TN IAM PROJECT

Quality Management field Guidelines for WRD Engineers

Tamil Nadu Irrigated Agriculture Modernization Project
Multi-Disciplinary Project Unit

INDEX

1. BEST CONSTRUCTION PRACTICE

i) Rehabilitation / Strengthening of Earthen Bunds

a) Preparation

- For raising the earthwork on the old bund, care shall be taken to ensure proper bonding of the freshly laid soil with the old embankment. Accordingly, all bushes, vegetation, roots trees, etc., from the existing portion of embankment proposed to be raised are duly removed to the complete satisfaction of the Engineer-in-Charge.
- The base shall be stripped to a depth of at least 20cm, and a key trench of 45 x 45 cm to be provided, and properly moistened before placement of the new earth fill layer.
- Cutting "benches" on upstream / downstream slopes of bund.

b) Placement of Earthwork and Compaction

- The earthen bunds being of homogeneous section, proper type of soils (GC, GM, SC, SM type of coarse grained soils) from the borrow areas shall be used. Representative samples of soil to be used as earth fill shall be first got tested for their suitability from Quality Control Laboratory. Use of fine grained soils (CL,ML,CI,MI,CH,MH, type soils) be done after approval from CDO, especially where the dam height is more than 5m, Grain size analysis shall be got done to know the classification of soils proposed to be placed in the embankment.
- Earth fill shall be laid in suitable layers of 25cm thickness for power roller compaction. Clods shall be broken to 7.5cm size. Any roots, grass, and rubbish shall be removed from the fill. Cobbles / gravels / boulders of size more than 7.5cm shall also be removed.
- In case initial water content in the soil is less than the optimum moisture content, water shall be uniformly sprinkled over the freshly laid layer before compaction.
- Compaction of earth fill layers shall be done by 8-10 Ton Power Roller. Following criteria for control of compaction shall be adopted.

Type of soil	% of + No.4 fraction by dry weight of total material	Minimum acceptable density (D)
Cohesive soils controlled by Proctor test	0-25 26-50	D = 95 D = 92.5

Or, a general acceptance criteria of 95% of Proctor density at OMC (optimum moisture content), as per direction of the Engineer-in-Charge shall be adopted.

- During raising of earth fill, compaction in extra width shall be done to be sure that the designed section of bund gets fully compacted. The extra width shall be trimmed to the designed slopes and the trimmed earth re-used.
- In some situations where the space is not sufficient for deployment of Power Roller for compaction, earth fill shall be laid in layers of 15cm thickness and compacted by 'fuel – operated compactors' or pneumatic tampers or any other mechanical compactors.
- No hand rammers shall be allowed for consolidation of earth fill.
- Side slope compaction should be done by 1.0m x 1.6m steel plate fixed to the bucket which, when attached to the boom of the hydraulic excavator, provides a good "Compaction Mechanism".

c) **Provision of Free board in Tank Bunds:**

- For tanks of height up to 3mts. ----------1.25mts.
- For tanks of height more than 3mts. ------1.50mts.

d) **Slopes of Tank Bunds:** Both the front and rear slopes of tank bunds have been kept as 2(H) : 1(V) for raising and strengthening, which provision is in line with the Indian Standard IS 12169 : 1987.

e) **Consolidation of Tank Bunds:**

- Consolidations of bunds / banks are to be carried out by power rollers / Vibratory plate compactors / small width power roller as found suitable for the width of operation with proper benching.

- Degree of compaction also needs to be specified that each layer shall be compacted at least 95% of proctor density at OMC.
- Side slope compaction should be done by steel plate, replacing the bucket from the excavator.

f) **Settlement Allowance in Tank Bunds:** A settlement allowance of 2% of bund height be provided to fulfill the requirements of specifications. Such additional earth fill is to be placed on bund top without altering the side slopes. Requisite provision should be made in the cost estimates.

g) **Cross slope on Tank Bunds Top:** An outer cross slope (camber) of about 5% should be provided on top of every tank bund to allow drainage of rainwater towards the rear slope.

h) **Turfing the rear slopes of Tank bund:** In order to have long term sustainability of Tank bund slopes and subsequently minimum maintenance expenditure, it is suggested that turfing (viz. plantation of locally available grass) on rear slope should be done.

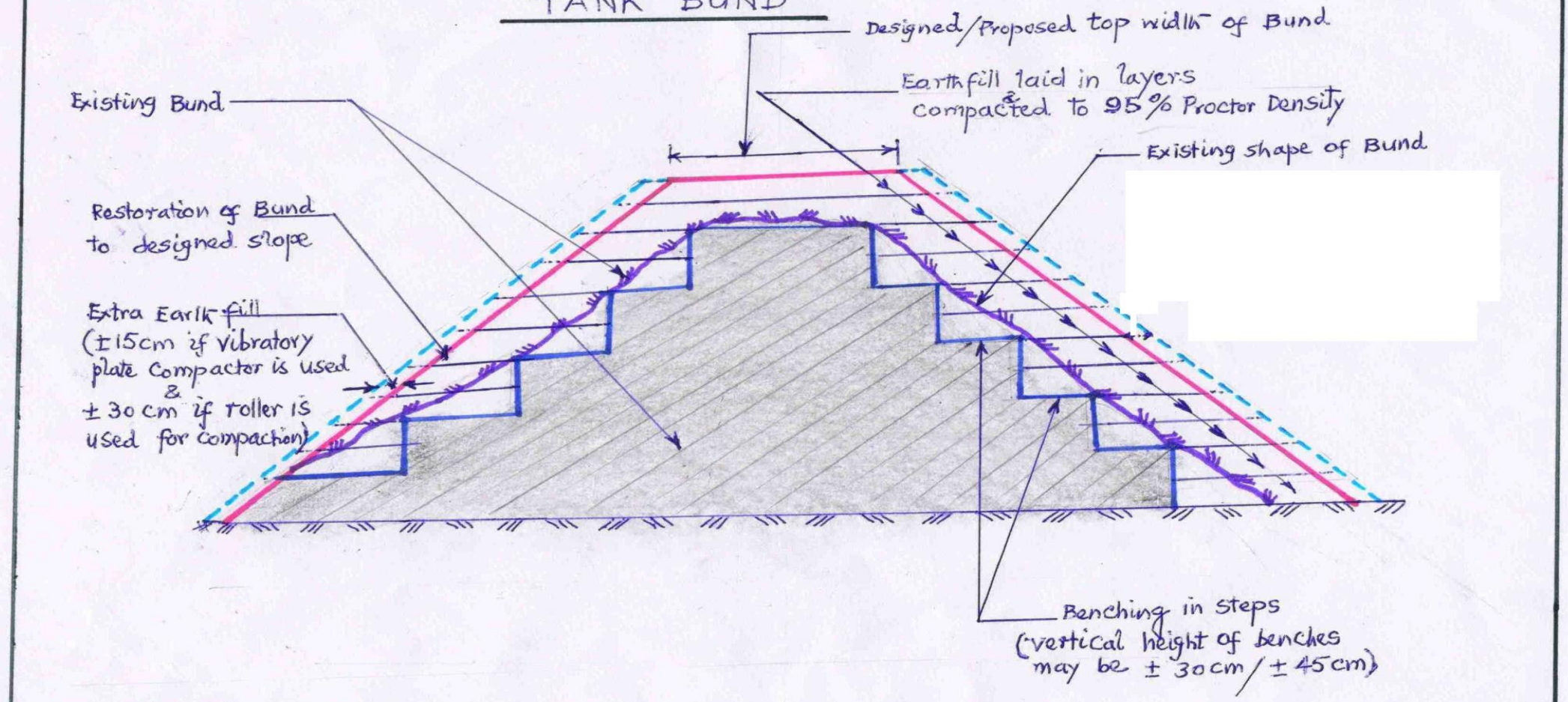
i) **Test and Frequency of Testing**

Test	Frequency
Standard Proctor Test	One test per day for individual Borrow Area
Field Density & Moisture content	One test for every 1500m3 of earthwork and at least one test in each layer laid on embankment

j) **Register to be maintained:** A register shall be meticulously maintained to list the above tests and the test results including the actual compaction efficiency obtained in each layer. It shall also list the results of 'grain size analysis' on classification of soils indicating the type of soils determined to be suitable for placement in the earth fill.

TYPICAL SKETCH

RAISING & STRENGTHENING OF TANK BUND



1.2 General Guidelines for Embankment Section

TABLE 1 GENERAL GUIDELINES FOR EMBANKMENT SECTIONS

(Clause 5.1.2.3)

Sl No.	Description	Height Up to 5 m		Height Above 5 m and Up to 10 m		Height Above 10 m and Up to 15 m	
i)	Type of section	Homogeneous section/Modified homogeneous section		Zoned section/Modified hemogeneous section/Homogeneous section		Zoned section/Modified homogeneous section/Homogeneous section	
ii)	*Slopes*	*Upstream*	*Downstream*	*Upstream*	*Downstream*	*Upstream*	*Downstream*
	a) Coarse grained soil (GW, GP, SW, SP)	Not suitable		Not suitable		Not suitable for core Suitable for casing zone	
	b) Coarse grained soil (GC, GM, SC, SM)	(H) (V) 2 : 1	(H) (V) 2 : 1	(H) (V) 2 : 1	(H) (V) 2 : 1	Section to be decided based upon the stability analysis in accordance with IS : 7894-1975	
	c) Fine grained soil (CL, ML, CI, MI)	(H) (V) 2 : 1	(H) (V) 2 : 1	(H) (V) 2·5 : 1	(H) (V) 2·25 : 1	do	
	d) Fine grained soil (CH, MH)	(H) (V) 2 : 1	(H) (V) 2 : 1	(H) (V) 3·75 : 1	(H) (V) 2·5 : 1	do	
iii)	Hearting zone	Not required	—	May be provided		Necessary	
	a) Top width		—	3 m		3 m	
	b) Top level		—	0·5 m above MWL		0·5 m above MWL	
iv)	Rock toe height	Not neccssary up to 3 m. Above 3 m height, 1 m height of rock toe may be provided		Necessary $H/5$, where H is the height of embankment		Necessary $H/5$, where H is the height of embankment	
v)	Berms	Not necessary		Not necessary		The berm may be provided as per design. The minimum berm width shall be 3 m. The berm may be provided also on the downstream slope for facilities during maintenance.	

GW - well graded gravel GP - Poorly graded gravel SW - well graded sand SP - poorly graded sand --- GC - clayey gravel GM - silty gravel SC - clayey sand SM - silty sand	CL - Inorganic clays of low medium plasticity (lean clays) ML - Inorganic silts & very fine sands with slight plasticity CI - Inorganic Clays & silty clays of medium plasticity CH - Inorganic clays of high plasticity (Fat Clays). Expansive Soils MH - Inorganic Silt(Elastic Soils)

1.3 REQUIREMENT OF SOIL PARAMETERS FOR EMBANKMENT SUITABILITY

A) ALLOWABLE LIMITS

Sl. No.	Details	Casing Zone (SPZ)	Hearting Zone (IPZ)	Unsuitable
1.	Clay content	10-20%	25-40%	>40%
2.	Liquid Limit	25%	25.50%	>50%
3.	Shrinkage	>10	>10	<10
4.	Compact Density (Kg/m3)	1920-2000	1760-1920	<1760
5.	Optimum Moisture Content	6-12%	12-18%	>18%
6.	Cohesion (Kg/m2)	1000-2000	2000-4000	<1000
7.	Angle of internal friction	200-300	120-200	<120
8	Permeability (cm/sec)	10-3to10-5	10-6to10-8	>10-3

B) GENERAL GUIDELINES FOR SELECTING THE SOIL

Sl. No.	Requirements	Semi pervious Suitability (Casing Zone)	Impervious Suitability (Hearting Zone)
1.	Clay content	Upto 20% (GM SM)	25 to 4% SC,CL,CI.
2.	Maximum Dry Density	More than 1920 Kg/M3	1680-1920 Kg/M3
3.	Permeability	>0.30m/year (10-3cm/sec to 10-6 cm/sec)	<0.30m/year (10-6 cm/sec to 10-8cm/sec)
4.	Shear Cohesion	3900Kg/M2	4880Kg/Mm2
	Angle of Friction	150	200
5.	Free swell	<50	<50

Compaction Requirement:

95% of compaction for casing

90% of compaction for hearting

CRITERIA FOR SELECTING SOIL FOR HOMOGENEOUS SECTION OF EARTHEN BUND

SUITABLE SOIL FOR SMALL HOMOGENEOUS DAM

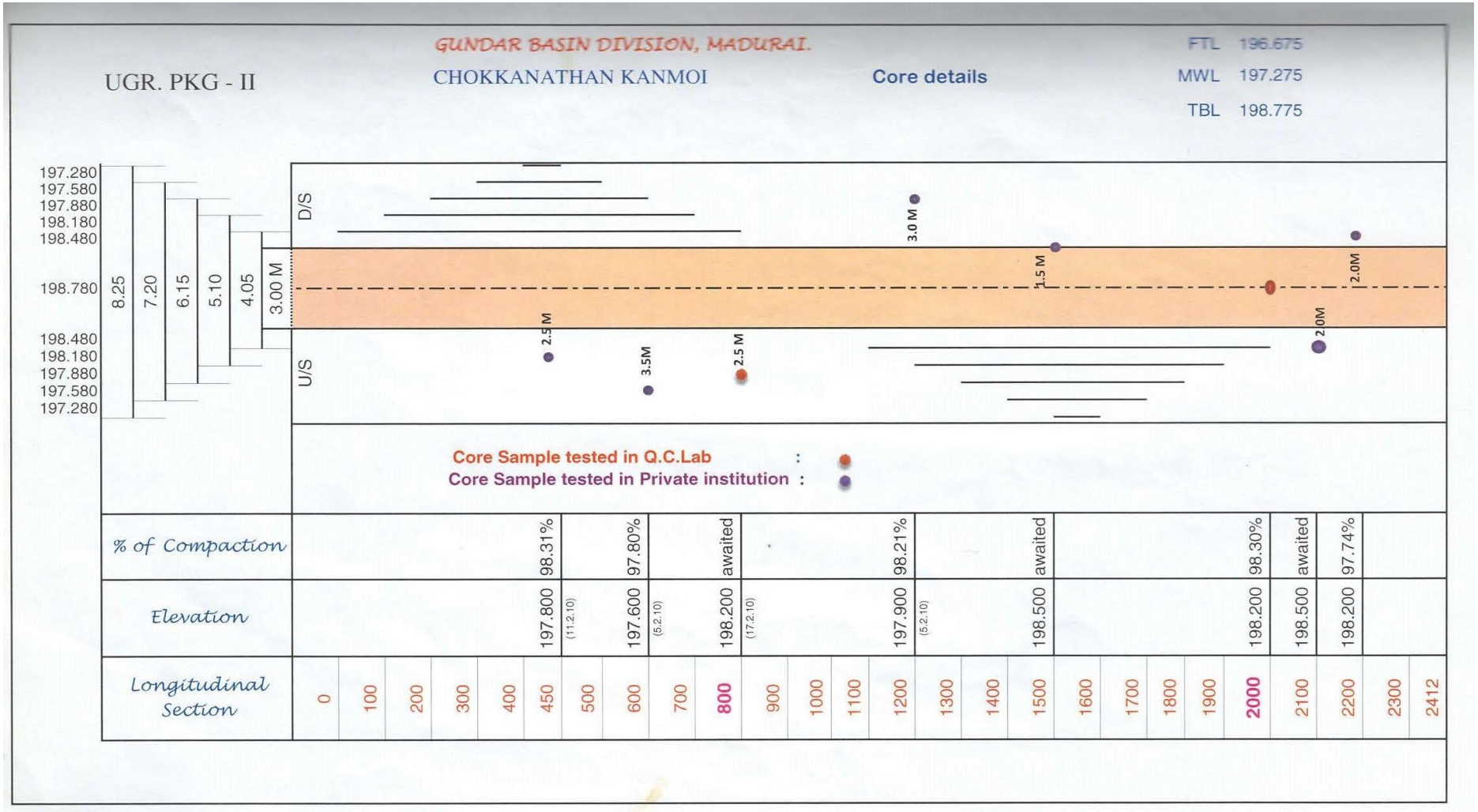
Soil Type	:	SC, SM, CL.
Range of values for different properties:		
Clay content	:	20-25%
Compact Density	:	1.76 – 2.0 gm/cc

SHEAR PARAMETER:

Cohesion	:	0.3 – 0.4 kg/cm2
Angle of Friction	:	180 - 200
Permeability coefficient	:	10-5 to 10-6 cm/sec

SC	:	Sand Clay mixture (Clayey Sand)
SM	:	Sand Silt mixture (Silty Sand)
CL	:	Clay of Low Plasticity
		(Inorganic Clay of low medium plasticity lean clays)

1.4 The typical chart showing the location of core samples taken from the tank bund



1.5 Procedure for Determining Percentage of Compaction Using Rapid Moisture meter

Collection of Soil Sample and Determination of Maximum Lab Dry Density

1. Prior to the Execution of Work Soil Sample should be taken in presence of quality control staff at various locations in tank and it should be submitted to quality control lab to check the soil suitability and Maximum Lab Dry Density (D lab)

2. Determination of water content using Rapid Moisture meter
   - 2.1 Set the Balance
   - 2.2 Take 6 grams of soil in the pan (The balance is pre-loaded to indicate level with index mark when 6 grams of soil is placed)
   - 2.3 Unclamp the instrument
   - 2.4 Place steel balls and one scoopful of absorbent (calcium carbide)
   - 2.5 Transfer the weighted soil from pan to cup
   - 2.6 Clamp the cum and shake the unit up and down vigoursly for 15 seconds vertically
   - 2.7 Hold it horizontally and rotate it for 10 seconds
   - 2.8 Repeat for 4 to 8 min till the gauge reading (m) becomes constant
   - 2.9 Moisture content W = m/(100-m)

3. Determination of Field Wet Density
   - 3.1 Take Earth core using core cutter
   - 3.2 Note Weight of core (wt) in grams and height of core (h) in cms
   - 3.3 Field Wet Density (D) = wt/78.5h

4. Determination of Field Dry Density

   Field Dry Density (D field) = D/1+W

5. Determination of % of Compaction

   % of Compaction = (D field) x 100/(D lab) ≥ 95

2. Rehabilitation of Irrigation Sluices

- The existing irrigation sluices, whichever are seriously damaged, are to be dismantled and reconstructed.
- The moderately damaged sluices shall be appropriately repaired.
- In both cases, the embankment shall need to be cut open on either side of the barrel to expose the whole length of sluice barrel.
- CDO shall issue designs / drawings of the irrigation sluices required to be reconstructed.

a). Specifications / Methodology

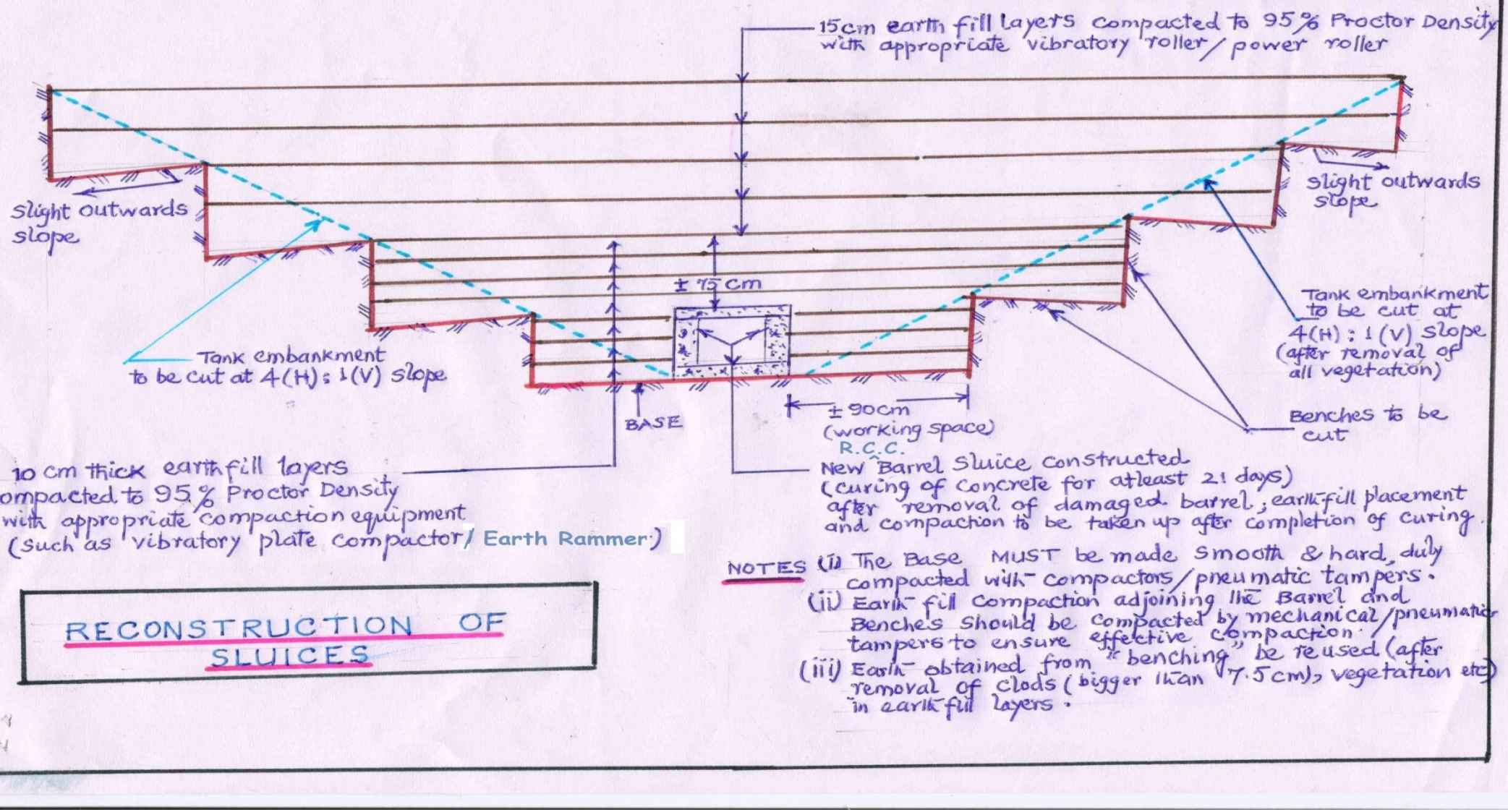
- The earthen embankment on either side of the sluice barrel / barrels shall be cut open at a slope not steeper than 4(H):I(V), in such a way that a convenient working space (+0.90m in width) is made available at the sluice level on either side of the barrel.
- After the severely damaged barrel/barrels is / are dismantled, the base shall be cleared and compacted with mechanical compactor
- The barrel/barrels reconstructed as per drawing
- The masonry walls and top concrete slab shall be cured for 28 days.
- The excavated slopes shall be stripped to a depth of 7.5cm and then cut in suitable benches (+45cm x 45cm) before the open cut portion of the embankment is taken up for filling up with approved soil in layers duly compacted.
- Soil shall be laid in layers not more than 15 cm thick, moistened, and compacted with mechanical tampers (fuel-operated compactor / pneumatic tampers) to specified density till the fill placement comes up to a level 90cm above the top slab of the barrel.
- The soil shall be laid in 25cm thick layers, moistened to OMC, and compacted to specified density with a power roller till the top level of embankment is reached or continued to be compacted with 15 cm thick layer with mechanical compactor if power roller is not to be used or

alternatively the compaction to the specified density are to be carried out with Dozer Tractor.

- The above specification / methodology shall also be adopted for carrying out repairs to the existing sluice barrel / barrels, except that the curing of repaired masonry shall be for 14 days. Also the approach channel to sluice shall be properly lined with R.R. Masonry.

Note: For expediting the replacement of existing damaged sluices (Which required to be reconstructed) feasibility of providing hume pipe barrel / barrel should be considered by SE (Designs) / C.E.(DR&CS) as alternative to the WRO proposed methodology of construction of masonry side wall with top slab of RCC This will afford a significant time saving method.

