GOVERNMENT OF MAHARASHTRA
WATER RESOURCES DEPARTMENT
Government Circular No. MIS-2015/(CR. No.253/15)/MP
Annex Mantralaya, 2nd floor,
Mantralaya, Mumbai-400 032
Dated 01/09/ 2015

Ref. Govt. Circular No. MIS 1094 / (156/94) MP (A), Dated: 10.02.1995

1. BACKGROUND

Presently the Design of open canals and distribution net work is done in accordance with the Government circular under reference. The review of these guidelines were under consideration. Accordingly Govt. had constituted the study group to review these guidelines by taking into account the provisions in concerned Indian Standards (IS), canal design practices in other states, CBIP recommendations, provisions in CPWD manual and experience gained in our state since 1995. The study group has submitted its recommendations recently. In view of the recommendations of the study group, the present canal design guidelines issued under reference is reviewed and revised guidelines are issued as below. The main objective of the revised guidelines is :

(a) Reduce the construction cost of canals & distribution net work thereby ultimately reducing the overall cost of Irrigation Projects.

(b) Design and construct the maintenance free canals. i.e. to design the canals such that it should have non silting non scouring velocities, which will lead minimum maintenance cost and it will reduce the rotation period, due to higher velocities provided.

(c) Minimize the canal widths to reduce the land acquisition.

(d) Design the canal so as to implement and facilitate the provision of water entitlement and equitable volumetric distribution to all the WUAs in MMISF Act 2005 & MWRRA Act 2005.

(e) Minimize the discretion in selecting the canal design parameters and to have uniform practice of canal design on all the projects irrespective of the designer.

(f) Design the efficient canals so as to assure water supply with design discharges in all distributaries.

To achieve the objectives mentioned above, some new dimensions (parameters) are added in present guidelines e.g. finalisation of design discharge of the canals, Canal efficiencies, Rotation period, Capacity factors, Step by step method of design of

canals, Design of tunnels, Operation schedule of canals, Canal alignment, Cut of statement etc.

Similarly some provisions in old circulars are deleted considering their utility viz. Dowels (Daula), Barrow Pits, Shrinkage Allowance and Profile walls Other provision are modified considering the provisions in IS, CBIP recommendations and practices in other states in India, having similarity of field conditions in our state.

The revised guidelines for designing the canals are recommended as below :

2. DISCHARGE CARRYING CAPACITY OF CANAL

The discharge carrying capacity of the canal plays an important role in its performance during the irrigation water management, as the planned operation of canal and distribution system depends on the carrying capacity of channels. Government, from time to time, has issued Circulars / letters / directives for working out the capacity of canal and distribution system. The oldest Circular in this respect is Circular No. MIP 2262/26101-IP (1), dated 16 th August 1962. This Circular giving conventional practice of adopting Al/DC (Area Irrigated per Day Cusec) forms the basis for capacity design of canal and distribution system of Major, Medium and Minor Irrigation Projects. Subsequently considering the advancements in irrigation technology, new and more scientific concepts and practices are being adopted for capacity design. The discharge carrying capacity of canal shall be decided such that it should achieve following goals.

(i) It should be sufficient to deliver the irrigation water to planned command area (Irrigation potential) and designed cropping pattern of project in expected rotation period i. e. fortnightly.

(ii) It should aim to deliver the water entitlement to all WUAs in entire command area of project. As per provision in MMISF ACT 2005 and MWRRA 2005 ACT the irrigation water is to be supplied only to WUAs and not to the individual farmer. In view of this the designer shall bear in mind while designing the canal that the WUAs will be formed on 100% command area of projects and the water has to be supplied to them on volumetric basis, as per their due water entitlement.

In view of ultimate aim of canal and distribution system, the carrying capacity of canal shall be decided very carefully.

2.1 The guiding principle for deciding carrying capacity of canal :

The carrying capacity of the canal and its distributary shall be maximum of

(a) The carrying capacity calculated on the basis of the fortnightly crop water requirement as per the design cropping pattern and planned ICA of the project as per Administratively Approved project report.

OR

(b) The carrying capacity calculated on basis of due water entitlement of the CCA of the canal or distributary as per the provisions in the MMISF Act 2005 and MWRRA Act 2005.

OR

(c) The carrying capacity calculated on basis of the operation schedule of the canal or distributary.

The procedure to work out carrying capacity of canal for above alternatives is as given below.

2.1.1 Carrying capacity of canal on the basis of crop water requirement:

The fortnightly crop water requirement of the planned ICA of the canal shall be calculated by Modified Penman Method. For this, the cropping pattern approved in the Administratively Approval project report shall be considered. The ICA of the canal shall be decided after completion of detailed command area survey of project. Once the design cropping pattern and ICA of the canal is finalized the fortnightly crop water requirements / Net Irrigation requirement (NIR) is worked out by Modified Penman Method. The gross Irrigation requirement (GIR) of canal shall be calculated by adding the canal conveyance losses up to crop root zone. The canal efficiencies to be considered while deciding conveyance losses are as given in Table-1.

