# Model Answer: Winter-2018

**Subject: Irrigation Engineering** | **Sub. Code: 17502**

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**Important Instructions to examiners:**

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and Communication Skills.)
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by the candidate and those in the model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and the model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

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| Que. No. | Sub. Que. | Model Answers | Marks | Total Marks |
|---|---|---|---|---|
| **Q.1** | **a)** | **Attempt any THREE of the following :** | | **12** |
| | **(i)** | **State the methods of determining average annual rainfall. Explain any one method.** | | |
| | **Ans.** | **Methods of determining average annual rainfall:**<br>1) Arithmetic Mean method<br>2) Thiessen's polygon method<br>3) Isohyetal method | **2** | |
| | | **Arithmetic Mean method of determining average annual rainfall:**<br>1) This is a simple method of determining average annual rainfall using simple arithmetical formula.<br>2) For this we require rainfall data of various years, based on which we can calculate average annual rainfall.<br>3) Table format followed for this method is as follows, | **2 (any one)** | |

| Sr. No. | Year | Rainfall in mm/cm |
|---|---|---|
| 1 | 1989 | 650 mm |
| Readings | | |
| | n = no. of years | $\sum$ P = Sum of all rainfall |

4) The arithmetical formula for this method is,

$$\text{Average annual rainfall} = \frac{\sum \text{rainfall of all years}}{\text{No. of years}} = \frac{\sum P}{n}$$

5) This is simple and easy method for rapid determination of average annual rainfall.

**Thiessen's Polygon Method / Representative Area Method:**

- In this method adjacent stations are joined by straight lines and thus dividing entire area into series of triangles and then perpendicular bisectors are erected on each of these lines and thus forms series of polygons each polygon contain one rain gauge station.

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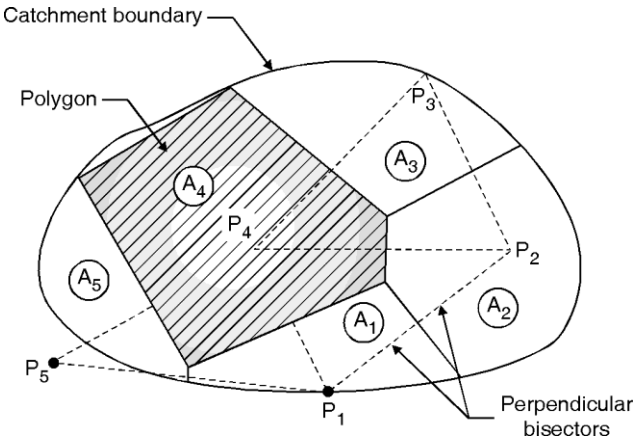
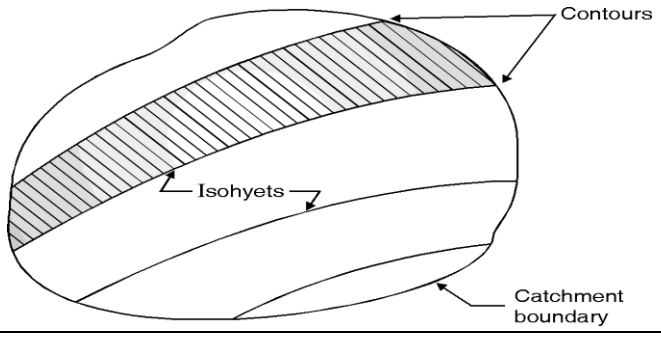
| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.1** | **a) (i)** | • It is assumed that the entire area within any polygon is nearer to the rain gauge station which is included in polygon than to any other rainfall station.<br>• Then find the area of each polygon shown in Fig. 2.5.1.<br>• If P is the mean rainfall on the basin the area of basin is A then,<br>$P = \frac{A_1P_1 + A_2P_2 + A_3P_3 \ldots + A_nP_n}{A} = \frac{\sum A \times P}{\sum A}$<br>• Where $P_1, P_2, P_3, \ldots P_n$ represent rainfall at the respective stations. And $A_1, A_2, A_3, \ldots A_n$ are the areas of respective polygons.<br>  <br><br>**Isohyetal Method:**<br>• Isohyets are the contours of equal rainfall. In this method rainfall values recorded at various rain gauge stations are collected and from that isohyetal map is prepared and the area between successive isohyetes is measured with the help of planimeter.<br>• Let them be $A_1, A_2, A_3, \ldots A_n$ and the average rainfall for these areas are $P_1, P_2, P_3 \ldots P_n$ then,<br>$P_{avg} = \frac{\frac{A_1(P_1 + P_2)}{2} + \frac{A_2(P_2 + P_3)}{2} + \ldots}{A_1 + A_2 + \ldots}$<br>$\therefore P_{avg} = \frac{\frac{\sum A_n (P_1 + P_2)}{2}}{\sum A}$<br>  <br> | | **4** |

# Model Answer: Winter 2018

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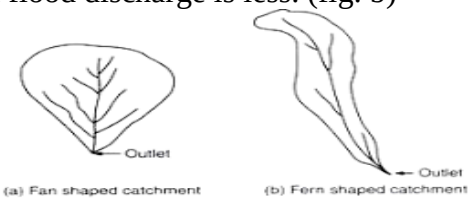
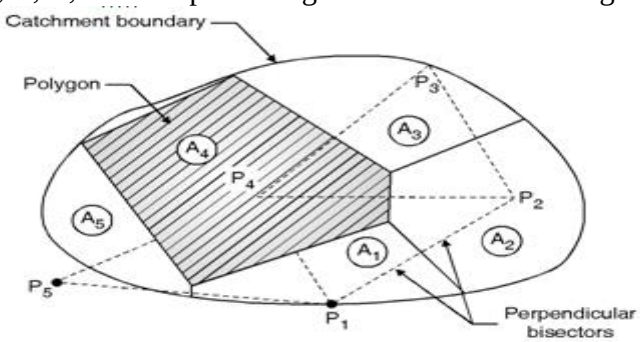
| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.1** | **a) (ii) Ans.** | **State the effect of type of catchment on maximum flood discharge.**<br>The area from where the surface runoff flows to the dam or river through the tributaries, streams, springs is termed as catchment area. This area is bounded by watershed line.<br>There are two types or shapes of catchment area that effect maximum flood discharge such as, Fan shape and Fern shape<br>**1) Fan shape:** In fan shape catchment area the amount of runoff and maximum flood discharge is more. (fig. a)<br>**2) Fern shape:** In fern shape catchment area the amount of runoff and maximum flood discharge is less. (fig. b)<br>  <br>(a) Fan shaped catchment (b) Fern shaped catchment | **1**<br>**1**<br>**1**<br>**1** | **4** |
| | **(iii) Ans.** | **Explain Thiessen's Polygon method of calculating average rainfall with neat sketch.**<br>Thiessen's polygon method is used for determining average rainfall of catchment. In this method, rainfall recorded by each station is weighed according to the area. It is also known as weighed mean method. It is more accurate than the arithmetic mean method. Consider rain gauge stations A, B, C, and D representing the area as shown in figure.<br>  <br>1) Join the adjacent rain gauge stations A, B, C, and D by straight lines.<br>2) Construct the perpendicular bisectors of each of these lines.<br>3) A Thiessen's network is thus constructed. Each polygon contains rain gauge station. It is assumed that the entire area within any polygon is nearer to the rain gauge station that is included in the polygon.<br>4) Find the area of each polygon shown hatched in the figure.<br>5) Multiply the area of each polygon by the rain gauge value of the enclosed figure.<br>6) Find the total area. (ΣA) of the basin.<br>7) Compute the average precipitation or rainfall from the equation –<br>Let, $A_1$, $A_2$, -------$A_n$ = Area<br>$P_1$, $P_2$, --------$P_n$ = Average rainfall of that station<br>$$P_{av} = \frac{A_1P_1 + A_2P_2 + \text{--------} + A_nP_n}{A_1 + A_2 + \text{--------} + A_n} = \frac{\sum A \times P}{\sum A}$$ | **1**<br>**1**<br>**1**<br>**1** | **4** |

