***Unit 1***

**#SPILLWAYS:-** A passages constructed either within a dam or in the periphery of the reservoir at the crest level in order to safely pass or expel the excess water in the river during flood is called as spillways. Thus spillway is an arrangement made at the crest of the dam to pass the excess water when it goes above the FRL (full reservoir level) during flood**. PURPOSE:-** Topography of the ground and geological condition. Inflow of incoming flood .The capacity of the spillway governing the following factors: Storage characteristics of the reservoir. Or Crest height of the spillway. Reservoir out flow conditions at the beginning of the flood. Spillway gate. (Gated or ungated) site conditions. Type of dam and its purpose ix. Capacity of outlet.

**#CLASSIFICATION OF SPILLWAYS:- 1.Emergency Spillway** :- This type of spillway is provided in addition to the main spillway and only get operated during emergency. Emergency spillway are usually situated in the saddles for the embankment dam or earthen dam only to prevent the failures of the dam caused by overtopping Emergency spillway are required in following situations which may lead to emergency. i. Improper functioning of spillway gate. ii. An enforced shutdown of the outlet works**. 2. Auxiliary spillway** :- This type of spillway is provided so as to supplement the main spillway. It operates only when the design floods in the main spillway is more or exceed. . **3.main spillway** This type of spillway starts functioning first in order to pass the entire design flood. Service spillway is made in masonry construction or inconcrete construction provided with the essential a nnecessary components.***Classification of Spillway Based on Features:-** 1. Ogee Spillway2. Straight drop spillway or free overfall spillway3. Side channel spillway4. Chute or open channel or trough spillway5. Shaft spillway or morning glory spillway6. Siphon spillway 7. Tunnel spillway8. Stepped spillway9. Saddle spillway. . **1.Ogee Spillway** The main advantages of ogee spillway is that the overflowing water is guided smoothly over the crest and always remains in contact with the d/s side of thespillway.The upper portion of the ogee or S-shaped spillway coincide with the lower surface of the sheet of water called as lower nappe.**2. overfall spillway** The spillway in which the flow drops freely from the crest is called as straight drop spillway or free overfall spillway. Such type of spillway is not suitable for high drops. he free overfall spillway without anyprotection on downstream side. free overfall spillway with provision of protection on downstream side. **3. Side channel spillway** When it is not possible to use overfall spillway especially in embankment dams, then side channel spillway is more suitable. LIn such type of spillway, water flow after passing over the crest is further conveyed in the side channel which running parallel to the crest. i) It is adopted in case of a long overflow crest provided to limit the surcharge head.(ii) It is adopted or preferred when the control structure is to be joined to a narrow discharge channel.

**#DESIGN OF OGEE SPILLWAY:-** Ogee spillway or overflow spillway is the most common type of spillway provided on gravity dam profile of ogee spillway is S shaped or ogee overflow or ogee spillway are classified high and low spillway depends upon of the height of the spillway (P) crest measured from the river bed to the design head (H). **Technical terms 1. Head (H)** The distance measured vertically from the water surface in upstream to the crest axis is called as head (H).(**2) Design head (Ha)**The value of head for which the ogee profile is designed, is called as design head (H).(**3) Head due to velocity of approach (H)**Head due to velocity of approach is the velocity headgiven .Ha=v2a/2g V.a= velocity approach (**iv) Total energy head (H.)b** When the actual head is added in the head due to velocity approach, then it gives total energy head (H.).$H_2$ = H+$H_2$ If H He then H, H+H. where H= design head and H= = head due to velocity approach. ***Steps in the design of spillway:- 1**. Computation of design head Crest profile for vertical upstream face(**a**) Design criteria of downstream profile**(b)** Design criteria of upstream crest profile **3**. Crest profile for inclined upstream face.4. Design of downstream bucket.

**#ENERGY DISSIPATERS:-** Water flowing over a spillway has very high velocity due to conversion of P.E. (i.e. potential energy) of water on u/s side to K.E. (i.e. Kinetic energy) as it flows down on d/s. Water flowing with a high velocity over a spillway if discharged into the d/s end without any protection provided at d/s end, then it causes scouring to the downstream bed or river bed and it may affect or damage the spillway and dam**. (i) Hydraulic jump type dissipater** For dissipation of excessive kinetic energy possessed by water or excessive velocity by the water flowing over the spillway; a hydraulic jump is developed. Sudden and turbulent passage of water from super critical to subcritical state is called as hydraulic jump (**ii) Bucket type energy dissipater** Bucket type energy dissipaters can be classified into two types namely**: (**a) Roller bucket: It can be either plain solid roller type or slotted roller type.