TYPICAL SKETCH



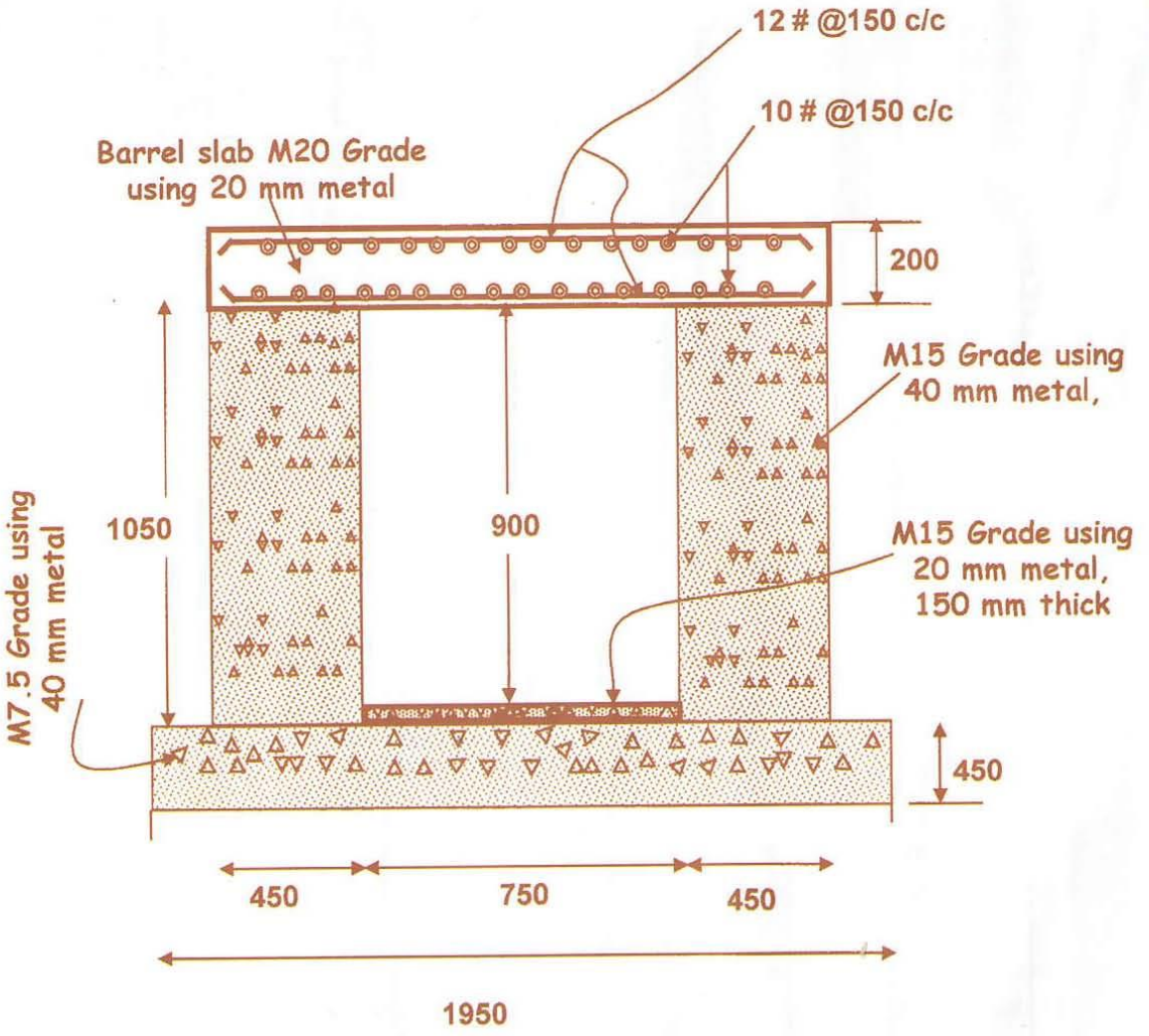
RECONSTRUCTION OF SLUICES

NOTES (i) The Base MUST be made smooth & hard, duly compacted with compactors / pneumatic tampers.

(ii) Earth fill compaction adjoining the Barrel and Benches should be compacted by mechanical / pneumatic tampers to ensure effective compaction.

(iii) Earth obtained from "benching" be reused (after removal of clods (bigger than 7.5 cm), vegetation etc) in earth fill layers.

TYPICAL CROSS SECTION OF SLUICE BARREL



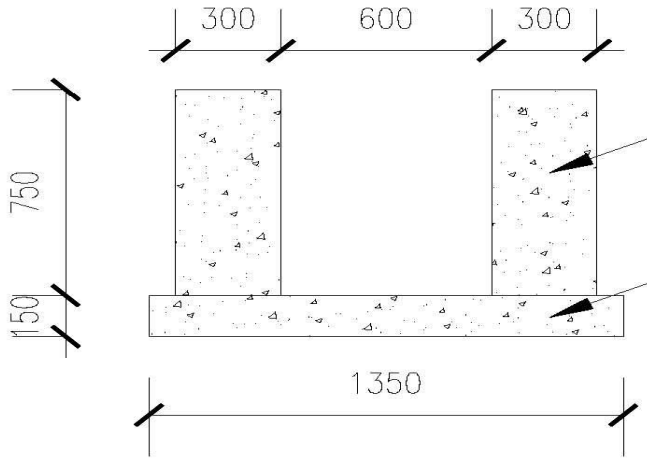
Nominal cover to steel reinforcements = 30 mm

ALL DIMENSIONS ARE IN MM

Note:

Nominal cover to steel reinforcements should not deviate from the specified cover of 30 mm by +10 mm & -0 mm

TYPICAL CROSS SECTION OF LINED IRRIGATION CHANNEL

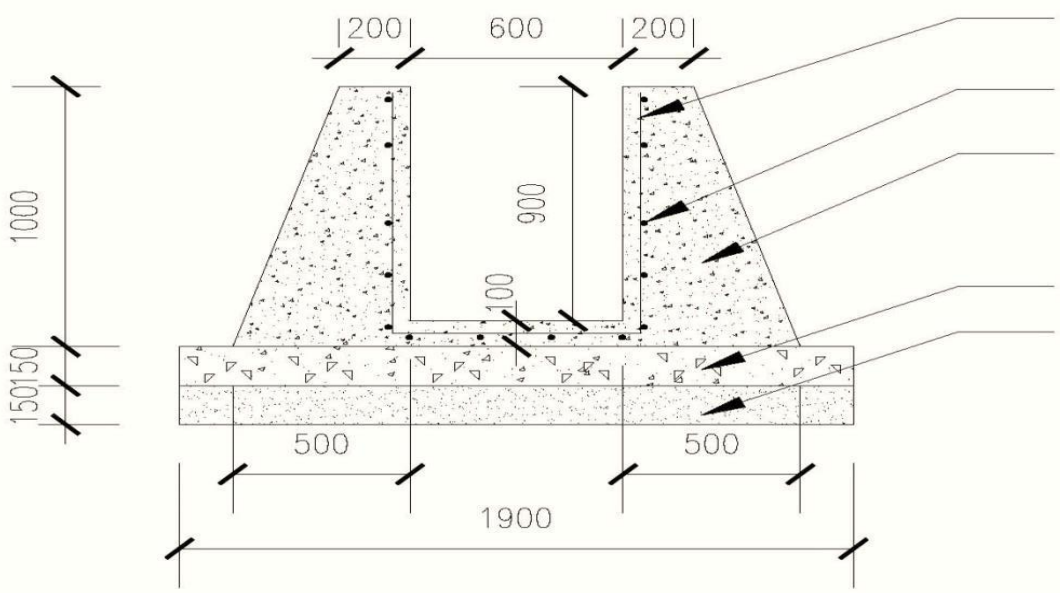


Note:—

Incase the site conditions necessitate increase the Channel sectionreqisite modifications be made there—in duly ensuring the stability section

All Dimensions are in mm

LINING OF IRRIGATION CHANNEL
TYPICAL CROSS SECTION
FOR BLACK COTTON SOIL



Main Rod 8mm @ 200mm c/c

Distributor Rod 6mm @ 300mm c/c

CC M15 Using 20mm aggregate

CC M7.5 using 40mm aggregate

Sand filling

Note:–

1. This section to be used in Black cotton soil.
2. Soil samples to be got tested for swell pressure and adequacy of channel section provided to be checked before adoption.
3. Nominal cover to steel reinforcements = 30 mm

All Dimensions are in mm

3. Repairs of Surplus Weirs

The surplus weirs are reported to suffer from one or a combination of the following types of damages:

Damage to pointing of joints in the body wall; leakages through the bottom of weir and leakages through the body wall of weirs; pot holes in the solid apron; and damage to the talus portion etc. Board guidelines on repairs to these damages are outlined below:

a) Damage to Pointing of Joints

Specifications

- All loose mortar shall be removed from the affected joints.
- Raking of all such joints shall be done to a depth of atleast 20mm
- The joints shall be thoroughly cleaned with water (or air jet)
- The cement-sand-water mortar of specified grade required consistency (90-110 mm) shall be prepared, preferably, in a small mixer or alternatively prepared on a smooth water tight platform making sure that no foreign material gets mixed with mortar nor the mixing water flows out. (dry sand and cement shall be mixed thoroughly by turning over to get a mixture of uniform colour; Water shall then be added gradually and mixing continued until mortar of required consistency of 90 to 110 mm is obtained.)
- Keep the cleaned up and raked up joints moist for about 2 to 3 hours before filing these with the wet mortar.
- Ensure that the wet mortar is used to fill up the joints within 30 minutes of its mixing.
- Proper Pointing of joints be done.
- Curing of the joints shall be done for 7 days.

b) Leakages through Weir

In case the weir suffers from appreciable leakages from the body wall, it shall be repaired either through external plastering or construction of skin wall of concrete to the upstream body wall of weir.

- **External plastering – Specifications:** After the hollow joints in masonry are duly filled up as per guidelines outlined in (a) above, these shall be kept moist (viz) cured for 72 hours) and the following steps taken to apply external plastering.
  - Roughening of surface of body wall shall be done to improve the bond of plaster.
  - The surface shall be moistened sufficiently.
  - Plaster of specified thickness and of specified grade shall than be applied to the surface from top and worked down. The mortar shall be stiff enough to the surface and hold when laid.
  - At the end of the day, the plaster shall be kept in a clean horizontal or vertical line.
  - When recommencing the work on next day, the edges of old plaster shall be scrapped clean and wetted and treated with cement slurry before the new plaster is laid adjacent to it.
  - Water-curing of plastering shall be done uninterruptedly for 7 days.
  - Any cracks which appear on the surface and all such portions which sound hollow when tapped or found soft or otherwise defective shall be cut in rectangular shape and redone.

- **Concrete Skin Wall**

Provision of concrete skin wall shall provide a water-tight barrier and stop all leakages through the weir, Typical construction of this wall is illustrated in figure and its salient features are outlined below:-

Grade of concrete	:	M20 (with 20mm maximum size of aggregate)
Thickness of concrete	:	200mm (150mm for smaller heights, say upto 1.5m)
Thickness of concrete	:	300mm (200mm for smaller heights) at bottom
Reinforcement in skin wall	:	8mm dia at 200mm centres in both directions
Anchor bars	:	16mm dia

The skin wall shall be anchored with top of weir by removing the top one layer of existing stone. The wall is to be taken below upstream ground level/apron level to a depth of 450mm (or 600mm) and width of 600mm (or 900mm) throughout the length of weir, depending upon the height of weir. The shape of crest shall not be changed

➢ **Specifications for construction of concrete skin wall**

- Joints in the existing masonry shall be raked to a depth of at least 20mm
- Roughen the surface through manual chipping or pneumatically operated tool.
- Keep the surface, after raking of joints and roughening of surface wet for 72 hours, prior to placement of skin concrete (M 20)
- A coat of cement slurry with cement – mortar mix (1:2.5) with water – cement ratio of 0.70 shall be applied over the masonry surface, with joints thoroughly packed
- 50mm dia holes shall be drilled in the masonry and the holes cleaned by air-water jet.
- Cement – sand mortar (1:2) with water cement ratio of about 0.33 shall be pushed into the drill holes while the holes while the holes are still wet after cleaning. Then 16mm dia steel anchors be pushed in. Drill holes for anchors shall have an inclination of 5 degrees with the horizontal downwards into the body wall.
- Concrete placement shall be done in convenient lifts and deploying good shuttering. Slump of concrete shall be in the range of about 50mm and needle vibrators used for consolidation.
- Curing of concrete wall be done for 21 days.

  Note: In cases where the leakages are through the bottom of weir, the provision of skin wall shall not be taken to the full height of the weir, but shall be restricted to about 0.60m to 0.7m. Fine – tuning or any modifications if considered necessary be got done through CDO.

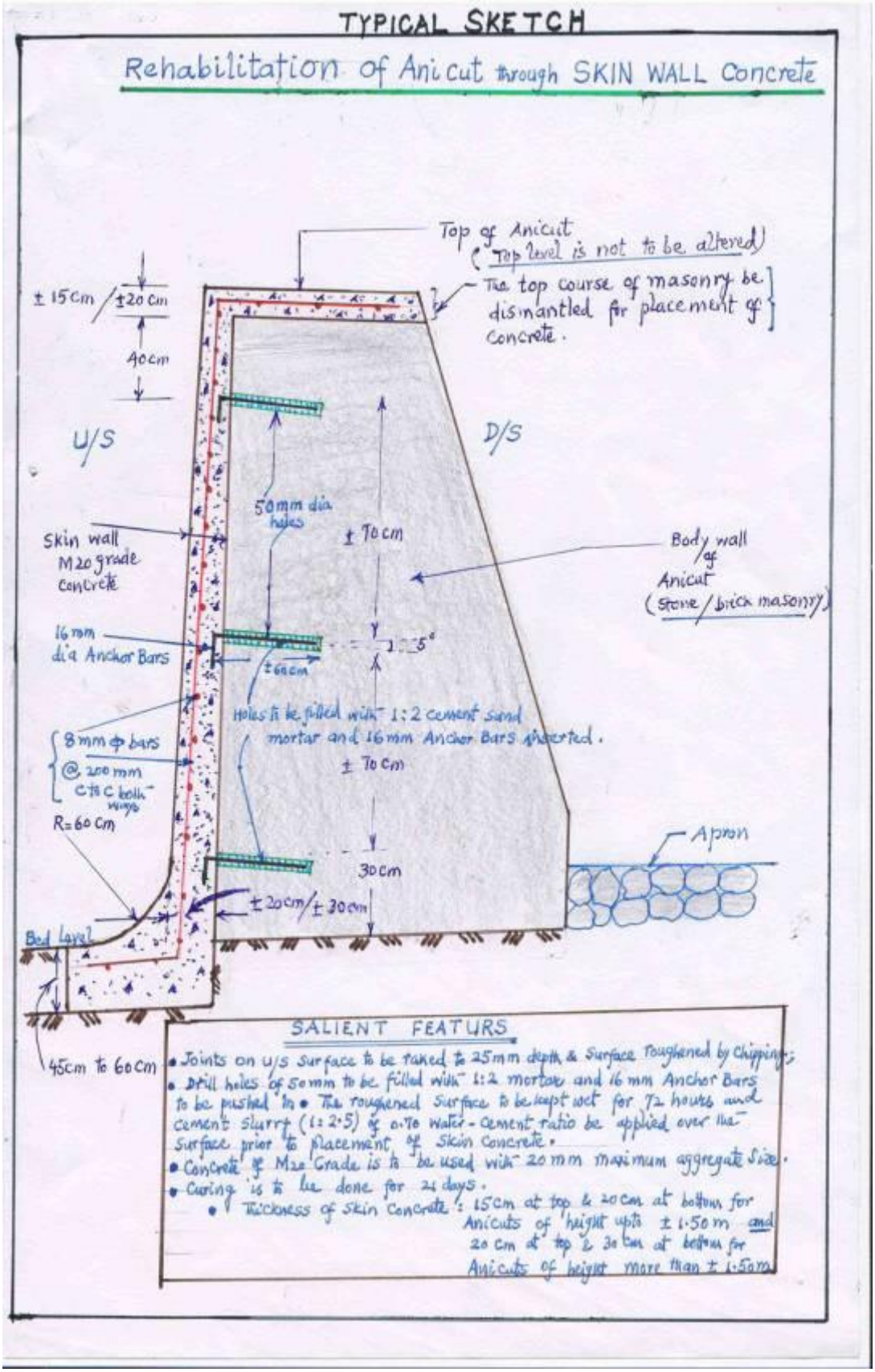
c. Damage to Apron

In case the damage to the apron consists of only few pot holes and the rest of the apron is generally alright, the pot holes shall be cleaned and the sides chipped wherever necessary and then filled up with plain cement concrete of M 7.5 grade (equivalent to 1:4:8) duly consolidated.

Note: Approach channels to Irrigation Sluices shall be adequate Sections duly lined.

TYPICAL SKETCH

Rehabilitation of Anicut through SKIN WALL Concrete



SALIENT FEATURS

- Joints on u/s surface to be raked to 25 mm depth & Surface roughened by Chipping.
- Drill holes of 50 mm to be filled with 1:2 mortar and 16 mm Anchor Bars to be pushed in.
- The roughened surface to be kept wet for 72 hours and cement slurry (1:2·5) of 0.70 water-cement ratio be applied over the surface prior to placement of Skin Concrete.
- Concrete of M20 Grade is to be used with 20 mm maximum aggregate size.
- Curing is to be done for 21 days.
- Thickness of skin Concrete: 15 cm at top & 20 cm at bottom for Anicuts of height upto ± 1.50 m and 20 cm at top & 30 cm at bottom for Anicuts of height more than ± 1.50 m

4. Rehabilitation of Supply Channel / Canals:

a. **Design of Irrigation Channel:** The actual re-sectioning and strengthening of the channels be based on 1 (H) : 1 (V) slopes from overall consideration of slope stability. In sandy / predominating sandy reaches provision for flatter slopes 1.5(H) : 1 (V) be made in DPR or provision for masonry or concrete walls (as considered economical) be made in vulnerable reaches.

b. **Placement of cast-in-situ CC Lining in select reaches in the supply channels:**

The requisite for CC lining:

- Thickness of Cement Concrete Lining = 10 cm
- Grade of concrete for CC lining = M15
- Cement level in the lining concrete mix = Minimum 250 kg / m3 concrete
- Maximum size of coarse aggregate in concrete mix =20 mm
- Water – Cement Ratio =0.55
- Transverse contraction joints =At 3.0m spacing in cc lining
- Side slopes of channels for placement of CC lining =1.5 (H) : 1.0 (V)
- Length of top horizontal key / lug =30cm
- Transverse contraction joints to be filled with approved sealing compound.

➢ In case of placement of cc lining in the channels passing through the swelling black cotton soils (BC Soils), provision of CNS (cohesive non swelling soil) treatment of the sub grade is most essential prior to placement of lining, as per Indian Standard IS 9451 : 1994 summarized below:

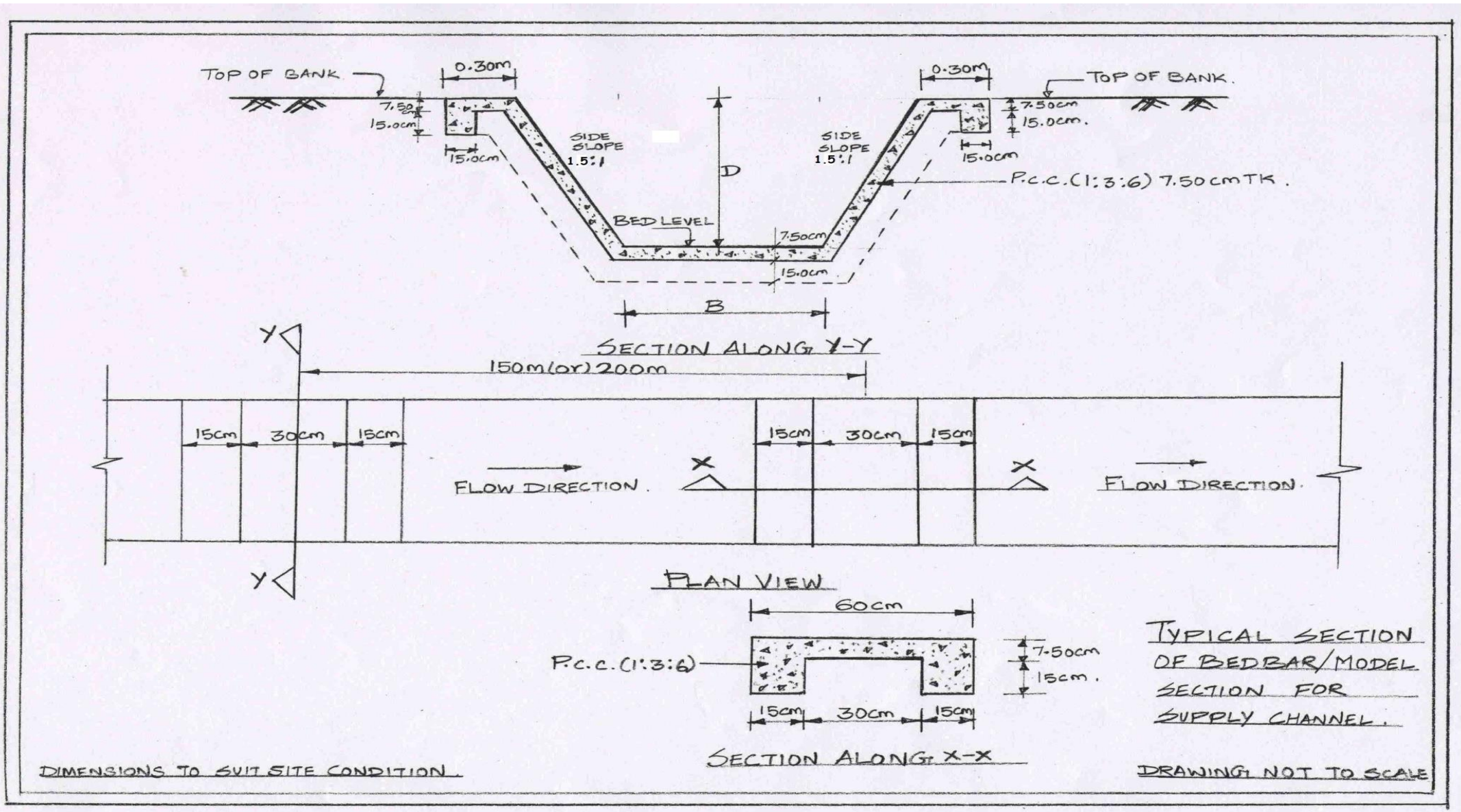
Table 1A: Thickness of CNS Layer, Carrying Capacity Less Than 2 Cumecs (70 cusecs)

Discharge in Cumecs	Thickness of CNS Layer in cm (Min)	
	Swell Pressure 50-150 kN/m2 (0.50-1.5 kg/cm2)	Swell Pressure more than 150 kN/m2 (1.5 kg/cm2)
1.4-2 (50-70)	60	75
0.7-1.4 (50-25)	50	60
0.3-0.7 (10-25)	40	50
0.03-0.3 (1-10)	30	40