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| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.1** | **a) (iv) Ans.** | **Enlist methods of assessment of irrigation water and explain any one.**<br>**Methods of assessment:**<br>1) Volumetric assessment<br>2) Assessment on area basis<br>3) Assessment on seasonal basis<br>4) Composite rate<br>5) Permanent assessment<br>**1. Volumetric assessment:**<br>In this method charges are levied on actual volume of water supplied to the cultivators. This is ideal system under which cultivators has incentive for using water economically. However this method has no practical value induce up till now. This method is necessary to install numerous water meter on irrigation outlets, scattered all over the canal system. It is very costly process and difficult to maintain also.<br>**2. Assessment on area basis:**<br>In India this type of assessment is generally adopted, the charges are levied on the actual area which is under irrigation. The charges are fixed crop wise. This method has a few disadvantages as the charges are levied on area basis and not on the actual quantity of water used. It leads to wasteful use of water. This type of irrigation encourages intensive irrigation rather than extensive irrigation.<br>**3. Assessment on seasonal basis:**<br>In this type of assessment the assessment is based on the kind of crop grown in that area in crop season.<br>**4. Composite rate basis:**<br>In this type of assessment the combined land revenue and tax are levied on cultivators. It is not normally in practice. | **2**<br><br>**2 (any one)** | **4** |
| | **b) (i)** | **Attempt any <u>ONE</u> of the following:**<br>**The base period intensity of irrigation and duty of various crops under a canal are given in the table below. Find the reservoir capacity if the canal has 20 % losses and reservoir has 12 % losses.** | | **6** |

| Sr. No. | Name of crop | Duty at field (ha/ cumec) | Base period (days) | Area under crops (ha) |
|---|---|---|---|---|
| 1. | Wheat | 1800 | 120 | 4000 |
| 2. | Rice | 800 | 120 | 3200 |
| 3. | Sugarcane | 700 | 360 | 4500 |
| 4. | Cotton | 1500 | 120 | 2400 |
| 5. | Vegetable | 600 | 120 | 1600 |

| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.1** | **b) (i) Ans.** | **1) Water requirement for Wheat:**<br>Discharge required=Area under crop(ha)/ Duty of field in (ha/cumec)<br>= 4000 / 1800 = 2.22 cumec<br>Volume of water required = discharge x days<br>= 2.22 x 120 = 266.4 cumec- days<br><br>**2) Water requirement for Rice:**<br>Discharge required=Area under crop(ha)/ Duty of field in (ha/cumec)<br>= 3200 / 800 = 4 cumec<br>Volume of water required = discharge x days<br>= 4 x 120 = 480 cumec- days<br><br>**3) Water requirement for Sugarcane:**<br>Discharge required=Area under crop(ha)/ Duty of field in (ha/cumec)<br>= 4500 / 700 = 6.43 cumec<br>Volume of water required = discharge x days<br>= 6.43 x 360 = 2314.8 cumec- days<br><br>**4) Water requirement for Cotton:**<br>Discharge required=Area under crop(ha)/ Duty of field in (ha/cumec)<br>= 2400 / 1500 = 1.6 cumec<br>Volume of water required = discharge x days<br>= 1.6 x 120 = 192 cumec- days<br><br>**5) Water requirement for Vegetable:**<br>Discharge required=Area under crop (ha)/Duty of field in (ha/cumec)<br>= 1600 / 600 = 2.66 cumec<br>Volume of water required = discharge x days<br>= 2.66 x 120 = 319.2 cumec- days<br><br>Total volume of water required on the field for all crops = 266.4 + 480 + 2314.8 + 192 + 319.2 = **3573.2 Cumec-day**<br><br>Total volume of water required on the field = 3573.2 x 24 x 60 x 60 Cum. = 30872448 Cum. = 30872448 / 10000 = **30872.448 Ha-m**<br><br>Since the losses in the canal system are 20 % , the volume of water required at the head of canal = 30872.448 X (100/80)<br>= **38590.56 Ha-m**<br>Allowing 12 % reservoir losses , the storage capacity of the reservoir<br>= 38590.56 X (100/88)<br>= 43852.91 Ha-m **say 43852.91 Ha-m**<br><br>***(Note: 1 mark for calculation of crop discharge and 1 mark for calculation of volume.)*** | **2***<br><br>**1**<br><br>**1**<br><br>**1**<br><br>**1** | **6** |

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| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.1** | **b) (ii)** | **Fix FRL of dam from the following data.**<br>**DSL = 110.00 M**<br>**Tank Losses = 1500 $M^3$**<br>**Effective Live Storage = 8000 $M^3$** | | |

| **Contour RL (M)** | **110** | **112** | **114** | **116** | **118** | **120** |
|---|---|---|---|---|---|---|
| **Capacity $M^3$** | **1000** | **3000** | **5000** | **6000** | **9000** | **12000** |

**Ans.**

Effective live storage = 8000 $m^3$
Tank losses = 1500 $m^3$
Total live storage = Effective live storage + Tank losses **1**
= 8000 +1500
= 9500 $m^3$
Dead storage = 1000 $m^3$ (corresponding to RL 110) **1** **6**
Gross storage = 9500 $m^3$ + 1000 $m^3$ = 10500 $m^3$ **1**

$$FRL = 118 + \frac{(120 - 118)(10500 - 9000)}{(12000 - 9000)}$$ **2**

= 118 + 1
= 119 M **1**
**FRL = 119 M**

**Q.2** **Attempt any <u>FOUR</u> of the following:** **16**

**a) Ans.** **What are the advantages and disadvantages of Bandhara irrigation?**

**Advantages of Bandhara Irrigation:**

1. The system of irrigation is economical.
2. The irrigated area is compact and hence irrigation is intensive,
3. The water of small catchments which would otherwise have gone waste is fully utilized.
4. As length of canal is less, transit losses are also less, all these factors lead to this irrigation efficient