**#Types of buckets:- 1. Solid roller bucket:-** This type of bucket consist of a concave circular apron of large radius The bucket rollers developed on the surface of roller moves in anticlockwise direction known as bucket roller or surface roller Definition: The other bucket roller developed on the ground surface moves in the clockwise direction called as ground rollers. **2. Slotted roller bucket:-** A slotted roller bucket consists of concave circular apron having large radius; like solid circular bucket In such type of bucket also two rollers are developed as developed in solid roller bucket. But in this type water leaves lip of the bucket at a flatter angle and only a part of it get jumped upwards. In this case, less violent ground roller occurs which makes the smoother flow on d/s side**3. Ski-jump bucket** When tail water depth is less, then in such case a ski- jump bucket can be used. In such bucket the lip of the bucket is shaped in such way that the complete sheet of water flowing over the bucket is jumped or deflected as a free jet. This free jet further falls back into the river at a safe distance away from the spillway

**#STILLING BASIN:-** A structure built with the auxillary devices on the downstream side which dissipates the energy of water flow by offering resistance is called stilling basin. The auxillary devices can also be used for controlling the jump Various agencies have developed the various types of stilling basin and the designs of stilling basin have been innovated on the basis of long experience in dam construction field and experiment on various model with a basic view of protection and economy. Various Agencies has standardised stilling basin forbdifferent ranges of Froude numbers. Hence according recommendation of Agencies, they have made the categories of standard stilling basin as follows:1. Stilling basin type I, II, III and IV (IS.I. standardised basin, IS 4997-1968) 1.S.A. is IndianS tandard Institution. 2. U.S.B.R. stilling basin II3. U.S.B.R. stilling basin 3. U.S.B.R. stilling basin II U.S.B.R. recommended for basin II for large structure like dam spillway, large canal structures etc. when Froude number (F) is more than 4.5 i.e. F> 4.5, then U.S.B.R. stilling basin II are provided U.S.B.R. stilling basin IV U.S.B.R. stilling basin IV. This type of basin IV is used for the Froude number between 2.5 and 4.5 which normally occurs in canal weirs, canal fallNote that only rectangular cross section of a basin is applicable in such type II.

**#CLASSIFICATION OF SPILLWAY CREST GATES:- Non Automatic Gates** :- **1. Vertical lift** gate It is non-automatic gate. A vertical lift gates are rectangular in shape and consisting of frame work of steel members. A skin plate of steel is attached to framework on u/s side. Such gates moves vertically in their own plane ingrooves or sockets provided in piers at their two ends. The gates are raised or lowered by cables attached to them. Such type of gates can be operated from an overhead platform by winches worked manually or by power. **Radial gate or tainter gate** It is non-automatic type of gate consisting of a skin plate of steel formed to a segment of a cylinder supported on a steel frame. Steel frame work is pivoted on trunnions or pins which is set in the d/s portion of the piers on the spillway as **Advantages** ii. Suitable for moderate spans and heights.✓ More economical than vertical lift gate of the same size. iii. Requires less headroom for the operating platform than vertical lift gate.**3. Flashboards** Such type of gates consist of a series of wooden boards or panels placed on the crest of spillway. Flashboard are classified into two type Temporary flashboards ii. Permanent flashboard Temporary flash boards is made of a series of wooden boards **4**.**Drum gate** Drum gate is made up of segment of a cylinder formedby skin plates attached to the internal bracing Drum gate is hinged at the centre of curvature. Curvature can be on u/s side or d/s side. ***Automatic Gate. Reynolds's gate** Reynolds gate is fixed roller gate provided with the automatic arrangement. There is a counter weight which is connected to the gate with the help of pulleys and chain.There is a well provided on the crest in which the counter weight is kept. Well is connected to the u/s water face. **Vishweswarya gate**This type of gate consists of 8 gates in which two gates are light weight and two gates are heavy connected to each other on both the sides of master pier.There is a counter weight well constructed behind each master pior. This well is connected to the reservoir

**#Maintenance and Inspection of Spillway Gate :-** 1. As the gate is constantly in contact with water, it get corroded, hence corrosion resistance paint should be properly applied.2 Electric motor capacity should be checked and control panel should be upgraded.3. Movement or operation of gate should be smooth, hence it should be regularly greased.4. Spillway gate is heavy part and hence bearings at pivotshould be periodically renewed or replaced. 5. Motor operation of the gates should be in good condition.6.In automatic system, the control panel at the instrument station of the dam should be error free**. Inspection of Spillway Gate** Safety inspection of gates is a part of dam safety activities. The safety inspection activity can be performed into three part: (i) Preparation of task.(ii) Inspection technique.(iii) Documentation of report. Preparation of task involve the activities such pre- planning of inspection, reviewing documents, preparation on the field; personal safety arrangement.

