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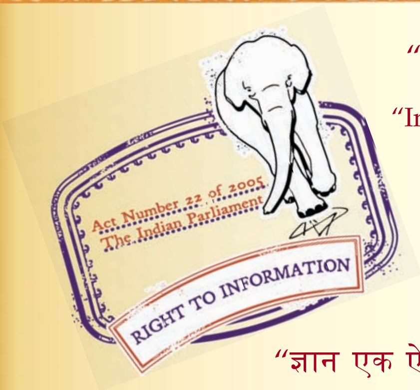

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GUIDELINES FOR PLANNING AND DESIGN OF SURFACE DRAINS

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GUIDELINES FOR PLANNING AND DESIGN OF SURFACE DRAINS

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Indian Standard

GUIDELINES FOR PLANNING AND DESIGN OF SURFACE DRAINS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 21 June 1978, after the draft finalized by the Canals and Canal Linings Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Drains are constructed with the object of relieving excess water from agricultural and other areas and disposing of surplus water not required for normal agricultural operations. The proper disposal of surplus rain water is also essential to avoid its percolation down to the water table which may otherwise lead to rise in the water table thereby aggravating or creating the problem of waterlogging.

0.3 The drains may be natural or artificial. As per accepted principles, these are generally aligned along the valley lines between ridges. However, in some cases in order to reduce the length of the drain or to have proper outfall conditions, the drains are taken across the valleys. These are known as *forced or diversion reaches.*

0.4 At present the practices adopted in various States for planning and design of the drains vary considerably. Most of these practices are based on *ad hoc* decisions and in some cases on the recommendations of technical committees appointed to examine problems in specific areas/States from time to time. This standard is intended to lay down general guidelines on rational basis for planning and design of drains on a uniform basis throughout the country.

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1. SCOPE

1.1 This standard lays down broad guidelines and principles for the planning and design of surface drains for uniform application throughout the country.

1.2 This standard is applicable only for surface drains in agricultural/rural areas. This does not apply to the planning and design of drains in urban areas, for which the practices are entirely different.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Catchment or Catchment Area — The area from which a lake, stream or waterway, and reservoir receives surface flow which originates as precipitation.

2.2 Discharge — The volume of water flowing through a cross section of a channel in a unit time. It is also called rate of flow.

2.3 Drainage — The process of removing excess surface waters by artificial or natural means.

2.4 Drain — A channel either artificial or natural for carrying surplus surface water. It may also carry seepage water.

2.5 Capacity — The design discharge at full supply level of the drain.

2.6 Outfall — The point at which a drain discharges into another drain, nallah or river, etc.

2.7 Sub-soil Water Level — The level at which the sub-soil or ground water exists at a given time of the year.

2.8 Cross Drainage Works — Any structures constructed across or along the drain like railway and road bridges, irrigation channels, sluices, regulators, falls, etc.

2.9 Tidal Lockage — The period for which the discharge from the drain is locked on account of the tide levels being higher than the fully supply levels in the drain.

2.10 Dominant Flood Discharge — The discharge in the river corresponding to the dominant flood level.

2.11 Dominant Flood Level — That stage of the river/outfall, channel which is (a) attained and not exceeded for more than 3 days at a time; and also (b) attained and not exceeded 75 percent of the time over a period of preferably not less than 10 years (*see* Appendix A for illustration).

3. CLASSIFICATION OF DRAINS

3.1 The drains are broadly classified into the following categories according to the purpose for which these are constructed:

a) *Outfall Drains* — These are the main drains outfalling into a nallah or a river from a particular catchment.

b) *Link Drains* — These are branch drains draining sub-catchment into the outfall drain. These are aligned along subsidiary valley lines.

c) *Field Drains* — These are small drains draining individual or a group of fields into the link drains.

d) *Ditch Drains* — These are constructed to drain the water by connecting borrow pits along roads, railway lines, etc.

e) *Cunnette* — This is a small drain constructed in the bed of main drain at a level lower than the normal bed levels of the main drain for carrying non-monsoon/seepage discharge without allowing it to spread across the entire section of the main drain.

f) *Seepage Drains* — These are constructed along the canals to collect the seepage water from the canal embankments and to drain it either directly into a natural outfall or into a carrier drain.