TABLE-1

Canal efficiency

Type	Lined	Unlined
Main / Branch canal	0.95	0.85
Distributory	0.90	0.85
Minor/ Sub Minor	0.90	0.85
Field Channel	0.90*	0.90*
Field Application efficiency	0.75	0.75
Overall efficiency (i.e. root zone to canal Head)	0.52	0.41

(* both lined only selectively)

2.1.1.1 Design Rotation Period of canal:

The rotation period (i.e. the interval at which canal water is to be supplied to crops) depends on soil type, crop pattern & climate. It would be better to use soil-crop-climate database to decide rotation period agro climatic zone wise. However, it is very difficult to workout actual crop water requirement in field at the canal design stage, as the actual cropping pattern used by farmers is not known. Hence till the final scientific approach is made available, rotation period including on and off

schedule as mentioned below (Table 2) may be adopted for the design purpose. The canal officer shall decide the rotation period on basis of the actual crops in command in each season during irrigation management in future.

TABLE-2

Rotation Period (Days)

Category of Project	Type Of Channel	Kharif and Rabi			H.W.			Remarks
		On	Off	Total	On	Off	Total	
Major	Main / Branch Canal	12	2	14	12	2	14	During Rabi peak when there is overlap of Kharif and Rabi crops the flow period may be lengthened to 14 days for all categories of Projects
	Distributor / Minor / Sub Minor	7	7	14	12	2	14	
	Field channel	6	8	14	12	2	14	
Medium & Minor	Main Canal / Branch Canal / Distributor /Minor / Sub Minor	12	2	14	12	2	14	
	Field channel	6	8	14	12	2	14	

2.1.1.2 Capacity Factor:

It is experienced that after construction of the canal, the various unanticipated water demands as mentioned below arises due to various reasons which affects the carrying capacity of canal assumed at the time of design of canal.

(i) The drinking and industrial water requirement demands.

(ii) The letting out of water in rivers, nala during scarcity period.

(ii) The demands for lift irrigation schemes on uncommand side of the Canals.

(iv) The increased water demand due to the rich cropping pattern (Water intensive) adopted by farmers in comparison with the cropping pattern provided in Administrative Approved Project Report.

(v) The demand for letting the water in storage tanks in command area and recharging of the command area during monsoon period.

(vi) Increase in ICA of project with aging (ICA of project becomes equal to CCA due to conjunctive water use)

The above are the unanticipated water demands which could not be avoided. However it becomes very difficult to full fill the above demands simultaneously with

regular irrigation water demands. Ultimately the rotation period of canal gets prolonged which badly affects the irrigation management and resulting in reduction in yield of the crops

In order to take care of the unanticipated demands in future, some provision is to be made in the carrying capacity of canal by adding capacity factor. For the design purpose, following capacity factors shall be considered while deciding carrying capacity of canal.

Main and Branch Canals	1.10
Distributary	1.15
Minor and Sub Minor	1.20

2.1.2 Design discharge of canal on the basis of due water entitlement as per provisions in MMISF Act, 2005 and MWRRA Act, 2005:

As per provisions in MMISF Act, 2005 and MWRRA Act, 2005, the irrigation water is to be supplied to the WUAs only and not to the individual farmers, on volumetric basis as per their due water entitlement. Hence it is essential to decide the master plan of WUA & their water entitlement at design stage. The canal carrying capacity shall be decided such that due water entitlement will be supplied to all the WUAs in command area of all canals of project.

To calculate the canal carrying capacity on basis of water entitlement, following guidelines shall be followed.

(i) The master plan of all the probable WUAs in command area of project is to be prepared, once command area survey and tentative alignment of all the canals is finalized.

(ii) The locations where water is to be supplied to the WUA is to be identified.(entry point in jurisdiction of WUA)

(iii) The water entitlement of the individual WUA and all the WUA on individual canal shall be worked out. The water entitlement of WUA and entire canal shall be decided on basis of the CCA of WUA and CCA of canal. The detailed provisions for calculation of water entitlement are given in the MWRRA Act, 2005. The total due water entitlement thus worked out shall be considered as gross water requirement (GIR) of canal. By deducting canal loses (canal efficiencies) the net water requirement (NIR) is calculated. The season wise and fortnightly gross water entitlement and net water entitlement for canal shall be worked out. On the basis of fortnightly water requirement, the canal design carrying capacity shall be decided.

Canal efficiencies& design rotation period of canal to be considered shall be as given in Table-1 & Table-2 above.

2.1.3 Design discharge of canal on basis of the operation schedule:

The ultimate aim of canal conveyance system is to provide the irrigation water to the planned ICA of the project. In flow irrigation system the rotational water system is followed and water is supplied by rotations of 14days. To supply the water in 14 days for entire planned ICA in command, it is very essential to prepare the operation schedule of all the minor, distributary, and branch canal off taking from main canal at design stage. Operation schedule of individual minor, distributary, branch canal is prepared first and then on basis of the operation schedule of all off taking canals, the operation schedule of main canal is to be prepared. The operation schedule of every individual off taking canal shall be planned such that the rotation period shall be limited to 14 days. Accordingly the design carrying capacity is provided to each minor, distributary and branch canal. The operation schedule of all off taking canal shall be tabulated in a statement, where off off-take and their rotation period shall be written from tail to head.

The off-take opening & its rotation period shall be planned & grouped judiciously, so that overall rotation period of main canal is restricted to the design rotation period of canal. Various trials shall be done to finalize the operation schedule of main canal so as to complete the overall irrigation rotation in 14 days. On basis of above guidelines, the carrying capacity of canal shall be worked out.