*Unit 4* **#Types of Earthen dams:- main types 1.Homogeneous embankment type of dam:-** It is one of the type of earthen dam which consist ofearthen embankment of simple type and made in a single material hence it is homogeneous throughout. When only one type of material is locally available and which is economical, then a purely homogeneoussection is used. This type of homogeneous section is used for low to moderately high dams and also for levees. **2.Diaphragm type of embankment dam:-** This type of embankment dam consist so of an impervious core called as diaphragm which is surrounded by earth or rock fill. Impervious core or diaphragm is made of impervious soils, timber, concrete, steel or any other suitable material. Diaphragm serves as a obstacles or water barrier so as to avoid the seepage through the dam**. 3.Zoned type embankment:-** dam Central core is useful to check the seepage. The transition zone is advantageous for preventing the piping through cracks which may likely to set up in the central core. The outer zone provides stability to the central impervious fill and also distribute the load over the larger area of foundations .Clay is highly impervious, but sometimes it does not make the best core, if it expands and shrinks in large extent. Hence clay is sometimes mixed with fine gravel or fine sand so as to make the most suitable material for the central core sometimes silty clay or silts can be used as the central core materials.

**#classification based on construction :- . Rolled-fill earth dam** In such type of earth dam, the embankment is constructed by placing suitable soil material in thin layers about 150 mm to 300 mm and these layers are further compacted with the help of rollers. The soil obtained from burrow pits are brought to the site and properly spread with bulldozers in layers which are further compacted by rollers of designed weights. For low embankments like levees or bunds, the ordinary road rollers are preferably used but for dams, the power-operated rollers are suitably used. **Hydraulic-fill-earth dam** Dam which is constructed by excavating and transporting soils by using water is called as hydraulic fill earth dam. In such dam, pipes (i.e. flumes) are placed along the cuter side or edge of the embankment and soil materials mixed with water P is pumped into pipes called as flumes. Through the outlets, slush is discharged into flumes at suitable intervals

**#CONSTRUCTION OF EARTHEN DAM:-** 1. Material of construction2. Site clearance and stripping or benching3. Excavation of cut-off french4.Excavation and filling of seepage drains5 Construction of upstream casing and hearting zone or core by raising6. Keying to flanks7. Construction of head regulator and spillway8. Earth work in hearting i.e. core and casing9.Rip-rap or pitching on u/s face10. Garge filling and finishing of d/s slope11. Construction of drains and berms

**#components of dam:- 1.cut off trench** When the trench is excavated below the ground level under hearing zone or core and filled with the same material as filled in hearting, Thus a cut-off is a barrier used to reduce the seepage of water through foundation. It also prevents the piping of the dam through foundation. In short, it prevents subsurface erosion caused by piping. **Rock toe:-** Rock toe is made of rock pieces which slogging of toe caused by seepage flow and thus increases the stability of dam.The main advantages of the rock toe is to facilitate drainage of seepage water and thus to protect the lower part of the downstream slope from failure due to water erosion**. Berms**:-When the offsets are provided on the downstream side, then it is called as berms Berms are provided at 8 to 10 m vertical interval of 3 to 5 m width..Following are the various function of berms:(i) It decreases the velocity of rainwater falling ond/s slope (ii) It collects rain water and drain it safely

#FAILURE OF EARTHEN DAM:- . hydraulic failure 1.Overtopping It is a major cause of earth dam failure occured due to: (a) Small spillway capacity to carry the design flood.(b) Large flood beyond spillway capacity 2.Gully formation on d/s slope There is a formation of gullies due to heavy rain and consequent run-off on the d/s slope. This gullies are formed due to insufficient down-stream slope protection by suitable grass cover 3.Toe erosion The d/s toe of the dam is eroded because of tail water or cross-current from spillway buckets resulting in seepage and failure of dam 4.Frost action This case is happened in very cold regions. Frost action causes heaving and cracking in the upper portion of the dam. Due to frost action, there is seepage and failure of dam. Structural failure:- To avoid foundation slides(a) Reducing the water level immediately(b) Filling all cracks and fissures with good material and proper compaction by using advance techniques To avoid spreading(a) Avoid poor foundation(b) Reduce the height of the dam(c) Adopt flatter slope instead of steep slope

3.Seepage failure:- Avoid the development of piping sand boiling by using correct design and construction process and procedure Filling of cracks after

settlement Providing the drainage to the d/s through filter. **To avoid sloughing** It can be controlled by providing suitable grass cove on the d/s slope.,**4. Earthquake failure**To avoid earthquake failure; make a suitable provisio in the design of the dam in a view of intensity earthquake and location of epi-centre.