4. ALIGNMENT OF DRAINS

4.1 The drains should generally follow the drainage line, that is the lowest valley line. As far as possible the alignment of the main or outfall drain should be in the centre of the area to be drained. If the alignment crosses any depressions, ponds or marshes, the drain should not pass through these, as apart from the difficulties in excavation, it affects the hydraulic performance of the drain. In such cases, it is preferable to take the drain away from the depression or pond, and suitably connect it to the drain if it is required to drain the pond or depression.

4.2 In selecting alignments, care should be taken to see that as far as possible these do not pass through village habitation. In the forced reaches, care should be taken to see that the embankments of the drains are not of an excessive height in order to minimize the danger of flooding in the event of breaches in the embankments.

4.3 As far as possible, the alignment of the drain should be such that the full supply level is below the natural surface level.

5. CAPACITY/DESIGN DISCHARGE OF DRAINS

5.1 Normally the cut sections of the drains are provided to accommodate the design discharge where drains follow natural valley lines. In such cases, no embankments should be provided along the drain so as to allow free flow of water from the surrounding areas. Wherever embankments are necessary for accommodating a portion of the design discharge or where disposal of excavated soil will be very costly, large gaps should be provided in the embankments on either side so as to allow unrestricted inflows, and in case of incidence of discharges higher than the channel capacity, the water should spill over the area and return to the channel freely when the discharge in it recedes. In the forced or diversion reaches, embankments on both sides are, however, provided as the design discharge cannot be accommodated within the cut section of the drain. However, even in such cases attempts should be made by selecting a proper alignment to keep the height of the embankments to the minimum. In such cases, inlets of adequate size should be provided in the embankments to admit the water from surrounding areas.

5.2 Intensity of Rainfall — Analysis of the storm rainfall throughout the country indicates that generally the duration of the storm is about 3 days. Therefore, for design of the drains, a storm rainfall of 3 day duration should be taken.

5.3 Design Frequency of Rainfall — In fixing the design capacity of the drain the following factors have to be taken into account:

a) *Economics* — Drains of a bigger size or catering for a rainfall of infrequent occurrence prove to be costly compared to the benefits. Drains are never designed to cater for the worst conditions. In other words, in any drainage project, occurrence of damage at periodical intervals is to be accepted.

b) *Performance* — The experience indicates that drains of a bigger size tend to deteriorate fast, as these are not required to carry the design discharge frequently. Consequently in carrying smaller discharge, drains tend to get silted soon. On the other hand, drains of a smaller size remain in a better condition and can occasionally carry higher discharges with marginal scour of bed and sides and encroachment on free board.

c) *Land Requirement* — On account of small land holdings, bigger drains involve larger land acquisition resulting in a permanent loss of the cultivated land.

d) *Design Frequency* — Generally the drains should be designed for three day rainfall of 5 year frequency. Studies carried out indicate that 5 year frequency gives optimum benefit cost ratio. However, in specific cases requiring a higher degree of protection, the frequency of 10 or 15 year can also be adopted. Adoption of such higher frequencies will need to be justified in terms of the economics.

5.4 Period of Disposal — The period of disposal of the excess rainfall is entirely dependent on the tolerance of individual crops. Crops like paddy can generally stand submersion for a period of 7 to 10 days without suffering any significant damage. Therefore, in paddy growing areas, the drainage should aim at disposing of the rain water in a period varying from 7 to 10 days. Based on experience the following periods of disposals are recommended:

a) Paddy	7 to 10 days
b) Maize, bajra and other similar crops	3 days
c) Sugarcane and bananas	7 days
d) Cotton	3 days
e) Vegetables	1 day (in the case of vegetables, 24 hour rainfall will have to be drained in 24 hours)

5.5 Run-Off — Run-off coefficient depends on the type of soil, crops, general topographical conditions like land slopes, etc. In plain areas, the run-off percentage is generally of the order of 15 to 20. In semi-hilly areas the percentage may be higher. Until precise data becomes available, the following run-off coefficients for different soils are recommended for plain areas:

a) Loam, lightly cultivated or covered	0·40
b) Loam, largely cultivated and suburbs with gardens, lawns, macademized roads	0·30
c) Sandy soils, light growth	0·20
d) Parks, lawns, meadows, gardens, cultivated area	0·05 — 0·20
e) Plateaus lightly covered	0·70
f) Clayey soils stiff and bare and clayey soils lightly covered	0·55