Canal efficiencies& design rotation period of canal to be considered shall be as given in Table-1 & Table-2 above.

2.1.4 Responsibilities and accountability of preparation of the operation schedule:

It is experienced in many cases that operation schedule of canal is not being prepared by field officers at canal design stage. Because of this, the canals are being designed either for over capacity or under capacity which affects its performance. Henceforth the operation schedule of canal should be prepared and approved by competent authority approving canal alignment by separate office order. It shall be considered individual accountability of the competent authority responsible for sanctioning canal alignment. Also it is the responsibility of technical sanctioning authority to verify correctness of operation schedule while according the technical sanction to the estimate of the canal.

2.2 Preliminary Carrying capacity of Distributory / Minor:

Detailed layout planning of canal and distribution system should be done after completion of detailed command survey. It is to be presumed that water will be supplied to the entire command area by rotational water supply method (RWS). The procedure for deciding carrying capacity of Distributaries / Minor is given below.

(i) It shall be presumed that Each outlet (Chak) to run at a constant and uniform discharge of 30 lit/sec (1 Cusec) The maximum Chak size shall be decided so

as to complete the irrigation of distributor / minor in a flow period of 6 days in a rotation of 14 days.

(ii) Prepare detailed Chak layout of Distributory / minor based on the criteria given in manual of design for On Farm Development Works, W.R. Govt. of Maharashtra And WALMI publication No. 12.

(iii) Estimate maximum running days of each outlet for peak water requirement by using appropriate efficiency from root zone to outlet head and discharging capacity of outlet as 30 lit/sec.

(iv) Prepare operation schedule of Distributory / minor sub minor by suitable and judicious pairing of outlets for a given flow period of distributary / minor to optimize the carrying capacity.

(v) Determine carrying capacity of minor / distributary in different reaches considering appropriate conveyance efficiency and capacity factor as given in Table-1 & Table-2 respectively.

2.2.1 Procedure for deciding the preliminary carrying capacity of main / branch canal :

(i) Prepare a statement of fortnightly net irrigation requirement (NIR) at root zone in mm and cum as per methods given in Para 2.1 for approved crop pattern for unit irrigation command area (ICA) Say

100 ha or 1000 ha.

(ii) Select the fortnight having maximum irrigation requirement i.e. peak water requirement and use this peak water requirement for designing the system.

(iii) Convert the peak water requirement of root zone to the requirement at canal/branch head using appropriate efficiencies.

(iv) Workout the total volume of water required at canal head for complete ICA of the system.

(v) Workout canal capacity for delivering the peak volume in a given flow period of the rotation. (Use 14 days as a flow period for the peak rotation)

(vi) Increase the capacity by using capacity factor.

In similar manner, workout the capacity of canal in different reaches considering respective I.C.A.

2.2.2 Final carrying capacity of main / Branch Canal:

The final carrying capacity of the canal shall be decided as per criteria given in Para 2.1 of this circular. Once the preliminary carrying capacity of distributaries/ minors off taking from main/ branch canal is calculated, the preliminary design of main/branch canal shall be rechecked and carrying capacity required during peak rotation shall be confirmed.Generally the carrying capacity of canal worked out by operational schedule method is more than, carrying capacity worked out on basis offortnightly

crop water requirement. However the final capacity of main / branch canal shall be decided only after the finalizing design discharge by the three prescribed criteria mentioned in Para 2.1. The flow period of Main/branch canal shall be taken as 14 days for peak rotation. Where the policy of "7 days off" is adopted for running of distributaries / minors.That means about half the distributaries / minors would flow for the first 7 days and the balance for the next 7 days. Exact splitting of off takes in two equal halves would hardly ever be possible. However the variation may be restricted to minimum by judicious and careful matching of off takes. This type of splitting is not necessary for distributaries / minors having flow period equal to that of main / branch canal.

2.2.3 Reach wise required carrying capacity of main canal and branches:

Theoretically the discharge requirement of main canal, branches and major Distributory gets reduced in proportionate with the reduction in the command area from head to tail reach. However, it is the discretion of the designer that in how long reach the design discharge of canal is to be kept unchanged. At present there are no specific guide lines for this. At every change in the canal section, there is major head loss due to the transitions, which affects the water supply in tail reach. Therefore it is advisable to keep the least transitions in long canals so as to assure water supply to tail reach. As per provisions in MMISF Act 2005 the irrigation management of canal is to be done on basis of head, middle and tail reaches i.e. three reaches. Therefore it is advisable that design discharge of canal shall be kept unchanged in head, middle & tail reaches. For this the length of canal shall be divided in to three reaches on the basis of the Culturable Command Area (CCA). The design discharge of canal shall be kept unchanged in the head; middle & tail reach i.e. only two transitions are to be provided on canal. The suitable measuring devices shall be provided at entry of Head, middle and tail reach of canal.

“The reach wise carrying capacity decided shall be adopted as design discharge for design of the hydraulic section of canal.