**1 each (any two)** **4**

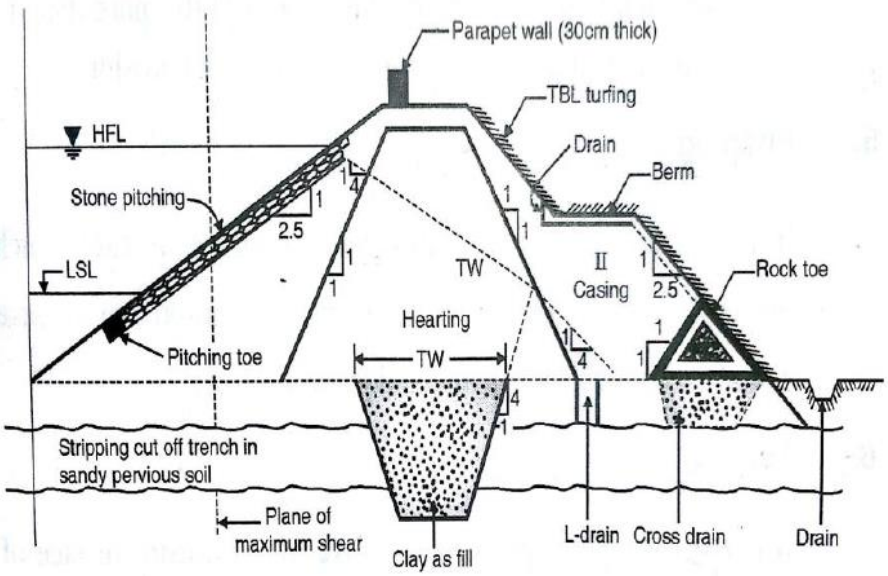
**Disadvantages of Bandhara Irrigation:**

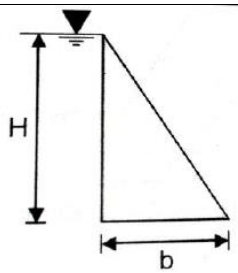
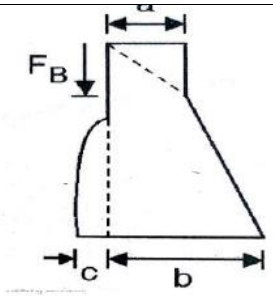
1. As irrigable area is fixed if more water is available for irrigation it cannot be used.
2. There might be uncertainty of supply of water in case of non-perennial river.
3. If number of bandhara are constructed on a stream downstream people may be adversely affected.

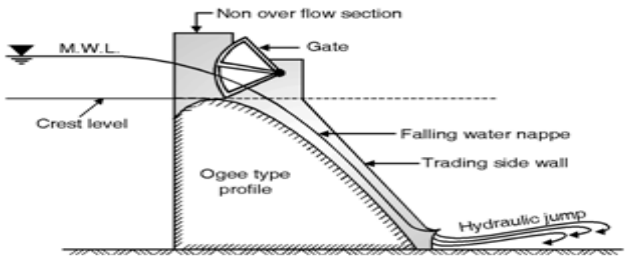
**1 each (any two)**

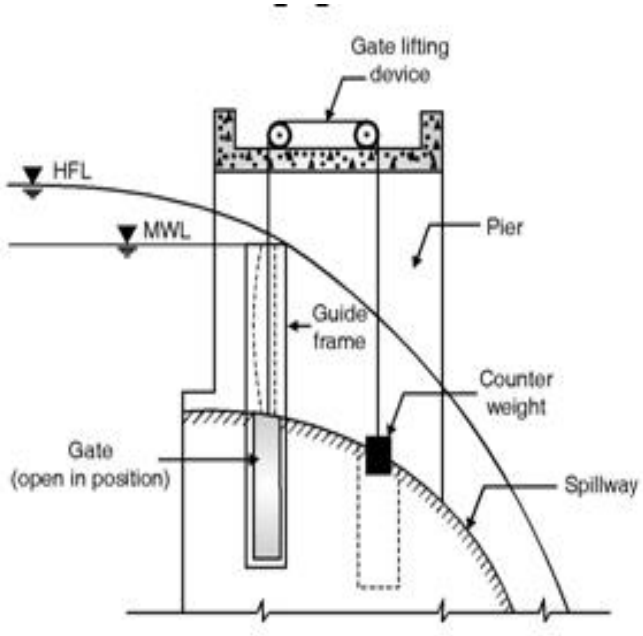
| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.2** | **b)** | **Explain the following terms with respect to Drip irrigation method, Head mains, Laterals, Drip nozzles.** | | |
| | **Ans.** | **1. Drip Irrigation Method:** It saves the water and fertilizer by allowing water to drip slowly to the root of the plants. In water scarcity zones, this system is much useful. There is no wastage of water in this system. It is most suitable for row crops.<br><br>**2. Head Mains:** Water is pumped from source and conveyed to the fields from the control head through head mainlines.<br><br>**3. Laterals:** Water is conveyed by pipelines which are perpendicular to head mains are called as lateral. laterals are generally made in PVC or polythylene hose which buried below ground.<br><br>**4. Drip nozzles:** It is a device by which the discharge of water from lateral to the plants can be controlled. These are generally spaced more than 1m apart with one another | **4** | **4** |
| | **c)** | **Differentiate between earthen and gravity dam with respect to foundation, seepage, construction and maintenance.** | | |
| | **Ans.** | | **1 each** | **4** |

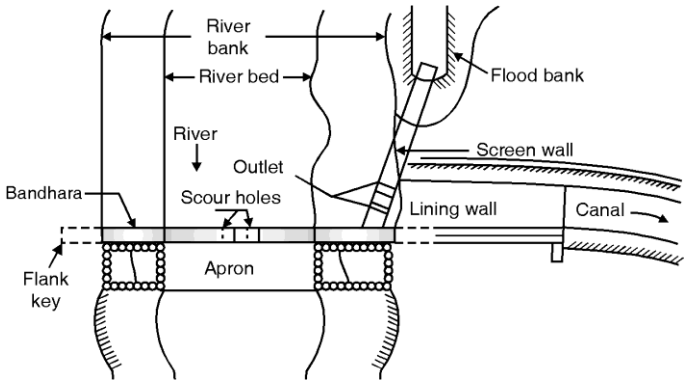
| Criteria | Earthen Dam | Gravity Dam |
|---|---|---|
| Foundation | They can be founded on any soil. | They cannot be found on any soil without any proper foundation. |
| Seepage | Seepage is more. | Comparatively there is less seepage in case of gravity dam. |
| Construction | 1. For its construction skilled labours are not required.<br>2. Construction cost of earthen dam is less | 1. For its construction skilled labours are required.<br>2. Construction cost of gravity dam is more. |
| Maintenance | Maintenance cost of earthen dam is more. | Maintenance cost of earthen dam is less. |

