CM & CD WORKS

- Canal Alignment, H.P's And Canal Section
- Cross-Regulator
- Canal Drops
- SLRB/DLRB
- Guidelines For Design Of Abutments, Wing Walls And Returns
- Under Tunnel / Pipe U.Ts
- Super Passages
- Aqueduct/Viaduct
- Canal Syphon
- Lift Irrigation Schemes
- Check Dam

Canal Alignment, H.P's and Canal Section

11.1.1 Alignment:

Irrigation canals can be aligned in any of the following three ways:

a. Ridge canal
b. Contour canal
c. Side Slope Canal

(a) Ridge Canal: For a canal system in plain areas, where land slopes are relatively flat and uniform, it is often necessary and advantageous to align canals on the ridge lines of the areas to be irrigated. The canal which is aligned along any natural ridge line is called a ridge canal

(b) Contour Canal: In Hilly areas, river flows in valley well below the ridge. It is imposible to take the canal on top of such a higher ridge line. In such conditions, contour canals are constructed. Contour canals follow a contour, except for giving required longitudinal slope to the canal. A contour canal irrigates only one side because the area on the other side is higher. As the drainage channel is always at right angles to the ground contours, such a channel would definitely have to cross natural drains and streams, necessitating construction of cross-drainage structures.

(c) Side slope canal: A side slope canal is that which is aligned at right angles to contours: ie along side slopes. Since such a canal runs parallel to the natural drains and streams, avoids the cross drainage of structures.

In major irrigation projects, the main canals are generally aligned as contour canals to give the benefits to the maximum extent possible. These contour canals have to necessarily cross a good number of ridges and valleys depending up on magnitude of project. In general, the canal alignments are finalised following the shorter routes available to minimise the ultimate length of canal.

11.1.2. Basic Points to be noted in alignment of Canal:

- The alignment should be such that, the cutting and filling of earth or rock should be balanced as far as possible.
- The alignment should be such that the canal crosses the natural stream at its narrowest point in the vicinity.
- As far as possible, curves should be avoided, in the alignment of canals, because the curves lead to disturbance of flow and a tendency to silt on inner bend and scour the toe of outer bend. If curves have to be provided, they should be as gentle as possible.

In order to finalise the layout of canal network for an irrigation project, the alignment of canal should be marked on Topo sheets, until an optimum is reached. The alignment is then transferred to field by fixing marking posts along the centre line of canal. A formal guidelines for canal layouts may be had from IS: 5968-1987- Guide for planning and layout of canal system for irrigation.

11.1.3 Canal Discharge: Canal Discharge is calculated based on based on crop water requirement of the ayacut, duly considering the seepage and transmission losses as per modified penman method.If there is any provision for drinking and industrial water supply, along the canal alignment, the same may be added duly considering losses.

11.1.4 Canal section: The canal section parameters such as bed width, FSD, Side slopes, n value etc., shall be finalised based on the following guide lines.

- ***b/d ratio:***
  - i. Simple conveyor system(where there is no command)
    Preferable range: 2 to 3
  - ii. Canal with Command:

Range: 5 to 8 or even higher depending on the terrain

- ***Critical velocity ratio V/V0***
  i. Diversions, silt carrying unlined canals
     Range 1.1 to 0.9 (head- tail end)
  ii. Lined canals
     Higher than unity is preferable to avoid any silting
- ***Coefficient of rugosity 'n'(irrespective of discharge)***
  i) Lined canals: 0.018
  ii) Normal Alluvial soils-0.0225
  iii) Murum- 0.025
  iv) Rocky strata- 0.03- 0.035
- ***Allowable Velocities***

  Unlined canals-Recommended velocities

All soils	0.6 to 1.1 m/sec
Hard clay or grit	1 to 1.5 m/sec
Gravel and shingle	1.5 to 1.8 m/sec
Cemented gravel conglomite	1.8 m/sec
Soft rock	1.4 m/sec
Hard rock	2.4 m/sec
Very hard rock	4.5 m/sec
Lined canals-for cc lining max. Permissible velocity-	2.7 m/sec

- ***Side slopes:*** Inner and Outer

Canal in cutting	1.5:1
Canal in banking	2:1
Canal in rock (According to classification of rock)	0.5:1/0.25:1