3.0 BASIC PARAMETERS FOR DESIGN OF HYDRAULIC SECTION

3.1 Co-efficient of rugosity (n):

The canals are designed using Manning’s formula. The value of the coefficient of rugosity(n) in the Manning’s formula shall be adopted as given in Table-3 and Table-4:

(a) Lined Canals

TABLE-3

Sr. No.	Type of lining	Value of “n”
1.	Cast in situ mechanised cement concrete lining for all Discharges	0.017

2.	Cast in situ manual cement concrete lining for all Discharges	0.018

(b) Unlined Canals

TABLE-4

Sr.No.	Type of Canals	Value of 'n'	
		Soil	Rock
1.	Discharge above 3.0 m^3/s	0.025	0.035
2.	Discharge below 3.0 m^3/s	0.030	0.035

3.2 Breadth To Depth Ratio (B / D) :

The designs of canal cross section shall be done on the basis of permissible velocity in different strata as mentioned in Para 3.5 of this circular. The B / D ratio shall be decided such that canal cross section should generate the permissible velocity prescribed in this circular.

3.3 Bed Gradient:

The longitudinal bottom slope (bed gradient) of canal is governed by topography of the command area. The bed gradient is important parameter responsible for the velocity generation. If the bed gradient is too steep, the command available will be less and velocity generated is more. If the bed gradient is too flat, the energy head available may not be adequate for generation of required velocity and canal becomes sluggish. Hence the bed gradient provided for canal system should be such that in steep terrain it should generate maximum prescribed permissible velocity and in flatter terrain it shall generate minimum prescribed permissible velocity as mentioned in Para 3.5

3.4 Inner Side Slopes:

Considering the occurrence of various types of strata such as Black cotton soil, soft murum, hard murum, gravel, soft rock and hard rock in Maharashtra, following values of inner side slopes as given in Table-5 should be adopted for purpose of design and actual construction.

TABLE-5

Inner side slopes

Sr. No.	For Design and Construction	
	Normal Reach (Full FSD Cutting or Banking)	Deep Cut And Heavy banking (Cutting more than 6.0 m and Banking height more than 6.0 m and length more than 200 m)
1.	1.5 : 1	1.5 : 1
2.	1.5 : 1	0.25 : 1
3.	1.5 : 1	1.5 : 1

Note:- 1. Above slopes shall be checked for stability for site specific soil parameters for a main canal and branches of major and medium projects

2. Excavation in H.R. above hydraulic profile shall be at slope 0.25

3.4.1 For reaches of black cotton soil (expansive soil) procedure for treatment have been prescribed separately under Government Circular No. MIS 1094 / (143/94) MP (A) dated 18/02/1995

3.4.2 Smooth transitions of 1:20 on both sides should be provided where ,there is change in the canal sides slopes.

3.5 Velocity:

The cross section of canal shall be designed on the basis of permissible velocities as below:

3.5.1 The permissible velocity for lined canal should be adopted in the range of 1.5 to 3.0 m/s.

3.5.2 For unlined canal, permissible velocity shall be adopted as given in Table-6 below.

TABLE-6

Permissible Velocity

Strata	Minimum Permissible Velocity (m/sec)	Maximum Permissible Velocity (m/sec)
Loose Sand	0.45	0.90
Ordinary Soil, Sandy loam, Black cotton and similar	0.45	0.90
Hard Murum	0.45	1.2
Gravel	0.45	1.2
Rock (disintegrated)	0.45	3.0

Important Condition: (Applicable for Para 3.5.1 & 3.5.2)

i) The adopted velocity shall not be less than 0.45 m /sec (non-silting velocity) in any type of strata.

ii) The effort shall be made to design the canal so as to attend the maximum permissible velocity with available natural bed gradient (Natural ground fall)

iii) As per as possible the falls shall be avoided. The natural fall of ground shall be utilized by providing steeper gradient to generate the maximum permissible velocity.

iv) The design of canal section having design discharge more than 25 cumecs shall be got approved from Central Design Organisation, Nashik.

4. HYDRAULIC DESIGN OF CANAL SECTION

4.1 Step by step procedure for designing of Hydraulic Section Of Canal By Permissible Velocity Method:

Generally Trapezoidal cross section is provided for gravity open canal. The hydraulic section of trapezoidal canal shall be designed by step by step method as given below.

Step-1 *Finalize carrying capacity of canal reach to be designed as described in para2.2.3 of this circular.*

Step-2 *Provide capacity factors given in Para 2.1.1.2 as per type of channel and calculate design discharge of canal*

Step-3 *Select value of 'n', inner side slopes and permissible velocity as prescribed in this circular.*

Step-4 *Decide the bed gradient (S) as per terrain in command area.*

Step-5 *Calculate Area A = Q / V*

Step-6 *Assume B / D in the range of 1 to 5 (**No limitations Prescribed**)*

Step-7 *Calculate B and D using step 5 & 6.*

Step-8 *Calculate wetted perimeter (P)*

Step-9 *Calculate hydraulic mean depth (R=A/P)*

Step-10 *Calculate velocity of assumed section by Manning's formula*

$$V = 1/n \times R^{2/3} \times S^{1/2}$$

Step 11 *If calculated velocity is less than permissible velocity, repeat the trial with other B/D or bed gradient so as to obtain the maximum Permissible velocity value as prescribed.*

Step-12 *Check for actual design discharge of assumed section*

$$Q = A \times V$$

Step-13 *If actual design discharge of assumed cross section matches with the design discharge, the canal section adopted is ok.*

(Important Note : The difference between provided design discharge and required design discharge shall not be more than 1 to 2%.)