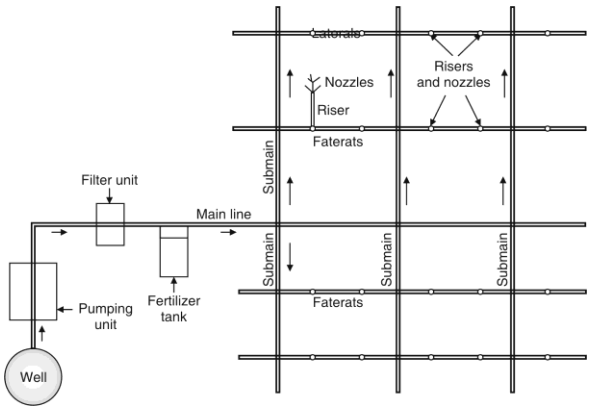
| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q. 2** | **d) Ans.** | **Draw a neat sketch of cross section of zoned type earthen dam and show all components of it.**<br>  <br><br>**Fig. Zoned Earthen Dam**<br>***(Note : 2 marks for sketch and 2 marks for labeling)*** | **4** | **4** |
| | **e) Ans.** | **Differentiate between elementary profile and practical profile of gravity dam.** | **1 each** | **4** |

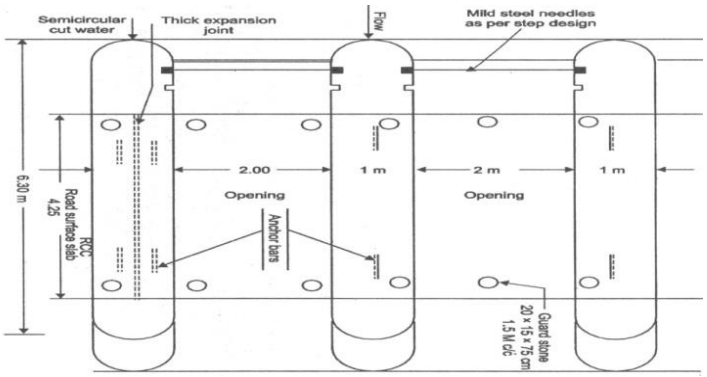
| Sr. No. | Elementary Profile | Practical Profile |
|---|---|---|
| 1 | Provision of free board is not provided. | Provision of free board is provided. |
| 2 | Roadway at top is not possible. | Roadway at top is possible. |
| 3 | For reservoir empty condition it will provide maximum possible stability. | For reservoir empty condition tension id developed at toe and hence some masonry is provided on u/s side. |
| 4 |  |  |

| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q. 2** | **f)** | **State the meaning of cut-off. Why is it necessary? Give construction details of cut-off.** | | |
| | **Ans.** | **Cut-off:** | | |
| | | A structure provided in a dam for control of seepage through dam foundation is called 'Cut-off'. | **1** | |
| | | **Necessity:** It is necessary to control the seepage through dam foundation and to provide support to the dam foundation and dam body. | **1** | |
| | | **Construction details:** | | **4** |
| | | **1) Cut–off Trench:** It is excavated below the hearting zone up to impervious strata and filled with impervious soil. The width and slopes of trench are generally selected according to convenience of construction. The bottom width is kept 2 to 6 m and side slope of 4 V: 1 H. it reduces seepage up to 90 %. | **1** | |
| | | **2) Concrete Cut off walls:** It consist of thin concrete. Cut of walls are placed in slurry trench excavated in foundation. These are made up of concrete or sheet piles and are extended through entire depth of previous foundation so as to achieve effective seepage control. | **1** | |
| **Q. 3** | **a)** | **Attempt any <u>FOUR</u> of the following:** | | **16** |
| | **Ans.** | **What is spillway? State the purpose of emergency spillway. Draw a neat labeled sketch of ogee spillway.** | | |
| | | Spillway is a masonry or concrete overflow portion provided for every dam. It is also called as overflow portion of dam. It is very important component of a dam. | **1** | |
| | | Emergency spill way is provided to dispose-off the excess flood water more than the designed flood. The top of emergency spillway is kept below the top of main dam, but slightly above the H.F.L. When abnormal high intensity flood occurs the weaker portion gets washed and flood water flows through that portion which acts as additional spillway and thus avoids possibility of failure of the dam. It can be reconstructed afterwards. Thus emergency spillway helps main spillway in emergency. | **1** | **4** |
| | |  | **2** | |
| | | **Fig. Ogee Spillway** | | |

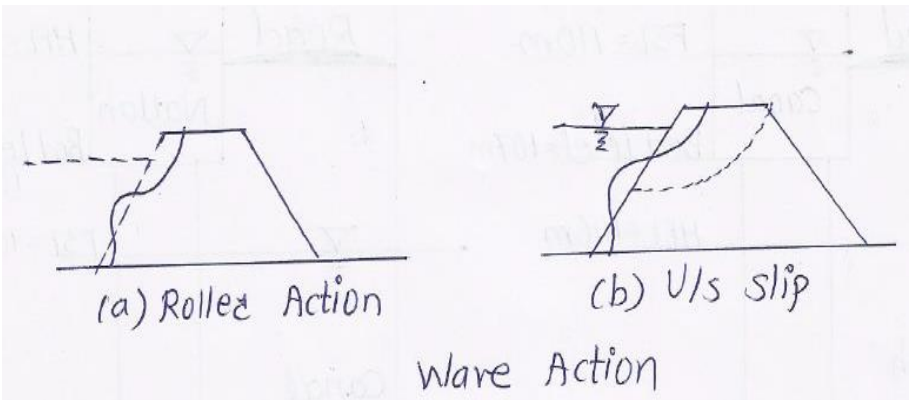
| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q. 3** | **b)** | **Give the function of following components of earthen dam.**<br>**i. Cut off trench**<br>**ii. Pitching**<br>**iii. Rock toe drainage arrangement** | | |
| | **Ans.** | i. **Cut off trench**: The function of cut off trench is to prevent or reduce seepage flow through the pervious foundation. It prevents piping of dam through foundation.<br><br>ii. **Pitching**: It prevents the erosion of material on the upstream face caused due to wave action and protects the slope from sudden drawdown.<br><br>iii. **Rock toe drainage arrangement:** It helps to prevent sloughing of the toe due to the seepage flow and increases the stability of dam. | **4** | **4** |
| | **c)** | **Draw labeled sketch of vertical sliding gate, state where it is suitable.** | | |
| | **Ans.** |  <br>**Fig. Vertical Sliding Gate**<br><br>**Suitability:** Vertical sliding gate is suitable for span more than 15 m. | **3**<br><br>**1** | **4** |

