सत्यमेव जयते

GOVERNMENT OF GUJARAT

MANUAL
ON
DRAINAGE SCHEMES

PUBLIC WORKS DEPARTMENT
SACHIVALAYA
GANDHINAGAR.

DRAINAGE SCHEMES

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DRAINAGE SCHEMES

1.0 INTRODUCTION :

In flat countries due to heavy rains during monsoon, large areas of culturable land get flooded causing heavy damage to the standing crops as the area cannot be drained for a considerable time. Thus the land becomes water logged and in saline soils this enhances the percentage of salinity. It is therefore, necessary to resort to channelised disposal of such accumulated waters into a big nalla, river or sea. This can be accomplished by excavating an artificial drainage chainnel having sufficient capacity to drain the water from the submerged areas within a reasonable period. In Gujarat State such type of problems are met with particularly in Ahmedabad, Vadodara, Bharuch, Mahesana and Bhavanagar Districts and in flat coastal areas.

2.0 INVESTIGATION :

Investigation should be carried out to determine the permeability of the Soil at various depths and also its salinity before undertaking a drainage scheme. Data regarding the existing type of irrigation, spring levels, topography and existing natural drainage, precipitation etc. should also be collected.

3.0 TYPE OF DRAINS :

The drains can be divided into two main categories :—

(i) The drains carrying upland floods through other lands without draining the water from the adjacent areas on way and

(ii) The drains which also drain the lands adjacent to them all along their course.

The drains referred to at (ii) above may again be divided into two categories viz.

(a) The drains which purely drain wet lands.

(b) The drains which drain wet lands and also carry irrigation water.

The peculiarities of drains referred to in (a) above are :—

(i) Usual flat surface falls and flat catchments of wet lands.

(ii) The smallness of drain sections.

(iii) Flooding, during high water of the lands and drain margins with the following characteristics :—

(a) Submergence of lands for about a week.

(b) Large volumes of floods stored on fields. This field storage reduces the water level of the drains and serves to moderate the floods.

(c) Increased water way during the high floods as water flows over the drains, berms and fields in high floods.

Some drains also carry irrigation discharge either to fill up the tanks for irrigating the culturable lands or to command area directly from the drains in such cases, if the irrigation discharge is more than the drainage discharge and particularly where the difference is very large. It would be economical and better to separate the drainage from the irrigation system, if possible because while the irrigation channel will need banking the drainage channel will be effective without banking. If this is not practicable low banks with arrangement for regulation of ample water will have to be provided so that the channel may have ample discharging section in high water.

4.0 ALIGNMENT OF DRAIN :

The alignment should be in a valley with high grounds on both the sides. Generally it should follow the path of natural drainage. The alignment should, therefore, be decided based on the strip contouring done along the proposed alignment. The surface of the water in the channel which traverses the lands draining into it must be below the level of these lands so that the channel is effective to drain out the accumulated water from the submerged lands within a reasonable period. The purpose of drainage would be served if cultivated lands and the crops on it are effectively drained within a reasonable period upto which the crop can stand the accumulated water without much damage. As far as possible minimum curves should be provided along the drains and where these are unavoidable, their radius should be more than 40 times the bed width of the drain. The connection of the drain wherever it is proposed to be connected with an irrigation tank may be by a small connecting drain with regulating arrangements. Every drain should be provided with an outfall either into a bigger drain or a natural stream. As far as practicable banking should be avoided.

5.0 CAPACITY OF DRAIN :

Whether primarily designed for that purpose or not open drains can not be prevented from carrying storm run offs. It is also not at all necessary to provide drainage capacity for rare floods. The aim of drainage system is to counteract water logging and not to guarantee against flooding. This purpose can be served within the permissible cost if the drainage system can carry away the water expeditiously in most of the years.

The surface run-off for a given rainfall is governed by the shape, extent and topography of C. A. and type, texture and structure of soils and also cropping pattern in the command area etc.

In case of drains having elongated catchments the problem of submergence is relatively less acute. For such drains it can safely be assumed that rainfall may not occur all along the catchment and the time of concentration can be accounted for this. It is therefore suggested that in designing the sections of the drainage lines it should be assumed that the storm occurs on the water shed of not more than 300 sq. kms at one time.