5. OTHER PARAMETERS FOR CANAL SECTION

5.1 Free Board:

The following free board should be adopted for lined and unlined canals:

TABLE-7

Sr. No.	Discharges	Free Board for unlined canals (m)	Free Board for lined canals	Note
1	Above 30.0 cumecs	1.0	0.75	Free board should be as mentioned in column aside OR Full Supply Depth whichever is less
2.	7.0 to 30.0 cumecs	0.90	0.75	
3.	3.0 to 7.0 cumecs	0.75	0.6	
4.	0.6 to 3.0 cumecs	0.60	0.5	
5.	Less than 0.60 cumecs	0.60	0.3	

5.2 Top Width of Bank:

The following top width is provided for canal banks.

TABLE-8
Top Width of Canal banks

Sr. No.	Discharge (cumecs)	Service Bank top width (m)	Inspection Path top width (m)
1.	Above 7	5.0	3.50
2.	3 to 7	5.0	3.0
3.	0.6 to 3	3.60	1.5

5.2.1 Service road is generally provided on the left hand side of a ridge canal and on side of command area in case of a contour canal. The services road should be given an out-ward cross slope of 1:20 to 1:40 to drain away the rain water.

5.2.2 In case of canals in full cutting the service road and inspection path shall be restricted to 0.30m thickness above ground level.

5.3 Outer Side Slope of embankment:

5.3.1 Canal embankment up to 3.00 m. height:

The outer slope for canal embankment up to 3.00 m. height should be normally 2:1 from top and will be flattened to provide a minimum cover of 1.00 m over the saturation gradient of 4:1.

5.3.2 Canal embankment above 3.00 m. height and up to 10 m. height:

For the canal banks above 3.00 m. height and up to 10 m. height sections given in M. I. Manual would generally be sufficient.

5.3.3 Canal embankment above 10.00 m. height:

For bank above 10 m. height, the slopes will necessarily be designed on the basis of properties of soil and stability analysis in consultation with C.D.O. Nasik.

5.4 COT (Cut off Trench) for embankments:

5.4.1 Proper stripping should be done and the base should be scarified or ploughed and properly watered and compacted before any bank is laid thereon. Even where the canal is in partial cutting and partial bank, cut-off should be provided below the bank

a little on the water side toe. Depth should be at least about half the water depth, above the ground level or up to impervious strata whichever is less. Base width of COT should be 3.5 m. Deletion of COT may be permitted only with the approval of the Chief Engineer.

5.4.2 For full banks above 3.00 m. height and up to 6.00 m. the depth of cutoff may be kept as 0.60 m. or half the depth of water above ground whichever is more and with a bottom width of 3.50 m.

5.4.3 In full embankments exceeding 6.00 m. in height, a cut-off trench of 2.5 m. depth with BW (Bed Width) of 3.50 m. and side slopes of 1/2:1 should be provided. In cases where the soil is very pervious, the depth may have to be increased depending on the site condition.

5.4.4 COT shall not be provided in embankments built on impervious strata.

5.5 Berms:

Wherever the depth of canal above Free Board Level is more than 5 m., a berm should necessarily be provided at the level of free board. The width of the berm should be 3.5 m.

5.6 Ramps

In the portion of deep cutting of more than 6 -10 m depth and length up to one kilometer, a ramp should be provided for *ease* of maintenance like desilting and removal of slips during irrigation season. The width of ramp shall be kept as 4.5 m so that machinery can ply on it. The ramp shall be also provided in high banking inner slopes with height of banks more than 6 m. and length up to 1km. For the deep cut or banking having depth and height more than 6.0 m respectively and length more than 1.0 km, ramp should be provided at every 5 km interval.

5.7 Embankment

The canal embankment more than **3.00** m. heights is required to be constructed as per specification of earthen dam. Typical section for the canal reaches that is full cut, partial cut and full bank of the canals in the various soils along the alignment shall be got approved from competent authority.

For banks above 10 m. height, the pucca out-fall drain may be provided on the outer slope to drain away the rain water from the top of the bank without causing rain cuts. Out fall drains will have a spacing of about 200 m. I. S. code 4701-1982 for earth work on canals should be referred to.

5.8 Catch Water Drains

Catch Water Drain should be provided on canals where it is absolutely necessary, with prior approval of Chief Engineer. Otherwise Boundary gutters of Width = 0.45 m., Depth = 0.45 m. and side slope 1.25:1 should be provided.

6. Approval to hydraulic design of canal Section

Reach wise Canal Hydraulic section shall be approved by alignment sanctioning authority by special office order, along with approval of canal alignment and cutoff statement. The copy of Hydraulic section along with its calculation, the order shall be included in Technical Sanction estimate.

7. CUTOFF STATEMENT AND DESIGN STATEMENT OF CANAL

Cutoff statement of canal shall be approved by alignment sanctioning authority with special office order.

The sanction order copy of Cutoff statement shall be included in Technical Sanction estimate.

8. DRIVING HEAD

The following driving head should be provided which will help in the determination of FSL in the canal.

(i) Head over field should be 0.15 to 0.30 m, depending on the condition in each minor.

(ii) Minimum working head at outlet should be 0.15 m.

(iii) The distributary shall be so designed that it will draw full designed discharge when the main canal is running at 2/3rd the designed FSD. This would mean that FSL of the distributary will be fixed 0.30 m lower than the 2/3 FSD of the main canal.