- ***Berms:*** In deep cut reaches, it is desirable to have 1st berm at FSL + FB and at around 5m ht. For subsequent depth, a minimum berm of 3m wide on each side shall be provided, preferably at 5m depth intervals.
- Free board , dowel banks, Bank Top widths, HGL, Catch water drains and Roadway and etc., shall be as per Is:7112-1973 and IS:10430-2000

11.1.5 Hydraulic Particulars of canal: The following guide lines shall be followed for preparing H.Ps of canal.

A. As far as possible, the alignment may be taken along the FSL contour avoiding higher embankments and deep cuts.

B. The canal section may be changed after 10 to 20 % reduction in canal discharge followed by a Cross Regulator

C. A Cross Regulator /Drop may be proposed at change of section or change of bed fall or at maximum interval of 40 km to take care of breaching at embankment sections

D. Avoid number of interchange points/curves in the alignment so as to have straight alignment

E. Canal drops are recommended where the canal bed slope is flatter than the slope of the ridge. Drops may be located where the canal cutting comes to FSL cutting.

F. The sluices at the head of the large distribution channel are recommended to be capable of passing full supply in to the distributor with three fourth discharge at head to half supply in the tail end i.e, when the parent canal discharge is about 20 % .The driving head should not be less than 15 cms. The sill level of the sluice should be fixed such that they get lower and lower as the location go towards the tail end.

G. As far as possible, avoid CM and CD works in curves.

H. As far as possible ,avoid canal siphons

I. As far as possible, avoid flume sections.

J. As far as possible ,inlets in to canal may be avoided

K. Avoid skew crossings of bridges /CM and CD works wherever possible.

L. No. of bridges have to be proposed at designated roads, without foregoing the available facility.

M. Reduce number of CM and CD works by diversions/combining /combining SLBs & DLB s with Regulators/ super passages etc.

N. The loss of heads recommended for the CM and CD works are as follows.

- Cross Regulators: 0.075 to 0.15 m
- Aqueducts: 0.075 m to 0.15 m or as per calculations for major drain crossings.
- Canal siphons: 0.075 m to 0.15 m or as per calculations for major drain crossings
- For bridges (SLB/DLB) & SP's: 0.075 to 0.10 m
- Measuring devices: 0.075 m

O. To finalise type of structure i.e., UT / SP/Aqueduct /Viaduct / Syphon /Inlet with reference to CBL, DBL and ground levels

P. To finalise mileage/length of canal along the curve.

Q. To propose Canal Escapes on U/S of embankment reach near river/drain course combined with a Cross Regulator for 50 % canal discharge

R. Measuring devices are suggested at 40 km .(Where there are no Regulators) for effective water management .

S. To finalise salient features of drain/ river like catchment area, MFD,DBL, MFL, OMFL and bed width of drain/ river. The MFD may be finalized as per the formula indicated in the Tender Document/agreement or in general the M.F.D of drain /river may be finalized as per Dicken's formula/Ryve's of Mithra committee report for upland and deltaic catchments.

11.1.6 Statements and Drawings:

1. Statement of hydraulic particulars
2. Deatiled reachwise discharge calculations.
3. Design of reachwise canal sections
4. Reach wise ayacut statement
5. H.P's statement-Reachwise and structure wise
6. Curves statement
7. Statement showing Regulators
8. Statement showing off takes
9. Statement showing Drops

11.2. CROSS-REGULATOR

11.2.1. Preamble: Cross-Regulator is a structure constructed across a canal provided with arrangements to regulate the discharge to feed offtaking canals in low supplies.

11.2.2. Site survey required for taking up the design of Cross-Regulator

1. Approved H.Ps of the canal on U/S & D/S of Regulator with typical Canal Section.
2. List of the structures on either side of the structure for 3 Kms.
3. Longitudinal Section of the canal for a distance of 1.0 Km.
4. If the Regulator is clubbed with road bridges, mention the road level and type of bridge (Single lane / Double lane).
5. Approved H.P s of offtake distributory in case of O.T Sluice combined with regulator & mention the ayacut for the O.T sill level proposed and the highest field level.
6. Trial pit particulars up to hard strata with minimum 3No.s T.Ps covering Abutment, Pier and Stilling Basin.