The storm run–off can be estimated by hydrological studies of the given area. Generally the design discharge is calculated on the basis of the run-off which is based on average annual rainfall.

The run-off coefficients for the design of drains may be worked out on individual water shed basis. The run–off volumes should be calculated for the 24 hours storm with a frequency of once in 5 years and the drains should have a capacity to dispose this volume in 72 hours for paddy areas. A reduction of 100 mm of rainfall is required to account for pending while working out the run-off from such paddy areas. However some extra capacity in the drains may also be necessary to cater for the present practice of the cultivators of draining the paddy fields during storms.

The run–off is assumed to be 19 mm ($\frac{3}{4}''$) per day for areas having average rainfall below 762"mm (30") e. g. Ahmedabad and Mahesana Districts. It may be taken as 38 mm ($1\frac{1}{2}''$) per day for the area having average rain fall of over 762 mm (30") e. g. in Districts like Broach and Surat. From this the design discharge of a drain could be calculated as shown in Appendix No. I & II.

6.1 SECTION OF DRAIN :

The cross section of drain is designed on the same general principles as that of an irrigation channel. For the calculated designed discharge, suitable section of the drain may be assumed, such that B/D (Breadth/Depth) ratio may be more than 1.5. The velocity may be calculated by using Manning's formula given below :-

$V = 1/N \ R^{2/3} \times S^{1/2}$ in MKS Units, where :—

V = Velocity in Meter/Sec.

N = Coefficient of rugosity.

R = H. M. D.

S = Bed Gradient.

(i) Since the drainage channels generally get infested with weeds and may not be able to be maintained in good condition without any obstruction in the flow of water, a value of 0.030 to 0.035 will have to be used for co-efficient of rugosity "N" in the Manning's formula.

(ii) The drain should be in cutting. The depth of cutting should be sufficient to keep the F. S. L. at least 0.3 meter below the ground level, as far as possible. The design bed gradient should be provided in accordance with the out-fall conditions and the drains may be kept as deep as possible consistent with outfall levels of the drains.

(iii) The side slopes in cutting should be kept as 1:1. In order to allow for reduction of section of channel due to silting and deterioration etc., the design calculations are recommended to be made taking side slope ½ : 1. The Discharge of the section would be equal to $Q = A \times V$ where :—

Q = Discharge in cumecs.

A = Area in smt.

V = Velocity in Mt/Sec.

(iv) In order to aim at economy in earth work, C.D. Works and land acquisition, the entire length of the drain should de divided in to suitable components. The sections of each part should be proposed to be designed for the discharge from the corresponding catchment area and the sections for all the parts along the entire length of the drain should be worked out accordingly.

6.2 CRITICAL VELOCITY :

The critical velocity (Vo) may be calculated by the formula $Vo = 0.55 \ (D)^{0.64}$ where Vo = critical velocity in mt/Sec. and D = The depth of water in meter.

6.3 VELOCITY RATIO :

The velocity ratio i. e. V/Vo should be between 1.0 to 1.4 i. e. on scouring side. Typical calculations for the design of drains are given in Appendix No. I & II.

6.4 GENERAL :

(i) Once the Layout and designs of the main drains are finalised the design of the field drains based on the available out fall conditions may be worked out.

(ii) The construction of laterals and sub-laterals should not be left to be taken up as and when found necessary. They should follow immediately after the construction of the main drains to derive full benefits from the main drains.

(iii) Lateral drains required for connecting local depressions with the main drains may be taken up after watching the improvements in the drainage conditions brought about by improvements of the main drainage lines.

(iv) The surplus excavated stuff may be spread over the nearby fields if it can be done without causing damage to them, otherwise it has to be deposited in the form of spoil banks. Spoils should be thrown sufficiently away so that they are not required to be rehandled if at a later stage widening of the drain is thought necessary.

(v) Consideration for seepage from higher land, run-off from excess irrigation and breaches in canals and prolongated storms should also be done in specific cases.

(vi) Incase of drains receiving both seepage and storm water it is desirable to have a cunnette to carry small discharges.