(iv) Minimum Driving head of 0.15m. would be adopted for distributary to minor and from minor to sub minor.

(v) As far as possible the sill level of the distributary or other off take will be kept at the bed level of the canal.

9. TRANSITION

The function of a transition is to avoid excessive energy loss to eliminate cross flow and other turbulence and to provide safety to structures and waterway. The optimum maximum angle between canal axis and line connecting the canal side will be 12.5°. The canals banks near structures need to be raised where velocity is obstructed to avoid higher head loss and afflux near these structures.

Whenever the canal section changes, appropriate transitions are necessary. These transitions shall be along the length and where necessary also along the side slopes. As far as possible the transition angle between the axis of two slopes should be kept less than 12.5°.

10. CANAL CURVES

10.1 Minimum radius of curve as per I. S. 5968 –1987 shall be provided.

TABLE-9

Minimum radius of curve

Sr. No.	Discharge	Minimum radius of curve
Unlined Canals		
1.	80 m3/Sec and above	1500 m.
2.	80 m3/Sec to 30 m3/Sec	1000 m.
3.	30 m3/Sec to 15 m3/Sec	600 m.
4.	15 m3/Sec to 3 m3/Sec	300 m.
5.	3 m3/Sec to 0.3 m3/sec	150 m.
6	0.3 m3/sec and less	90 m
Lined canals		
1.	280 m3/Sec and above	900m.
2	280 m3/Sec to 200 m3/Sec	760 m.
3.	200 m3/Sec to 140 m3/Sec	600 m.
4	140 m3/Sec to 70 m3/Sec	450 m
5.	70 m3/Sec to 40 m3/Sec	300 m.
6	40 m3/Sec to 10 m3/Sec	200 m
7	10 m3/Sec to 3m3/Sec	150 m
8	3 m3/Sec to 0.3 m3/Sec	100 m
9	Less than 0.3 m3/sec	50 m

10.2 Protective work / turf shall be provided at every curve portion to overcome the problem of erosion.

11. CROSS REGULATOR /ESCAPE

An escape would usually be provided in the main canal in the initial reaches i.e. just downstream of Head regulator itself along with a suitable escape channel. The escape location shall be in cutting and desirably in hard rock.

11.1 The first escape shall be provided with the same discharging capacity as of the main canal at the head.

11.2 The discharge capacity of an escape except the first one should be equal to 1/2 the full supply discharge at its location.

11.3 Escape should also be provided on the main canal at every 10 km. up steam of strategic and vulnerable reaches e.g. Heavy bank, costly structures, tunnels etc.

11.4 An escape must essentially be combined with a cross regulator.

11.5 The cross section of the nalla into which the escape discharges needs to be taken into account. As far as possible the design discharge of escape shall be adjusted to design discharge of the nalla and degradation of the nala shall be avoided. The location of the escape shall be decided on a location of suitable drainage nalla.

11.6 The cross regulators should be provided at downstream of the major off-take of branch or distributary. Linear waterway should be provided as per IS 7114 – 1973.

12. GHAT AND CATTLE RAMPS

Properly planned Ghats and cattle ramps should be provided near villages. These cattle ramps should also be provided near bridges where there is a heavy traffic. But they should not obstruct the waterway.

13. PROTECTION OT OUTER SLOPES OF STRATEGIC BANKS

In areas of rainfall more than 2000 mm. specific protection to strategic bank particularly of height more than 5 m. would be provided, by pitching an outer side slope. In other areas and other cases, turfing of outer slope should be provided as a part of protective measures for high banks.

14. MEASURING DEVICES

Measuring devices should be provided on main canals branches and distributaries at suitable distances and at head of all off takes. For canal reaches with more than 25 cumecs discharge, the automatic gauging devices shall be provided in addition of conventional devices as prescribed below.

TABLE-10

Type of Measuring Devices

Sr. No.	Discharge	Type of Measuring Device
1.	Above 25 m^3/s	Automatic gauging devices
2.	25 cumecs to 1 cumecs	SWF (Standing Wave Flume)
3.	1 cumec to 0.30 cumecs	Parshall flume or SWF
4	Below 0.30 cumecs.	Cut-Throat flume.

In addition to the measures devices mentioned as above, all the important structures on canals shall be calibrated to measure discharges at various locations to know the canal capacity and seepage losses. For lined canals, a gauge along the sloping portion shall be provided at every 1.00 km. measuring devices should also be provided at all talukas and management section boundaries. Also the measuring devices shall be provided at the entry point of head; middle & tail reach of canal.

15 DESIGN OF CROSS SECTION OF TUNNELS (GRAVITY FLOW)

CBIP manual as planning and Design of Hydraulic tunnels shall be referred at planning stage. Important guide lines are as fallow.

15.1.1 Hydraulic Cross section of the Tunnel shall be designed as a Lined Tunnel and shall be designed as per hydraulic requirement only; from practical consideration the minimum 3m x 3m tunnel section can be provided.

15.1.2. The design parameters for tunnel shall be adopted as below.

(a) Value of coefficient of Rugosity' (n) = 0.017 (considering concrete lining for hydraulic section)

(b) Permissible velocity 1.5 to 3.0 m/sec

15.1.3 Following points shall be considered while designing & executing tunnel, for gravity canals.

1. Generally if tunnels are not planned in initial phases of project planning becomes costly. Tunnel location and lengths need to be identified initially in command identification phase only and accordingly adequate head loss provision shall be kept so that it is possible to have adequately steeper bed slopes & generate higher velocity and hence reduce size.