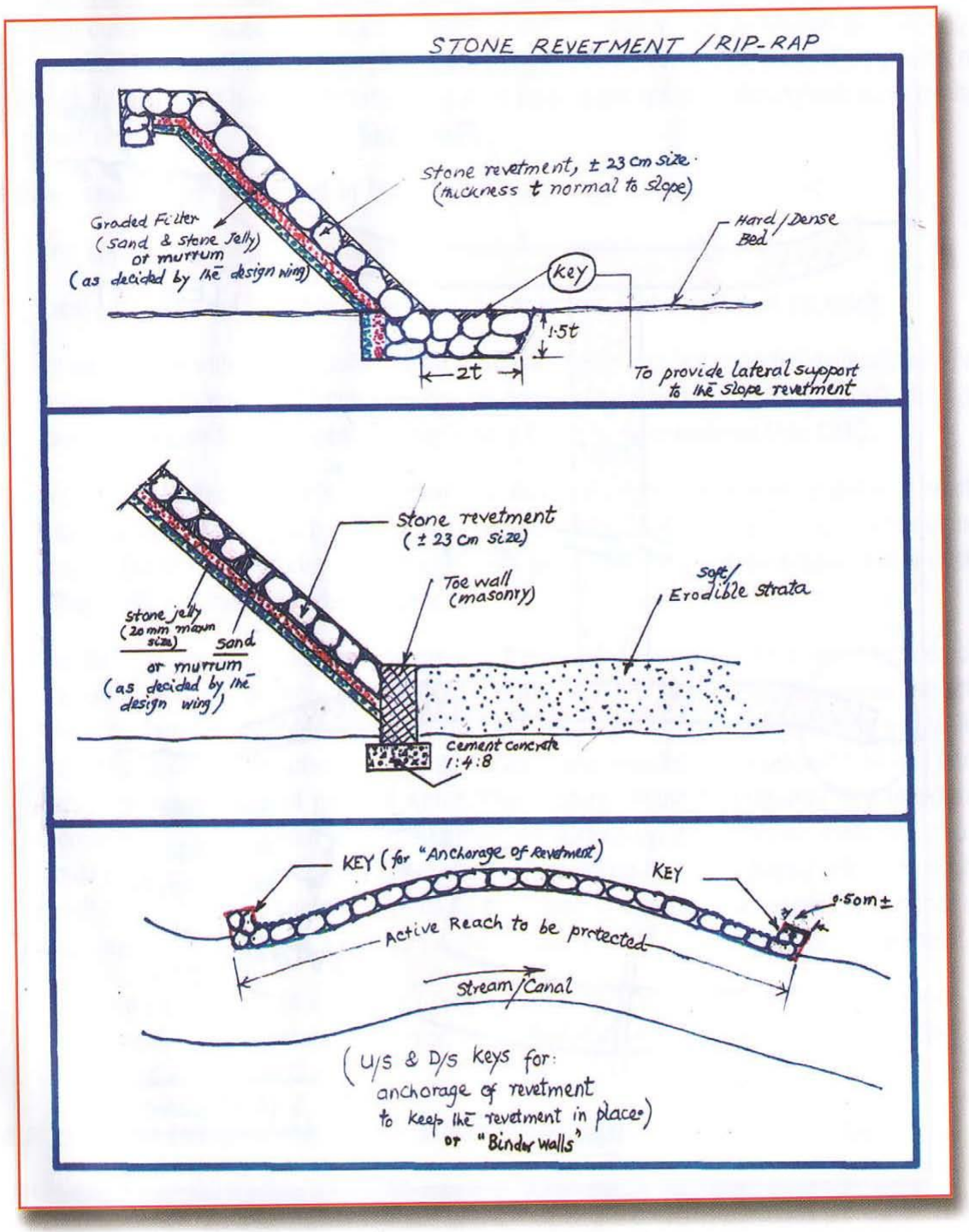
Table 1B Thickness of CNS Layer, Carrying Capacity of 2 Cumecs and More

Swelling Pressure of Soil kN/m2	Thickness of CNS Materials cm (Min)
50 to 150 (0.50-1.5kg/cm2)	75
150 to 300 (1.50-3.0 kg/ cm2)	85
300 to 500 (3.00-5kg/ cm2)	100

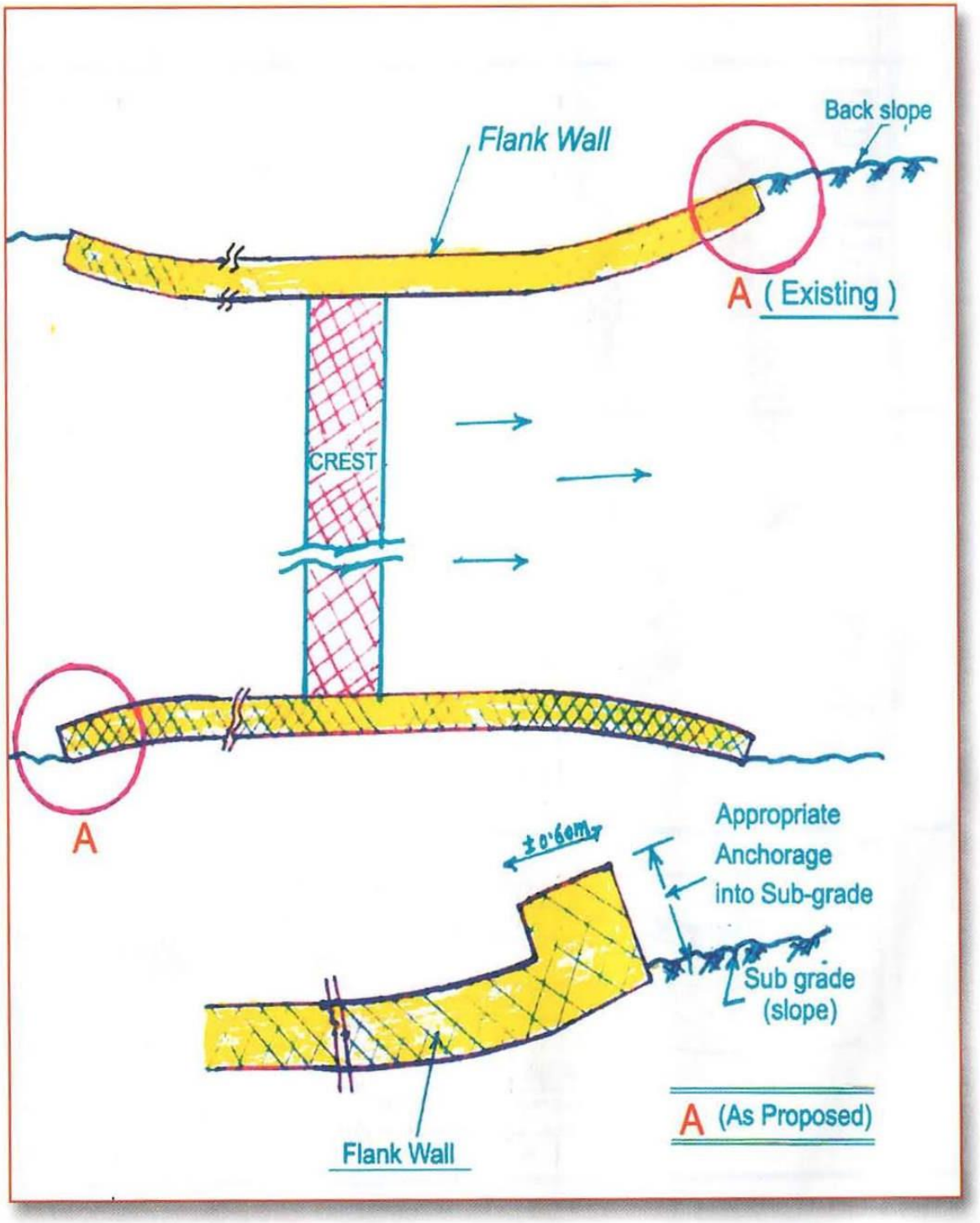
- **Bed bars / Model Sections in channels:** *The functional requirement of model sections being to provide "profile walls", the existing provisions of model sections in the unlined irrigation channels should be modified to the extent indicated below:*
  - M10 grade concrete be provided instead of M15 grade concrete.
  - 7.5 cm thick concrete lining, 30 cm in width, and incorporating cut-off walls on either side, 15cmx15 cm, (making a total width of 60 cm) homogenous with the CC lining (to avoid undermining of lining during canal flow) be provided instead of 10 cm thick lining.
  - The provision of 15 cm thick sand layer between the sub grade and lining be deleted.
  - The provision of top horizontal key / lug be restricted to 30 cm length instead of 100 cm length presently provided.
  - In order to be effective the spacing of bed bars / model sections be, preferably, kept as 150 m ± to 200 m ± instead of 500 m spacing.
  - Hard and smooth sub grade to the specified shape/ dimensions has to be prepared prior to placement of cement concrete lining.


TOP OF BANK
0.30m
7.50cm
15.0cm
15.0cm
SIDE SLOPE 1.5:1
D
BED LEVEL
7.50cm
15.0cm
B
SIDE SLOPE 1.5:1
0.30m
TOP OF BANK.
7.50cm
15.0cm.
15.0cm
P.C.C.(1:3:6) 7.50cm TK.
SECTION ALONG Y-Y
Y
150m(or)200m
15cm
30cm
15cm
FLOW DIRECTION.
X
X
FLOW DIRECTION.
Y
PLAN VIEW
60cm
P.C.C.(1:3:6)
7.50cm
15cm.
15cm
30cm
15cm
SECTION ALONG X-X
TYPICAL SECTION OF BEDBAR/MODEL SECTION FOR SUPPLY CHANNEL.
DIMENSIONS TO SUIT SITE CONDITION.
DRAWING NOT TO SCALE

ANCHORAGE FOR STONE REVETMENT / RIP RAP - KEY & TOE WALL



ANCHORAGE OF FLANK WALL ENDS



5. Measuring Structures / Devices:

CONSTRUCTION OF FLOW MEASURING DEVICES IN IRRIGATION CHANNELS.

An efficient irrigation system requires provision of flow measuring devices in canals, channels and distribution system. Measuring devices ensure that design discharge is flowing in the system and, that, the farmers receive their authorized share of water. There are 3 types of flow measuring devices such as Cut Throat Flume; Parshall Flume; and V-Notch. V-Notches are generally used to measure small discharges like seepages from drains and galleries of dams and toe drains. V-Notches can measure discharges from 1 lit/sec to 120 lit/sec. A V-Notch has its own limitation and due to obstruction of silt, it is not suitable for field channels discharge measurements. The Cut Throat Flumes and Parshall Flumes offer reliable and efficient measuring devices. Normally, a Cut Throat Flume is used for measuring the flow discharge ranging from 0.30 cusec to 80 cusec (2.265 cumec) and the Parshall Flume beyond 80 cusec.

CUT THROAT FLUME (CTF) , The Cut Throat Flume (CTF) is a flat bed structure consisting of only a 'converging inlet section' and a 'diverging outlet section' to measure the discharge of flowing water in hydraulic channels. Since the flume has 'zero throat length' this device is named as 'cut throat' or 'throat less flume'. Three dimensions are required to completely specify the geometric parameters of cut throat flume. The most important dimension is the throat width (W); secondly, the flume length (L); and finally, the height of flume walls (H). **Sketch 12 in Annex-3** depicts the cut throat flume features, like: converging inlet section & its length, diverging outlet section & its length, throat width, respective widths at the entry and exit of converging inlet and diverging outlet sections, splays of converging inlet and diverging outlet sections, and location of measuring gauge in the converging and diverging section.

Photo Copy P 12 in Annex-3 depicts the views of Cut Throat Flumes installed in the channels.

Location of Cut Throat Flume. (i) Cut Throat Flume should be located in a straight section of the channel and placed level in the channel (ii) The flume should be aligned straight with the channel and is to be level longitudinally and laterally (iii) The flow of the channel should be turbulent free.

It is preferable to have CTF operated under free flow conditions. It should not be installed in a curved reach of the channel. *Following requirements shall also be fulfilled* :

Capacity in cusec	Min. straight reach in U/S & D/S side of flume	Min. flume distance from controlling gate	Min. lining required in U/S & D/S side of flume
1 to 4 cusecs	2 to 3 meters	2 to 3 meters	1 to 1.5 meters
5 to 20 cusecs	4 to 5 meters	5 to 10 meters	1.5 to 2 meters

Design Of CUT THROAT FLUMES (CTF). Designs of CTF of various capacities are given below:

1.Construction of Cut Throat Flume (CTF) for *1 Cusec Capacity* in Irrigation Channel d/s of Sluice in Tank Bund.

Design Details of Irrigation Channel.

(i)	Design Discharge	: 0.64 cusec (0.018 cumec)
(ii)	FSD	: 200 mm (0.20 m)
(iii)	Free Board (FB)	: 150 mm (0.15 m)
(iv)	Bed Width	: 400 mm (0.40 m)
(v)	Bed Slope	: 1 in 2800
(vi)	Channel Bed Level (CBL)	: 23.500 m
(vii)	FSL (Full Supply Level)	: 23.700 m
(viii)	Top Bank Level (TBL)	: 23.850 m

Calculations for Selection of Flume Size and Setting of Hump.

Step No.1. Select Flume size for 1 cusec / 0.028 cumec (28 litres / sec) *from* **Table A / Table C in Annex-3 (Designed for 1 Cusec)**

W = 20 cm (0.20 m); L = 90 cm (0.90 m); L1 = L / 3 = 30 cm (0.30 m); L2 = 2L/3 = 60 cm (0.60m)

H (from Table A) = 30 cm (0.30 m) or 300 mm.

Step No. 2. For Q max (28 litr/sec) & Flume Size (20 x 90 cm), find Ha *from* **Table A / Table C in Annex-3** for free flow condition: **Ha** = 17 cm = 0.17 m (170 mm)

Step No. 3. Find Max value of Hb for free flow to occur. Hb = Ha x submergence limit for flume section of 20 cm x 90 cm.

Submergence Coefficient for the Flume of 90 cm length for free flow condition is 65.3 % *from* **Table B in Annex-3.** Thus, Max value of **Hb** = 0.17 x 0.653 = 0.11 m = 11 cm (110 mm)

Step No. 4. **Hump** = FSD – Hb = 0.20 m – 0.11m = 0.09 m (90 mm)

Step No. 5. Depth of flow in upstream of the Flume will be:

= Ha + Hump = 0.17 m + 0.09 m = 0.26 m

Step No. 6. **Afflux** caused by the Flume will be:

= Upstream Depth - FSD = 0.26 m – 0.20 m

= 0.06 m. *This is less than the Free Board of 0.15 m; Hence, O. K.*

Drawing of this Cut Throat Flume of 1 Cusec Capacity is enclosed as D 1 in Annex – 3.

2. Construction of Cut Throat Flume (CTF) for *2 Cusecs Capacity* in Irrigation Channel.

Design Details of Irrigation Channel.

(i)	Design Discharge = 1.87 cusec = 0.053 cumec = 53 litres / sec	
(ii)	FSD	= 0.30 m
(iii)	Free Board (F.B)	= 0.15 m
(iv)	Bed width	= 0.60 m
(v)	Bed Slope	= 1 in 2800
(vi)	Channel Bed Level (CBL)	= 23.100 m
(vii)	Full Supply Level (FSL)	= 23.400 m
(viii)	Top Bank Level (TBL)	= 23.550 m

Calculations for Selection of Flume Size and Setting of Hump.

Step No. 1 Select Flume size for 0.057 cumec (57 litres/sec) *from* **Table A in Annex-3 (Designed for 2 Cusecs):**

W = 20 cm (0.20 m); L = 90 cm (0.90 m); L1 = L/3 = 30 cm (0.30 m); L2 = 2L/3 = 60 cm (0.60 m); and,

H (from Table A) = 35 cm (0.35 m)

Step No. 2. For Q max (57 lit/sec) & Flume Size (20 x 90 cm), find Ha required for free flow condition *from* **Table A / Table C in Annex-3: Ha =** 25 cm = 0.25 m (250 mm)

Step No. 3. Find max value of Hb for free to occur. Hb = Ha x Submergence limit for flume section 20 cm x 90 cm. Submergence Coefficient for flume of 90 cm length for free flow condition *from* **Table B in Annex-3** is 65.3 %.

Thus, **Hb** = Ha x 65.3 % = 0.25 x 0.653 = 0.16 m (160 mm)

Step No. 4. **Hump** = F.S.D - Hb

= 0.30 m – 0.16 = 0.140 m

Step No. 5. Depth of flow in the Upstream of the Flume will be :

= Ha + Hump = 0.25 m + 0.140 m = 0.390 m

Step No. 6. **Afflux** caused by the Flume will be:

= Upstream Depth – F.S.D.

= 0.390 m – 0.300 m = 0.090 m.

This is less than the Free Board of 0.150 m; Hence, O. K.

Drawing of this Cut Throat Flume of 2 Cusecs Capacity is enclosed as D2 in Annex-3.

3. Construction of Cut Throat Flume (CTF) for 7 *Cusecs Capacity* in Irrigation Channel.

Design Details of Irrigation Channel.

(i)	Designed discharge	: 6.89 Cusecs = 0.195 Cumecs = 195 Litres / Sec
(ii)	F. S. D. (Full Supply Depth)	: 0.50 m
(iii)	Free Board (F.B.)	: 0.30 m
(iv)	Bed Width	: 1.00 m
(v)	Bed Slope	: 1 in 3200
(vi)	Canal Bed Level (CBL)	: 6.400 m
(vii)	Full Supply Level (FSL)	: 6.900 m
(viii)	Top Bank Level (TBL)	: 7.200 m

Calculations for Selection of Flume Size and Setting of Hump.

Step No. 1. Select the Flume size for 0.198 Cumec (198 Litres/Sec) *from* **Table A / Table C in Annex-3 (Designed for 7 Cusecs).** *Flume Size will be* = 40 cm x 180 cm

W = 40 cm (0.40 m); L = 180 cm (1.80 m); L1 = L/3 = 60 cm (0.60 m); L2 = 2L/3 = 120 cm (1.20 m); and,

H (from Table A) = 50 cm (0.50 m).

Step No. 2. For Q max (198 Lit/Sec) and Flume Size (40 cm x 180 cm), find Ha required for free flow condition *from* **Table A / Table C in Annex-3** : **Ha** = 38 cm (0.38 m) or 380 mm.

Step No. 3. Find max value of Hb for free flow to occur. Hb = Ha x Submergence limit for 40 cm x 180 cm section. Submergence Co-efficient for Flume size 40 cm x 180 cm for free flow condition *from* **Table B in Annex-3** is 73.8 %.

Thus, **Hb** = Ha x 0.738 = 0.38 x 0.738 = 0.28 m (280 mm)

Step No. 4. Hump = F. S. D. - Hb

Hump = 0.50 m – 0.28 m = 0.22 m (220 mm)

Step No. 5. Depth of flow in the Upstream of the Flume will be:

= Ha + Hump = 0.38 m + 0.22 m = 0.60 m

Step No. 6. Afflux caused by the Flume will be:

= Upstream Depth – F.S.D.

= 0.60 m – 0.50 m = 0.10 m

Afflux (0.10 m) is less than Free Board (0.30 m); Hence, O. K.

Drawing of this Cut Throat Flume (CTF) of 7 Cusecs Capacity is enclosed as D3 in Annex-3.

4. Construction of Cut Throat Flume (CTF) for *4 Cusecs Capacity* in Irrigation Channel.

Design Details of Channel.

(i)	Designed Discharge	= 3.28 Cusecs = 0.093 Cumec = 93 Litres / Sec
(ii)	Full Supply Depth (F.S.D.)	= 0.35 m
(iii)	Free Board (F.B.)	= 0.15 m
(iv)	Bed Width	= 0.80 m
(v)	Bed Slope	= 1 in 3000
(vi)	Channel Bed Level (C.B.L.)	= 13.975 m
(vii)	Full Supply Level (F.S.L.)	= 14.325 m
(viii)	Top Bank Level (T. B. L.)	= 14.475 m

Calculations for Selection of Flume Size and Setting of Hump.

Step No. 1. Select Flume Size for 0.113 cumec (113 litres/Sec) *from* **Table A / Table C in Annex-3 (Designed for 4 Cusecs).** Flume size will be 20 cm x 90 cm.

W = 20 cm (0.20 m); L = 90 cm (0.90 m); L1 = L/3 = 30 cm (0.30 m); L2 = 60 cm (0.60 m); and,

H (from Table A) = 45 cm (0.45 m) or 450 mm.

Step No. 2. For Q max of 113 Litr/Sec & Flume Size of 20 cm x 90 cm, find Ha required for free flow condition *from* **Table A / Table C in Annex-3. Ha** = 0.36 m (360 mm)

Step No. 3. Find max value of Hb for free to occur. Hb = Ha x Submergence limit for section 20 cm x 90 cm. Submergence Co-efficient for Flume of 90 cm length *from* **Table B in Annex -3** is 65.3 %.

Thus, **Hb** = 0.36 x 0.635 = 0.24 m. (240 mm)

Step No. 4. **Hump** = Full Supply Depth – Hb = 0.35 m – 0.24 = 0.11 m (110 mm)

Step No. 5. Depth of flow in the Upstream of the Flume will be:

Upstream Depth = Ha + Hump = 0.36 m + 0.11 m = 0.47 m

Step No. 6. **Afflux** caused by the flume will be : Upstream Depth- Full Supply Depth.

Thus, **Afflux** will be = 0.47 m – 0.35 m = 0.12 m.

The Afflux of 0.12 m is just less than the Free Board of 0.15 m (Afflux is almost equal to the Free Board). It shall, therefore, be advisable to provide a Free Board of 0.30 m instead of the present provision of 0.15 m. Accordingly, the Top Bank Level (TBL) shall need to be increased from 14.475 m to 14.625 m.

Drawing of this Cut Throat Flume (CTF) for 4 Cusec Capacity (with a Free Board of 0.15 m) is enclosed as D4 in Annex-3. However, requisite changes shall need to be made in this drawing with the suggested increase in Free Board from 0.15 m to 0.30 m to cater to the afflux, as brought out above.

Construction of Cut Throat Flumes (CTF). Salient action points for the construction of Cut Throat Flumes are outlined below:

- The existing ground is first leveled using a spade and spirit level both longitudinally and transversely. The spirit level is placed at different points so as to remove the high and low spots in order to level the ground. There after, the flume is constructed in concrete. The bottom and top of flumes are to be ensured for horizontality.
- It shall be desirable to place a 'steel angle' at the throat section and embed it in concrete.
- Smooth finish inside the flume walls is to be ensured.
- Once the flume is constructed, its sides should be connected with the channel banks and sealed with proper material which should be intact with the channel banks and flume.
- The " painted gauges" should be set vertically at the specified locations: a staff gauge at 2L/9 upstream of the throat in the converging inlet for measurement of Ha and the other gauge at 5L/9 downstream of throat in the diverging outlet for measurement of Hb.

Maintenance of Cut Throat Flumes (CTF). Salient action points for the maintenance of Cut Throat Flumes are outlined below:

- Any debris which may have collected on the flume floor should be removed.
- Any moss which may have collected on the flume walls should be removed.
- Flume walls may become encrusted and the encrustation should be removed with a steel wire brush.
- After a few months of operation, and at the end of the season or year, it shall be desirable to check the flume bottom to be sure that it is still level.
- Flumes may 'settle' or tilt sideways due to improper construction or the flume operation. Accordingly, CTF should be constructed under strict supervision. The usual place for settlement to occur is the exit section because of the channel erosion which takes place immediately downstream of the flume caused by the jetting action of water. Prompt remedial action should be taken for addressing the erosion.

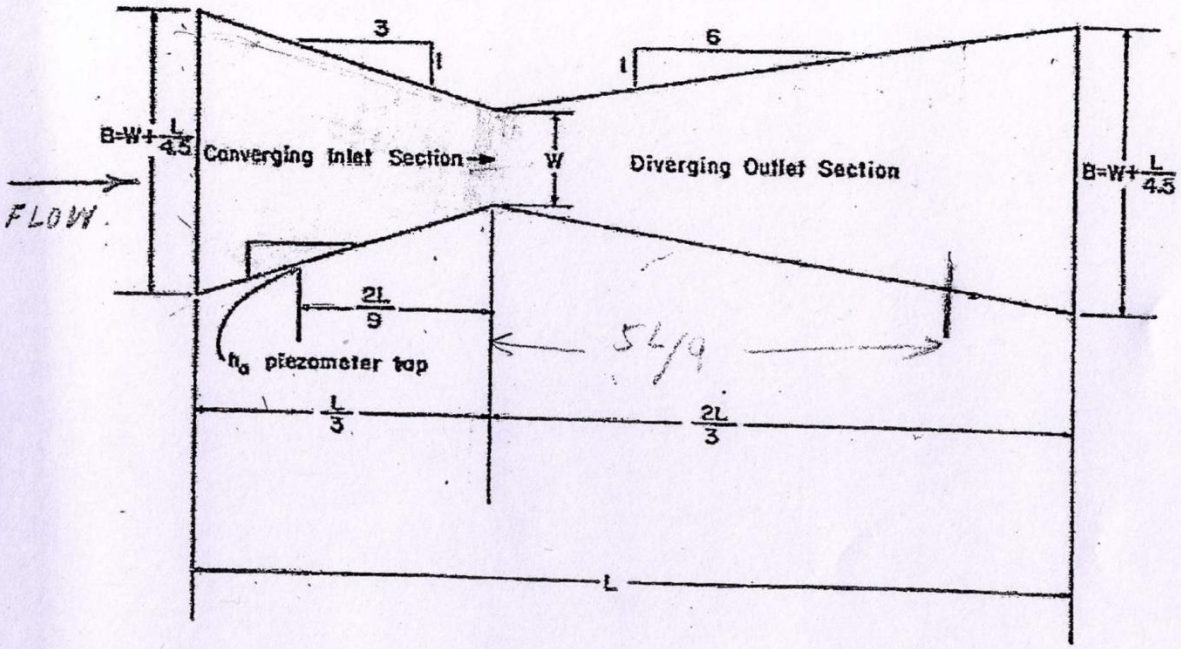
Costs of Cut Throat Flumes (CTF). Approximate costs of Cut Throat Flumes of various capacities are indicated below.