#Control of Seepage through Embankment:- Providing the impervious clay core :- A core or hearting of impervious material like clayey silt or silty clay is provided centrally in order to reduce the seepage through the body of earth dam.Impervious core the body of earth dam forms a barrior within the body of earth dam against seepage water. This barrier depends upon the availability of material topography; site conditions etc. #relif walls:- The main purpose of relief wall is to decrease the sub- stratum uplift pressure downstream of the dam. If the relief wall is not provided, there will be formation of sand boils and possibly sub-surface piping.Relief walls intercept the seepage and control the outlet for seepage. They type of seepage control system was first used by U.S. corporation of Engineers. **Providing chimney drain:-** The horizontal permeability is more than vertical for high degree of embankment stratification and it causes the greater horizontal spread of seepage.To control this seepage, a vertical drain called aschimney drain is provided which can completelyintercept the embankment seepage.

#pheratic line: When flow of water occurs through soil, the top surface of the flow zone is called the phreatic surface, and in section, the top line of flow zone is called the phreatic line. In earth retaining structures, the flow due to seepage will cause the phreatic line. All the points on the phreatic line have equal seepage pressure and it can be taken as atmospheric pressure. phreatic lines in different types of earth dams. Phreatic or seepage line is the line within a dam section below which there is positive hydrostatic pressure exist in darn and it is atmospheric on it.

#SWEDISH SLIP CIRCLE METHOD OF STABILITY ANALYSIS OF EARTH DAM:- Stability and development of stresses has prime importance in the design of earthen slopes and has to be carefully studied. An earth embankment generally fails due to the sliding of a large soil mass along a curved surface. Hence stability of slops of an earthen embankment can be studied and examined by a method called as slices method or Swedish slip circle method in which the condition of plane strain with failure along a cylindrical arc and location of the centre of the possible failure arc are assumed.In this method, the earth mass is split up into number of vertical segments termed as slices, spacing between the verticals are usually equal 6 to 12 slices are sufficient as per the requirement of accuracy.

#significance of: Steady seepage condition.:- When the reservoir filled full of water and the seepage is taking place of full rate, the most critical condition for which the stability of the downstream slope occurs, hence should be checked. Pore pressure on the soil the mass is due to the seeping water below the phreatic line and this pore pressure on the soil mass lies below the phreatic line. Therefore if the slices of the critical arc. Then shear stress induced on those slices shall be reduced correspondingly.Net shear stress on slices = c AL + (N-U) tan, Where, U pole pressure c = unit cohesion AL =curve length of the slice 0 = angle of internal friction of the soil

#Stability of Upstream Slope During Sudden Drawdown:- The critical region can be occurred near the downstream face, when the reservoir is full. For no drainage arrangement and steep downstream slope, the phreatic line may intersect the downstream slope which causes serious conditions which can be prevented further by providing drainage filter or drainage toe or by broadening the base of the dam.When the reservoir is suddenly emptied, the critical cor.dition may occur of for the downstream slope and the water level within the soil remains as it was, when soil pores became with full of water. Then weight of water contained in the soil starts sliding over the upstream slope along the curve.

#sudden drawdown condition:- When rate of withdrawal of reservoir or the reservoir after operation for sometime and having attained steady seepage condition is lowered or draw-down; then the flow sets in from inside the dam towards the upstream face and it may cause the sliding of the upstream side.If the lowering or draw-down of reservoir is sudden or rapid, it is reasonable to assume that the top seepage line with respect to steady seepage condition retains its original position for a short interval after draw-down. In sudden draw-down condition, the rate of lowering of reservoir water level do not permits full dissipation of pore pressures simultaneously with the lowering of reservoir level. When there is sudden draw-down of the reservoir after it is completely filled,

*Unit 5* #CANALS When there is sudden draw-down of the reservoir after it is completely filled, then it may pose a critical problem on its upstream side if the embankment is unable to drain quickly. A canal can be defined as "It is an artificial channel which has been constructed to carry water from a stream or tank or an artificial reservoir Canals for navigations, canals for power generation etc. Among them the irrigation canal is constructed to carry the water up to the agricultural fields from their Sources. The import canals constructed for irrigation purpose in India are, Ganga canal, western Yamuna canal, Bhakra canal**,. CANAL ALIGNMENTT** he area to be commanded for canal irrigation should be maximum.The length of canal should be minimum. The canal should be aligned in such way that the maximum area is to be commanded with least length of canal. The number of cross drainage work should be less so as to reduce the cost of cross-drainage workAs far as possible, curves should be avoided in the alignment of canals.