6.5 CUNNETTE :

Cunnette is a small drain in the bed of a large one. It is usually provided in the centre of the bed of the drain which in turn is gently sloped towards it from both sides. This arrangement keeps most of the bed of drain free of water except during storms and reduces the problem of maintenance. The drainage which would otherwise have run at small depths and low velocities over the entire bed of the drain would lead to problems such as silting and weed growth. Thus with a cunnette it flows in a smaller section with higher velocities thereby obviating the adverse effects.

7.0 STRUCTURES ON DRAINS :

Generally the following structures are provided on the drains :

(i) Inlets (ii) Regulators (iii) Paved dips (iv) Cart-track crossings or Road Bridges.

7.1 INLETS :

In the openings on either side or in the spoil banks of the drains, inlets are provided to drain the water of the surrounding submerged areas into the drain. The position of the inlets are so fixed that the water from all the sides may be concentrated there and can be efficiently drained into the drain in a short period and without damaging the spoils.

7.2 REGULATORS :

For feeding the tanks along the alignment of drain, regulators with feeders are provided so that the tanks may be filled up when there is sufficient water in the drain, when it is not necessary to have further addition of water in the tank, the regulator can be closed.

7.3 PAVED DIPS :

While the drain crosses a cart track or a small village road, paved dips are provided so that normal transportation could be done even in the monsoon when the water level in the drain goes up.

7.4 C. T. CROSSINGS OR ROAD BRIDGES :

These are provided on established cart tracks or roads.

Design procedure for these structures are the same as in case of similar structures provided on canal systems.

8.0 LAND ACQUISITION :

(i) The land acquisition and cross drainage works may be provided for the ultimate capacity of the drain whereas the excavation of drains may be limited to about 2/3rd of this capacity in the first instance.

(ii) The width of the land to be acquired for a drain should be decided considering the bed width, side slopes, berms etc. and also the width required for maintenance and other purpose.

9.0 MAINTENANCE OF DRAINS :

The drains will be running with low discharges for most of the time in a year. With silt-free seepage water, there will be profuse weed growth. Silt ladden water cuts-off sunlight and prevents weed growth. Therefore, in case of drains, the main problem of maintenance is to keep it free of weeds. This work is usually done manually by maintenance gangs.

Implements have been evolved which could be dragged in the bed for carrying out partial clearance. They make the water muddy and help in retarding the weed growth. Attempts are also made to use weed poisons but its use is dangerous bearing in mind the possibility of its effect on the life of cattle, fish and even human beings who may use such waters in the drain.

10.0 BENEFIT COST RATIO :

The area to be protected from submergence, benefits due to preventing damages to crops, types of crops, their market value etc. should be calculated to decide the usefulness of the drains. Having worked out the cost of the drain and the corresponding benefit, the cost benefit ratio should be worked out.

A typical calculation for the cost benefit ratio is given in Appenflix No. III.

APPENDIX—I

Design calculations for drains in area having average annual rainfall less than 762 mm (30")

I—Data :

(i) Av. annual rain fall : Less than 762 mm,

(ii) Rain-fall intensity : 19 mm (3/4") per day.

(iii) Catchment area : 33.67 sq. kms.

II—Design Discharge :

$$Q=\frac{19\times 33.67\times 10^6}{10^3\times 24\times 3600}$$
$$= 7.36 \text{ cumecs}$$

III—Adopting Section of Drain :

(i) Width	(B)	=8.0 mt.
(ii) Depth	(d)	=1.35 mt.
(iii) Gradient	(S)	=1 in 2500
(iv) Co-efficient of rugosity	(N)	=0.030
(v) Side slopes	(n)	=½ : 1 (for design)
		=1 : 1 (In execution)

IV—Area of section :

$$A=(B+nd)\ d$$
$$=(8.0+\tfrac{1}{2}\times 1.35)\ 1.35$$
$$=11.70 \text{ sq. mt.}$$

V—Wetted Perimeter :

$$P=B+2d\sqrt{1+n^2}$$
$$=8.0+2\times 1.35\sqrt{1+(\tfrac{1}{2})^2}$$
$$=11.37 \text{ mts.}$$