Capacity of Cut Throat Flume (CTF)	Approximate Cost (US$)
1 Cusec	115 $
2 Cusecs	125 $
3 Cusecs	135 $
4 Cusecs	150 $
7 Cusecs	220 $

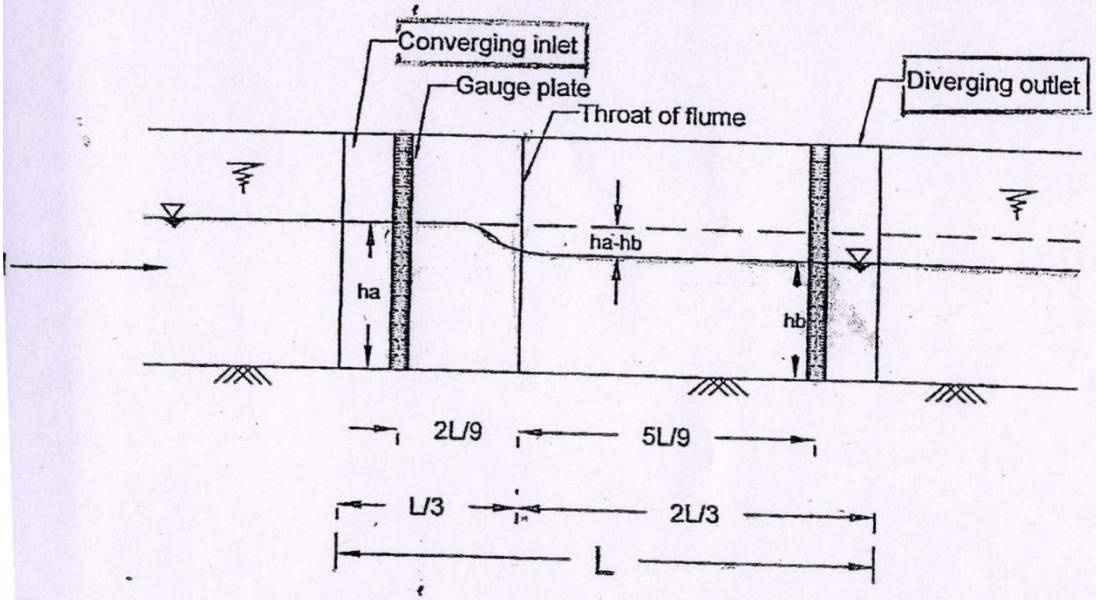
CUT THROAT FLUME DIAGRAMS

Annex-3

Sketch 12

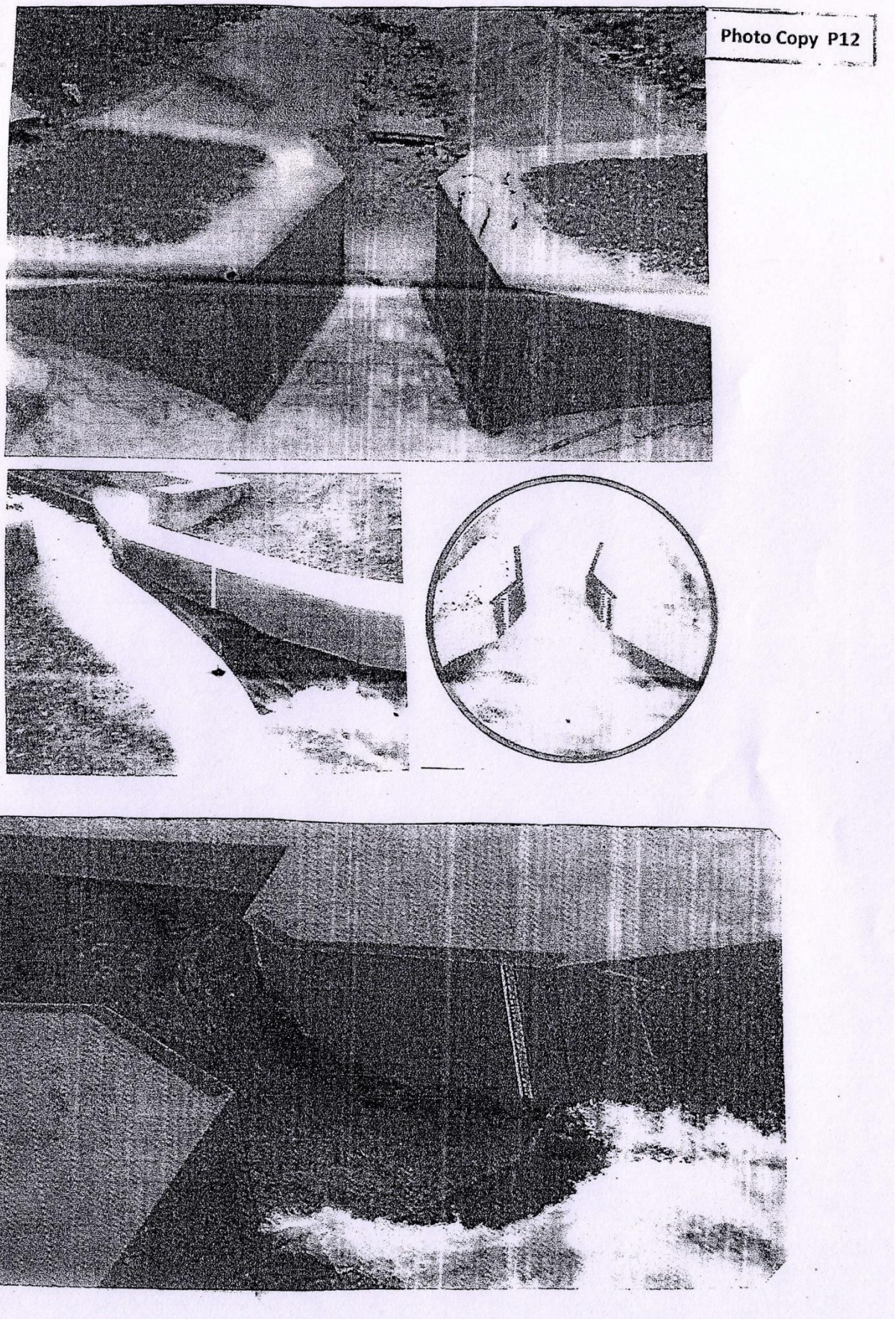


Cut Throat Flume

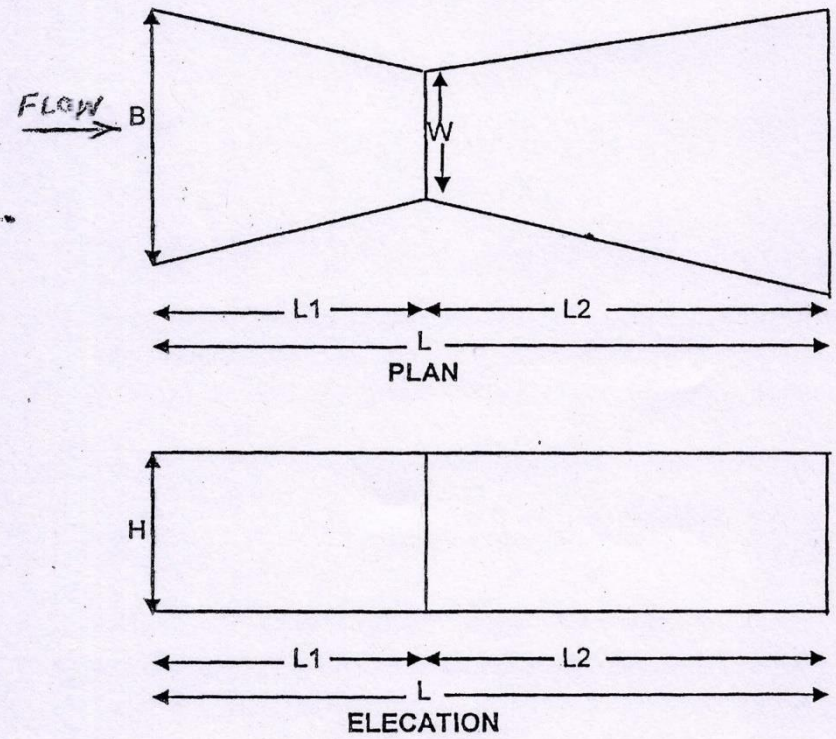


Annex-3

VIEWS OF CUT THROAT FLUMES IN IRRIGATION CHANNELS



CUT THROAT FLUMES :



CAPACITY & DIMENSIONS OF C.T.F.

TABLE A

Capacity Cusecs	Cumecs	Lit/Sec	Section cm	W	L1	L2	L	B	Ha	H
0.3	10 Lit/Sec	10	10 X 90	10	30	60	90	30	14	20
0.5	15 Lit/Sec	15	10 X 90	10	30	60	90	30	17.5	25
1	0.028	28.0	20 X 90	20	30	60	90	40	17	30
2	0.056	57.0	20 X 90	20	30	60	90	40	25	35
3	0.084	85.0	20 X 90	20	30	60	90	40	31	40
4	0.113	113.0	20 X 90	20	30	60	90	40	36	45
5	0.410	142.0	40 X 180	40	60	120	180	80	31	45
6	0.169	170.0	40 X 180	40	60	120	180	80	34.5	50
8	0.226	227.0	40 X 180	40	60	120	180	80	41	55
10	0.283	283.0	40 X 180	40	60	120	180	80	47	60
12	0.340	340.0	40 X 180	40	60	120	180	80	52.5	65
15	0.424	425.0	40 X 180	40	60	120	180	80	60	75
18	0.509	510.0	40 X 180	40	60	120	180	80	67	80
20	0.566	566.0	40 X 180	40	60	120	180	80	71.5	85
25	0.708	708.0	100 X 270	100	90	180	270	160	49	65
30	0.850	850.0	100 X 270	100	90	180	270	160	55.5	70
35	0.990	991.0	100 X 270	100	90	180	270	160	61.5	80
40	1.132	1133.0	100 X 270	100	90	180	270	160	67	90
50	1.146	1416.0	100 X 270	100	90	180	270	160	77.5	100
60	1.699	1699.0	100 X 270	100	90	180	270	160	87	115
70	1.982	1982.0	100 X 270	100	90	180	270	160	96	120
80	2.265	2265.0	100 X 270	100	90	180	270	160	104.1	140

TABLE B

Relationship between Cut Throat Flume length (L), Transition Submergence (St), Coefficient and Exponents for Free Flow, and Submerged discharges

L Meters	St %	Free Flow n	k	Submerged Flow ns	ks
0.6	62.0	1.989	5.17	1.600	2.90
0.7	63.0	1.932	4.63	1.550	2.60
0.8	64.2	1.880	4.18	1.513	2.35
0.9	65.3	1.843	3.89	1.483	2.15
1.0	66.4	1.810	3.6	1.456	2.00
1.2	68.5	1.756	3.22	1.427	1.75
1.4	70.5	1.712	2.93	1.407	1.56
1.6	72.0	1.675	2.72	1.393	1.45
1.8	73.8	1.646	2.53	1.386	1.32
2.0	75.5	1.620	2.4	1.381	1.24
2.2	77.0	1.600	2.3	1.378	1.18
2.4	78.4	1.579	2.22	1.381	1.12
2.6	79.5	1.568	2.15	1.386	1.08
2.7	80.5	1.562	2.13	1.390	1.06

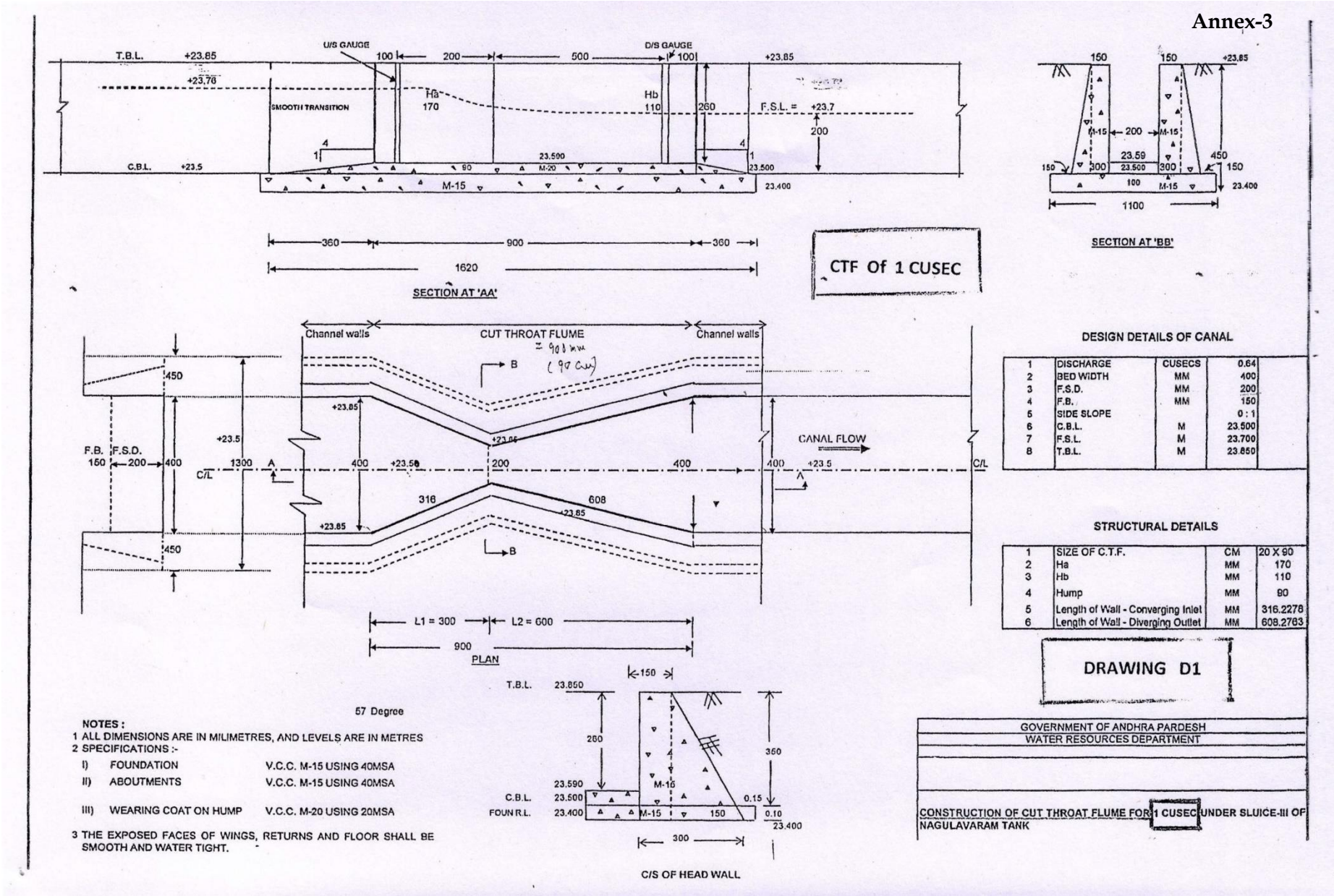
TABLE C

DISCHARGE TABLE FOR C.T.F. UNDER FREE FLOW CONDITION IN LTR/SEC

Ha in cm	10 X 90 Ltr/Sec	20 X 90 Ltr/Sec	40 X 180 Ltr/Sec	100 X 270 Ltr/Sec
5	1.5	3.0	7.1	19.8
6	2.1	4.2	9.6	26.3
7	2.7	5.6	12.4	33.5
8	3.5	7.1	15.5	41.2
9	4.3	8.8	18.8	49.5
10	5.3	10.7	22.3	58.4
11	6.3	12.8	26.1	67.8
12	7.4	15.0	30.2	77.6
13	8.5	17.4	34.4	88.0
14	9.8	19.9	38.9	98.8
15	11.1	22.6	43.6	110.0
16	12.5	25.5	48.4	121.7
17	14.0	28.5	53.5	133.8
18	15.6	31.7	58.8	146.3
19	17.2	35.0	64.3	159.1
20	18.9	38.5	69.9	172.4
21	20.7	42.1	75.8	186.1
22	22.5	45.9	81.8	200.1
23	24.5	49.8	88.0	214.5
24	26.5	53.9	94.4	229.2
25	28.5	58.1	101.0	244.3
26	30.7	62.4	107.7	259.8
27	32.9	66.9	114.6	275.5
28	35.2	71.5	121.7	291.6
29	37.5	76.3	128.9	308.1
30	39.9	81.3	136.3	324.8
31	42.4	86.3	143.9	341.9
32	45.0	91.5	151.6	359.3
33	47.6	96.9	159.5	377.0
34	50.3	102.3	167.5	395.0
35	53.0	107.9	175.7	413.3
36	55.9	113.7	184.0	431.8
37			192.5	450.7
38			201.2	469.9
39			210.4	489.4
40			218.9	509.1
41			228.0	529.1
42			237.2	549.4
43			246.6	570.0
44			256.1	590.8
45			265.7	611.9
46			275.5	633.3
47			285.4	654.9
48			295.5	676.8
49			305.7	699.0
50			316.0	721.4
51			326.5	744.1
52			337.1	767.0
53			347.9	790.1
54			358.7	813.5
55			369.7	837.2
56			380.9	861.1
57			392.1	885.2
58			403.5	909.6
59			415.0	934.2
60			426.7	959.1
61			438.4	984.2
62			450.3	1009.5
63			462.3	1035.0
64			474.5	1060.8
65			486.7	1086.8
66			499.1	1113.0

Ha in cm	10 X 90 Ltr/Sec	20 X 90 Ltr/Sec	40 X 180 Ltr/Sec	100 X 270 Ltr/Sec
67			511.6	1139.5
68			524.3	1166.2
69			537.0	1193.1
70			549.9	1220.2
71			562.9	1247.5
72			576.0	1275.1
73				1302.8
74				1330.8
75				1359.0
76				1387.4
77				1416.0
78				1444.9
79				1473.9
80				1503.2
81				1532.6
82				1562.3
83				1592.1
84				1622.2
85				1652.5
86				1682.9
87				1713.6
88				1744.5
89				1775.5
90				1806.8
91				1838.2
92				1869.9
93				1901.7
94				1933.8
95				1966.0
96				1998.4
97				2031.0
98				2063.8
99				2096.8
100				2130.0
101				2163.4
102				2196.9
103				2230.6
104				2264.6
105				2298.7
106				2333.0
107				2367.4
108				2402.1

Annex-3



DESIGN DETAILS OF CANAL

1	DISCHARGE	CUSECS	0.64
2	BED WIDTH	MM	400
3	F.S.D.	MM	200
4	F.B.	MM	150
5	SIDE SLOPE		0 : 1
6	C.B.L.	M	23.500
7	F.S.L.	M	23.700
8	T.B.L.	M	23.850

STRUCTURAL DETAILS

1	SIZE OF C.T.F.	CM	20 X 90
2	Ha	MM	170
3	Hb	MM	110
4	Hump	MM	90
5	Length of Wall - Converging Inlet	MM	316.2278
6	Length of Wall - Diverging Outlet	MM	608.2763

DRAWING D1

NOTES :

1 ALL DIMENSIONS ARE IN MILIMETRES, AND LEVELS ARE IN METRES

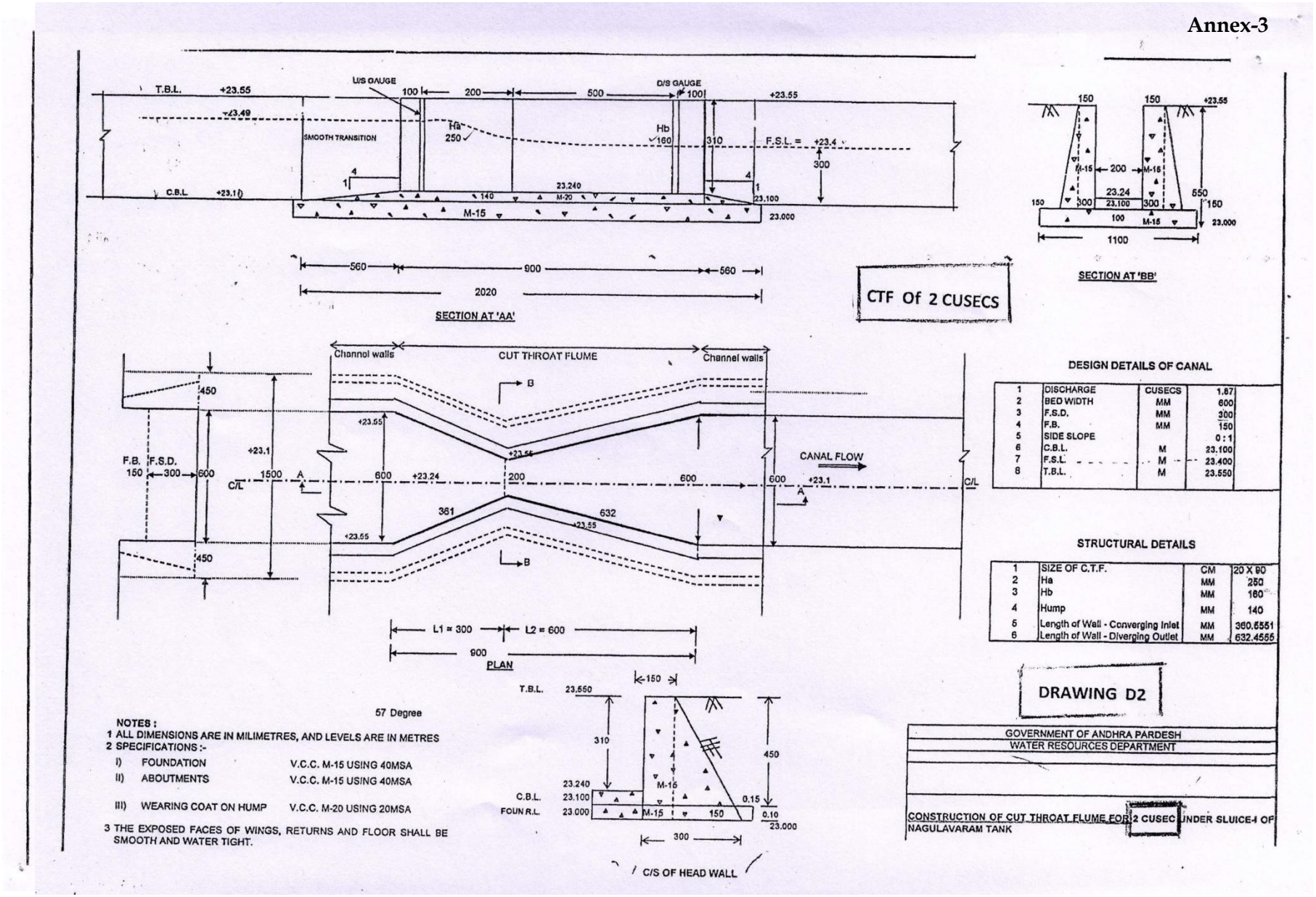
2 SPECIFICATIONS :-

I)	FOUNDATION	V.C.C. M-15 USING 40MSA
II)	ABOUTMENTS	V.C.C. M-15 USING 40MSA
III)	WEARING COAT ON HUMP	V.C.C. M-20 USING 20MSA