#CLASSIFICATION OR TYPES OF CANALS:- Contour canals Classification of canals based on alignment When the canal is aligned practically parallel to the contours of the areas, then it is called as contour canals. It is not possible to align the canal along the watershed or ridge in hill areas. In such situation, canal can be aligned as contour canal. **Ridge canal** When the canal is aligned along the ridge or the natural watershed line, then it is called as ridge canalLarge area can be brought under cultivating due to ridge canal and thus the ridge canal has a higher commands.No drainage can intersect a ridge line or watershed and therefore no cross drainage work (C. D. W) is required. Theridge canals are quite economical**. 3. Side slope canal** When the canal is aligned at right angles to the contours of areas, then it is called as side slope canal. Sach type of canal is neither aligned on the watershed nor in the valley but it is aligned somewhere in between the two along the slope. In short, such canal is aligned across contour.

#SELECTION OF CANAL ALIGNMENT:- 1. The areas to be irrigated or to be commanded should be maximum.2. There is command area which should be at higher level.3. Number of curves along the alignment should be less. 4. The alignment of canal should not be made in a rocky or cracked strata or broken land.5. In hilly areas, The alignment of canal should be parallel to the contours. 16.The length of canal should be minimum. 8 The number of cross-drainage work (C.D.W) should be less so that cost of construction becomes less. section.9 Canal section should be most economical .

#diff between :- **Kennedy's Theories1**.has indicated that the vertical component of eddies generated from the bed of the channel keeps the silt carried by water, in suspension. So he has given the relation between V and D while2.For making his equation applicable to the channels flowing in different soils of different grades, Kennedy has introduced the concept of critical velocity ration 'm' but has not developed any method to calculate the value of 'm'.3To determine the mean velocity of flow, Kennedy has used Kutter's equation (which has its own drawbacks) Kennedy has not developed any equation for the bed-4.slope of a channel and has used wood's table. Kennedy has not mentioned anything about the shape of the section of a stable channel &*Lacey 1.believed that, the silt carried the water flowing in the channel, is kept is suspension by the vertical component of eddies, generated from the entire perimeter of the channel and so, he has given the relation between 'V' and 'R'.2.Lacey has introduced the silt factor f, for making his equation applicable for the channels flowing in different soils having different grades and has provided a relation between 'f and the mean particle size 'm', which is used to determine the value of '3.Lacey has developed his own equation to determine the velocity of flow. 4.Lacey has developed his own equation for the bed slope ofthe channelLacey has made a mention about the shape of a channel (true regime channel has a semi-elliptical section)

#CANAL LINING:= When he impervious layer is provided to the sides of canal and bed surface; then it is called as canal lining. Canal lining protect the sides and bed of the canal Impervious layer having thickness varying from 25 mm to 150 mm is applied over the sides and bed of the canal. **Lining of canal.** Lining an irrigation canal or channel needs extra amount to be spent on the construction but in the long run, this lining which helps to control the seepage through the banks and bed and this extra water made available through the process of lining can justify the extra expenses made on the lining of the channel .**#advantages** . Canal lining prevents the water logging caused by seepage through unlined canal. 2. Repair and maintained cost of lined canal is less.3. Canal lining reduces the wastage of water or seepage and thus irrigation water can be saved and used for maximum command area.4. Stepper bed slope provide higher velocity and thus evaporation losses can be minimized 5. Deposition of silt in canal is less due to higher velocityin case of lined canal. 6. There is no weed growth on lined canal and hencetr anspiration losses are less. . There are more chances of leakage through joint**.*disadvantges:-** 1Initial cost of lined canal is more. 3. There are no berms provided in lined canal.2. It is difficult to repair, when there is damage.3. It is difficult to shift outlet in later stage due to rigid structure of lined canal.