11.2.3. Code books required for taking up the design of Canal Drop:

1. Design of cross –Regulator for Canals-IS 7114-1973.
2. Design criteria for Canal head Regulators- IS 6531-1994.
3. Design of hydraulic jump type stilling basin with horizontal and sloping apron-IS 4997-1968.
4. Khosla’s theory- CPWD guidelines.

11.3 CANAL DROPS

11.3.1 Preamble: A Canal Drop is a structure designed to secure lowering of the water surface in a canal and to dissipate safely the surplus energy so liberated.

11.3.2 Site survey required for taking up the design of Canal Drop :

1. Approved H.Ps of the Canal by Chief Engineer.

2. Longitudinal Section of canal covering 500 M on U/S & D/S with levels @ 10M intervals.

3. Site plan with flow direction of canal along with net levels@ 10 M.

4. Contour Plan.

5. Trial pit particulars up to hard strata.

11.3.3 Code books required for taking up the design of Canal Drop:

1.”Central Water and Power commission Manual “on Canal Falls.

2. Khosla’s theory- CPWD guidelines.

11.4 SLRB/DLRB

11.4.1 Preamble: A bridge is proposed when a road is crossing the canal/drain.

Site surveys should be furnished as per check slip or Bridges with the following details.

1. The copy of approved Hydraulic Particulars of Canal.
2. T.P particulars/S.B.C of soil at the location.
3. Longitudinal section of drain as per approved H.P's covering 500m on U/S & D/S with levels at 10m interval.
4. Longitudinal Sections of road with levels at 10m intervals up to 500m on U/S and D/S.
5. Net levels @ 10m interval and also covering the approaches to a sufficient distance not less than $1/4^{th}$ Km on either side.
6. Site plan along with flow direction, roadway direction & skew angle if any.
7. Important details of Road Bridge such as road level, connecting villages etc.

11.4.2. Code books required for taking up the design of SLRB/DLRB

1. IRC: 5-1998 - Standard specifications and code of practice for road bridges, section-I, General features of Design.
2. IRC: 6-1998 - Standard specifications and code of practice for road bridges, section-II, Loads & Stresses.
3. IRC: 21-1998 - Standard specifications and code of practice for road bridges, section-III, Cement concrete (Plain & Reinforced).
4. IRC: 78-1998 - Standard specifications and code of practice for road bridges, section-VII, Foundation & Substructure.
5. For DLRB and Girder bridges adopt MOST drawings/Plates.
6. IS 456 – 2000 - Code of practice for Plain & Reinforced Concrete.

11.5 GUIDELINES FOR DESIGN OF ABUTMENTS, WING WALLS AND RETURNS

11.5.1 INTRODUCTION:

ABUTMENTS:

Abutments are basically earth retaining walls which will retain earth on one side and may carry superstructure on other side. The walls which form the end part of river/canal control structures are also called abutments.

EXAMPLES:

1) Earth retaining walls of bridges,
2) Earth retaining walls carrying canal trough
3) Earth retaining walls at the both ends of weirs, spill ways, canal drops etc.,

COMMON STRUCTURAL FORMS OF ABUTMENTS:

1) Solid type
2) Buttressed type
3) Counterfort type

Most common form of abutment adopted is solid type. Abutments may be constructed in plain, RCC, and masonry.

11.5.1.1 DESIGN OF ABUTMENT:

Abutments are designed for no tension at foundation.

For masonry walls no tension shall be allowed in the body wall also.

11.5.1.2 FORCES ACTING ON ABUTMENT:

A) Earth pressure
B) Water thrust if any
C) Reaction from super structure
D) Dead load/ self weight
E) Earth quake forces(for important structures)

11.5.1.3 EARTH PRESSURE:

Earth pressure due to back fill is computed by TVA (Tennis Vally Acadamy) procedure based on COULOMBS THEORY.