3 THE EXPOSED FACES OF WINGS, RETURNS AND FLOOR SHALL BE SMOOTH AND WATER TIGHT.

GOVERNMENT OF ANDHRA PARDESH
WATER RESOURCES DEPARTMENT

CONSTRUCTION OF CUT THROAT FLUME FOR 1 CUSEC UNDER SLUICE-III OF NAGULAVARAM TANK



DESIGN DETAILS OF CANAL

1	DISCHARGE	CUSECS	1.87
2	BED WIDTH	MM	600
3	F.S.D.	MM	300
4	F.B.	MM	150
5	SIDE SLOPE		0 : 1
6	C.B.L.	M	23.100
7	F.S.L.	M	23.400
8	T.B.L.	M	23.550

STRUCTURAL DETAILS

1	SIZE OF C.T.F.	CM	20 X 90
2	Ha	MM	250
3	Hb	MM	160
4	Hump	MM	140
5	Length of Wall - Converging Inlet	MM	360.6551
6	Length of Wall - Diverging Outlet	MM	632.4555

NOTES :

1 ALL DIMENSIONS ARE IN MILIMETRES, AND LEVELS ARE IN METRES

2 SPECIFICATIONS :-

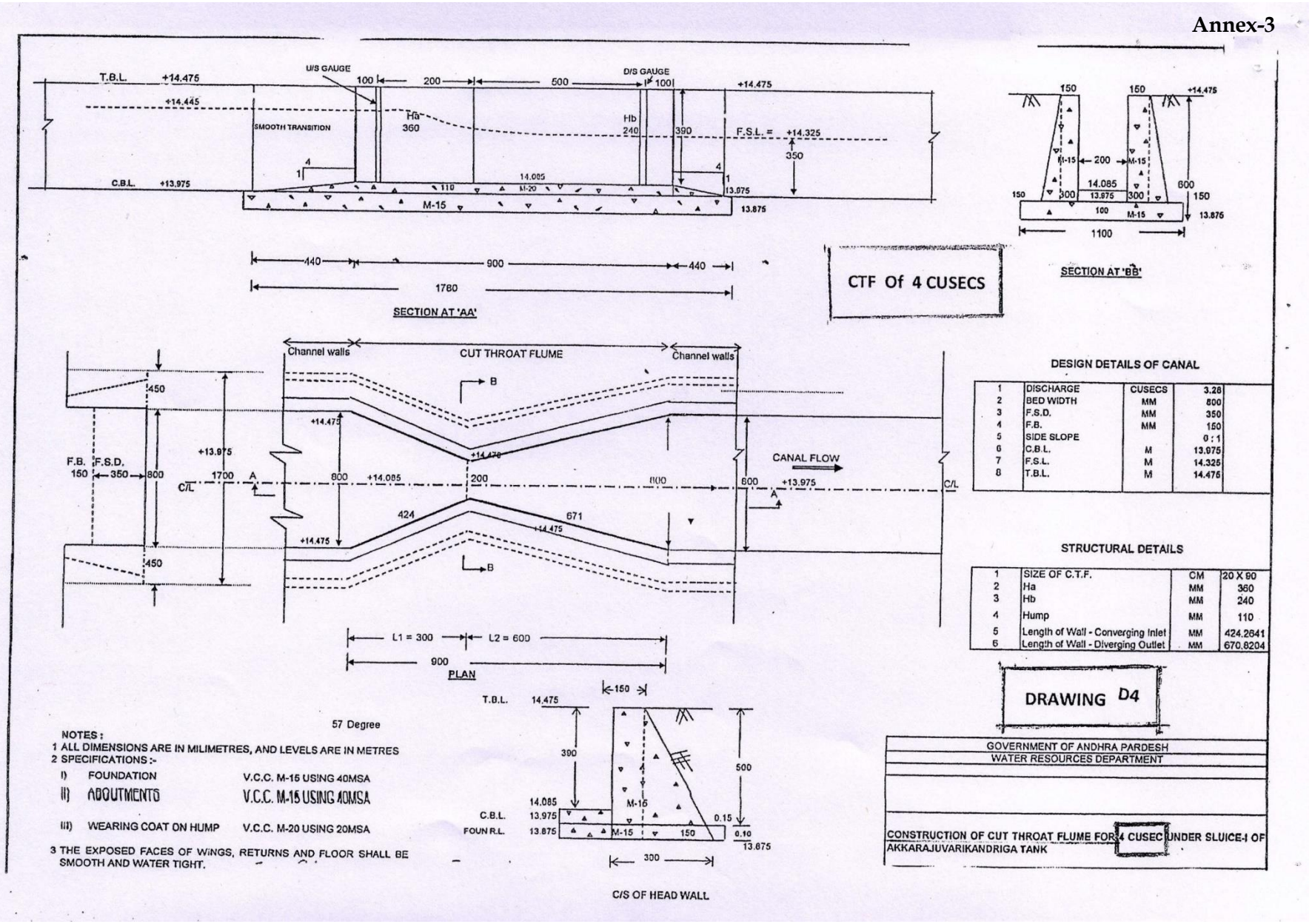
I)	FOUNDATION	V.C.C. M-15 USING 40MSA
II)	ABOUTMENTS	V.C.C. M-15 USING 40MSA
III)	WEARING COAT ON HUMP	V.C.C. M-20 USING 20MSA

3 THE EXPOSED FACES OF WINGS, RETURNS AND FLOOR SHALL BE SMOOTH AND WATER TIGHT.

DRAWING D2

GOVERNMENT OF ANDHRA PARDESH
WATER RESOURCES DEPARTMENT

CONSTRUCTION OF CUT THROAT FLUME FOR 2 CUSEC UNDER SLUICE-I OF NAGULAVARAM TANK



DESIGN DETAILS OF CANAL

1	DISCHARGE	CUSECS	3.28
2	BED WIDTH	MM	800
3	F.S.D.	MM	350
4	F.B.	MM	150
5	SIDE SLOPE		0 : 1
6	C.B.L.	M	13.975
7	F.S.L.	M	14.325
8	T.B.L.	M	14.476

STRUCTURAL DETAILS

1	SIZE OF C.T.F.	CM	20 X 90
2	Ha	MM	360
3	Hb	MM	240
4	Hump	MM	110
5	Length of Wall - Converging Inlet	MM	424.2641
6	Length of Wall - Diverging Outlet	MM	670.8204

DRAWING D4

GOVERNMENT OF ANDHRA PARDESH
WATER RESOURCES DEPARTMENT

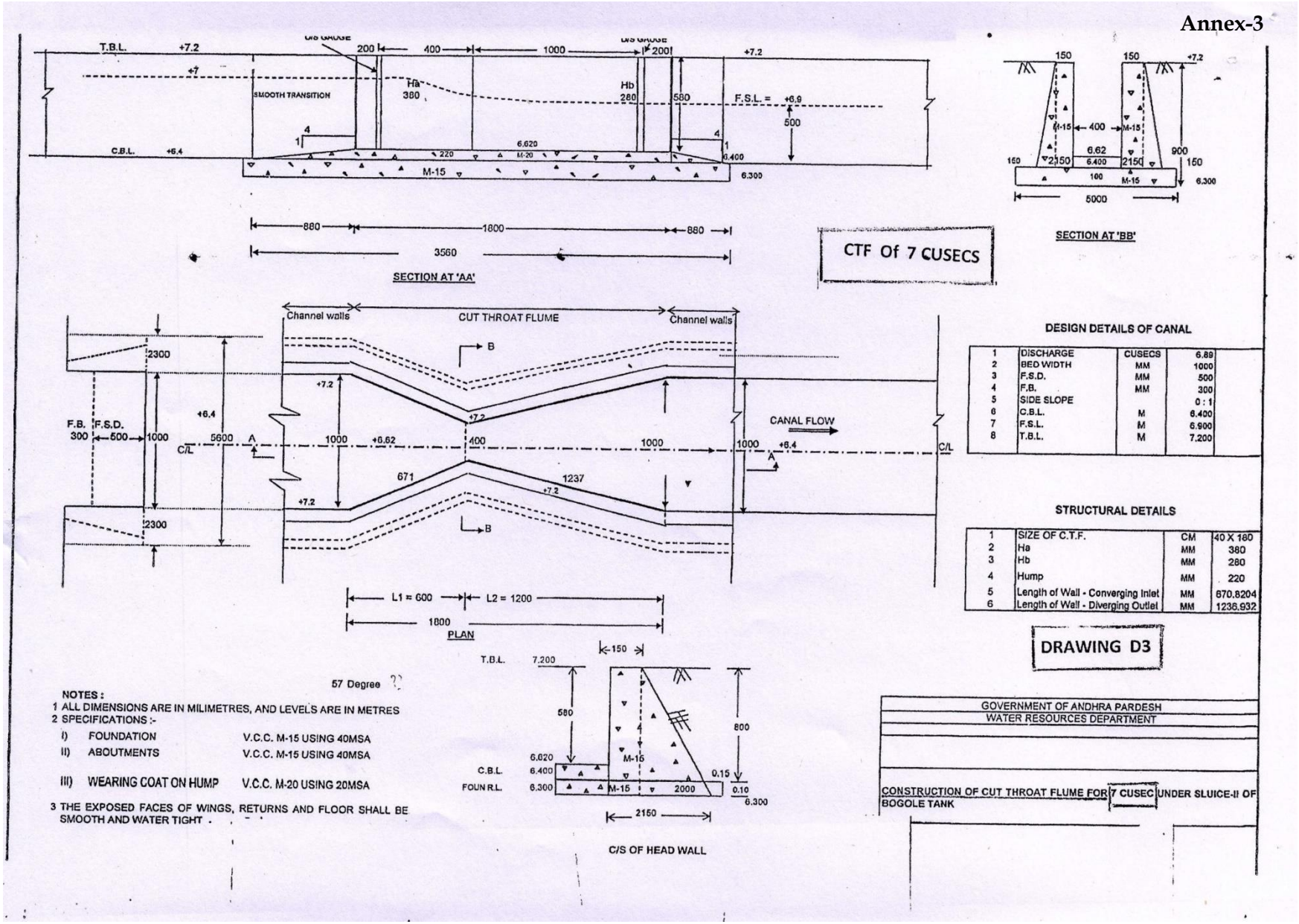
CONSTRUCTION OF CUT THROAT FLUME FOR 4 CUSEC UNDER SLUICE-I OF AKKARAJUVARIKANDRIGA TANK

NOTES :
1 ALL DIMENSIONS ARE IN MILIMETRES, AND LEVELS ARE IN METRES
2 SPECIFICATIONS :-

I)	FOUNDATION	V.C.C. M-15 USING 40MSA
II)	ABOUTMENTS	V.C.C. M-15 USING 40MSA
III)	WEARING COAT ON HUMP	V.C.C. M-20 USING 20MSA

3 THE EXPOSED FACES OF WINGS, RETURNS AND FLOOR SHALL BE SMOOTH AND WATER TIGHT.

Annex-3



DESIGN DETAILS OF CANAL

1	DISCHARGE	CUSECS	6.89
2	BED WIDTH	MM	1000
3	F.S.D.	MM	500
4	F.B.	MM	300
5	SIDE SLOPE		0 : 1
6	C.B.L.	M	6.400
7	F.S.L.	M	6.900
8	T.B.L.	M	7.200

STRUCTURAL DETAILS

1	SIZE OF C.T.F.	CM	40 X 160
2	Ha	MM	380
3	Hb	MM	280
4	Hump	MM	220
5	Length of Wall - Converging Inlet	MM	670.8204
6	Length of Wall - Diverging Outlet	MM	1236.932

DRAWING D3

NOTES :
1 ALL DIMENSIONS ARE IN MILIMETRES, AND LEVELS ARE IN METRES
2 SPECIFICATIONS :-

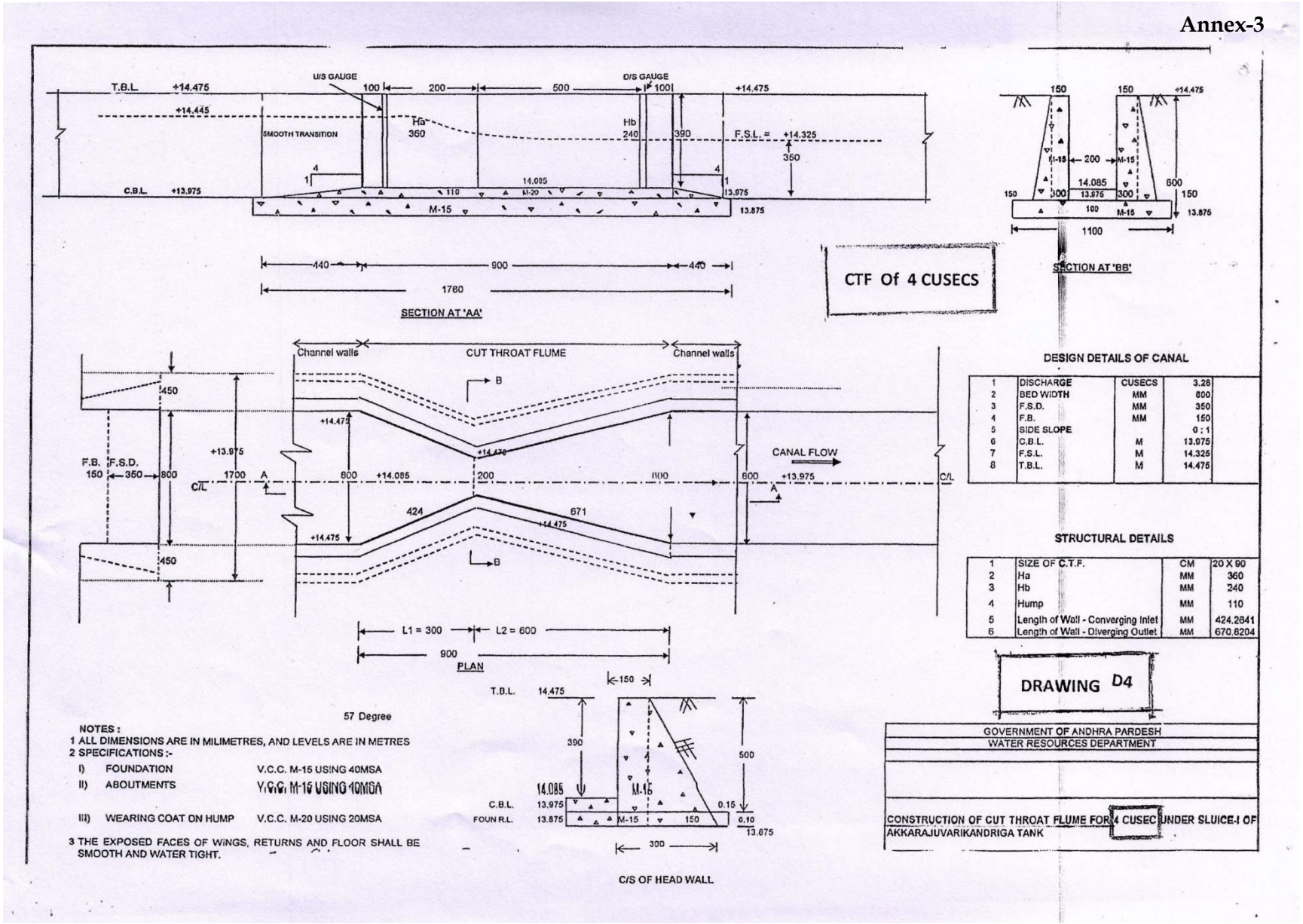
I)	FOUNDATION	V.C.C. M-15 USING 40MSA
II)	ABOUTMENTS	V.C.C. M-15 USING 40MSA
III)	WEARING COAT ON HUMP	V.C.C. M-20 USING 20MSA

3 THE EXPOSED FACES OF WINGS, RETURNS AND FLOOR SHALL BE SMOOTH AND WATER TIGHT .

GOVERNMENT OF ANDHRA PARDESH
WATER RESOURCES DEPARTMENT

CONSTRUCTION OF CUT THROAT FLUME FOR 7 CUSEC UNDER SLUICE-II OF BOGOLE TANK

Annex-3


T.B.L. +14.475
U/S GAUGE
D/S GAUGE
100
200
500
100
+14.475
+14.445
SMOOTH TRANSITION
Ha
360
Hb
240
390
F.S.L. = +14.325
350
C.B.L. +13.975
14.085
M-20
110
M-15
13.875
440
900
440
1780
SECTION AT 'AA'
CTF Of 4 CUSECS
150
150
+14.475
M-15
200
M-15
14.085
600
150
300
13.975
300
150
100
M-15
13.875
1100
SECTION AT 'BB'
Channel walls
CUT THROAT FLUME
Channel walls
B
450
+13.975
F.B.
150
F.S.D.
350
800
C/L
1700
A
800
+14.085
200
1000
600
+13.975
C/L
CANAL FLOW
+14.475
+14.475
424
671
+14.475
450
B
L1 = 300
L2 = 600
900
PLAN
57 Degree
T.B.L. 14.475
150
390
500
14.085
M-15
C.B.L. 13.975
0.15
FOUN R.L. 13.875
M-15
150
0.10
13.875
300
C/S OF HEAD WALL
DESIGN DETAILS OF CANAL
1 DISCHARGE CUSECS 3.28
2 BED WIDTH MM 800
3 F.S.D. MM 350
4 F.B. MM 150
5 SIDE SLOPE 0 : 1
6 C.B.L. M 13.075
7 F.S.L. M 14.325
8 T.B.L. M 14.475
STRUCTURAL DETAILS
1 SIZE OF C.T.F. CM 20 X 90
2 Ha MM 360
3 Hb MM 240
4 Hump MM 110
5 Length of Wall - Converging Inlet MM 424.2641
6 Length of Wall - Diverging Outlet MM 670.8204
DRAWING D4
GOVERNMENT OF ANDHRA PARDESH
WATER RESOURCES DEPARTMENT
CONSTRUCTION OF CUT THROAT FLUME FOR 4 CUSEC UNDER SLUICE-I OF AKKARAJUVARIKANDRIGA TANK
NOTES :
1 ALL DIMENSIONS ARE IN MILIMETRES, AND LEVELS ARE IN METRES
2 SPECIFICATIONS :-
I) FOUNDATION V.C.C. M-15 USING 40MSA
II) ABOUTMENTS V.C.C. M-15 USING 10MSA
III) WEARING COAT ON HUMP V.C.C. M-20 USING 20MSA
3 THE EXPOSED FACES OF WINGS, RETURNS AND FLOOR SHALL BE SMOOTH AND WATER TIGHT.

6. Remedial measures of treatment of Cracks

The following measures are broadly suggested for treatment of cracks:

- The cracks which occur near the top edges of the embankment are "separation cracks" and such cracks can case large scale slippage of earth. These should be treated by removing all earth fill above the "slippage plane", benching the back slope and thereafter, placing new earth fill in suitable layers and compacting each layer to the specified density with earth rammer/hand rammer.

The other cracks may be treated in the manner mentioned below:

- Find approximate depth of crack by excavating an inspection pit.
- Excavate the cracked reaches in the form of a trench up to the bottom of the crack.
- Fill each trench with suitable soil in layers of 10 cm thickness duly compacted manually with hand rammer or earth rammer, compaction can be done even by persons by tamping with their gum boots put on their feet. The earth fill should have 2 to 3% more moisture than OMC
- In case the depth of cracks is substantial, say, 60 cm or more, "clay-cement-water mix" injection may be done. This is done by driving pipes into the cracks at about 60 cm spacing and manually pouring the fluid mix of clay-cement-water into pipes The fluid mix be prepared in a bucket, stirred well, and then poured into pipes.
- Treatment of deeper cracks can be more effectively done by excavating trenches in the cracked reaches to a depth of about 60 cm, exposing the cracks at the bottom of trenches; and then filling the trenches with a solution of "bentonite" (a very fine clay powder easily available in market) and water. Proportioning of bentonite and water may be in the ratio of 1:45 viz, I part of bentonite powder and 14 parts of water. This mixture should be prepared in a bucket and thoroughly stirred and then poured into trenches Gradually, the bentonite-water mix solution would penetrate into the cracks right to their bottom, filling these completely. When no solution is left in the trenches,

suitable soil should be placed in layers in the respective trenches and each layer compacted with earth rammer/hand rammer right up to the top of embankment.

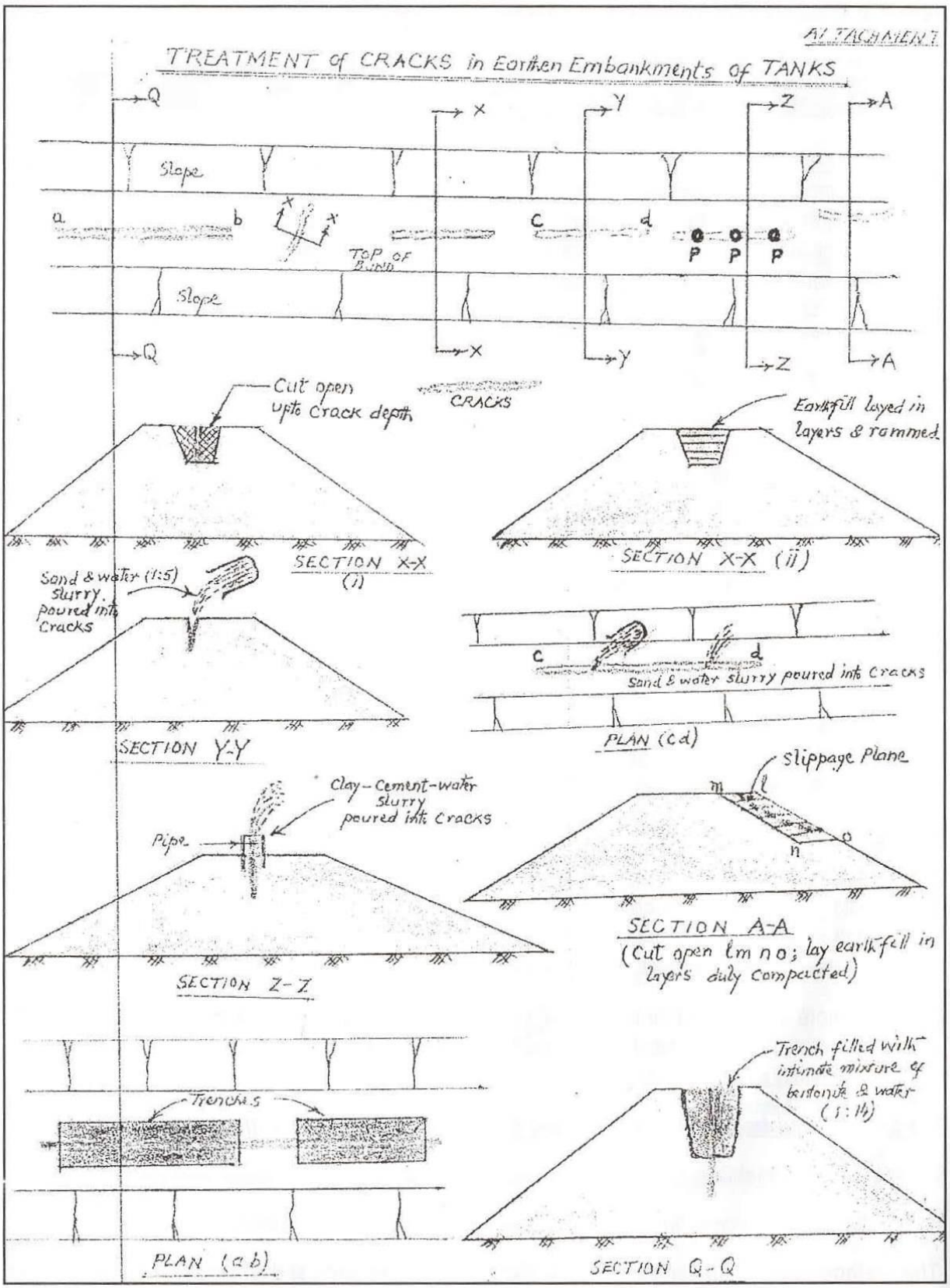
- It is more expedient to fill the shallow cracks by pouring a well stirred mixture of fine sand and water directly in to the cracks. Proportioning of sand-water mixture may be kept as 1:5,viz one part of sand and 5 parts of water

The above listed treatment measures are illustrated in sketches in the Attachment.

Suggestions for tackling the seepages

In case the seepages occur, "Inverted filters" may be provided to avoid formation of "piping".