#CANAL FALL: In a canal, any structure which is constructed to regulate the discharge with a full level or velocity is termed as a regulation work.1. Canal fall2. Cross regulator3. Head regulator4. Canal outle 5. Canal escape **Regulation works**. Such regulation works are necessary for the safety and also for the safely of the channel (i) Falls or Drops(ii) Distributory head regulators(iii) Cross Regulators (iv) Escapes **Location of Falls** When the natural slope of the ground is greater than the designed bed slope of the channel, it is necessary to reduce the differences between these slopes. 0 This is done by providing the vertical falls or drops, in the bed of the channel at the suitable intervals

**#Canal Fall necessary?** A structure constructed across a canal to lower down the water level and vanishes. The surplus energy developed during the falling of water which prevents scouring the bed and banks of the canal is called as fall. Hence it is very essential to built the fall structure so that scouring of the bed and banks of canal can be avoided.Location of fall can be decided from the various considerations.

#TYPES OF CANAL FALLS:- In the historical period, to avoid the construction of falls, the length of the channel was increased by providing sinuous curves e.g.It is found in the east Yamuna canal, which was constructed by the Mughal Emperors. This method, isnot only uneconomical but also has failed to serve the commode area efficiently Types of Fall **types** 1. Ogee fall2. Rapid fall3. Steeped fall4. Notch fall (Trapezoidal)5. Vertical drop type of fall6. Glacis type fall7. Meter or Non-meter fall8. Flumed and full width fall9. Cylinder fall10. Buffle fail or Inglish fall11. Montagu fall12. Sarada fall13. Siphon falls14. Chute fall15. Pipe fall or shaft fall. **Ogee Fall:-** This type of falls are constructed on Ganga canal. The basic aim of such fall is to get the smooth transition from upstream to the downstream water level; and to have minimum impact. The ogee falls have two short comings.Due to heavy drawdown on the upstream side of the fall, the bed and the side erosion is beavy. **Stepped Falls:-** These falls are modified from the rapid falls i.e. The long glacis of the rapids fall wave converted to the floors in steps in these steeped falls. The cost of the construction of such falls, also is very high

#CANAL OUTLETS:- Canal outlet is a type of device through which the water is released from the distributing canals into the actual field channel or water course.Thus canal outlet act as a head regulator for field channel or water course delivering water to the fields.The complete maintenance of distributing channels are carried out by the government control and authority. But field channels are maintained and controlled by cultivators. Thus outlet acts as a connecting line between government and cultivator. 1. Kennedy's Gauge outlet2. Open fume outlet3. Orifice semi-module4. Modular outlet 5. Semi-modular outlets. ***Requirments:-** 1. It should be long lasting, durable, strong and cheap. 2. Construction and maintenance of canal outlet should be easy and simple.3. It should able to draw proportionate silt and proportionate water according to discharge. 4. It must be simple in design easy for construction and for operation.5. It should not be easily tampered by farmer to rise thedischarge in the field channel.

#classification of outlets:- . **Non-modular outlets** They consist of a rectangular or the circular opening, with a pavement (or a submerged pipe). The diameter of these submerged pipe vary between 100 and 250 mm. These pipes are laid down on a light concrete foundation to prevent any leakage through uneven settlement. These pipes are kept horizontal and at the right angles to the central line of the distributing channel. To prevent tempering, these inlets and the exit ends are fixed in a masonry ***advantages:-** i. The discharge of the pipe outlet can be increased by deepening the water course (this is done to lower down, the water surface level in the water course.) ii. These outlets can work with very small available heads. **Disadvantages:-** The discharge of these outlets depends upon the difference in the water levels i.e. water level in distributing channel and in the water course. So, the discharge varies, as the water level changes. . **2.Semi-modular outlets** On the basis of the functioning, the semi-modular outlets can be sub-classified as, **(1) Pipe outlet** If any pipe outlet is set in such a manner that its discharge has a freefall into the water course and so, it acts as a semi-modular outlet.**2. Open Fume Outlet** is a smooth weir with a constricted throat to ensure hyper-critical velocity i.e. The velocity above the critical value. The length of the throat is such that the controlling section remains within the throat at all the discharges. A gradually expending flume is provided, below the throat for ensuring the formation. . **3.Modular Outlets or Rigid Modulus** A number of rigid modules have been invented some of the modules have some moving parts and some don't have any moving parts.