5.6 Run-Off for Composite Crops — In large areas, there are often different types of crops grown. In such cases, the field and link drains can be designed on the basis of the crops grown in a particular area. For the outfall drain, either a composite discharge can be worked out or the total discharge can be worked out by taking into account the discharges from individual link drains. As the area grows larger, the chances of synchronization of discharge from the entire area become less. As such, working out a composite discharge may also serve the purpose. However, individual cases will have to be studied on their own merit.

6. DESIGN DISCHARGE FOR CROSS DRAINAGE WORKS

6.1 Cross drainage works are always designed for a higher discharge than the cut sections of the drains. This is mainly on account of the fact that the damage caused to the structures in the event of flows resulting from rainfall higher than the designed rainfall, can be much more than to the drain. Besides, any remodelling of the structures at a later date for higher discharges will not only be costly but time consuming, apart from involving dislocations to facilities like roads, railways, irrigation canals, etc. The drains can, however, be remodelled without much dislocation. The present practices vary considerably.

All the cross drainage structures should, therefore, be designed for a 3 day rainfall of 50 year frequency, time of disposal remaining the same depending on the type of crop.

In fixing the waterways, care should be taken to see that afflux is within the permissible limits.

7. DESIGN OF DRAIN SECTIONS

7.1 Velocity — The drain section shall be adequate to carry the designed discharge and the velocity shall be non-silting, non-scouring to be determined by Manning's formula. The coefficient of rugosity '*n*' shall have a value of 0·025 for earthen sections. Where the lined section has to be provided due to local conditions, the value of '*n*' may be obtained from IS : 4745-1968*.

7.2 Discharge of the Drain — In order to obtain the discharge of a drain it is necessary to know the mean velocity of flow as obtained above which when multiplied by the area of the cross section of the drain in square metres will give the discharge in m^3/s.

7.3 Side Slopes — In selecting the side slopes for the drain, it will be necessary to consider the kind of material through which the drain is to be excavated. Generally side slopes of $1\frac{1}{2}$ horizontal to 1 vertical are provided.

7.4 Cross Section of the Drain — Although deeper sections of the drain may be desirable, the width to depth ratio should be so selected that the section is both hydraulically efficient as well as economical in excavation. In the case of drains with embankments, the berm width equal to the depth of the drain, subject to a minimum of 1 m should be provided between the toe of the embankment and the section of the drain. The top of the embankments should be 1 m higher than the design full supply level.

*Code of practice for design of cross section of lined canals.

Wherever, there is likelihood of backing up effect on account of floods in a river into which the drain outfalls, the top of the embankments should be so designed that the flood levels on account of back water conditions are accommodated within the section over which the minimum freeboard, is to be provided.

7.5 Fixation of FSL at Outfall — Whenever the drain is outfalling into a river, the FSL should be slightly higher than the dominant flood level. In cases where the topography permits, the FSL can be above the highest flood level. However, if such a level results in flatter slopes or in FSL becoming higher than the natural ground level, FSL at outfall should be kept slightly above the dominant flood level. In such cases, there will be backing up in the drain when the river rises above the dominant flood level. Such occurrences being infrequent and of short duration can be tolerated. Care shall, however, be taken in determining the dominant flood discharge and the level.

7.6 Hydraulic Slope — The FSL of the drain as far as possible should be at or below the ground level. Where it cannot be ensured, the FSL should in no case be more than 0·3 m above the average ground level at the starting point of the drain. The hydraulic slope should then be determined adopting this stipulation and the criteria laid down for fixation of FSL at outfall. The hydraulic slope should normally be such as to provide permissible velocities as indicated in **7.1** above.

7.7 Tidal Lockage — In the case of drains outfalling into rivers subjected to tidal influence, the reaches of the drains which will be subjected to tidal lockage should be determined. In these reaches capacity of the drains should be increased to provide for duration of the tidal lockage gradually diminishing from the outfall towards the upstream. For this purpose, it will be necessary to plot the dominant tidal curves. The FSL of the drains in such cases should normally be fixed at mean tide levels. This will also be known as cut off level. This will be the level at which the drain will cease to discharge on account of rising tide. The release level will be the level at which the drain will again start discharging during the ebb tide. This level will always be higher than the cut-off level.