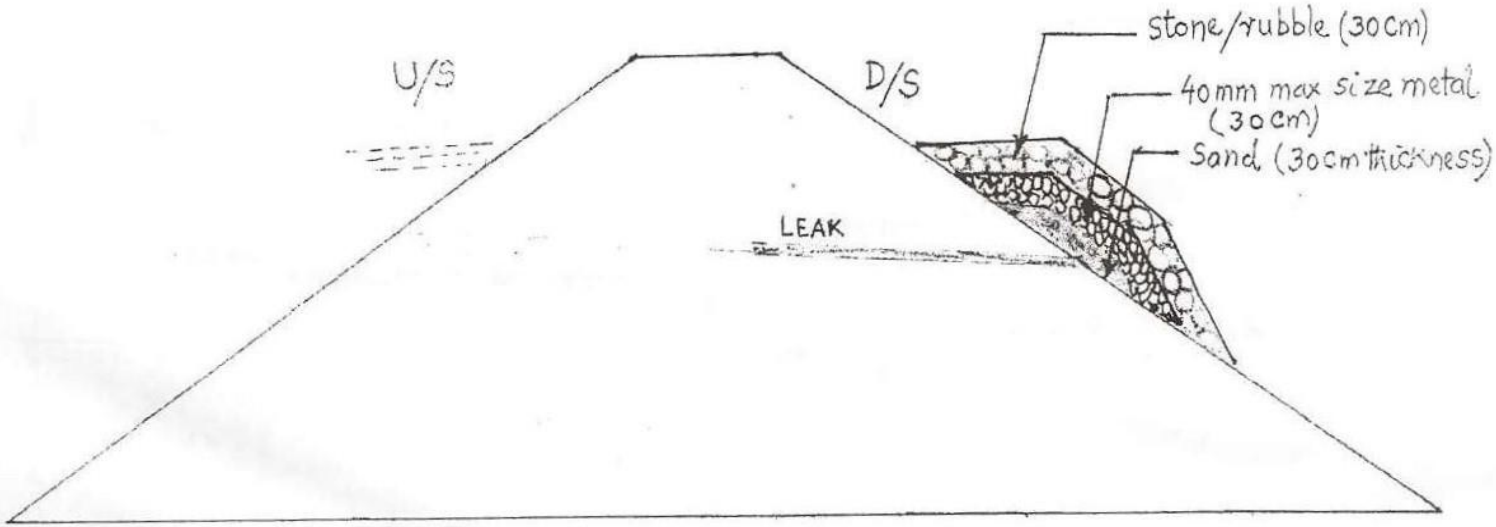
The methodology of "Inverted filter" is illustrated in the enclosed sketches I & II


ATTACHMENT
TREATMENT of CRACKS in Earthen Embankments of TANKS
Q
X
Y
Z
A
Slope
a
b
c
d
P P P
TOP OF BUND
Slope
Cut open upto crack depth
CRACKS
Earthfill layed in layers & rammed
SECTION X-X (i)
SECTION X-X (ii)
Sand & water (1:5) slurry poured into Cracks
SECTION Y-Y
Sand & water slurry poured into Cracks
PLAN (cd)
Slippage Plane
Clay-Cement-water slurry poured into Cracks
Pipe
SECTION Z-Z
SECTION A-A
(Cut open lmno; lay earthfill in layers duly compacted)
Trenches
PLAN (ab)
Trench filled with intimate mixture of bentonite & water (1:14)
SECTION Q-Q

SKETCH II

Tackling leakage through the Earthen Tank Bund

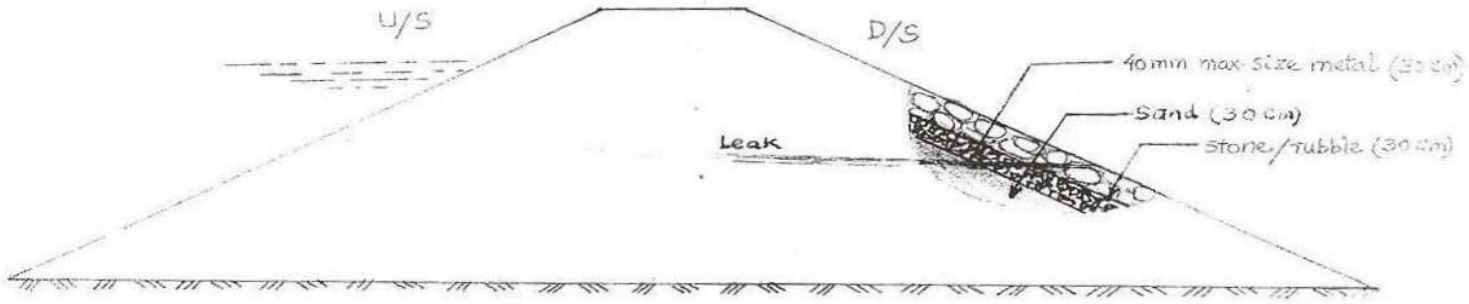
OPTION 2: If the leakage is substantial or when the 'bowel shaped' excavation in the d/s slope not considered safe or feasible, the "INVERTED FILTER" should be placed directly on the slope after removing any vegetation etc from it



Tackling leakage through the Earthen Tank Bund

SKETCH I

OPTION I: A 'bowel shaped' excavation should be made in the downstream slope and a filter consisting of sand, gravel or metal and stone/rubble should be placed in the 'bowel'. The sand layer is to be placed against the leakage face.



Memodology of "Inverted Filter"

7. Some DOs and DO NOTs

I. EARTH WORK

(IS CODES : 2720, 4701, 8237, 9481, 4081, 1200 and 9451)

The procedures to be adopted while doing earth work excavation for various jobs and the precautions to be taken are prescribed in the IS specified above. The important Do's and Don'ts are given below for ready reference.

A) EXCAVATION OF CANALS

DO'S	DO NOTS
1. Fix up the centre line and set the curves correctly.	
2.Take working levels, real variation in ground levels and classification of soils.	
3. Get top soil vegetation etc., removed	
4. Form spoil bank as per drawing and away from the side drain with suitable gaps for drainage into the valley.	
5. Form Dowel Bank, as per drawing .	
6. Form Inspection path to a uniform longitudinal gradient and with gentle transverse slope towards drains.	
7. Compact over excavation/ breakage portion with suitable soils, gravel, spalls.	
8. Provide CNS treatment in expansive black cotton soils.	

B) FORMATION OF EMBANKMENTS	
1. Get the top spoil, vegetation and sand patches removed to complete depth.	1. Do not raise the bank in piecemeal.
2. Soil required for embankment to be obtained from borrow area should be got tested for proctor density & O.M.C. before start of work.	2. Do not allow new layer without scarification and wetting of old layer
3. Scarify the ground and wet properly.	3. Do not allow new layer unless the old layer compacted up to required density
4. Obtain Proctor density OMC for the useful soils and borrow soils.	4. Don't leave any loose layer un-rolled at the end of the day in rainy season

5. Raise embankment to full width with uniform horizontal layer of 15 cm to 22.5 cm thickness.	5. Don't allow compacted layer to be more than 150mm.
6. Break clods, remove roots, big boulders and other materials etc. larger than 75mm from the soils used in embankment.	6. No new layer to be laid unless the over moistured layer is either completely removed or allowed to dry.
7. Supplement deficit moisture whenever required.	7. Don't dump soils in heaps
8. Compact with 8 to 10 tonnes power roller or Fuel - operated vibratory plate compactors.	9. Don't dump the soils in water and slush.
9. Conduct field compaction tests and determine compaction efficiency.	10. Do not forget to provide settlement allowance of 2 cm/mtr. of Height of bank.
10. Check embankment profiles periodically.	

II. Canal Lining Preparation of Sub grade

DO'S	DO NOTS
1. Check the model section to the canal profile i.e., bottom or lining viz side slopes, bed width, top width, slant length, smoothness of slant length.	1. Do not allow concrete lining on loose sub-grade.
2. Check the canal profile with reference to model section. Profile be prepared at 15 M intend in case of tile lining.	2. Do not allow any root or stumps to be on sub-grade.
3. Remove roots and stumps completely from the sub-grade	3. Do not allow lining in expansive soils without treatment with C.N.S. soils.
4. Compact over-excavation in soils with earth gravel duly wetted.	4. Do not place the porous plug below the surface of the lining.
5. Compact over-excavation in rocky area or fill up with not concrete as per specification.	5. Do not allow lining without wetting the sub-grade suitably.
6. Provide treatment with C.N.S. soils in expansive soils.	6. Do not allow movement of labourers after preparation of subgrade.
7. Provide porous plugs of specified size in each panel with specified local filters of graded metal and sand.	
8. Check whether porous plugs are freely draining or not.	

III. Canal Lining

DO'S	DO NOTS
1. Check the canal prism and verify the bed levels.	1. Do not allow concrete lining on loose sub-grade.
2. Check the gradation analysis of fine and coarse aggregate to the requirement of mix at batching plant.	2. Do not allow lining without wetting sub-grade
3. Allow the ingredients of fine and coarse aggregate as per required mix by weigh batching.	3. Do not allow C.C. lining manually without vibration.
4. Check the calibration of weighing machine at batching plant.	4. Do not allow segregation of concrete while laying through discharge conveyor.
5. Check the water meter and its discharge.	5. Do not allow concrete directly on subgrade from transit mixer.
6. Check the batch of cement, its make and test results.	6. Do not form contraction joints over longitudinal drains.
7. Check the water cement ratio and record the slump.	7. Do not fill up contraction joints with sealing compound without cleaning with air water jet or sand blast.
8. Check whether any retarders and air entraining agents are added.	8. Do not allow any projections or contraction joint over the surface of the lining.
9. Maintain load register.	9. Do not allow the C.C lining without applying suitable primer to sides.
10. Record the No. CC cubes cast and its compressive strength.	10. Do not remove the channels immediately before setting of C.C.
11. Cure CC Lining with water for 28 days.	11. Do not use untested cement.
12. Ensure smooth surface with paver roller passes.	12. Do not allow to sink the porous plugs in the drains.
13. Form the contraction and construction joints as per approved drawing.	13. Do not allow lining without making proper arrangements for curing with water.
14. Check the thickness of C.C. lining for each panels.	14. The Co-efficient of variation in the compressive strength of cement should not be more than 8%.

DO'S	DO NOTS
15. Check placing of mastic pad at structures of construction joints.	
16. Allow concrete lining at temperature between 15oC and 32oC.	
17. Check periodically the coefficient of variation in the compressive strength of cement.	
18. The batching plant to be used shall confirm to the required of IS 4925-1968.	

8. CEMENT CONCRETE LINING IN CANALS

(With Particular Reference To Bigger Section/High Discharge Capacity Canals)

8.1 CEMENT CONCRETE LINING Of CANALS: SPECIFICATIONS, CONSTRUCTION PROCEDURES, QUALITY CONTROL & QUALITY ASSURANCE REQUIREMENTS.

1. Small Section/Small Capacity Irrigation Channels. Provision of "Model Sections" in cement concrete in the unlined irrigation channels at about 20 m to 25 m spacing as well as placement of "Selective Concrete Lining" in about 10 percent to 12 percent length of the channels in vulnerable reaches of the channels were comprehensively outlined and illustrated in Section C of the Guidance Note (already furnished), titled: Rehabilitation & Modernization Of Irrigation Channels. It was brought out that the provision of proposed model sections and selective concrete lining greatly helped in improving the conveyance efficiency and functional reliability of the distribution system besides affording ease of maintenance of the channels to their respective design profiles.

2. Bigger Section / High Discharge Capacity Canals. In some cases, it may become necessary to line long reaches of the bigger section main and branch canals. Design of cement concrete lining as well as the requisite job-specific technical specifications and quality control /quality assurance requirements for ensuring durable concrete lining in the canals are outlined in the following paragraphs. *These cover:* design of canal section, preparation of proper sub grade duly compacted, equipment/devices for compaction of sub grade, addressing surface irregularities in the sub grade to specified tolerance levels, device for checking the final sub grade, design mix of cement concrete lining, durability aspect of concrete mix, air-entraining agent (AEA) in the concrete mix, lining thickness, control of water-cement ration in the concrete mix, placement & compaction of lining, tolerance levels in lining thickness, contraction joints in lining, curing of lining with water, curing of lining with curing compound, elimination of cold joints in the lining and filling of contraction joint grooves in the lining. Importantly, provision of "under-drainage arrangement" for the cement concrete lining is also explained and illustrated.

(a) Rehabilitation through Re-Sectioning & Strengthening of existing Canal Sections. Cross-sections of the existing canal at 20 m to 25 m interval should be observed and plotted. L-section of the canal should also be observed and plotted. Hydraulic designs of the canal should be conducted to bring the existing unlined canal sections to the designed trapezoidal lined sections by assuming the co-efficient of rugosity of cement concrete lining as 0.018 and side slopes as 1.5(H):1(V). Side slopes of 1.5 (H): 1(V) for bigger section canals are considered to be stable slopes for placement of concrete lining. Side slopes of 1.25(H):1(V) can, however, be kept for small section canals. The existing canal sections should, accordingly, be re-sectioned & strengthened and brought to the designed sections through the needed cutting and earth fill duly consolidated.

(b) Preparation of Proper Sub Grade. It is of paramount importance that the sub grade (designed bed and sides of canal sections) on which cement concrete lining is to be placed *must be* uniform, dense and hard without any loose pockets. Accordingly, the sub grade should be free from surface irregularities and be well consolidated / compacted prior to

placement of lining. Regular density tests should be conducted to ensure that the sub grade has been adequately compacted.

Significance of Proper Sub Grade. In case, the sub grade is not properly prepared and adequately compacted / consolidated and the concrete lining is placed on a loose & non uniform sub grade, pre-mature deterioration / failure of lining can occur within a short period of the running of canal due to loss of sub grade soil adjacent to the lining.

(c) Equipment for Consolidation / Compaction of Sub Grade – Small Section Channels. It has been outlined in Section C of the Guidance Note, already furnished and titled: Rehabilitation & Modernization of Irrigation Channels, that the sub grade of the small section irrigation channels can be effectively consolidated through deployment of a simple device comprising "a needle vibrator clamped on to a steel plate with 2 handles welded on it for ease of its operation by a worker. This vibrator is operated by either ½ H.P. or 1 H.P. diesel engine or is operated electrically. This device, when operated and pressed against the sub grade, transmits strong vibrations / impulses, thereby, consolidating the sub grade surface. *This device in operation is illustrated in Photo Copy P1 in Annex P.*

(d) Equipment for Consolidation / Compaction of Sub grade – Bigger Section Canals.

(i) Rig Mounted Plate Compactor. For the compaction of bigger section/high capacity canals, the sub grade of such canals can be very effectively compacted through deployment of "Mobile Rig Mounted Plate Compactor". Bucket of the hydraulic excavator (back-hoe) is removed and a steel plate incorporating stiffeners is attached to its boom end. The steel plate of 20 mm thickness may be of size 1.0 m x 0.75 m or 1.2 m x 0.75 m or 1.5 m x 1.0 m depending upon the capacity of excavator. The steel plate, when struck against the sub grade surface, compacts both the sides and the bed of the canal sub grade. In case, the bed width ranges from 1.25 m to about 3 m, small vibratory power roller (of 0.90 m/ 1.0 m width) can be deployed for consolidation of bed and a standard vibratory power roller of about 2.2 m width can be deployed for compaction of the bed sub grade of canal of 3.0 m or more width. However, the sub grade on side slopes is to be compacted by the mobile rig-mounted steel compactor. *This equipment in operation is illustrated in Photo Copy P2 in Annex P.*

(ii) Rig Mounted Vibratory Hydraulic Compactor. Another useful equipment for compaction of the bed and sides of bigger section/high capacity canals is "Mobile Rig-Mounted Vibratory Hydraulic Compactor" in which the stationary steel plate is replaced with a vibratory fixture incorporating a steel base plate The vibratory fixture, when pressed against the bed / side slopes sub grade, transmits powerful vibrations / impulses, thereby, effectively compacting the sub grade surface. There are several manufacturers of this compactor. *Particulars of various models, titled: HC-Hydraulic Compactors supplied by the manufacturer Atlas Copco are listed below for illustration*:

HC-hydraulic compactor	HC 103	HC 308	HC 409	HC 920	HC 2040
Vibrating force	1.4 ton	2.3 ton	3.0 ton	7.3 ton	10.5 ton
Vibrating frequency (cycles/min)	2100	2100	2200	2200	2200
Base Plate Size (Wx L)	290x678 mm	455x 693mm	610x 929mm	710x1178mm	864x1136mm
Operating Wt. of Fixture	160 kg	320 kg	430 kg	880 kg	1050 kg

There are other manufacturers also who supply such compactors. *Tata Hitachi* is amongst such suppliers. *Particulars of various models supplied by Tata are listed below:*

Hydraulic Compactor Model	DMV 50	DMV 140	DMV 230	DMV 300
Impulse Force	3 ton	6 ton	8 ton	10 ton
Vibrating Frequency (cycles/min)	2400	2400	2400	2400
Base Plate Size (WxL) mm	600x800	700x900	800x900	850x1150
Operating Weight of Fixture	250 kg	600 kg	700 kg	860 kg

Rig Mounted Hydraulic Vibratory Compactor in operation is illustrated in Photo Copy P3 & P4 in Annex P.

(iii) Heavy Duty Vibratory Soil Compacting Roller. This equipment is deployed for very speedy compaction of the sub grade of both the bed and side slopes of the bigger section / high capacity canals. The equipment, operated by about 130 H.P. diesel engine, comprises a smooth steel drum of about 2.14 m width in front and two pneumatic wheels in the rear. It is capable of moving up and down even on 1.5(H):1(V) slopes with ease. During its movement, the vibrating roller drum imparts very powerful vibrations to the sub grade surfaces, there by, effectively compacting these to more than 95 % Proctor density. *This equipment in operation is illustrated in Photo Copy P5 in Annex P. Also, Rig Mounted Plate Compactor, Rig Mounted Vibratory Hydraulic Compactor & Heavy Vibratory Soil Compacting Roller are all depicted together in Photo Copy P6 in Annex P for illustration.*

(e) Surface Irregularities in the Sub Grade & Tolerance Levels of Surface Irregularities. The sub grade surface should be uniform and free from irregularities, abrupt protrusions and depressions. It should conform to the designed line and grade. Acceptance tolerance limit of surface irregularities is 6.5 mm for the invert and 12.5 mm for the side slopes. The sub grade surfaces exceeding these limits are not to be accepted for placement of cement concrete lining. Such surfaces must be rectified through cutting the protrusions appropriately and back filling the depressions with selected pervious soil duly tamped.

Simple Device for Checking Surface Irregularities. For the small section channels, surface irregularities can be conveniently checked by a smooth wooden template consisting of a straight edge or the equivalent there-of for the curved surfaces placed against the sub grade surface.

For the bigger section / high capacity canals, surface irregularities & accuracy of side slopes can be checked by *a simple device illustrated in Photo Copy P7 in Annex P*. It comprises a small triangular steel frame incorporating one horizontal arm and the other inclined one conforming to the designed side slope. This device is fixed at the top inner edge of the canal with a string fixed to its inclined end. The string, covering the entire slope, is stretched and is tied right at the toe of invert. Any excessive protrusions and deep depressions would be clearly indicated by the stretched string and the needed rectification should then be done to bring the sub grade surface within acceptable tolerance limits.

Significance of the Specification relating to Surface Irregularities. Surface irregularities associated with abrupt protrusions and deep depressions in excess of the tolerance limits tend to weaken and restrain the concrete lining, there by, causing cracks to occur in the lining. A rough and irregular sub grade surface causes abrupt variations in the lining thickness. Definite constraint gets developed at such locations in the concrete lining analogue to the creation of "anchors" which cause cracking. It is, therefore, essential to eliminate surface irregularities and bring the sub grade within acceptable tolerance levels of surface irregularities.

(f) Checking Density Of Sub-Grade. In order to ensure that the final sub grade is dense and hard prior to placement of lining, density of the side slope sub grade in some panels should be regularly checked. Checking the density with the conventional "Core Cutter" method being time consuming, state-of-art "*Non Nuclear Soil Density Gauge*" should be deployed for rapid determination of density. Such intervention shall be very productive for the long term durability & sustainability of lining. *Photo Copy P8 in Annex P depicts deployment of "Non Nuclear Soil Density Gauge" for checking the density of the sub grade on side slope of canal.*

(g) Moistening Of Sub Grade. It is very important to appropriately moisten the final sub grade prior to the commencement of lining operation. The dry sub grade must be uniformly moistened with water with a fine 'spray nozzle' or with a 'gardener can'. Water should not be sprayed with an open hose pipe since it would erode the sub grade and also create muddy conditions.

Significance Of this Specification. In case, concrete lining is placed on a dry sub grade, it would absorb substantial quantity of water from the concrete mix. This would retard the *hydration process* (chemical reaction of cement with water producing "Calcium–Silicate-Hydrate Gel ", which imparts strength to the cement paste), since the needed quantity of water would not be available for completion of the hydration process. Consequently, it would adversely affect the strength and durability of concrete.

(h) Thickness Of Plain Cement Concrete Lining. United States Bureau of Reclamation (USBR) broadly specifies the thickness of plain (unreinforced) cement concrete lining corresponding to the various discharges as per the following Table:

Discharging capacity of Canal (Cusec)	**Thickness of Lining in inches (mm)**
Up to 500 Cusec (65 mm)	2.5 inches
500 – 1500 Cusec (75 mm)	3.0 inches
1500 –3500 Cusec (90 mm)	3.5 inches
3500 – 7000 Cusec (100 mm)	4.0 inches
More than 7000 Cusec	4.5 to 5.5 inches (115 to 125 mm)

The above Table provides a broad framework for the adoption of lining thickness and slight changes can be made in it. As per USBR, there is no purely theoretical design approach for fixing the lining thickness. Methods of placement of concrete lining, side slope lengths of canal on which lining is to be placed, site conditions and maintenance considerations influence the selection of lining thickness.

Thickness of Reinforced Concrete Lining. Size of reinforced steel bars influences lining thickness. Normally, minimum thickness of reinforced concrete lining has to be 6 inches (150mm) in case steel bars are used and 125 mm minimum thickness if wire mesh reinforcement is used.

(i) Concrete Mix (Grade of Concrete, Coarse Aggregate Size, Slump, Water-Cement Ratio). As per modern practice, M15 Grade concrete (1:2:4) should be used for the lining. Further more, in view of the fact that the canal lining suffers alternate wetting and drying during its operation, concrete mix should not be of strength less than M 15 grade. Design Mix M15 grade concrete is to be preferred over the volumetric M15 grade mix (1:2:4). The maximum size of well graded coarse aggregate should be 20 mm for the lining thickness up to 75 mm and 40 mm maximum size for the lining thickness of 100 mm. A slump of 60 mm to 65 mm is considered to be satisfactory for manual placement of lining. Slump of 50 mm to 55 mm is adequate for mechanized placement of lining with Concrete Pavers. Water-Cement Ratio (W/C) should, preferably, be restricted to 0.55. In any case, it should not be more than 0.60 from the strength and durability considerations of concrete.

Air-Entraining Agent (A.E.A) in Concrete Mix. Purposeful entrainment of 2 to 4 % air in the concrete mix through addition of A.E.A. greatly improves its workability and durability. This also permits the use of aggregates less well graded than required if air is not entrained. Addition of A.E.A. also ensures ease and "better finish" of concrete surface.

Purpose of Air Entraining Agent (AEA) Addition of A.E.A in the concrete mix causes dispersion of hundreds of tiny spheres of air of diameter ranging from 0.075 mm to 1.0 mm throughout the concrete mix. This reduces the "water channel structures" in concrete, there by, reducing voids, bleeding and segregation of concrete and, consequently, improving its workability and durability.