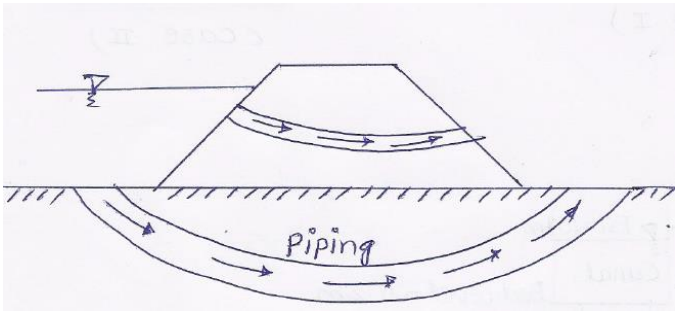
| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.3** | **d)** | **Draw a layout of Bandhara irrigation scheme showing different components.** | | |
| | **Ans.** |  | **4** | **4** |
| | | **Fig. Layout of Bandhara Irrigation Scheme**<br>***(Note: 2 marks for diagram and 2 marks for labeling)*** | | |
| | **e)** | **What is percolation tank? Why it is necessary? What are important points considered for selection site for percolation tank.** | | |
| | **Ans.** | **Percolation tank:** It is an earthen bund constructed across the water flow so that water is obstructed and allowed to percolate in the ground to raise the ground water table in the command area. | **1** | |
| | | **Necessity of Percolation tank :**<br>Percolation tanks are constructed on pervious soils so that percolation of water takes place through foundation soil and will be available on d/s in wells for lift irrigation when required. | **1** | |
| | | **Important points considered for selection site for percolation tank:**<br>i) The tank bed should be pervious.<br>ii) The nalla or stream should have sufficient discharge in monsoon.<br>iii) There should be number of wells on downstream side of the tank.<br>iv) A good agricultural land should be available near each well.<br>v) The flanks on both the sides of the nalla should be rising with steep slopes.<br>vi) The materials of construction, labour, machinery, approach road should available nearby. | **½ each any four** | **4** |
| | **f)** | **Define Hydrology and explain hydrological cycle.** | | |
| | **Ans.** | Hydrology is defined as a science regarding rainfall, rainfall losses, surface runoff and other water surveys. It is science which deals with occurrence, distribution and circulation of water on earth or below the earth. | **1** | |
| | | Hydrological cycle is a cycle followed by the water in three phases i.e. evaporation, precipitation and runoff. The amount of water remains unchanged. Only its form is changed. After the rainfall the water in the form of runoff flows and get accumulated in the river, lakes, sea. Some water goes to underground source. Due to heat of sun the water is evaporated and goes up word to form clouds. Again due to condensation water drops are formed and falls in the form of rainfall. This cycle is continued as hydrological cycle. | **3** | **4** |

| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.4** | **a)** | **Attempt any <u>THREE</u> of the following** : | | **12** |
| | **(i)** | **Discuss sprinkler irrigation system with respect to merits and demerits, sketch and trouble shooting of it.** | | |
| | **Ans.** | **Merits of Sprinkler irrigation system:**<br>a) Erosion of land can be controlled<br>b) Uniform application of water can be possible<br>c) Leveling of land is not required.<br>d) Elimination of seepage and percolation losses and prevents water logging.<br>e) Fertilizers can be applied ion solution form along with irrigation water.<br>f) More land is available for irrigation.<br>g) Small streams of irrigation water can be used effectively.<br>h) It is standby pumping set. | **½ each (any two)** | |
| | | **Demerits of Sprinkler irrigation system:**<br>a) Uniformity of irrigation is not achieved when wind velocity is more than 16 km/hour.<br>b) Initial cost of sprinkler set is high.<br>c) Not suitable for crops requiring frequent large depth of irrigation water.<br>d) A constant supply is needed for economical use of equipment.<br>e) Water must be clean and free from sand.<br>f) The power requirement is high. | **½ each (any two)** | **4** |
| | | **Trouble Shooting in Sprinkler irrigation system:**<br>a) Pump does not prime or develop pressure.<br>b) Sprinkler does not rotate.<br>c) Leakage from coupler or fittings.<br>d) Sand particles if present may offset irrigation.<br>e) Perforated pipe laid on ground may get choked. | **½ each (any two)** | |
| | |  | **1** | |
| | | **Fig. Layout of Sprinkler Irrigation System** | | |

| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.4** | **a) (ii) Ans.** | **What is Kolhapur type weir? Draw a neat sketch of it.**<br>This type of bandhara is commonly constructed in Kolhapur district It is constructed to raise the water level on upstream side so that it can be diverted in the canals on one side or both sides of banks.<br>It is fully open weir. It consists of number of piers and has side grooves for fixing wooden needles. The needles are put across the piers for the required height to form continuous weir. The height can be changed by removing needles or putting additional needles. Needles are removed during floods to avoid rise of water on u/s.<br>  <br><br>**Fig. Plan: Kolhapur Type Bandhara**<br>***(Note: Only plan or only section of KT bandhara should be considered.)*** | **2**<br><br>**2** | **4** |
| | **(iii) Ans.** | **Write any eight component parts of diversion head work**.<br>A diversion head work consist of following component :<br>1. Weir (barrage)<br>2. Under sluice/scouring sluices<br>3. Fish ladder<br>4. Divide wall<br>5. Canal head regulator<br>6. Silt excluder<br>7. Guide bank<br>8. Marginal bunds | **½ each** | **4** |
| | **(iv) Ans.** | **What is function of pick up weir? Under what situation it is constructed**.<br>It is a solid weir with crest gates constructed in concrete or stone masonry. It is constructed some distance downstream of dam to form a large reservoir to raise the water level up to FSL of canal.<br>**Situation under which pick up weirs are constructed:**<br>i. The command area not near the reservoir.<br>ii. Canal has to run idle.<br>iii. Geographically difficult terrain so that the canal alignment is very costly or impossible. | **2**<br><br>**1 each (any two)** | **4** |

| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.4** | **b)** | **Attempt any ONE of the following :** | | **6** |
| | **(i)** | **State the main components of drip irrigation and describe the function of each.** | | |
| | **Ans.** | The main components of drip irrigation are<br>1. Pump unit<br>2. Control heads or control valves<br>3. Mainlines, sub mains and laterals<br>4. Emitters or drippers | **2** | |
| | | **Functions of each unit:**<br>**1) Pump unit:** It conveys water from source and provides pressure for delivery into pipe system.<br>**2) Control heads or control valves:** These valves control discharge and pressure of water in complete system.<br>**3) Mainlines, sub mains and laterals:** Water is pumped from source and conveyed to the fields from the control head through mainlines, sub mains and laterals.<br>**4) Emitters or drippers:** It is a device by which the discharge of water from lateral to the plants can be controlled. | **4** | **6** |
| | **(ii)** | **Design the section of an unlined channel from the following data.**<br>**Q = 50 $m^3$/sec V = 1.0 m/sec B/D = 6,N = 0.0225 Side slope – 2:1** | | |
| | **Ans.** | For unlined canal. | | |
| | | Area of section (A)= $\frac{Q}{V} = \frac{50}{1} = 50\ m^2$ | **1** | |
| | | $A = (b + Zd)\ d$<br>$= (b + 2 \times d) \times d$ | **1** | |
| | | As B/D = 6, B = 6 D | **1** | |
| | | $\therefore A = (6D + 2 \times D) \times D$ | | |
| | | $50 = 8D^2$ | **1** | |
| | | D=2.5 m , B= 15m | | |
| | | Perimeter $P = b + 2d\sqrt{(1 + Z^2)}$<br>$= 15 + 2 \times 2.5\sqrt{(1 + 2^2)}$<br>$= 26.18m$ | | **6** |
| | | $\therefore R = \frac{A}{P} = \frac{50}{26.18} = 1.90\ m$ | **1** | |
| | | $\therefore$ Slope from Manning formula<br>$V = \frac{1}{0.0225} \times R^{2/3} \times \frac{1}{\sqrt{s}}$<br>$= \frac{1}{0.0225} \times (1.9)^{2/3} \times \frac{1}{\sqrt{s}}$<br>$1 = \frac{1}{0.0225} \times (1.9)^{2/3} \times \frac{1}{\sqrt{s}}$<br>$S = \frac{1}{4740}$ | **1** | |

| Que. No. | Sub. Que. | Model Answers | Marks | Total Marks |
|---|---|---|---|---|
| **Q.5** | | **Attempt any TWO of the following:** | | **16** |
| | **a)** | **Mention various investigation survey required for reservoir planning and explain engineering survey in detail.** | | |
| | **Ans.** | **Following investigations are required for reservoir planning.**<br>1. Engineering Survey<br>2. Geological Investigation<br>3. Hydrological Investigation | **2** | **8** |
| | | **Engineering Surveys:** In this type of surveys or investigations, various types of surveys e.g. plane table survey, traverse survey aerial and photographic survey etc. are carried out. The aim of this type of survey is to prepare a contoured map or topographic map. The contour map will furnish the following necessary information.<br>1. Water spread<br>2. Arrangement of lines of communication<br>3. Capacity of reservoir<br>4. Suitable dam site<br>5. Site for waste weir and outlets<br>6. Area elevation curve<br>7. Storage elevation curve<br>8. Map of the area to indicate the land property to be surveyed | **6** | |
| | **b)** | **Explain type of failure in earthen dam and its remedial measures**. | | |
| | **Ans.** | **(1) Hydraulic Failure:** It may be caused due to following.<br>**a) Overtopping:** If the actual flood discharge is much more than the estimated flood discharge or the free board is kept insufficient or there is settlement of the dam or capacity of spill way is insufficient, then it results in the overtopping of the dam. During overtopping the crest of the dam may be washed out and the dam may collapse.<br>**b) Erosion:** If the stone protection on u/s side is insufficient, then the u/s face may be damaged by erosion due to wave action. The d/s side also may be damaged by tail water, rain water etc. The toe of the dam may also get damaged by water flowing through spillways. | **2** | |
| | |  | | |

| Que. No. | Sub. Que. | Model Answers | Marks | Total Marks |
|---|---|---|---|---|
| **Q.5** | **b)** | **(2) Seepage Failure:** It may be caused due to following.<br>**a) Piping or Undermining:** Due to continuous seepage, flow through the body of the dam and through the sub-soil below the dam. The d/s side gets eroded or washed out and a hollow pipe like groove is formed which extends gradually towards the u/s through the base of the dam. This phenomenon is known as piping or undermining. It weakens the dam and ultimately causes the failure of the dam.<br>  <br><br>**b) Sloughing:** The crumbling of the toe of the dam is known as sloughing. When the reservoir runs full, for the longer time, the d/s base of the dam remains saturated. Due to the force of seepage water the toe of the dam goes on crumbling gradually. Ultimately the base of dam collapses.<br><br>**(3) Structural Failure:**<br>**a) Sliding of side slopes:** Sometimes it is found that the side slope of the dam slides down to form some steeper slope. Then the dam goes on depressing gradually and then overtopping occurs which leads to the failure of the dam.<br>**b) Damage by Earthquake:** The earthquake cracks may develop on the body of the dam. It may eventually collapse.<br>**c) Damage by burrowing animals:** Some burrowing animals like craw, fish, snake, squirrel etc. causes damage to the dam by digging holes through the foundation and body of the dam.<br><br>**Remedial measures to avoid failure of earthen dam:**<br>1) **Control of seepage through embankment.**<br>a) Provide Hearting in the central portion of dam.<br>b) Provide casing over the hearting.<br>c) Provision of horizontal drainage blanket<br>2) **Control of seepage through foundation.**<br>a) Provide cutoff trench under hearting zone.<br>b) Provide concrete cut-off wall.<br>3) **Control of seepage in general.**<br>a) Provide rock toe on d/s face at toe.<br>b) Provide pitching on u/s slope.<br>c) Provide turfing on d/s slope.<br>d) Provide berms at 8m to 10 m vertical interval on d/s. | **2**<br><br>**2**<br><br>**2 each any two)** | **8** |