Following parameters are used in computation

1	Angle of internal friction	Φ
2	Angle of friction between wall face and earth	δ
3	Inclination of the surface of fill with the horizontal	i
4	Inclination of wall face to the vertical	α
5	Weight of saturated earth	2.10 t/m2
6	Weight of concrete	2.40 t/m2
7	Pressure	P
8	Weight of back fill	W

$$P = Ka\ W\ H^2$$

$$\mathbf{K_a} = \left\{ \frac{\cos(\Phi-\alpha)}{(1+n)\cos\alpha} \right\}^2 X \frac{1}{\cos(\alpha+\delta)}$$

$$\mathbf{n} = \frac{\sqrt{\{\mathrm{Sin}(\Phi+\delta)\mathrm{Sin}(\Phi-i)\}}}{\{\mathrm{Cos}(\alpha+\delta)\mathrm{Cos}(\alpha-i)\}}$$

11.5.1.4 GENERAL CASES AND EARTH PRESSURE COEFFICIENTS FOR EARTH PRESSURE:

A) Φ=32□ ,δ= 16□,α=0 for roller back fill

B) Φ=28□ ,δ= 14□,α=0 for masonry construction with stepped wall

C)

i) FOR Φ=32□ ,δ= 16□,α=0

a. Level surcharge I.E i=0

P_v=0.0384 WH^2, P_h=0.1338 WH^2

b. Sloped surcharge

S.NO.	SLOPE	P_v	P_h
1	1H:1V	0.1031 WH^2	0.3596 WH^2
2	1 ½ H:1V	0.1031 WH^2	0.3596 WH^2
3	2 H:1V	0.0623 WH^2	0.2174 WH^2
4	2 ½ H:1V	0.05375 WH^2	0.1875WH^2

ii) For Φ=28□ ,δ= 14□,α=0

a. Level surcharge I.E i=0

P_v=0.0395 WH^2, P_h=0.1584 WH^2

b. Sloped surcharge

S.NO.	SLOPE	P_v	P_h
1	1 ½ H:1V	0.0972 WH^2	0.3898 WH^2
2	2 H:1V	0.0749 WH^2	0.3005 WH^2

P_h And P_v acts at a height 0.4h from base.

For abutments /retaining walls in case where live load is expected a surcharge equivalent to 1.2m height of earth fill is assumed for stability analysys as per IRC:78-2000 clause 710.4.3

11.5.2. WING WALLS AND RETURNS:

These are also basically earth retaining walls and designed to with stand earth pressure as per TVA procedure.

The returns shall be keyed to the banks at least 0.60 to 1.00m.

The top level of abutments, wings and returns shall be at 0.60m above HFL or at TBL. In case of CM, CD works the top level of wings shall be at higher of MFL+0.6m and ground level. A top width of 0.50m to 0.60m shall be provided.

11.5.3 FOUNDATION:

The foundation level shall be carried to maximum scour depth level/ minimum depth of foundation as required.

The stresses coming on soil shall be limited to safe bearing capacity of soil. The type of foundation adopted will be based on soil classification and safe bearing capacity.

Generally a foundation concrete of 0.60m thick in cc m15 grade shall be provided under abutments, wings and returns. If sheet rock is met with 0.30m thick foundation concrete is adequate. Anchorage to rock may be provided. In case of water logged/ retaining structure grade of concrete adopted shall be m15 for PCC and m20 for RCC.

The safe bearing capacity of soil is adopted as per IS:1904-66

11.5.4 The following codes shall be followed for design:

i) IRC 6-2000
ii) IRC 21-2000
iii) IRC 40-1995
iv) IRC 78-2000
v) IS 456-2000
vi) IS 3370(PART I&II)-2009
vii) IS 7784(PART II)-1995

11.5.5 **BOOKS FOR REFERENCE:**

1) TYPE DESIGN OF IRRIGATION STRUCTURES-R.S.N MURTHY
2) DESIGN OF IRRIGATION STRUCTURES (VOL II)-VARSHNEY AND GUPTA

11.6 UNDER TUNNEL / PIPE U.TS

11.6.1 Preamble: UT is proposed when the drainage M.F.L is higher than the canal B.L. but sufficiently below the canal F.S.L. The headway is not sufficient at the crossing. In this case the drain flows under syphonic action (pressure flow).

Site surveys should be furnished as per check slip with the following details.