In major outfall drains, an outfall regulator should invariably be constructed to prevent tides entering the channel, which will result in silting of the drains.

7.8 Falls — Normally no falls are to be provided in drains except in rare cases where there is a sudden appreciable drop in the natural surface level or where the FSL is likely to be more than natural surface level without provision of falls.

8. LONGITUDINAL SECTION

8.1 Collection of Data — The following data should be collected while carrying out surveys along different alternative alignments of drains:

a) Cross sections at every 150 metres to the full land width.

b) Natural ground, design bed and full supply levels at every 150 metres.

c) Locations of inlets of link/field drains with related hydraulic data.

d) Full data of all crossings like roads, railways, irrigation canals, etc.

e) Representative soil samples to determine the probable stable side slopes.

f) Ground water levels at a distance of about 2 kilometres.

g) Boundaries and slopes of the areas needing drainage.

h) Existing drains.

j) Location and elevation of all depressions, drains, mounds and ridges.

k) Location and elevation of possible inlets (outfalls).

m) Area that will drain into each part of the system.

n) Flood data of outfall river and study of backwater effect of flood.

8.2 Preparation of Longitudinal Section

8.2.1 Fix outfall level considering the dominant flood levels in the river/drain and the likely backing up.

8.2.2 Hydraulic slope to be determined on the basis of the ground levels, permissible submersion and the outfall levels determined in **8.2.1**.

8.2.3 Plot the natural ground levels, design bed levels, full supply levels and the backwater profiles, if any.

8.2.4 Divide the drain in convenient reaches between inlet sites or the junction of tributary/link drains. The capacity of the drains in each of these reaches should be uniform. The capacity will change with the addition of discharge from tributary/link drains.

APPENDIX A

(*Clause* 2.11)

METHODOLOGY FOR DETERMINING THE DOMINANT FLOOD LEVEL

The record of gauge hydrographs of a river as available from 1962 to 1971.

To determine levels which were attained and not exceeded for more than 3 days at a time. The result of examination of the plotted hydrographs is as under:

Year	*Levels Attained and Not Exceeded for More Than 3 Days at a Time*						
1962	138·30;	137·20;	138·00;	135·75;	125·00		
1963	137·85;	136·85;	135·00;	132·00;	129·60		
1964	138·10;	136·50;	133·75;	132·47;	124·45		
1965	137·30;	132·10;	123·60;	121·00;			
1966	136·45;	135·30;	128·75;				
1967	135·60;	133·10;	133·00;	130·45;	128·62;	120·15	
1968	137·00;	135·62;	135·45;	132·45;	130·46;	128·60;	132·60
1969	137·60;	136·60					
1970	139·30;	138·31;	138·60;	133·30;	122·75		
1971	142·45;	142·30;	139·28;	128·55;	129·00;	114·00	

To determine the level which is attained and not exceeded for 75 percent of the time, arrange the above levels in ascending order:

Event	*Level*	*Event*	*Level*
1	114·00	10	128·62
2	120·15	11	128·75
3	121·00	12	129·00
4	122·75	13	129·60
5	123·60	14	130·45
6	124·45	15	130·46
7	125·00	16	132·00
8	128·55	17	132·10
9	128·60	18	132·45

Event	*Level*	*Event*	*Level*
19	132·47	34	136·85
20	132·60	35	137·00
21	133·00	36	137·20
22	133·10	37	137·30
23	133·30	38	137·60
24	133·75	39	137·85
25	135·00	40	138·00
26	135·30	41	138·10
27	135·45	42	138·30
28	135·60	43	138·31
29	135·62	44	138·60
30	135·75	45	139·28
31	136·45	46	139·30
32	136·50	47	142·30
33	136·60	48	142·45

There are 48 occurrences; the level that is attained and not exceeded 75 percent of the time is at order No. $\frac{48 \times 75}{100} = 36$ namely 137·20.

Thus the dominant flood level in the river is *RL 137·20.*

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s²
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m²
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m²

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