2. Necessary geological survey shall be conducted from experienced geologist and geological mapping shall be done showing approximate boundaries of different types of strata, faults and other rock defects discovered during survey and investigations. The geological mapping shall be done from G.L. to 6 meter below CBL. On the basis of geological survey and investigations geological report shall be prepared; which shall cover following details.

a) Tentative classification of rock, defects observal.
b) Minimum top and side cover of competent rock,
c) Various parameters required to evaluate Rock Quality Index (Q) Viz.

Joint Structure Number (Jn),
Joint Roughness Number (Jr),
Joint Alteration Number (Ja),
Joint Water Reduction Factor (Jw),
Stress Reduction Factor (SRF),
d) Rock Quality Index
e) Rock Support Pressure.
f) Recommendations about self-supporting span.

3. Minimum hard rock cover equivalent to 3 D should be kept at portal locations.

4. If rock is weak, active support system shall be preferred (Rock bolting and short creating) rather than passive support. (Permanent support system)

5. Portal should be invariably constructed before proceeding tunnel activity inside the proposed tunnel.

6. The design of tunnel cross section and that of support system shall be decided in consultation with Koyna Design Circle / CDO, Nashik.

7. If in exceptional circumstances, permanent supports are proposed then they should be provided at earliest moment i.e. after excavation of length of 3D or safe excavation span proposed by designer. Permanent support system provided after completion of entire tunnel is of no use as rock deformations causing stress redistribution is effected till that time. During tunneling hard rock excavations are uneven, Permanent support system erected touches at very few locations and only that point offers reaction under load. Hence blockings, shall be tightly wedged between steel ribs and rock surface immediately after erection of ribs. Also, suitable lagging and packing shall be provided on erected ribs before proceeding further inside the tunnel. I.S : 5878 (Part IV) – 1971 shall be refereed for further details. If permanent supports are recommended, then for ribs ISHB or ISWB shall be provided as it offers more surface for blockings and lagging and also offers greater resistance to twisting. The H-sections are suitable for posts.

16. PREPARATION OF CUTOF STATEMENT

Cutoff statement shall be prepared as per the guidelines given in Para 2.1.3 and 2.2 of this circular.

Cutoff statement of canal alignment shall be approved by competent authority with proper office order.

The sanction order copy of Cutoff statement is to be included in Technical Sanction estimate.

17. HEAD LOSS TO BE CONSIDERED IN PREPARING CUT OFF STATEMENT

a) The actual head loss at structure should not be more than that Considered for design.

b) It is desirable to design entire canal in one step to account head losses in structures.

c) To minimize the head loss & to achieve maximum irrigation in less.

length of canal, following guide lines shall be adopted.

(i) Culverts should be provided without fluming of the canal cross section.

ii) Canal water through pipe shall be avoided for canal discharge more than 1 cumecs.

iii) For canals having discharge < 1m3/sec pipe crossing may be provided.

The diameter of pipe shall not be less than FSD of canal. The area of flow in this case should not be reduced compared to canal flow area.

iv) Bridge pier shall not be provided in canal Waterway. Abutment should be provided along existing canal side slopes. Fluming of canal section shall be avoided.

v) As for as possible canal syphons should be avoided.

d) Following provision of head loss shall be made in the cut off statement of canals.

Sr. No.	Type of structure	Head loss (mm)
1.	Head Regulator	150
2.	S.W.F.	10 % of FSD
3.	Aqueducts	As per actual design requirement
4.	Canal Syphon	Loss of head to be actually calculated.
5	Super passage	
	(a) Span at FSL + FB ≤ 10 m. (No pier or abutment in hydraulic section)	Nil
	(b) Span at FSL + FB > 10 m.	2.5 for each pier
6	Bridges	
	(a) Span at FSL + FB < 10 m. (No pier or abutment in hydraulic section)	Nil
	(b) Span at FSL + FB > 10 m.	2.5 for each pier
7.	Cross regulator	i) When the transitions are smooth inlet loss is zero and '0.5 x change in velocity head' at exit. ii) When transition are abrupt the loss is' 0.5 x change in velocity head' at inlet and '1.5 x change in velocity head' at exit. iii) The losses of head in structure due to friction are negligible and need not be computed.

Note: All *bridges and super passages and all other canal crossing including pipeline are designed such that, the piers & abutments will be planned out of hydraulic cross section of the canal. Hence no head loss is to be provided in design for any canal crossings*.

e) Provision of sufficient head loss shall be made for aqueducts and tunnels so as to provide maximum prescribed permissible velocities. For this the preliminary design of hydraulic cross section area required for aqueducts and tunnels shall be worked out.

18. GUIDELINES FOR PREPARING CANAL ALIGNMENT (As per IS 5968-1987 Reaffirmed **2012**)

18.1 The command area Survey maps shall be prepared showing the contours, spot levels and important land features for whole area to be irrigated.

18.2 Alignments of main canals, branches & distributaries shall be tentatively marked on the map. A typical canal system may be generally represented as a main canal aligned as a contour canal and branches and distributaries aligned as ridge or water shed or side slope canals.