1. Report accompanying the site survey.
2. The H.P's of canal and drain/river.
3. Site plan showing the flow direction of canal & drain with net levels @ 10m interval.
4. L.S of the drain/river covering up to 500m on U/S & D/S with levels @ 10m interval.
5. C.S of the drain/river @centre, U/S, D/S @ 10m, 25m, 50m, 100m and @ 100m interval beyond for a length of 500m.
6. The C.S levels shall be @ 3m to 5m interval in the gorge portion and 10m interval in the flanks and extended up to M.F.L touching the ground.
7. The catchment area of the river/drain.
8. The observed MFD may be computed from the observed MFL and shown on the LS and CS's.
9. Trial pit particulars @ centre, U/S and D/S side of the structure.

11.6.2 Code books required for taking up the design of Under tunnel

1. 7784 (Part – 1):1993 - code of practice for design of cross drainage works, General features.
2. 7784 (Part – 2/Section-1):1995 - code of practice for design of cross drainage works, Aqueduct.
3. 7784 (Part – 2/Section-5):2000 - code of practice for design of cross drainage works, Under Tunnels (Syphon Aqueduct).

4. IS 783 - 1985 – Code of practice for laying of concrete pipes.
5. IS 458 - 1988 – Specifications for precast concrete pipes concrete pipes (with & without Reinforcement.
6. IS 3370 – 1965 - Code of practice for concrete structures for storage of liquids, Part I - General requirement & Part II - Reinforced concrete structure.
7. IS 456 – 2000 - Code of practice for Plain & Reinforced Concrete.

11.7 SUPER PASSAGES

11.7.1 Preamble: SP (Super Passage) is proposed when the drain B.L is higher than the canal F.S.L. Where the canal runs under gravity.

Site surveys should be furnished as per check slip with the following details.

1. Report accompanying the site survey.
2. The H.P's of canal and drain/river.
3. Site plan showing the flow direction of canal & drain with net levels @ 10m interval.
4. L.S of the drain/river covering up to 500m on U/S & D/S with levels @ 10m interval.
5. C.S of the drain/river @centre, U/S, D/S @ 10m, 25m, 50m, 100m and @ 100m interval beyond for a length of 500m.
6. The C.S levels shall be @ 3m to 5m interval in the gorge portion and 10m interval in the flanks and extended up to M.F.L touching the ground.
7. The catchment area of the river/drain.
8. The observed MFD may be computed from the observed MFL and shown on the LS and CS's.
9. Trial pit particulars @ centre, U/S and D/S side of the structure.

11.7.2 Code books required for taking up the design of Under tunnel

1. 7784 (Part – 1):1993 - code of practice for design of cross drainage works, General features.
2. 7784 (Part – 2/Section-2):1995 - code of practice for design of cross drainage works, Super Passages.
3. IS 783 - 1985 – Code of practice for laying of concrete pipes.
4. IS 458 - 1988 – Specifications for precast concrete pipes concrete pipes (with & without Reinforcement.

5. IS 3370 – 1965 - Code of practice for concrete structures for storage of liquids, Part I - General requirement & Part II - Reinforced concrete structure.

6. IS 456 – 2000 - Code of practice for Plain & Reinforced Concrete.

11.8 AQUEDUCT/VIADUCT

11.8.1 Preamble: Aqueduct is proposed when the canal B.L is higher than the drain M.F.L. In this case the drain flows under gravity.

Site surveys should be furnished as per check slip with the following details.

1. Report accompanying the site survey.
2. The H.P's of canal and drain/river.
3. Site plan showing the flow direction of canal & drain with net levels @ 10m interval.
4. L.S of the drain/river covering up to 500m on U/S & D/S with levels @ 10m interval.
5. C.S of the drain/river @centre, U/S, D/S @ 10m, 25m, 50m, 100m and @ 100m interval beyond for a length of 500m.
6. The C.S levels shall be @ 3m to 5m interval in the gorge portion and 10m interval in the flanks and extended up to M.F.L touching the ground.
7. The catchment area of the river/drain.
8. The observed MFD may be computed from the observed MFL and shown on the LS and CS's.
9. Trial pit particulars @ centre, U/S and D/S side of the structure.