VI—Hydraulic Mean Depth :

$$R=\frac{A}{P}=\frac{11.70}{11.37}=1.03$$

VII—Velocity as per Mannings formula :

$$V=\frac{1}{N}\times R^{2/3}\times S^{1/2}$$
$$=\frac{1}{0.030}\times (1.03)^{2/3}\times\left(\frac{1}{2500}\right)^{1/2}$$
$$=0.68 \text{ mt/Sec}$$

VIII—Discharge :

$$Q=A\times V$$
$$=11.70\times 0.68$$

=7.95 Cumecs as against required discharge of 7.36 Cumecs..................(i)

IX—Critical Velocity :

$$Vo=0.55\ (d)^{0.64}$$
$$=0.55\ (1.35)^{0.64}$$
$$=0.66 \text{ mt./Sec.}$$

X—Velocity Ratio :

$$\frac{V}{Vo}=\frac{0.68}{0.66}=1.03$$

Thus the velocity Ratio is between 1.0 and 1.4..................(ii)

As the two conditions as worked out at (i) and (ii) above are satisfied, assumed section may be adopted.

APPENDIX I–A

Design calculations for drains in area having average annual rainfall less than 762 mm (30")

I–DATA :

(i) Av. annual rain fall = less than 762 mm
(ii) Rain-fall intensity = 19 mm ($\frac{3}{4}$") per day
(iii) Catchment area = 33.67 sq. kms.

II–Design Discharge :

$$Q = \frac{19 \times 33.67 \times 10^6}{10^3 \times 24 \times 3600} = 7.36 \text{ cumecs}$$

Now, considering 2/3rd capacity of the section design discharge will be $2/3 \times 7.36 = 4.91$ cumecs

III–Adopting Section of Drain

(i) Width (B) = 6.0 mt.
(ii) Depth (D) = 1.35 mt.
(iii) Gradient (S) = 1 in 2500
(iv) Coefficient of rugosity (N) = 0.030
(v) Side slope(n) = $\frac{1}{2}$:1 (for design)
1:1 (for execution)

IV–Area of Section :

$$A = (B + nd)\ d$$
$$= \left(6.0 + \tfrac{1}{2} \times 1.35 \right) 1.35$$
$$= 9.00 \text{ sq.mt.}$$

V–Wetted Perimeter :

$$P = B + 2d\sqrt{1+n^2}$$
$$= 8.0 + 2 \times 1.35\sqrt{1+(\tfrac{1}{2})^2}$$
$$= 9.00 \text{ mt.}$$

VI–Hydraulic Mean Depth :

$$R = \frac{A}{P} = \frac{9.00}{9.00} = 1.00$$

VII–Actual velocity as per Manning's formula :

$$V = \frac{1}{N} \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}$$
$$= \frac{1}{0.030} \times 1.00^{2/3} \times \left(\frac{1}{2500} \right)^{\frac{1}{2}}$$
$$= 0.667$$

VIII–Actual Discharge :

$$Q = A \times V$$
$$= 9.00 \times 0.667$$
$$= 6.0 \text{ Cumecs}$$

As against required discharge of 4.91 cumecs..(i)

IX–Critical Velocity :

$$Vo = 0.55\ (d)^{0.64}$$
$$= 0.55\ (1.35)^{0.64}$$
$$= 0.66 \text{ Mt/Sec.}$$

X–Velocity Ratio :

$$\frac{V}{Vo} = \frac{0.667}{0.660}$$
$$= 1.01$$

Thus the velocity ratio is between : 1.0 & 1.4. . . . (ii)

As the two conditions as worked out@(i) & (ii) above are satisfied, assumed section may be adopted.

APPENDIX II

Design calculations for drain in area having average annual rain-fall more than 762mm.(30")

I–DATA :

(i) Average Annual Rain-fall = More than 762 mm.
(ii) Rain-fall intensity = 38 mm. ($1\frac{1}{2}$") per day.
(iii) Catchment area = 23.52 sq. km.