**#Canal escapes :-**It is a structure constructed on an irrigation channel to dispose off the surplus water, from the channel. So, it is also called as surplus water Escape or Canal Surplus Escape. It also has same more important functions to carry out like. It can scour out the silt from the bed of the head- reaches. So, it is also called as Canal Scouring Escape. **Significance** 1. Due to human error, the function of regulation does not work properly. 2. Due to unexpected heavy rains in the upper reaches extra water enters in the channel

Unit 6

#diversion head work:- When the structures is built across the river and at the head of off taking canal in order to divert the water from the river into canal for irrigationpurpose, then such structure is called as diversionhead work It is essential to construct certain structure called diversion head work across the river and at the head of off taking canal to take the water from river into canal for irrigation purpose.There are two types of canal head works namely: i. Storage headworkii. Diversion headwork. )**TYPES** :- **Temporary diversion headwork**It is a temporary structure consist of a spur or bund built across the river to raise the water level in the river in order to divert it into the canal.This type of structure can be damaged by the floods, hence it is required to construct these bunds every year 20 after the floods.▷ **(ii) Permanent diversion headwork**• It is a permanent structure and do not get damaged due to floods. It consist of weir or barrage built across the river in order to raise the water level in the river and divert it into the canal. **COMPONENTS:- 1. Under sluice** Under sluice is also called as scouring sluices which is located on the same side of off-taking canal, Under-sluices are the gated openings provided in the weir wall between the divide wall and the head regulator as shown ***FNC=** i. It control the entry of silt, gravel etc into the canal. iii. It provide a deep channel due to low crest. v. It scour the silt deposited in the river bed well above the approach channel. vi. It save the time and labour required for raising thshutters. **2 Divide wall** It is a component part of diversion head work. Divide wall is also called as divide groyne which is a concrete wall or masonry wall built at the right angle to the axis of the weir or barrage.Such type of wall divides the river into two parts namely the weir part and the under-sluice part. **Fnc** ii. It divides the river into two parts namely the weir part and under-sluice part. In short, it separate the under sluice from weir. iii. It reduces the effect of main river flow current on the flow conditions in the regulator. **3.Fish-ladder** It is one of the component of diversion head works Fish-ladder is also called as fish way. The main function of fish-ladder is to make safe movement of fish way through head work If fish-ladder is not carefully done, then it causes a large scale destruction of fish life. Fish-ladder is designed in such way that it maintain the velocity of 3 to 3.5 m/s in which fish can travel safely in water . **4 Silt excluding devices** It is a component of diversion head work by which entry of silt into the canal is prevented. Such type of devices are constructed at the head of main canal.▷ **6. Silt ejectors** It is a component of a diversion head work which is built across the canal in order to eject silt deposited in canal section.

#diff between :- a.weir 1.There is no control over river in low floods There is excessive afflux in high floods. Weir structure is relatively cheaper. It requires shorter period for its construction. Initial cost of construction is low.**2.barriage** :- There is perfect control over river flow in low floods There is minimum afflux even in high floods. Barrage structure is costly. It requires longer period for its construction. Initial cost of construction is more.

#Limitations of Bligh's Theory:- No differentiation between the vertical creep and horizontal creep. Bligh gives the same importance to both.2. Head loss variation is linear but actual head loss variation is non-linear. 3. The effect of varying length of cut-off or sheet piles notconsidered.4. No distinction is considered between the head loss on outer face and on the inner faces of sheet piles.5. No theoretical or practical method to find the creepcoefficient or the safe gradient. 6. The exit gradient is not considered.

#diff between lane theorys & bligh theory:- Lane observed that vertical creep is more effective than the horizontal creep.2.Lane's weighted creep theory is an improvement over Bligh's theory because it give more weightage to vertical creep. According to Lane's weighted creep theory, an3.irrigation structure will be safe if the average safe hydraulic gradientH Lwweighted hydraulic gradient is less than the For that soil, Lane's theory is not accurate and is rarely used in India. **BLIGH** =Bligh made no distinction between horizontal and vertical creep.Bligh's theory does not give more focus or weightage tovertical creep.Bligh consider the downstream pile only as a component of a total creep length and not as a controlling factor for the exit gradient and the piping. Bligh's theory does not give even the approximate results if the horizontal distance between the piles is less than twice their depth. This theory was popular previously in India. But Khosla's theory is now become popular for its accurate.

#KHOSLA'S THEORY BASED ON POTENTIAL THEORY APPROACH:- The design of hydraulic structure on permeable foundation by Bligh theory is accepted theory from 1910 onwards and most the design of hydraulic structure on permeable foundation were based on the Bligh theory.Later on some of the structure becomes troublesome and some of them are failed and other remained stable.In 1926-27, the siphon on Upper Chenab Canal was designed based on Bligh's theory and further this structure started giving undetermining problems and then investigation of this problem or trouble raised. After investigation, it is clearly observed that the actual uplift pressure for which the horizontal floor designe was quite .