(j) Placement & Compaction of Concrete Lining; Provision of Contraction Joints & Curing of Lining. Concrete can either be placed *manually* or its mechanized placement can be undertaken by deployment of *Slip Form Steel Gantry (for medium size canals)* and by *Concrete Paver (for bigger section high discharge capacity canals.* Manual Placement of Lining. In case it is placed manually, needle vibrator should not be used directly for compaction of lining since it could puncture and disturb the sub grade. Instead, "Plate Vibrator" should be used for the vibration and compaction of concrete. A simple device, constituting the plate vibrator, explained in paragraph (c) above and illustrated in photo Copy P1, can be conveniently deployed for the compaction of concrete lining also. *Such device in operation for the compaction of lining is illustrated in Photo Copy P9 in Annex P.*

Placement Of lining through Slip Form Steel Gantry. The bed lining is placed manually and lining on the side slopes is placed by the steel gantry. It can be a 'single track' or a 'double track' gantry moving on rails depending upon the canal section. Vibratory motors, each of 1 H.P., are fitted on the side steel shutters of the gantry for the vibration and compaction of concrete. The steel shutter length parallel to the canal is 1.2 m or 1.25 m. The gantry is moved manually. *Principal features of such gantry as well as* **a** *typical steel gantry on a single track and the one on a double track are illustrated in Photo Copy P10* ***in*** *Annex P.*

Typical Example: A double deck Slip Form Steel Gantry *actually used* for placement of concrete lining on the side slopes of the canal of following hydraulic particulars is explained below:

Bed width of canal = 1.52 m. Full Supply depth = 0.61 m. Free Board = 0.30 m

Side Slopes = 1.5 H) : 1 (V). Length of each side slope = 1.64 m. Velocity = 2.16 m / sec

Full Supply discharge = 34.56 cusec.

Bed lining was placed manually and mechanized placement of lining was concurrently undertaken on each side slope of the canal through the steel gantry. One *concrete mixer* of 10/7 cft was operated on each canal bank to deliver M 15 grade concrete mix behind each steel shutter of the gantry through a *chute.* The concrete was very efficiently vibrated by the vibratory motors fitted on the steel shutter of 1.25 length (along the canal) covering the entire side slope on each side. Thereafter, the gantry was pulled forward manually and concrete delivered behind the shutters again. *The Concrete lining operation was, thus, a continuous one.*

Canal *Lining Operation with double track steel gantry are depicted in Photo Copy P11 & P12 in Annex P.*

Optimum Canal Sections for efficient placement of lining & progress of placement by Steel Gantry. The Slip Form Steel Gantry can be deployed for efficient placement of concrete lining on the side slopes of the canals of bed width up to about 2.0 m and side slopes of up to about 2.7 m length. The progress of placement is about 4 m^3 concrete per hour. *The Cost of a double deck steel gantry shall be about SLR* 1.2 *million including the vibratory motors*. It should be noted that after completion of the job, the contractor can sell the gantry as a scrap at almost the purchase cost since the steel prices go on increasing. Thus, mechanized lining is quite economical and offers good progress & better quality than manual placement

Tolerance in Lining Thickness. In view of the fact that it is very difficult to prepare the sub grade to perfect line and grade, a reasonable tolerance in the lining thickness during its placement is needed. International Standards broadly specify a tolerance level of ± 10 % of the design thickness provided the overall average thickness of lining placed in the respective reaches at the end of the day is not less than the designed thickness. This implies that for the specified design lining thickness of 75 mm, the thickness of lining actually placed at some locations should not be less than 75 mm – 10 % of 75 mm or 67.5 mm and, that, placed in other locations be not more than 75 mm + 10% of 75 mm or 82.5 mm. This means a tolerance of 7.5 mm as "under-run" and of 7.5 mm as "over-run". In this context, lining thickness should be regularly checked with a vernier caliper and recorded. These tolerance levels shall bind the contractor to do a good job. Also, project engineers shall exercise strict field control. The overall average thickness of lining (*in mm*) placed at the end of day's work can be calculated as following:

Average lining thickness (mm) =Total concrete placed (m^3) x 1000 divided by Surface area (m^2) covered.

Provision of Contraction Joints in Concrete Lining. Contraction joints should be provided in the lining at a spacing not exceeding 36 times lining thickness broadly in conformance with the USBR (United States Bureau of Reclamation) practice. Transverse contraction joints are provided across the canal section and longitudinal joints are provided longitudinally. No longitudinal contraction joints are provided in the lining in such canals in which the wetted perimeter is less than 9.0 m. As for example, the spacing of contraction joints in 75 mm thick canal lining is not to exceed 2.7 m (36 x 75 mm = 2700 mm or 2.70 m). Likewise, spacing of these joints in 100 mm thick lining should not exceed 3.6 m (36 x 100 = 3600mm or 3.60 m). *The shape of the contraction joint grooves and their dimensions corresponding to the concrete lining of various thickness are depicted in Sketch P 13 in Annex P*.

Significance of Contraction Joints in Concrete Lining. Shrinkage of concrete occurs during the curing process and the temperature changes occurring in concrete cause cracking in the lining. *Provision of contraction joint grooves of the shape & dimensions depicted* in *P13 in Annex P and spaced at interval not exceeding 36 times lining thickness allows the formation of "weakened plains" at such joints*. Accordingly, cracks would form only at these controlled locations / joints and these cracks do not travel down beyond the depth of the grooves, viz, beyond about one third of the lining thickness. No cracks would occur on the concrete surface between the contraction joints. The contraction joints are, thus, crack-control joints and save

the lining from the occurrence of random cracks on the lining surface. The contraction joint grooves, after thorough cleaning, are finally filled with the approved sealing compound.

Curing of Cement Concrete Lining.

(i) *Water Curing of Lining.* Consistent and un-interrupted water curing of lining for at least 21 days should be ensured though extended curing for 28 days shall be desirable. What is needed is a fool-proof curing arrangement and no compromise, what so ever is to be made on this count. Proper and adequate curing reduces the permeability of lining and increases its strength. Curing of bed lining is best done by making small earthen bunds at suitable interval and ponding water in the reaches between the bunds . In respect of curing of the side lining, , entire lined surface on both side slopes should be covered with 'double hessian cloth rolls' or rolls of gunny bags and kept these fully saturated with water by sprinkling water over these rolls. The contractor should be allowed to commence the lining operations only when he has arranged sufficient hessian cloth rolls / gunny bags rolls along with water tanker fitted with hose and nozzle as well as availability of workers round the clock for sprinkling water on the rolls.

(ii) *Curing with Membrane-Forming Curing Compound.* In case, availability of adequate quantity of hessian cloth / gunny bags rolls and making fool-proof water arrangement pose constraint, curing of side lining should be done with 'Membrane-Forming Curing Compound'. The white-pigmented curing compound should conform to ASTM (American Society Of Testing Materials) –C- 309-81 Type 2. Curing of bed lining shall, however, be done by ponding water between the small height earthen bunds constructed in the bed. Methodology of curing by the 'Curing Compound" has been explained in the Guidance Note No. F, titled Plain and Reinforced Cement Concrete Construction, Section A (already furnished). *However, it is again summarized herewith.* "The contractor should furnish manufacturer's test certificate of the curing compound. The curing compound has to be sprayed by a nozzle on the lining surface only after the 'shine' on it disappears ie, when no moisture is left on the surface and it gives a dull appearance. The time to commence spraying of curing compound after placement of lining in a reach will depend upon weather conditions. It may vary from 45 minutes in hot summer months to about 75 minutes in cold weather. In respect of dosage, one litre of curing compound should cover only 4 m^2 of lining surface and not more.

(j) Filling of contraction Joint Grooves in Cement Concrete Lining. Filling of contraction joint grooves in the lining should be taken up only after 28 days of placement of lining in the respective reaches. All grooves should be fully cleared of sand, silt, mortar or any other material. Any repairs to bring the grooves to the specified shape & dimensions should be duly carried out. The grooves should then be properly filled with the approved sealing compound. It should be recognized that the long-term performance of lining would depend

a lot on how well the grooves were cleaned and how well these were filled with the sealing compound.

Factors Influencing Strength and Durability of Concrete Lining.

Strength and Durability of concrete are the two essential requirements. More stress is now given to the durability of concrete structures world over. *Durability of concrete* is its ability to successfully resist the harmful effects of environment to which it would be exposed during its operational / service life with minimum maintenance requirement. It implies longevity of the functional reliability of the concrete structures. Concrete lining being a thin lamina, it must be dense and impervious to the possible extent in order to ensure its long-term sustainability and durability in its performance & functional reliability with minimum maintenance requirement. *Factors influencing both the strength and durability of concrete lining are summarized below:*

1. Removal of Vegetation & Roots. It is extremely essential that all roots, vegetation, plants etc. are removed prior to the preparation of sub grade in the canal reaches proposed to be lined. Any plants in the vicinity of the sub grade (prone to contributing roots) should also be removed /uprooted. If not done and the lining is placed, it would get punctured and severely damaged by the force of "root mass" in a short period. *Such serious situation is depicted in Photo Copy P14 in Annex P.*

2. Preparation of Proper Sub Grade. Preparation of a uniform, smooth and dense sub grade to receive lining is of paramount importance for the long-term durability of concrete lining. Surface irregularities in the sub grade must be removed. Both the bed and sides of the canal section sub grade must be adequately compacted with appropriate equipment as is already brought out. The lining placed on a sub grade associated with loose pockets, depressions and abrupt protrusions would suffer pre- mature deterioration and large scale damages within a short period.

3. Water-Cement Ratio of Concrete Mix. Water-Cement Ratio (W/C) has the maximum bearing on the strength and durability of concrete. High water-cement ratio reduces both the strength and durability. High water content increases "porosity" in concrete and higher porosity results in higher "co-efficient of permeability", which makes the concrete highly vulnerable to easy ingress of environmental elements (carbon dioxide, moisture, oxygen, chlorides, sulphates etc) into concrete. Such easy ingress causes early deterioration of concrete lining. Further more, porous concrete allows easy ingress of water into the sub grade behind the concrete lining making the lining vulnerable to high hydrostatic pressure. The lower the water-cement ratio, the lower would be the permeability of concrete and, consequently such concrete lining would be more durable. In this context, the water-cement ratio in the concrete mix for the lining should not be allowed to exceed 0.58. Super-plasticizer should be used for achieving enhanced workability of concrete mix in hot weather in order to restrict the water-cement ratio to 0.58 or even less, say, 0.50. Chemical

admixture (super-plasticizer) may be used in the concrete mix in the hot weather to increase its workability (slump) without addition of any extra water.

4. Use Of Portland Pozzolana Cement – PPC (fly ash based) in Concrete Mix. Either Ordinary Portland Cement (OPC) or Portland Pozzolana Cement (PPC) can be used in the concrete mix. However, it is preferable to use PPC (fly ash based). It has been conclusively established that the permeability of concrete made with PPC (fly ash based), incorporating 20 % fly ash, is much lower than the concrete made with OPC. The "Chloride Ion Permeability Test" as per American Society of Testing Materials ASTM – C- 1202 has established this fact which is outlined below. (For details, Refer Guidance Note G, titled Plain and Reinforced Cement Concrete Construction- Section B, already furnished).

(a) *Chloride Ion Permeability of Concrete made with OPC (Ordinary Portland Cement)*

Grade of Concrete Mix Specimen	Charge passed (Coulomb)	Degree of Permeability
M20 (1: 1.5:3)	4186	**High**

(b) *Chloride Ion Permeability of concrete made with PPC – Portland Pozzolana Cement (fly ash based)*

Grade of Concrete Mix Specimen	Charge passed (Coulomb)	Degree of Permeability
M20 (1:1.5:3)	1365	**Low**

Thus, Concrete Mix should be made with Portland Pozzolana Cement- PPC (fly ash based). This would substantially reduce the permeability of concrete lining and shall accordingly increase its durability and long-term sustainability.

5. Proper Contraction Joints, Effective Compaction & Curing of Lining. Provision of contraction joints of proper shape & dimensions (*as per Sketch P13 in Annex P*) spaced at interval not more than 36 times lining thickness as well as effective compaction of concrete lining and its fool-proof curing are very important requirements for achieving high durability of lining.

Under-Drainage Arrangement in Concrete Lining.

Under-Drainage arrangement in very small section channels may not be necessary. However, under-drainage arrangement should be provided in the medium section and bigger section canals for the safety of canal lining against the hydrostatic pressure when the canal is de-watered. There is a very simple under-drainage arrangement which has been well tried and found to be effective and successful. It comprises provision of *"Porous Concrete Plugs"* in the lining which extend into the sub grade duly enclosed in the graded filter. The cylindrical plugs are pre-cast in porous concrete. The porous concrete mix consists of 1 part of cement and 4 parts of coarse aggregate of maximum nominal size of 20 mm. *No sand is to be used in the mix.* Small quantity of water is added which is just enough to adequately coat the coarse aggregate with cement. The plugs are of 75 mm diameter & of 250

mm length for medium section canals and of 300 mm length for bigger section canals. The bottom end of the plug is encased in graded filter. Suitable nitches are excavated in the sub grade to provide the requisite drainage arrangement. Porous plugs are provided on the sides at a height of d/3 from the canal bottom (1/3 full supply depth). One plug is provided between each transverse contraction joint panel and one plug is provided in the bottom in the alternate panels. The graded filter consists of sand and crushed coarse aggregate of 20 mm size. In bigger section canals, besides providing first row of porous plugs on the sides at 1/3 d, second row of plugs are also provided at 2/3 d (d is full supply depth).

It has to be ensured that the pre-cast porous concrete plugs are indeed porous. In this context, few porous plugs are regularly tested for porosity . A porous plug is held in one hand and water from a jug is poured on its top. In case, the water freely flows out from the plug, it is an indication that it is porous and conforms to the desired specification.

A Typical Under-Drainage Arrangement is Illustrated in Sketch P15 in Annex P.

ANNEX. P

CEMENT CONCRETE LINING IN CANALS

(With Particular Reference To Bigger Section / High Discharge Capacity Canals)

CONTENTS

ANNEX P

SIMPLE DEVICE for SUB GRADE COMPACTION
VIBRATOR CLAMPED ON A STEEL PLATE

ANNEX P

P2

RIG MOUNTED PLATE COMPACTOR IN OPERATION ON COMPACTION OF SUB GRADE ON SIDE SLOPE OF CANAL.

ANNEX P

P3

RIG MOUNTED VIBRATORY HYDRAULIC COMPACTOR IN OPERATION ON COMPACTION OF SUB GRADE ON SIDE SLOPE OF CANAL.

RIG MOUNTED VIBRATORY HYDRAULIC COMPACTOR IN OPERATION ON COMPACTION OF SUB GRADE ON SIDE SLOPE OF CANAL.

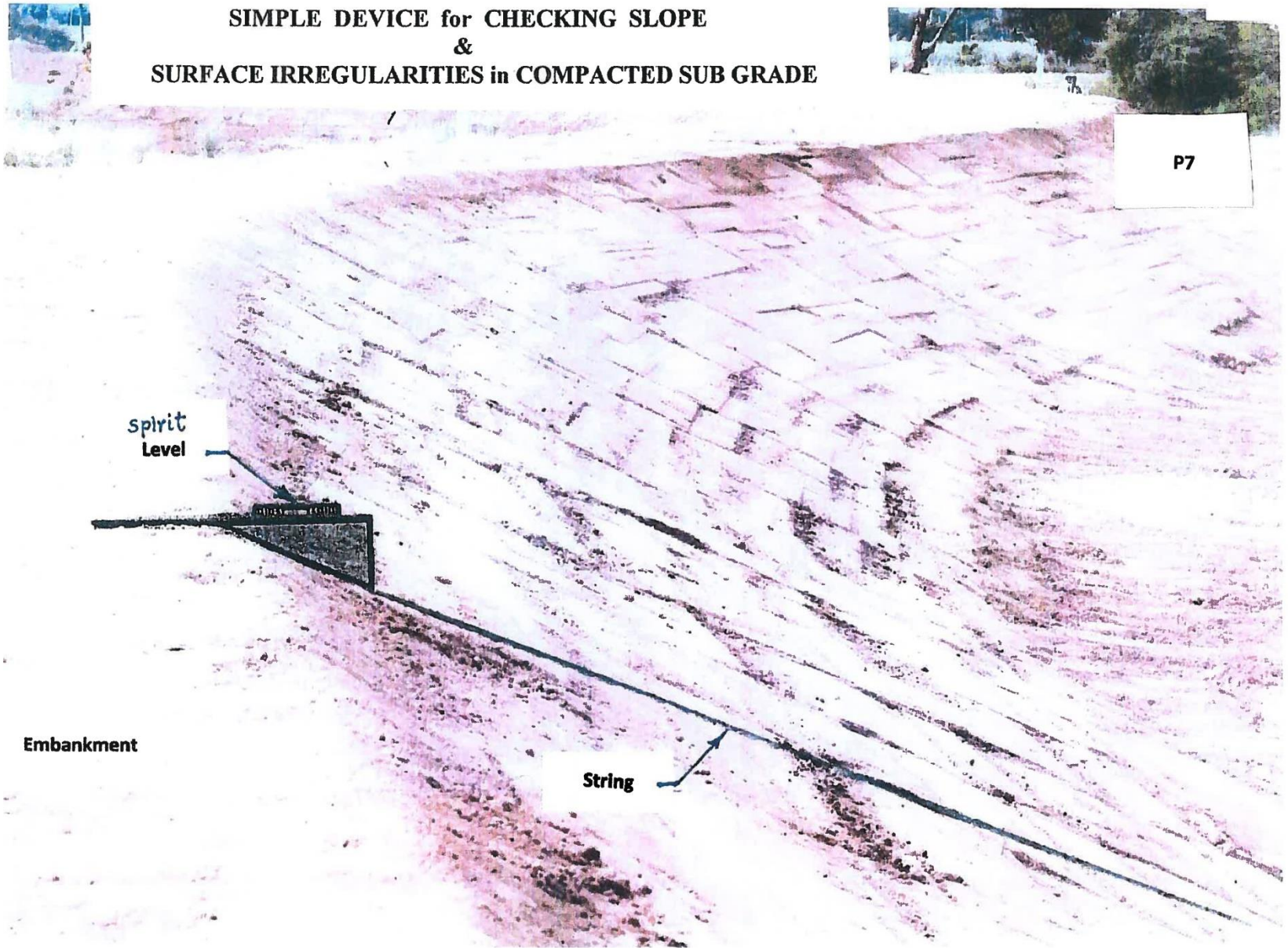
ANNEX P

HEAVY DUTY VIBRATORY SOIL COMPACTING ROLLER IN OPERATION ON COMPACTION OF SUB GRADE ON SIDE SLOPE OF CANAL.

ANNEX P

RIG MOUNTED PLATE COMPACTOR, RIG MOUNTED VIBRATORY HYDRAULIC COMPACTOR, HEAVY DUTY VIBRATORY SOIL COMPACTING ROLLER DEPICTED TOGATHER ON COMPACTION OF SUB GRADE OF CANAL.

SIMPLE DEVICE for CHECKING SLOPE
&
SURFACE IRREGULARITIES in COMPACTED SUB GRADE



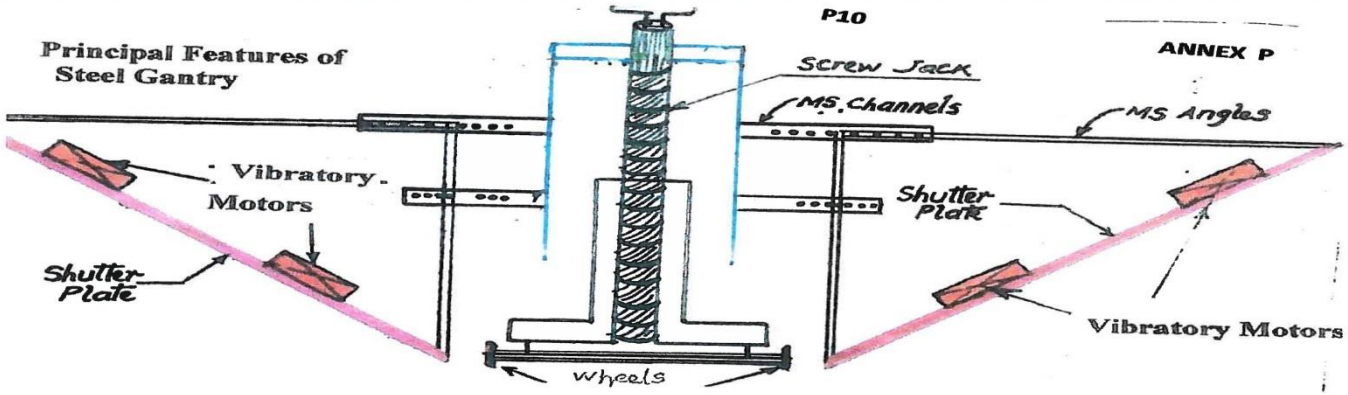
P8

DEPLOYMENT OF "NON NUCLEAR SOIL DENSITY GAUGE" FOR CHECKING DENSITY OF COMPACTED SUB GRADE ON SIDE SLOPE OF CANAL.

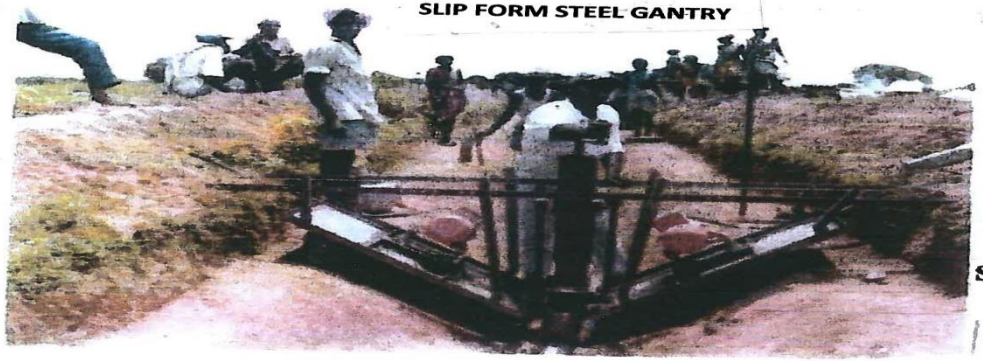
SIMPLE DEVICE IN OPERATION ON COMPACTION OF CONCRETE LINING ON SIDE SLOPE.

P10

ANNEX P



SLIP FORM STEEL GANTRY



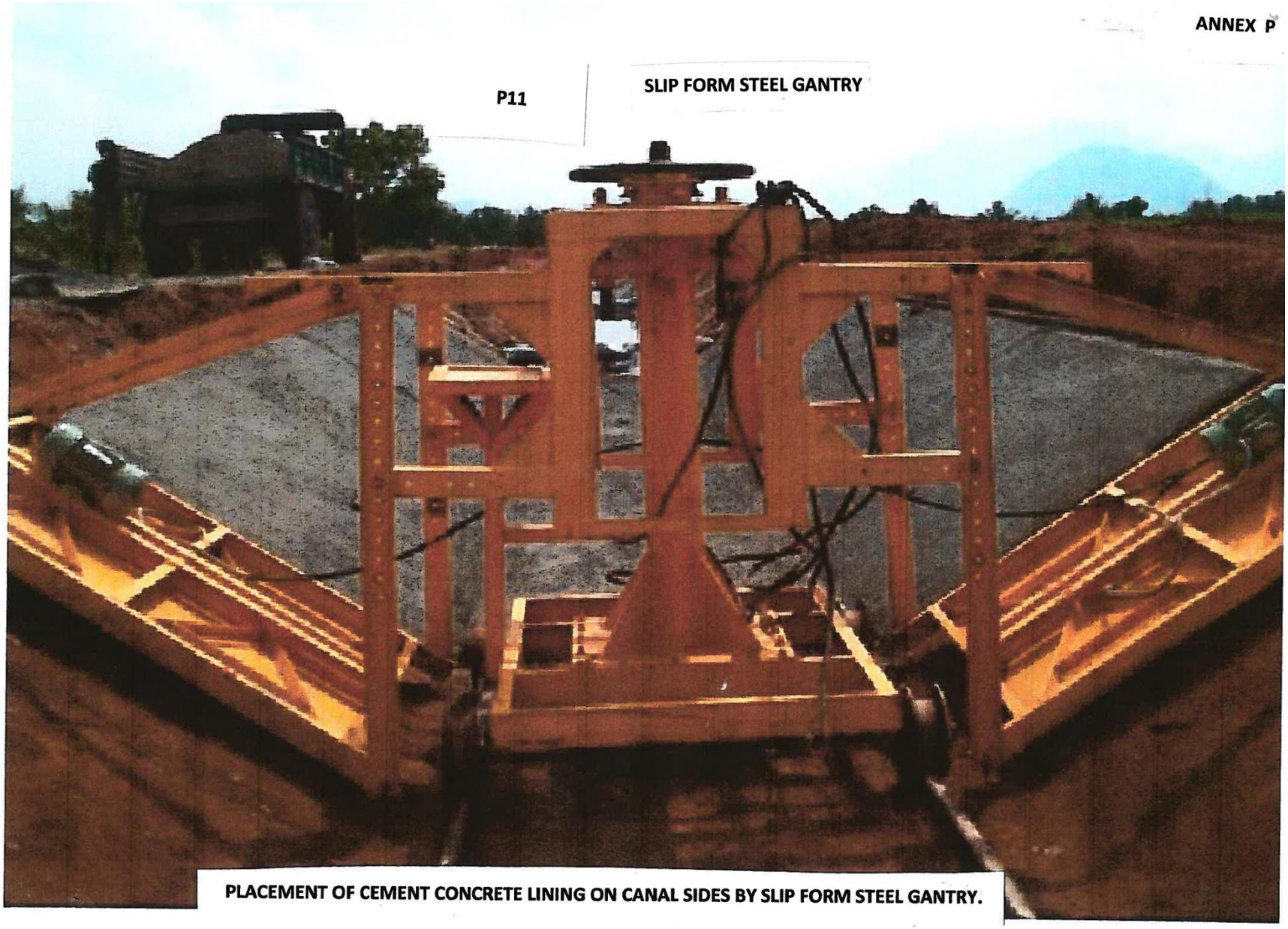
Steel Gantry on Single Track

Steel Gantry on Double Track

ANNEX P

P11

SLIP FORM STEEL GANTRY

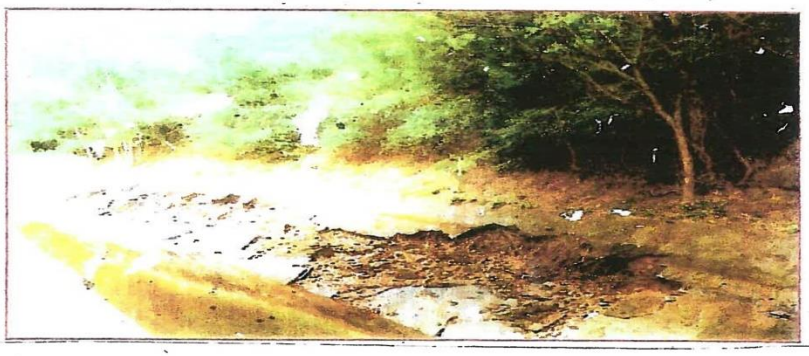


PLACEMENT OF CEMENT CONCRETE LINING ON CANAL SIDES BY SLIP FORM STEEL GANTRY.