II–Design Discharge :–

$$Q = \frac{38 \times 23.52 \times 10^{6}}{10^{3} \times 24 \times 3600} = 10.36 \text{ cumccs.}$$

III–Adopting Section of Drain :

(i) Width (B) = 9.0 mt
(ii) Depth (D) = 1.5 mt
(iii) Gradient (S) = 1 in 2500
(iv) Co-efficient of Rugosity (N) = 0.030
(v) Side slope (n) = $\frac{1}{2}:1$ (for design)
= 1.1 (In execution)

VI–Área of Section :

$$A = (B+nd)\,d$$
$$= (9.0+\tfrac{1}{2}\times 1.5)\,1.5$$
$$= 14.625 \text{ sq. mts.}$$

V–Wetted Perimeter :

$$P = B+2d\sqrt{1+n^2}$$
$$= 9.0+2\times 1.5\sqrt{1+(\tfrac{1}{2})^2}$$
$$= 12.75 \text{ mt.}$$

VI–Hydraulic Mean Depth :

$$R = \frac{A}{P} = \frac{14.625}{12.75} = 1.147$$

VII–Actual velocity as per Manning's formula :

$$V = \frac{1}{N} \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}$$
$$= \frac{1}{0.030} \times (1.147)^{\frac{2}{3}} \times \left(\frac{1}{2500}\right)^{\frac{1}{2}}$$
$$= 0.730 \text{ Mt/Sec.}$$

VIII–Actual Discharge :

$$Q = A \times V = 14.625 \times 0.730$$
$$= 10.67 \text{ cumecs.}$$

As against required discharge of 10.36 cumecs.........(1)

IX–Critical Velocity :

$$Vo = 0.55\,(d)^{0.64}$$
$$= 0.55\,(1.5)^{0.64}$$
$$= 0.71 \text{ Mt/Sec.}$$

X–Velocity Ratio :

$$= \frac{V}{VO} = \frac{0.73}{0.71} = 1.02$$

Thus the velocity ratio is between 1.0 and 1.4 .. .. (ii)

As the two conditions as worked out @ (i) and (ii) above are satisfied, assumed section is safe and adequate.

APPENDIX No. II–A

Design calcculations for drain in area having average annual rain-fall more than 762 mm. (30").

I–DATA:

(i) Average Annual Rain Fall = more than 762 mm.
(ii) Rain fall intensity = 38 mm. ($1\frac{1}{2}''$) per day.
(iii) Catchment area = 23.52 sq. km.

II–Design Discharge:

$$Q = \frac{38 \times 23.52 \times 10^6}{10^3 \times 24 \times 3600} = 10.36 \text{ cumecs.}$$

Now considering 2/3rd capacity of the section, design discharge will be $2/3 \times 10.36 = 6.91$ cumecs.

III–Adopting Section of Drain:

(i) Width (B) = 7.0 mt.
(ii) Depth (d) = 1.5 „
(iii) Gradient (S) = 1 in 2500
(iv) Co-efficient of rugosity (N) = 0.030
(v) Side slope (n) = $1:\frac{1}{2}$ (for design)
= 1:1 (in execution).

IV–Area of Section:

$$\begin{aligned} A &= (B + nd)\, d \\ &= (7.0 + \tfrac{1}{2} \times 1.50)\, 1.50 \\ &= 11.625 \text{ sq. mt.} \end{aligned}$$

V–Wetted Perimeter:

$$\begin{aligned} P &= B + 2d\sqrt{1+n^2} \\ &= 7.0 + 2 \times 1.50\sqrt{1 + (\tfrac{1}{2})^2} \\ &= 10.354 \text{ mt.} \end{aligned}$$

VI–Hydraulic Mean Depth:

$$R = \frac{A}{P} = \frac{11.626}{10.354} = 1.12$$

VIII–Actual Velocity as per Manning's formula:

$$V = \frac{1}{N} \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}$$

$$= \frac{1}{0.030} \times (1.12)^{\frac{2}{3}} \times \left(\frac{1}{2500}\right)^{\frac{1}{2}}$$

$$V = 0.719 \text{ Mt./Sec,}$$

VIII–Actual discharge:

$$\begin{aligned} Q &= A \times V \\ &= 11.625 \times 0.719 \\ &= 8.26 \text{ cumecs.} \end{aligned}$$

As against required discharge of 6.91 cumecs................(i)

IX–Crtical velocity:

$$Vo = 0.55\ (d)^{0.64}$$

$$= 0.55\ (1.50)^{0.64}$$

$$= 0.71 \text{ mt./sec.}$$

X–Velocity Ratio:

$$\frac{V}{V0} = \frac{0.719}{0.710} = 1.02$$

Thus the velocity ratio is between:
1.0 and 1.4 ....(ii)

As the two conditions as worked out @ (i) & (ii) above are satisfied, assumed section is safe and adequate.

