow of water through the drainage and the canal when they cross each other approximately at the same bed level .the level crossing consists of the following components.

crest wall:

.It is provided across the drainage just at the the upstream side of the crossing point .the top level of the crest wall is kept full supply level of the canal.

Drainageregulator:

.Itisprovidedacrossthedrainagejustatthedownstreamsideofthecrossingpointregulator consistsofadjustableshuttersatdifferenttiers.

Canal regulator:

.Itisprovidedacrossthecanaljustatthedownstreamsideofthecrossingpoint.Thisregulator alsoconsistupadjustableshuttersatdifferenttiers.
Operation: in a dry season when the discharge of the drainage is very low the drainage regulator is it kept closed and the canal water is allowed to flow as usual. In rainy season when the discharge of the drainage is very high drainage regulator is kept completely open and the canal regulator is adjusted according to the requirement the level crossing is recommended for the crossing of main Canal with large drainage.

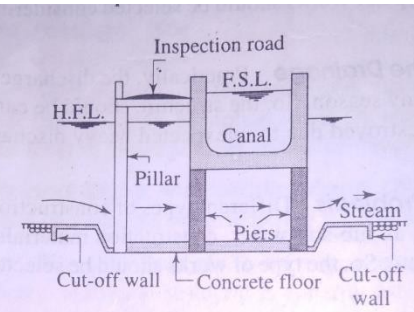


Fig. 13.2 Siphon aqueduct

6.2

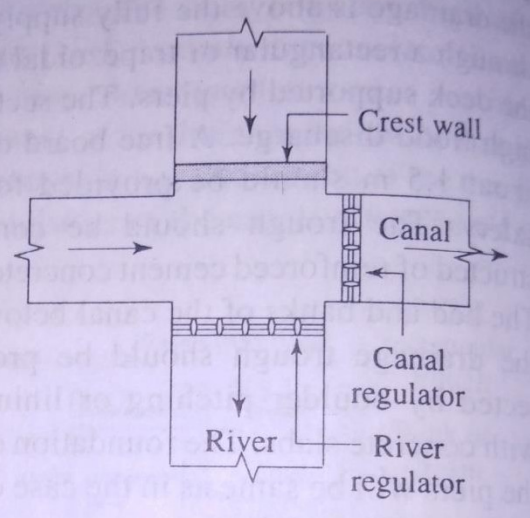


Fig. 13.5 Level crossing

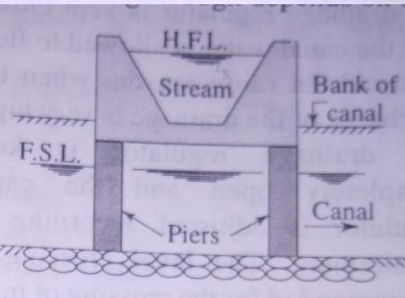
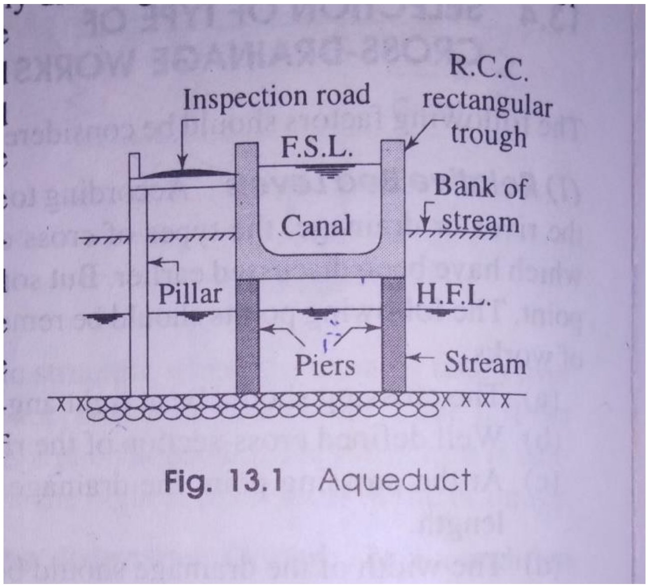


Fig. 13.3 Super passage



Short questions with answers:

Q. Define cross drainagework

Ans.Whentostreamcrosseachotherwithinapointsuitablestructuremostbeconstructed andthecrossingpointfortheeasyflowwaterofthe2streamlikedrainageandcanalinthe respectivedirectionthisstructureareknownascrossdrainagework.

Long questions :

Q. Write down the necessity and type of cross drainage work

Q. Write short note on Aqueduct, siphon aqueduct, super passage ,siphon super passage.

*

Chapter -7

Dams

Introduction : the high impervious barrier constructed across a river valley to form a deep storagereservoirisknownasdam.Thesurpluswaterisnotallowedtoflowoverthedam,butit flowsthroughthespillwaysprovidedatsomedesignedlevel.