11.8.2 Code books required for taking up the design of Aqueduct/Viaduct

1. 7784 (Part – 1):1993 - code of practice for design of cross drainage works, General features.
2. 7784 (Part – 2/Section-1):1993 - code of practice for design of cross drainage works, Aqueducts.
3. IS 783 - 1985 – Code of practice for laying of concrete pipes.
4. IS 458 - 1988 – Specifications for precast concrete pipes concrete pipes (with & without Reinforcement.

5. IS 3370 – 1965 - Code of practice for concrete structures for storage of liquids, Part I - General requirement & Part II - Reinforced concrete structure.

6. IS 456 – 2000 - Code of practice for Plain & Reinforced Concrete.

11.9 CANAL SYPHON

11.9.1 Preamble: Canal Syphon is proposed when the F.S.L of the canal is much above the B.L. of the drainage and sufficiently below the drain H.F.L. In this, the canal runs under syphonic action (pressure flow).

Site surveys should be furnished as per check slip with the following details.

1. Report accompanying the site survey.
2. The H.P's of canal and drain/river.
3. Site plan showing the flow direction of canal & drain with net levels @ 10m interval.
4. L.S of the drain/river covering up to 500m on U/S & D/S with levels @ 10m interval.
5. C.S of the drain/river @centre, U/S, D/S @ 10m, 25m, 50m, 100m and @ 100m interval beyond for a length of 500m.
6. The C.S levels shall be @ 3m to 5m interval in the gorge portion and 10m interval in the flanks and extended up to M.F.L touching the ground.
7. The catchment area of the river/drain.
8. The observed MFD may be computed from the observed MFL and shown on the LS and CS's.
9. Trial pit particulars @ centre, U/S and D/S side of the structure.

11.9.2 Code books required for taking up the design of Canal Syphon

1. 7784 (Part – 1):1993 - code of practice for design of cross drainage works, General features.
2. 7784 (Part – 2/Section-3):1995 - code of practice for design of cross drainage works, Canal Syphon.
3. IS 783 - 1985 – Code of practice for laying of concrete pipes.

4. IS 458 - 1988 – Specifications for precast concrete pipes concrete pipes (with & without Reinforcement.

5. IS 3370 – 1965 - Code of practice for concrete structures for storage of liquids, Part I - General requirement & Part II - Reinforced concrete structure.

6. IS 456 – 2000 - Code of practice for Plain & Reinforced Concrete.

12.0 LIFT IRRIGATION SCHEMES

Pump houses are proposed to lift the water from lower level to higher level.

Site surveys should be furnished as per check slip with the following details.

1. Copy of Bid document with the scope of scheme.
2. Comprehensive report of scheme along with
   a) Schematic diagram with plans, arrangements from Intake to ultimate delivery point.
   b) Index plan.
   c) Ayacut particulars.
   d) Longitudinal section along the alignment of pressure main and L.S & plans of Gravity canals with C/S @ 100 intervals covering 100m on either side.
   e) River crossing section at the 1st stage intake.
   f) H.P's of Gravity canals.
3. Site surveys at relevant location of structures with bore hole data.
4. Trial pit particulars along alignment of pressure main.
5. Technical details of Pumps and EOT/MOT crane details, valve details along with drawings.

CHECK DAM

It is an obstruction provided to the flow of water at stream or river in the form of wall to increase the water table in the adjacent areas. It is also called as mini percolation tank. These will be having very little submersion and also very small depth of storage. No sluice pipe need to be provided for percolation tank at the deepest portion. The height of the bund not exceeds 2.0m at the deepest section. They can be constructed in large numbers mostly in the outer half of catchment area of minor Irrigation tanks.

As per Minor Irrigation Guidelines important points to be considered, while designing the Check dam.

1 For calculating the discharge Combined catchment area is considered.

2 The depth of water stored @ FTL may be up to a maximum of 1.0m at the deepest point.

3 The depth of over flow over the weir may be about 0.30m.

4 The free board may be adopted 0.70m.

5 The Surplus course may be provided with nominal and minimum revetment.

6 The Submersion area may be about 0.50 ha. Hence it is preferable to construct these dams on Government land wherever feasible.