| Que. No. | Sub. Que. | Model Answers | Marks | Total Marks |
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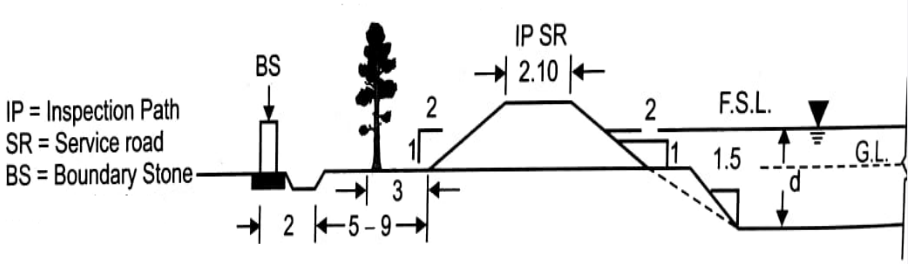
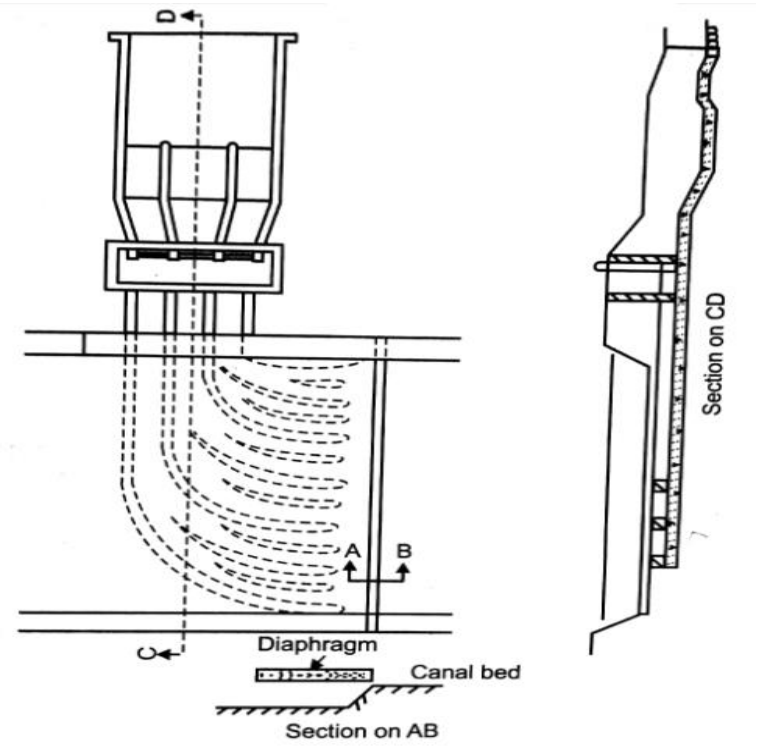
| **Q.5** | **c)** **Ans.** | **Draw cross section of canal in partial cutting and filling and name components.**<br>  <br><br>**Fig. Cross Section of Canal in Partial Cutting and Filling**<br>***( Note: 6 marks for diagram and 2 marks for labeling)*** | **8** | **8** |
| **Q.6** | **a)** **Ans.** | **Attempt any <u>FOUR</u> of the following:**<br>**State functions of silt ejector and draw its sketch.**<br>**Function of Silt Ejector:**<br>It is a structure constructed across canal to eject silt accumulated in canal section.<br>  <br><br>**Fig. Silt Ejector** | **1**<br><br>**3** | **16**<br><br>**4** |

| Que. No. | Sub. Que. | Model Answers | Marks | Total Marks |
|---|---|---|---|---|
| Q.6 | b) Ans. | **Draw a labelled layout of diversion head works and mention function of each part of it.**<br>**i) Head regulator:**<br>1) It regulates the supply of water entering in canal.<br>2) It controls the entry of silt into canal<br>3) It prevents the river flood entering the canal<br><br>**ii) Divide wall:**<br>1) To separate flow from the scouring weir which is at lower level than proper weir.<br>2) To separate the silting packet from scouring sluices<br>3) To prevent formation of cross currents to avoid domain effects<br>4) To cut off the main portion of the river and provide a comparatively quite packet in front of the canal head regulator resulting in deposition of silt in the pocket and enter clear water in canal<br><br>**iii) Fish ladder:**<br>1) To help the survival of the fishes<br>2) To provide free movement of fishes<br><br>**iv) Scouring Sluice:**<br>1) Deposited silt and soil are scoured through the scouring sluice<br><br>**v) Stilling Pond:**<br>1) To reduce velocity of water.<br>2) To settle down the silt and allow clear water to the canal. | **½ each (any four)**<br><br>**2** | **4** |

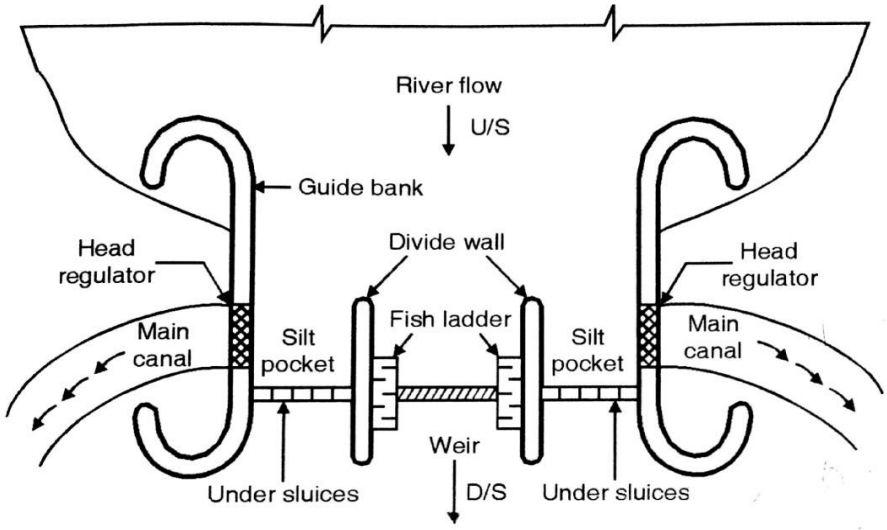
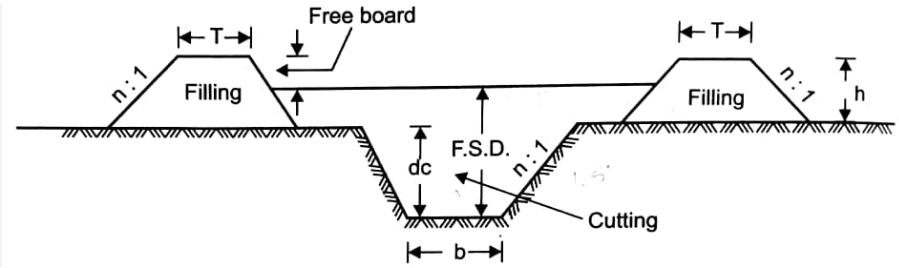