APPENDIX No. III

Benefit Cost Ratio

Name of Projcct :–

Benefits 'A'

Area Benefitted 2063.97 Hectares.

Likely crops which are at present affected due to non–construction of above project are as under.

Wheat : (a_1) 1031.985 hec. of the area with production of

(b_1) 2.3057 quintal per hec.

Cotton : (a_2) 1031.985 hec. of the area with production of

(b_2) 2.30/57 quintal per hec.

∴ Wheat :– $1031.985 \times 2.3057 = 2380$ quintals

Cotton :– $1031.985 \times 2.3057 = 2380$ quintals

cost of the above crops per quintal.

Rs. (c_1) 66.98 / quint. for wheat } as per present
Rs. (c_2) 80.31 / quint. for cotton } market rates.

Total benefit $= a_1 \times b_1 \times c_1 + a_2 \times b_2 \times c_2$

$= (1031.985 \times 2.3057 \times 66.98) + (1031.985 \times 2.3057 \times 80.31)$

$= 1{,}59{,}375 + 1{,}91{,}250$

Rs. $= 3{,}50{,}625$.

Cost 'B'

Total cost of the project	Rs. 3,02,210
1. Interest at 4½%	Rs. 15,778
2. Depreciation at 1%	Rs. 3,022
3. M and R at 1.5%	Rs. 4.533
4. Cost of labour and materials required to derive benefit (stated in (A) 50 % of A)	Rs. 1,75,313
	Rs. 1,98,646
∴ Total cost in	Rs. 1,98,646

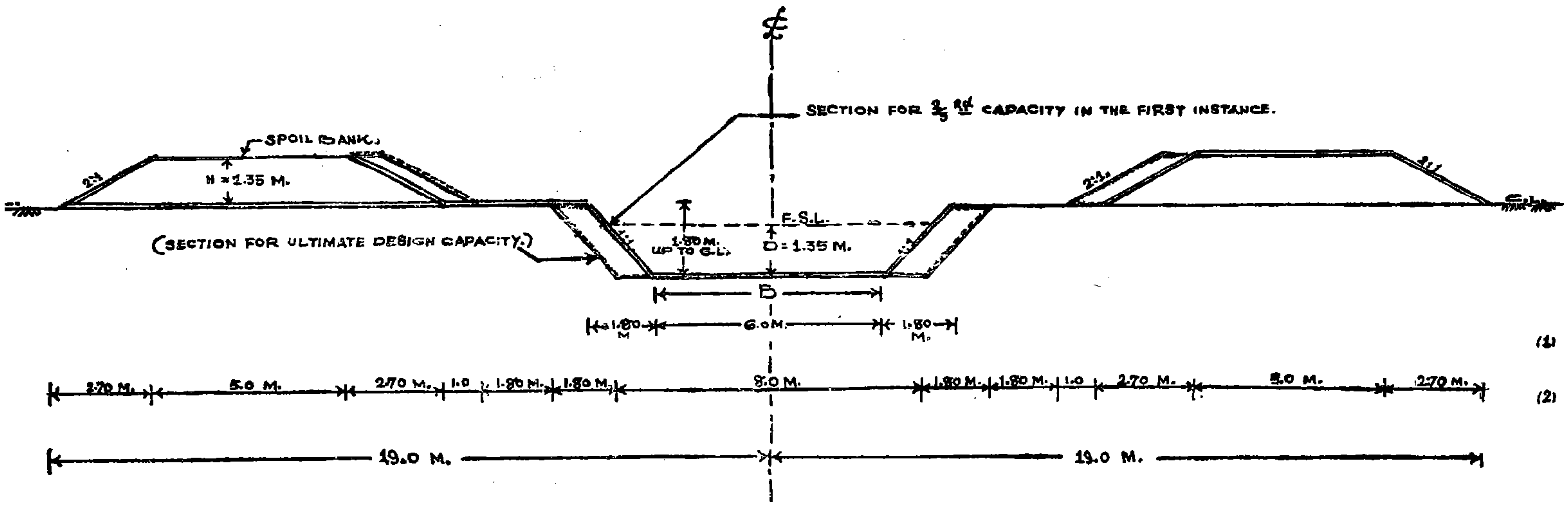
∴ Cost Benefit Ratio $= \frac{B}{A} = \frac{1{,}98.646}{3{,}50{,}625}$