7.1 Necessity of storage reservoir:

The storage reservoir is form for the following purposes

Flood control, irrigation water supply ,hydroelectric power generation ,development of fishery,navigation, soil conservation etc

Types of dams :

Based on material ofconstruction

Based on structuralbehaviour

Based onfunction

D based on hydraulic behavior

Based on material of construction:

Rigiddam

Non rigiddam

Based on structuralbehavior:

Solid gravitydam

Archdam

Buttressdam

Embankmentdam

Based on function:

Storagedam

Detentiondam

Diversiondam

Coffer dam

Based on hydraulic behavior:

Over flowdam

Non over flowdam

7.2 Earthen dam:

EarthendamareconstructedpurelybyEarthworkinatrapezoidalsectionthesearemost economicalandsuitableforweakfoundation.

Types : . rolled fill dam

. hydraulic field Dam

. semi hydraulic fillDam

. Homogeneous typedam

. Zoned typedam

. Diaphragm typedam

Causes of failure of earthen dam :

Hydraulic failure:

Overtopping

Erosion

Seepage failure:

Piping orundermining

Slouching

Structural failure:

Sliding of the sideslopes

Damage by burrowinganimals

Damage byearthquake

7.3 gravity dam:

.Agravitydamisadamconstructedfromconcreteorstonemasonryanddesignedtohold backwaterbyusingonlytheweightofmaterialandit'sresistanceagainstthefoundationto opposethehorizontalpressureofwaterpushingagainstit.

Type of gravity dam :

Based on theconstruction

1. Concrete dam
2.composite dam

Based on the shape orplan

Straightdam

Curveddam

Based on the structuralheight

1. Low dam
2. medium dam
Highdam

Causes of failure of gravity dam:

following are the causes of gravity dam .

By over turning:

.Thesolidgravitydammapfailbyoverturningatitstoyfindthetotalhorizontalforceactingon the dam are greater than the total vertical force in such a case the resultant force passes throughapointoutsidethemiddlethirdofthebaseoftheDamtheoverturningmaybecaused atthedownstreamedgeofanyhorizontalsection.

By sliding:

Total horizontal force acting on a dam tend to slide the entire Dam at its base for along any horizontalsectionoftheDam.theslidingmaytakeplacewhenthetotalhorizontalforceacting onthedamaregreaterthanthecombinedresistanceofferedbyshearingresistanceofthejoint and the staticfriction.

By over stressing:

.Ifthepermissibleworkingcompressivestressofconcreteormasonryexceedsduetosome adverseconditionsthenthedammayfailbycrushingduetooverstressingoftheconcreteor masonary.

By cracking:

.ThetensilestressesshouldnotbeallowedtodevelopontheupstreamfaceoftheDamifdue tosomereasonthetensionisdevelopedinthedamsectioncrackwillforminthebodyofthe Damandultimatelythiswillcausethefailureofthedam.

Protection measure :

.ToavoidfailureoftheDamthefollowingprecautionshouldbetakenwhiledesigningtheDam section

To avoid overturning the resultant of all force acting on the dam should remain with in the middle third of the base width of the Dam this condition should be achieved in both the case whenthe Reservoirslandalsowhenitisempty.

Inthedamsectionthecompressivestressoftheconcretearemachineryshouldnotexceed thepermissibleworkingstresstoavoidfailoverduetoCrossing.

Thereshouldbenotension in the damsectiontoavoidthe formation ofcrackswhich conditionmaybeachieved bymaintainingthemiddlethirdrule.

thefactorofsafetyshouldbetaken4to5

7.4 spillway:

The spillway are opening provided at the body of the Dam to discharge safely the excess water aur flood water when the water level rise above the normal pool level.

Types of slipway :

. The following are the common type of spillway

Dropspillway

Ogee spillway

Siphon spillway

Chute or troughspillway

Shaftspillway

Side channelspillway

Necessity of spillway :

. The spill way are provided on the dam for the following reasons

Theheightofthedamisalwaysfixedaccordingtothemaximumreservecapacitythenormal pool level indicates the maximum capacity of the reservoir the water is never storage in the reservoirabovethislevel.thedammayfailbyoverturningsoforthesafetyoftheDamspillway areessential. Thetopofthedamnitisgenerallyutilisedbymaking Road.thesurpluswaterinnotbe allowedtoovertopthedamsotostoptheovertoppingbythesurpluswaterspillwaybecome extremely essential.

ToprotectthedownstreambaseandflooroftheDamfromtheeffectofscoringanderosion thespillwaysareprovidedsothattheexcesswaterflowssmoothly.

Short questions with answers :

Q. Why are spill ways provided in a dam

Ans. The spillway are opening provide date the body of the Dam to discharge safely the excess water for flood water when the water level rise above the normal pool level.

Q. What is dam

Ans. And impervious Highway barrier which is constructed across a river valley to form a storage reservoir is known as a dam.

Q. What is earthen dam.

Ans. Earth Dam are constructed purely by earth work in trapezoidal section .these are most economical and suitable for weak Foundation.

Long questions

Q. Distinguish between drop spill way and ogee spill way.

Q. Describe an ogee spill way with neat sketch.

Q. Describe causes and failure of gravity dam.

Q. What is earthen dam.Causes of failure of earthen dam.

*