**Fig. Diversion Head Works**

| Que. No. | Sub. Que. | Model Answers | Marks | Total Marks |
|---|---|---|---|---|
| Q.6 | c) | **Calculate balancing depth for a section of a having the following data:**<br>**b = 10 m, FSD = 1.5 m, bank width = 2 m, side slope 1:1 in cutting and 1.5 : 1 in filling, free board = 0.5 m.** | | |
| | **Ans.** |  | | |
| | | Let $d_c$ be the balancing depth.<br>h be the height of bank above GL = $(1.5 + 0.5 - d_c) = (2 - d_c)$<br>Area of cutting = $(b + nd)\, d$<br>$= ( 10 + 1 \times d_c )\, d_c$<br>$= ( 10 + d_c )\, d_c$ | **1** | |
| | | Area of Filling = 2 ( area of each bank)<br>$= 2[ (b + nd)\, d ]$<br>$= 2[ ( 2 + 1.5 \times h )\, h]$<br>$= 2[ \{2 + 1.5 (2 - d_c)\} (2 - d_c)]$<br>$= 2[ (2+3-1.5\, d_c) (2 - d_c)]$<br>$= 2[ (5-1.5\, d_c) (2 - d_c)]$<br>$= 2[ (10-5\, d_c - 3\, d_c + 1.5\, d_c^2 )]$<br>$= 2[ (10-8\, d_c + 1.5\, d_c^2 )]$<br>$= 20-16\, d_c + 3\, d_c^2$ | **1**<br>**1** | **4** |
| | | Now, For balancing depth, Area of cutting = Area of Filling<br>$( 10 + d_c )\, d_c = 20-16\, d_c + 3\, d_c^2$<br>$10\, d_c + d_c^2 = 20-16\, d_c + 3\, d_c^2$<br>$0 = 20-16\, d_c + 3\, d_c^2 - 10\, d_c - d_c^2$<br>$0 = 20-26\, d_c + 2\, d_c^2$<br>$0 = 10-13\, d_c + d_c^2$<br>$d_c = + 13 \pm \sqrt{(13^2 - 4 \times 10)}$<br>$d_c = 0.82$ m | **1** | |

| Que. No. | Sub. Que. | Model Answers | Marks | Total Marks |
|---|---|---|---|---|
| Q.6 | d) Ans. | **Define lining. Enlist different types of lining and explain.**<br>**Lining of canal** means providing impervious thin layer of 2.5 to 15 cm thickness to protect the bed and sides of canal.<br>**Different types of lining** :<br>1. Hard surface Lining :<br>a. Cement concrete Lining<br>b. Shotcrete Lining<br>c. Precast Lining<br>d. Brick Lining<br>e. Cement Mortar Lining<br>f. Asphaltic concrete Lining<br>g. Stone Block Lining<br>2. Earth type Lining :<br>a. Clay Puddle Lining<br>b. Soil cement Lining<br>c. Sodium Carbonate Lining<br>3. Buried and protected membrane Lining :<br>a. Pre fabricated Light membrane Lining<br>b. Bentonite soil and clay membrane Lining<br>c. Road Oil Lining<br><br>**a. Cement concrete Lining:** Concrete as a lining material gives excellent hydraulic properties. The thickness of lining is governed by the requirement of imperviousness and structural strength. The thickness is provided is from 5 to 10 cm for M15 and 7.5 cm to 15 cm for M10 concrete. The concrete used for lining has mix ratio 1:4:8 or 1:3:6 or 1:4:6.<br>**b. Shotcrete Lining:** Mixture of cement and sand (1:4) is shot at the sub grade through a nozzle. The thickness of this type of lining varies from 2.5 to 6.5 cm. Shotcrete consumes large amount of cement. Shotcrete can be placed on irregular subgrade and fine dressing of subgrade is not required.<br>**c. Precast concrete Lining:** This type of concrete lining consists of precast slabs usually 90 cm x 30 cm in size. The thickness of each slab is from 5 to 6.5 cm. The blocks are manufactured with an interlocking arrangement. The slabs are laid on well prepared and compacted subgrade.<br>**d. Cement mortar lining:** Thickness for this of lining is kept from 1 to 4 cm. A large amount of cement is consumed in this type of lining and it is very costly.<br>**e. Brick Lining:** This type of lining consists of single or double layer of brick masonry or a layer of brick masonry followed by a layer of tiles laid is mortar. The first layer is laid on 12 mm layer of 1:6 cement mortar. A 12 mm thick layer of plaster in 1:3 | **1**<br>**1**<br>**2 each (any one)** | **4** |

| Que. No. | Sub. Que. | Model Answers | Marks | Total Marks |
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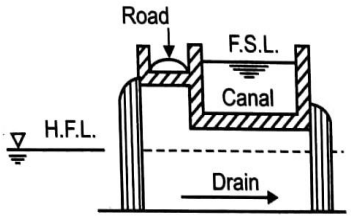
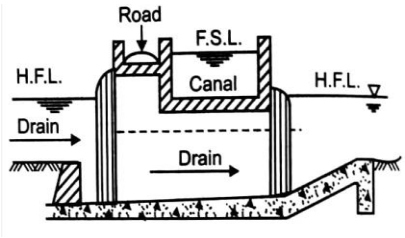
| **Q.6** | **d)** | cement mortar is laid over the first layer. Then the second layer is laid over it in 1:3 cement mortar.<br>**f. Asphaltic lining**: It is controlled mixture of asphalt and grade aggregate mixed and placed at a high temperature of $200^0$c and covered with 30 cm layer of earth material for a protection. The mix is placed either by hand or by equipment similar to that concrete.<br>**g. Clay Puddle Lining:** Clay puddle is produced from by first exposing clay to weathering. It is then mixed with water to bring it to the saturation and pugged thoroughly by trampling under man's or cattle's feet. This thickness of lining is 30 cm. It is then protected by layer of earth material.<br>**h. Sodium carbonate Lining**: The mixture consists of clayey soil (10%) and sodium carbonate (6%). The thickness of lining is kept as 10 cm. this type of lining is used for small canal and water course.<br>**i. Stone block lining:** This consists of undressed stone block set in mortar laid over prepared sub grade. The lining is able to check seepage effectively but has a considerable resistance to flow of water.<br>**j. Pre-fabricated light weight membrane:** They are matted fibers of asbestos or jute and are coated with asphalt. It is laid on a smooth and prepared subgrade, and is covered with layer of earth material.<br>**k. Bentonite and clay membrane:** This consists of bentonite or clay blanket 4 cm thick laid over a prepared subgrade and covered with earth.<br>**l. Road oil lining:** The road oil sprinkled on subgrade in thickness of about 1.5 mm is sufficient enough to saturate subgrade to depth 8 cm. the subgrade is then rolled so that oil enters the soil pores. | | |
| | **e)**<br>**Ans.** | **Classify Various types of cross drainage work. Mention difference between aqueduct and siphon aqueduct**.<br>**Types of cross drainage work:**<br>1. Aqueduct<br>2. Super Passage<br>3. Level Crossing<br>4. Inlet and outlet | **1** | |

| Que. No. | Sub. Que. | Model Answer | Marks | Total Marks |
|---|---|---|---|---|
| **Q.6** | **e)** **Ans.** | | **1 each** | **4** |

| Sr. No. | Aqueduct | Siphon Aqueduct |
|---|---|---|
| 1. | Drainage water flows freely under gravity. | The water runs under syphonic action. |
| 2. | HFL of drain is sufficiently below the canal bed. | HFL of drain is higher than canal bed but lower than FSL of canal. |
| 3. |  **Fig. Aqueduct** |  **Fig. Siphon Aqueduct** |