18.3 Main canal should be generally carried on contour alignment, until either it commands the full area to be irrigated or it attains the top of watershed. From such point, it should be aligned down to the watershed ceasing to be a contour canal.

18.4 Due consideration shall be given at planning stage only to the main Crossings of natural stream, railways and National State highways.

18.5 The alignment of at least 10 km in case of main canals and branches of major and medium projects shall be approved in one go. Also, alignments of distributaries and minors and of all minor projects shall be approved by competent authority in one go only.

18.6 Branch canals and distributaries should take off from a canal from or near points where canal crosses watershed.

18.7 After reaching watershed the main canal should be located along the main watershed and branch canal along secondary watersheds since it is generally observed that the slope of main watershed is less than the slope of secondary watershed and the branches are required for irrigating the area up to the adjacent drainages on either side of watershed crest.

18.8 The alignment of contour canals, especially in the upper reaches shall be decided after careful consideration of economy. Alternative alignments, their benefits and costs shall be compared.

18.9 Deep cuttings or high embankments should be generally avoided by suitable detouring, after comparing the overall costs of alternative alignments. Carrying canal in high embankment involves risk of breaching from risk of percolation. Careful judgment shall be exercised in fixing the point of crossing of drainage. It is desirable that alignment of a canal crosses least number of drainage.

18.10 The alignments of canals shall consist of straight lines with circular curves.

18.11 Distributaries may be spaced suitably depending upon the configuration of area.

18.12 In side long ground alignment shall be so fixed that the entire hydraulic section shall be in cutting so as to avoid leakage problems.

18.13 As per as possible, alignment shall be so fixed that no nala regradation is required while crossing the nalla.

18.2 Command Area

After the alignment of canals and drains is drawn in plan, areas served by various canals shall be calculated. The area depending on a branch/ distributary canal shall generally be limited to nearest drain

18.3 Full Supply Levels

18.3.1 After tentative alignments of a canal system are marked, full supply level shall be decided beginning with outlets, minors, distributaries, branch canals and then obtaining the full supply levels in main canal. This may be done by drawing longitudinal sections of main canal and its subsidiary canals. Longitudinal scale of about 1: 10000 to 1:20000 and vertical scale of about 1:100 is recommended. The following information shall be added below the datum line on longitudinal sections.

i) Natural ground level

ii) Full supply level

iii) Bed level

iv) Subsoil water levels

v) Water surface slope

vi) Bed width, value of 'n', side slope, FSD, velocity

vii) Free board

viii) Broad details of hydraulic data of outlets, regulators, bridges, drainage crossings, off taking channels etc.

18.4 Structures:

In working out longitudinal section, the provision of regulators, falls, escapes, cross drainage works etc. shall be considered. The losses shall be fully accounted for.

18.5 Any modification, alteration or inclusion of structure in the existing section shall not be done without written approval of the Chief Engineer.

19. GUIDE LINES FOR ECONOMICAL DESIGN OF STRUCTURES

i) Top width of Head walls abutment, wing wall and parapet wall of all the structures should not be provided greater than 0.30m. in case of C.C. Structures

ii) The head walls of outlets, HR shall be restricted 0.45 m. above (FSD + Free board)

iii) Height of parapet of Village road bridges, other district road bridges and major district bridges should be restricted to 0.30m. above road top level. The guard stone should be provided at appropriate interval.

iv) Road width of V.R.B. should not be kept more than 7.50m. in case of pipe as well as slab V.R.Bs.

v) While designing pipe culvert length of the pipe barrel should be provided from embankment toe of IP side to embankment toes of S.R. side, so that wing walls shall be avoided.

vi) The height of side walls of the falls shall be restricted to the TBL of canal and top width shall be 0.3 m.

vii) As far as possible location of structures other than cross drainage works should be avoided in the full banking sections of canals.

20 APPLICABILITY OF CIRCULAR

20.1 These guidelines are in supersession of the existing guidelines dated 10/02/1995. All the canals and distribution network for which execution is not started shall be redesigned & executed as per the revised guidelines. These guidelines shall not be applied for executed canal. In special cases the diversion from these guidelines shall be made with prior approval of Government.

20.2 These guidelines shall be reviewed after period of 10 years.

This Government circular of Maharashtra Government is available at the website www.maharashtra.gov.in. Reference no. for this is 201509011551334427. This order has been signed digitally.

By order and in the name of Governor of Maharashtra.

Vinay Madhav Kulkarni

Digitally signed by Vinay Madhav Kulkarni
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(V.M. Kulkarni)
Chief Engineer & Joint Secretary(V&P)
Water Resources Department
Government of Maharashtra

Copy to :-

1) P.S. to Hon. Minister, Water Resources Department, Mantralya, Mumbai
2) P.S. to Hon. State Minister, Water Resource Department, Mantralaya.
3) Prinicpal Secretary, Water Resource Department, Mantralaya.
4) Secretary, (CADA), Mantralaya.Mumbai
5) Director General, Maharashtra Engineering Research Institute, MERI, Nashik
6) Director General, Water And Land Management Institute, (WALMI), Aurangabad
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8) Chief Engineer, Hydrology Project, Nashik
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16) Chief Engineer And Joint Secretary, (WR), Mantralaya. Mumbai

17) Chief Engineer And Joint Secretary, (V&P), Mantralaya. Mumbai
18) Chief Engineer And Joint Secretary, (I), Mantralaya. Mumbai
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