7 Consolidation of bund may be done with Hand rammer or Two tone animal drawn roller.

8 A paved bye-wash with nosing may be provided for surplus arrangement at one end of the bund.

Design Concept: Check dam is one type of Weir, it is designed as Broad crested weir with submerged flow condition.

Design Requirements:

1. Combined Catchment area details.
2. Cross section of stream at 50m interval both U/S & D/S up to 500m.
3. Longitudinal section of the stream.
4. Maximum flood levels of the stream.
5. Highest Field levels.
6. Net level plan.

Design Procedure:

1. Maximum Flood Discharge may be calculated using Dickens formula

   $Q = CM^{3/4}$

2. Calculation of Maximum Flood Level for a given Discharge.
3. Check the length of the Checkdam from the cross section at center.
4. Calculation of Drowning Ratio (DR) = (D/S MFL – Crest level) / (U/S MFL – Crest level) accordingly read from Malikapur Graph Coefficent of Discharge (C_d).
5. Finding the Head over discharge by using $Q = C_d L H^{3/4}$, assume the crest level so that the MWL should not be exceed MFL.
6. From Hydraulic jump theory, calculate the height of jump at checkdam (D1) and height of jump after checkdam (D_2). Calculate the D_2 by assuming D_1 in such a way that Head loss (H_L) calculated from D_1 & D_2 and Head loss (H_L) due to U/S TEL & D/S TEL should be equal.

   $D_2 = D_1/2 ((1 + 8 F^2)^{0.5} - 1)$

$H_L = (D_2 - D_1)^3 / (4D_1D_2)$

H_L= U/S TEL – D/S TEL.

7. Check the discharge and length of the Checkdam with this formula

$Q = 2/3\ C1\ L\ (2g)^{½} [(H+ha)^{3/2} - ha^{3/2}] + C2\ L\ d\ (2g\ (H+ha))^{½}$

C1=0.577 & C2 = 0.80.

H= Difference of U/s & D/s water level.

ha = Head due to velocity of approach.

L = Clear length of water way

D = Depth of D/S water level above the crest.

8. Find the length of apron Lj = 5(D2-D1)
9. Find the Scour depth $R = 1.35 (q^2 / f)^{1/3}$

$q = Q/L$

Depth of U/S cutoff = 1.5 R

U/S cutoff level = U/S MWL – Depth of cutoff

Depth of D/S cutoff = 2.0 R

D/S cutoff level = D/S MWL – Depth of cutoff

10. Calculate the thickness of apron by using Khosla's theory.
11. Finding the stability of the body wall, Abutment and U/S & D/S wing wall.
12. Calculation of Rough stone apron thickness and Length.

Approval of canal Alignment and Hydraulic Particulars

1. Existing Hydraulic particulars of a canal.

2. Authenticated Ayacut and discharge particulars at head reach.
3. Aycut, discharge and duty details of a main canal.
4. Head reach regulators details.
5. Statement of OT's ayacut particulars in reach wise duly showing the sill levels, vent size, FSL, Discharge, FSD and Highest Field levels.
6. Statement of CM & CD works, Regulators and Drops details.
7. Trial pit particulars duly indicating the Ground levels and Soil depths.
8. Statement of Curve Particulars.
9. Longitudinal section of the main canal duly marking the CM & CD works.
10. Designed canal sections in reach wise.
11. The section should be checked for V/Vo, it should be within the limit of 1.10 to 0.90 i.e. non silting and non scouring velocity.
12. Critical velocity (Vo) should be checked for related delta formulae i.e. for Godavari delta Vo = 0.39 $FSD^{0.55}$, Krishna delta Vo = 0.53 $FSD^{0.52}$.
13. Consolidated statement of Hydraulic Particulars showing the details of No. of reaches, Distance in Km., Required Discharge, Designed Discharge, CBL, FSL, TBL at start & end, FSD, Loss of head, Free board, Bed fall, Side slopes, Value of 'n', Velocity, V/Vo and Remarks.

BIS codes to be followed: IS 7112 - 1973, IS 10430 – 2000, IS 5968 – 1987.

Books to be followed: GUIDELINES FOR PREPARATION OF PROJECT REPORTS FOR SURFACE WATER AND MINOR IRRIGATION WORKS BY T.HANUMANTH RAO, Chief engineer.