$= 0.566$

∴ Benefit cost Ratio $= \frac{B}{A} = \frac{3{,}50{,}625}{1{,}98{,}646}$

$= 1.765$

PLATE No. I

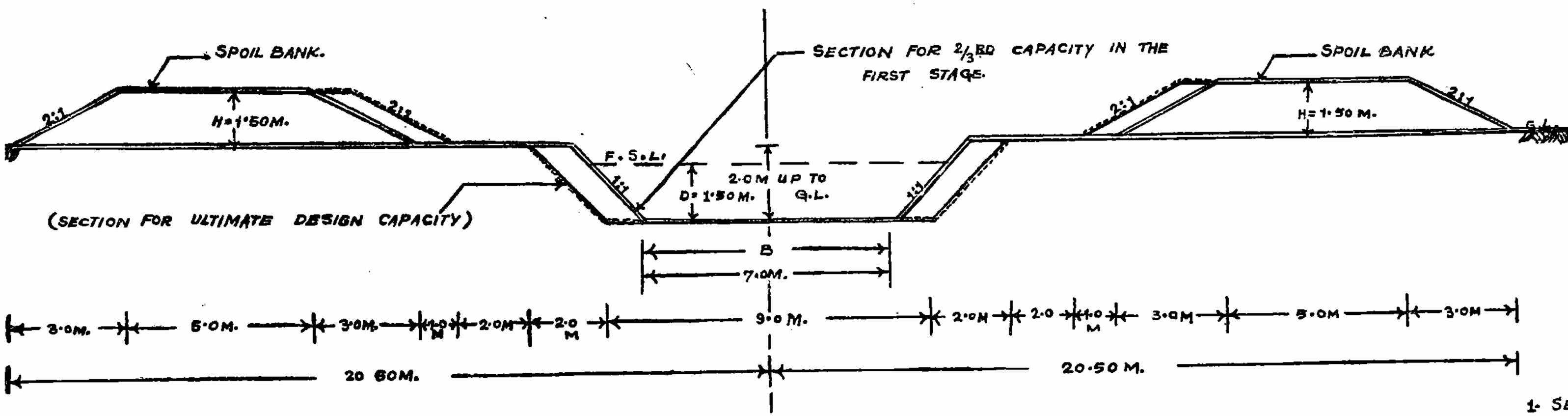


TYPICAL CROSS SECTION FOR
SURFACE DRAIN.
SCALE:- 1 cm = 1 MT.

REFERENCE:-

		SHOWN THUS
(1)	SECTION FOR ⅔ rd OF ULTIMATE CAPACITY (B = 6.0 M & D = 1.35 M)	——
(2)	SECTION FOR 13 mm RUN OFF PER DAY i.e. FOR ULTIMATE DESIGN CAPACITY (B = 8.0 M & D = 1.35 M)	-----

PLATE No. II



TYPICAL CROSS SECTION FOR-

SURFACE DRAIN

SCALE:-1CM=1MT.

REFERENCE:-

1. SECTION FOR 2/3RD OF ULTIMATE CAPACITY. (B=7.0M AND D=1·50 M.) SHOWN THUS - - - - - - - - - - - - - - - - ▬
2. SECTION FOR 38 M.M. RUN OFF PER DAY i.e FOR ULTIMATE DESIGN CAPACITY SHOWN THUS - - - - - - - - - - - - - - - - - ····· (B=8·0M AND D=1·50 M)