#Khosla's Theory of Independentn Variables: Dr. Khosla suggested the theory of independent variables to determine the uplift pressure at the key points for the structure consisting of a combination of a number of elementary forms such as a horizontal floor, three piles, U/S glacis and d/s glacis.In the method of independent variable, Dr. Khosla split up a complicated weir or barrage into number of standard simple forms for which the analytical solution is known.Uplift pressure is obtained from the basic assumption followed by the corrections. **Assumptions** (i) The floor has negligible thickness. (ii) There is only one sheet pile line.(iii) The floor is horizontal.Above assumptions are not satisfied due to an actualfile and hence corrections are applied to the erimposed values of uplift pressure corrections:(i) Correction for thickness of floor.(ii) Correction for slope of the floor.

#cross drainage works:- Structure constructed for crossing canal water safely over or under the drainage water is called as cross drainage work. C-D work is a structure which carry the discharge of a natural stream or river or nala across a canal intercepting the stream or river or nalah.A cross drainage work is generally expensive and should be avoided as for as possible by diverting one stream to another or changing the alignment of -the canal. NECESSITY The cross-drainage work is essential so as to dispose of the drainage water and hence C. D. work is built in such way that canal supply remains uninterrupted. ii) Canal at a cross-drainage work (C. D. work) is generally taken over the drainage or below the drainage.(iii) At the crossing point of canal and C. D. work, the water of canal and the drainage get intermixed, hence for the smooth running of the canal with its design discharge, the cross-drainage works is necessary. SELECTION OF A road bridge can easily be provided along with the3. canal trough with minimum cost. For small size drainage, a syphon aqueduct is preferred 4.to an aqueduct. For large size drainage, an aqueduct ismore preferable, hence selected.5. The cross-drainage work which involve less quantity of earthwork of canal should be preferred.6.The type of C. D. work should be selected based the onthe foundation available at the site.7. The type of cross-drainage work is selected for the site having the suitable type of construction materialavailable in large quantity. Cost of construction of C. D. work should be less and not expensive.9. The type of C. D. Work is selected considering the permissible loss of head.

#Classification or Types of Cross Drainage Work OR Types of CD Works1. A .**Aqueduct:-** When canal structure is carried over a natural drain, then it is called as aqueductWhen bed of the canal is well above the HFL (ie. High Flood Level) of the drain, then in such case an aqueduct is suitable to construct over the drainage work. **1. Pipe aqueduct** When canal section is very small and width of drain is large; then in such case, pipe aqueduct is more suitable. The water is conveyed through the pipe, hence it is called as pipe aqueduct. . **2.Syphon aqueduct** the water surface level of the drain at high flood is higher than the canal bed, then in such case siphon aqueduct is more suitable and hence constructed.The bed of drain is generally depressed and provided with R.C.C. floor which forms a barrel between thepiers in order to pass the drain water in case of syphon aqueduct.**(B).Super Passage**:- When the bed of drain is well above the F.S.L. (full supply level) of canal, then a structure of drain waterconstructed across the canal is called as super passage. A super passage is reverse of aqueduct. In super passage; the drain water is taken across thecanal which is in a trough supported on piers. The main function of super passage is to take streamdischarge safely across the canal and at higher level**. (C)Level Crossing** Inlet and Outlet InletWhen an open cut or pipe is provided in a canal bank in order to simply take the water into the canal; then it is called as inlet.Inlet and outletWhen the drain water taken into the canal through an inlet and it is further discharged through outlet, then such arrangement is called as inlet and outlet. An outlet is provided at a suitable distance along the canal.

#DESIGN CONSIDERATION OF C.D. WORKS;- 1.Fixation of waterway of the drain.(ii) Computation of maximum flood discharge and High Floor Level (HFL).(iii) Consideration of clearance and free board. (iv) Contraction of canal waterway for the type III aqueducts.(v) Consideration of head loss through syphon barrels.(vi) Design of bank connections. (vii) Computation of uplift pressure on the roof of trough and on the floor.

#diff between:- **Aqueduct :-** 1.In aqueduct HFL of drain is much below the bottom of canal.Water runs under normal gravity condition.Bed of drain is not depressed and provided wit horizontal floor of barrels. The drain water flows under gravity pressure.**2. Syphon aqueduct:-** 1The HFL of drain is much higher above canal bed.2Water runs under Syphonic action.3Bed of drain is depressed and provided with horizontal floor of barrels. 4The drain water flows under pressure through barrels.