ANNEX P

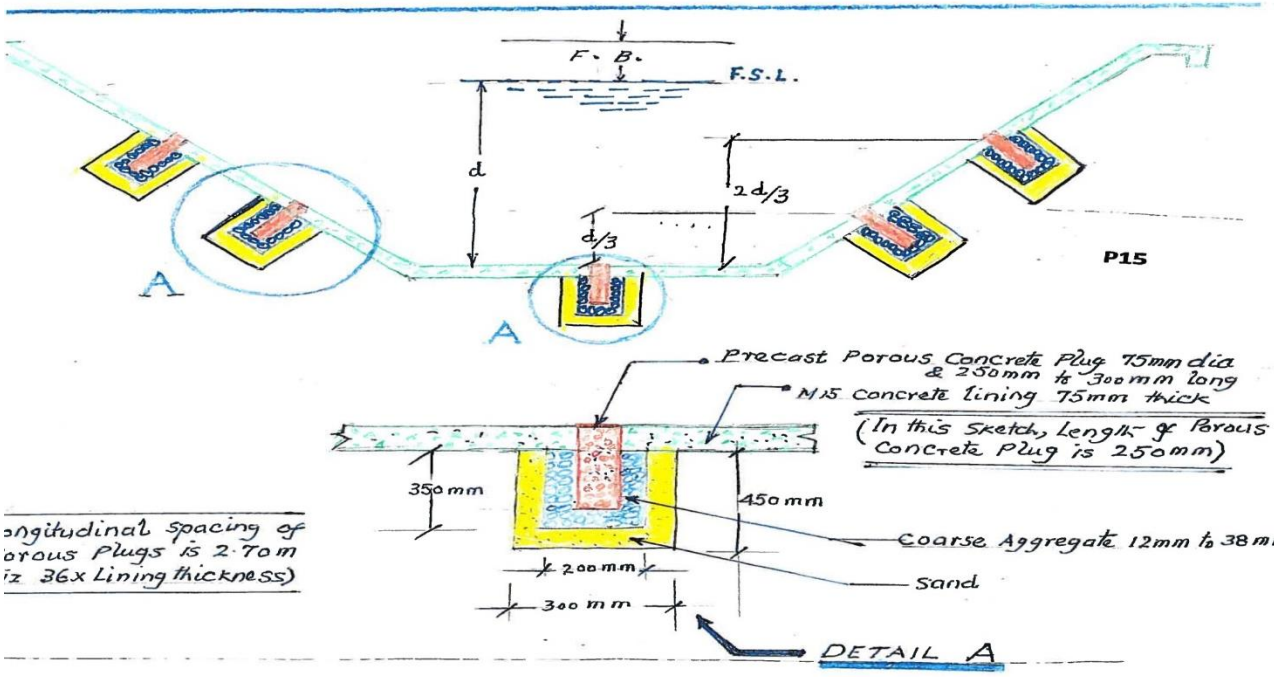
PLACEMEN OF CEMENT CONCRETE LINING ON CANAL SIDES BY SLIP FORM STEEL GANTRY

ANNEX P



P14

CONCRETE LINING SEVERELY PUNCTURED & DAMAGED BY THE FORCE OF ROOT MASS.

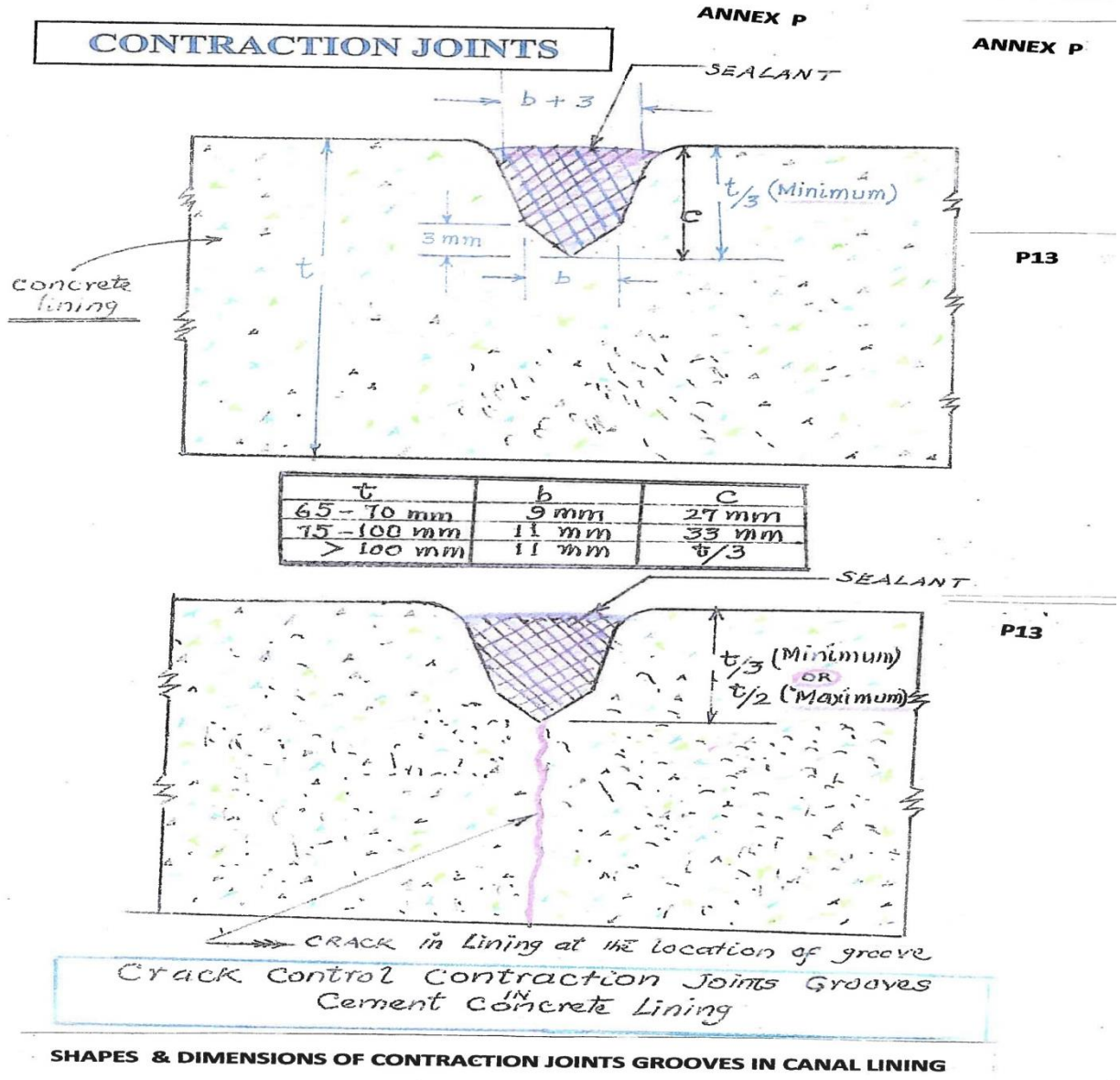


P15

TYPICAL UNDER-DRAINAGE ARRANGEMENT IN CONCRETE LINING OF CANAL.
(IN BIGGER SECTION CANALS)

ANNEX P

ANNEX P



t	b	c
65 - 70 mm	9 mm	27 mm
75 - 100 mm	11 mm	33 mm
> 100 mm	11 mm	t/3

SHAPES & DIMENSIONS OF CONTRACTION JOINTS GROOVES IN CANAL LINING

8.2 CANAL LINING WITH CONCRETE

8.2.1 PREPARING SUBGRADE FOR LINING

a. GENERAL

The provisions of this paragraph apply, to the preparation of all foundation upon which concrete lining is to be placed. The concrete lining may be cast in place or precast as shown in the drawing / or as directed by the Engineer in charge

The items of schedule for preparing foundations for concrete lining includes all excavation below the underside of the concrete lining required for placing selected bedding material wetting the surfaces, furnishing or procuring, excavating from stock piles, hauling, placing, moistening and compacting the selected bedding material and trimming the entire canal. this item also includes excavation, and preparing of foundation for providing under drainage facilities and pressure relief arrangements and placing test sections to verify that the procedures result in acceptable results.

The trimming operation shall be carried out immediately prior to laying of the lining . the time involved will not exceed 24 hours but in exceptional cases 2 days may be permitted by the Engineer in charge

In all, the preparation of sub grade for concrete lining shall conform to clauses of I.S.3873-1993 (Indian Code of Practice for laying in situ cement concrete /Stone slab Lining on canal.)

b .PREPARATION OF SUBGRADE FOR EXCAVATION.

As specified in clause 4.2 of I.S. 3873 1993 the sub grade in rock shall be excavated to the required cross section. Over excavation in rock shall be minimized by using wedging and barring methods for final dressing. The excavation shall conform to para 4.2.1 & 4.2.2

I The aspects to be considered shall be as follows

1) The bed and side slopes of the canal excavation profile over which the bedding material, under drainage and pressure relief arrangements are to be placed and overlaid with lining, shall be finished accurately true to the dimensions shown in the drawings.

2) Removal of surface irregularities to the acceptable tolerance level - 6.25 mm on slopes and about 12.5 mm on the bed; consolidation of sub-grade; checking the density of sub-grade at regular intervals; introduction of under-drainage arrangement, as per drawing; moistening of sub-grade with fine spray of water through a nozzle.
3) Immediately prior to placing the Ist lift of selected bedding material the surfaces of the excavation both in bed and slopes to receive the materials shall be thoroughly wetted to a depth of 15cm or to impermeable material, whichever is less as approved by the Engineer – in charge.
4) After the canal prism has be shaped to a reasonably true and even surface as described above, selected bedding material shall be placed on thoroughly wetted surfaces in layer of 15 centimeter maximum thickness to bring the bedding material to a height where it can be trimmed to form a true and even surfaces upon which to place the concrete lining or random rubble masonry lining.
5) In bed of the canal profile each layer of bedding material shall be placed and if required moistened and compacted in accordance with 4.3.6 of I.S. 3873- 1993.
6) Compaction of subgrade in bed should be done at OMC in layers of not more than 15cm thickness to obtain dry bulk density of not less than 95% of the density at Optimum Moisture Content. Consolidation of sides should be done by manual labourer to obtain the dry bulk density of not less than 90% of the density at OMC.
7) Before commencement of placement it shall be ensured that the subgrade has been properly prepared and is hard, uniformly well compacted and free or any loose pockets and that it is smooth and without any objectionable protractions. Prior to placement, it shall be moistured thoroughly so that moisture will not be withdrawn from freshly placed concrete. Moistening shall be done through fine spray nozzles of water so that moisture penetrates about 15 cm into the subgrade. The spray is to be such that no muddy conditions is created.

8) Preparation of Sub grade for laying of precast slab.

Wherever precast concrete slabs are used for side lining it should not be directly placed on the sub-grade. Instead, over has finished sub-grade, a layer of 1: 5 cement mortar 15mm thick may be spread and water cured for 24 hours. Over this cement plaster and before commencement of slab laying, a layer of 6 mm thick 1:3 cement mortar may be applied. The PCC slabs may then laid over the green mortar followed by raking, brushing, wetting and pointing of joints in CM 1:3

II Selection of Bedding Material

Rocks:

The selected bedding material in bed and sides of the canal in rock reaches shall be CC 1:5:10 (one cement five sand ten aggregate of maximum 40 mm size by volume) if the of filling is less than 15 (fifteen) cms and RR masonry with mortar 1:5 (one cement, five sand by volume) if the more than 15 cm (fifteen) cms.

Ordinary Soils:

Selected bedding material in the case bed and sides profile in normal soils shall be semi pervious material with sub grade materials and thoroughly compacted.

Expansive soils:

In expansive soils, cohesive non swelling soil will be used. The thickness of CNS layer shall be designed to swelling pressure of soil or as directed by the Engineer in-charge.

The bedding material shall conform broadly to gradation and index properties as below:

	Percent
Clay (less than 2 microns)	15 to 20%
Silt (0.06mm - 0.002mm)	30 to 40%
Sand (2mm - 0.06mm)	30 to 40%
Gravel (greater than 2 mm)	0 to 10%
Liquid limit	greater than 30% but less than 55%
Plasticity Index	greater than 15%

but less than 30%

The thickness of CNS layer given in table 1 of IS 9451-1994 (reproduced below)

Swelling pressure of soil	**Min thickness of CNS material**
KN/ M2	Millimeters
50 to 150	750
150 to 300	850
300 to 500	1000

The CNS layer shall be compacted to 95% proctor density. Compaction may be by power rollers. In large canals a horizontal width of about 2.25 m in a slope of 1:5:1is required for compaction of power rollers of 8 to 10 T. this may be done in the form of terraces as shown in picture No.2. The extra width is to be trimmed to the required profile.

C. PREPARATION OF SUBGRADE FOR EMBANKMENTS.

I The aspects to be considered shall be as follows

1) The bottom and side slopes , including the surfaces of compacted embankment, compacted selected bedding materials and compacted back fill over which concrete lining is to be placed shall be furnished accurately to true and even surfaces to the dimensions shown on the drawings.
2) Removal of surface irregularities to the acceptable tolerance level - 6.25 mm on slopes and about 12.5 mm on the bed; consolidation of sub-grade; checking the density of sub-grade at regular intervals; introduction of under-drainage arrangement, as per drawing; moistening of sub-grade with fine spray of water through a nozzle.
3) Where placing and compacting selected bedding materials on a sloping foundation the layers may be placed parallel to the surface of the foundation. If at any point the foundation materials disturbed or loosened during excavation process or otherwise it shall be moistened if required and thoroughly compacted by tamping, rolling or other approved methods to form firm foundations upon which to place the concrete lining.

4) Immediately prior to placing the first lift of selected bedding materials the surfaces of the canal profile to receive the materials shall be thoroughly wetted to a depth of 15cm or to impermeable material whichever is less as approved by the Engineer in charge
5) After the canal prism has been shaped to a reasonably true and even surface as described above selected bedding materials shall be placed on thoroughly wetted surfaces in layers of 150mm maximum thickness to bring the bedding material to a height where it can be trimmed to form a true and even surface upon which to place the concrete lining. Each layer of the bedding material shall be moistened in accordance with paragraph 4.3.6 of I.S. 3873 1993 and thoroughly compacted.
6) Compaction of subgrade in bed should be done at OMC in layers of not more than 15cm thickness to obtain dry bulk density of not less than 95% of the density at Optimum Moisture Content. Consolidation of sides should be done by manual labourer to obtain the dry bulk density of not less than 90% of the density at OMC.
7) The moisture content of the bedding material at the time of compaction procedures used shall be the same as those used in the demonstration section. Before commencement of placement it shall be ensured that the subgrade has been properly prepared and is hard, uniformly well compacted and free or any loose pockets and that it is smooth and without any objectionable protractions. Prior to placement, it shall be moistured thoroughly so that moisture will not be withdrawn from freshly placed concrete. Moisture shall be done through fine spray nozzles of water so that moisture penetrates about 15 cm into the subgrade. The spray is to be such that no muddy conditions is created

D TESTING

The contractor shall place test profiles at times and places designated by the Engineer – in- charge to show the accuracy of his construction procedures for placing and compacting in the bedding material.

The test profiles shall be checked conforming to clause 4.3.2 of IS 3873 -1993.

The bedding material shall be placed to sufficient thickness in the test sections to allow practical density testing of the compacted material. The dimensions and densities of the compacted bedding materials in the test section and the testing there of shall be in accordance with I.S. Modification shall be made to procedures until it is demonstrated that acceptable densities are being consistently obtained. The procedures shall there be used to compact the selected bedding material on the remainder of the work.

At the end panels of the existing lining against which lining is to be placed under these specifications all loose material shall be removed and all voids beneath the existing lining shall be refilled and thoroughly compacted.

Suitable material trimmed from canal shall be used to complete canal embankments to construct road embankments for back fill about structures or for selected bedding materials. Where materials suitable for selected bedding material determined by the Engineer – in –charge if encountered during trimming operations and cannot be placed in one continuous operation such material shall be stockpiled along the right of way were designated by the Engineer – in –charge. All material required for preparing foundation shall be furnished by the contractor.

8.2.2 SECTION OF CANAL

1. Side Slope

In 10430 – 2000 has prescribed standards for side slopes. The same may be followed for lining works wherever possible.

However in all IAMWARM works it is suggested to provide minimum side slope of 1:5:1 (i.e. 1.5 horizontal and 1.0 vertical) for lined canals in natural soil other than rock. This stable slope is for cutting and embankment portion of the lined canal.

2. Free board

Free board may be in accordance with clause 8.2. Of I.S. 10430-1982

Discharge in cumecs	Free Board in metres
>10	0.75
3 to 10	0.60
1 to 3	0.50
<1	0.30
Less than 0.1(w.c)	0.15

3. Thickness of concrete lining

It is more appropriate to have same thickness of concrete lining for bed and sides. The following may be the thickness of lining. As recommended in table 1 of clause 5.2 of IS 3873 1993

Canal discharge (M3/sec)	Depth of Water (in m)	Thickness of lining (in mm)
0 -5	0-1	50-60
5 -50	1-2.5	60-75
50-200	2.5-4.5	75-100
200-300	4.5-6.5	90-100
300-700	6.5-9.0	120-150

4. As a measure of protection against high velocities at transitions the thickness of lining may be doubled for a distance of say about 6 to 10m on both sides of any structure depending on the type of structure.

Alternatively if so desired by the Engineer in charge of work masonry lining may be provided by sides as per standards.

5. Junction of bed and side lining

The lining shall be lain continuously at the junction on bed and side as per IS 5517. However, at the junction of bed and side, in order to provide smooth corners the portion may be rounded with curvature or about 200 mm radius. To make up this transition, fillet material of PCC 1:2:4 may be provided as shown in the sketch – 3(a)

6. Keys or coping

At the top where lining is terminated, keys / coping may be provided for a width of not less than 300 mm and thickness not exceeding 100m using same grade of lining material.

7. Banks

Bank widths may generally confirm to practical standards. However based on safety considerations the minimum top width may be as per IS specifications (IS 10430 – 2000). The top width of the inspection bank (Motorable) should not be less than 4.00 metre.

The slopes of the bank may be decided based on stability considerations depending on the type of soil for embankment. However minimum slope of 1.5:1 may be provided in the front.

8. Dowels

Both sides of the canal lining, should be prevented from rain water seeping beneath the lining for which dowels / parapet may be provided on service road side on spoil bank side reverse slope may be provided. The collected storm water may be disposed off by providing catch drains of suitable size.

8.2.3 CONCRETE PRODUCTION & PLACEMENT:

Proportioning of ingredients of concrete mix shall be weight only. Concrete mix shall be prepared in a batching mixing plant and transported to the placement. Sites in mobile transit mixers. Alternatively, the contractor may deploy mobile self-loading weigh batching mixing and transporting mixers (Say about 2 cum drum capacity) for preparing concrete mix and transporting to the placement sites. He may also deploy a number of mechanical concrete mixtures and requisite weigh batching arrangements (for proportioning of concrete mix by weight) at a number of fronts to place in – situ concrete lining on bed and sides of canal.

The water cement ratio normally be not more than 0.60 and the slump may range as recommended by clause 5.1 may be adopted. In general slump values ranging from 50mm to 70 mm for better workability and good finishing is

recommended. Air entraining agents approved – by the Engineer -in –charge, shall be added in the concrete mix for canal lining for durability and better workability.

P.C.C in situ lining is proposed for the channel bed and sides in M15 concrete using 20mm machine crushed hard granite metal conforming to IS 383 standards.

Special attention shall be paid while placing the concrete on side slopes and suitable templates shall be provided. The concrete as placed shall be free of any segregation or honey combing and towards this end adequate workability and consistency of concrete mix shall be ensured and also more importantly, the concrete on slopes shall be efficiently and timely finished to a smooth finish. Water cement ratio and slump shall need to be adequately controlled. Water cement ratio be restricted to about 0.55. A slump of 60 to 70mm should generally be allowed. For heavier longitudinally operating slip form machines, a slump of 50mm at the laying point should be used. The slump can be appropriately modified (as directed by the Engineer in charge) as per site conditions to ensure efficient placement on side slopes. The contractor may use a crow type form work for side lining if he so desired

Manual placement

Adoption of manual placement for small section channels is usually done

In manual placement of concrete the following procedure shall be adopted

Placement of concrete for lining either directly from the Concrete Mixer parked on either end of canal and delivery of concrete for lining by chutes or transporting concrete in Transit Mixers from the Batching & Mixing plant and delivery of concrete to the placement site of lining through chutes.

i. Laying of in situ concrete for bed should be done for in alternate panels.
ii. The panel width should vary from 2 to 3m and shall not exceed 3m.
iii. Succeeding panel should be laid at an interval of 1 day.

Compaction of manually placed concrete lining with 'plate compactors' (vibrator hooked on to a steel plate fixed with a handle on either side); avoiding use of needle vibrators as these would puncture the sub-grade.

Mechanized placement

Mechanized placement with 'slip form steel gantry' in small section channels in case of lining in fairly long reach / reaches may be adopted.

Mechanized placement with Concrete Pavers in case of big size canal sections in long reaches.to ensure better quality

8.2.4 CONTRACTION JOINTS IN LINING

The joints shall be made along straight line, to the detailed dimensions shown in the drawings and shall be maintained to the required shape and dimensions during any subsequent finishing operation until the concrete has hardened.

Transverse contraction joints to be provided in lined section at a spacing of not more than 36 x lining thickness. No longitudinal contraction joints to be provided in small section channels, where the wetted perimeter is less than about 12 m.

All contraction joints to be thoroughly cleaned of sand, soil, set grout / concrete and restored to the specified design shape, Air-water gun to be used for final clearance; filling of the contraction joints with approved sealing compound.

The grooves for the joint shall be as below.

Lining thickness	Depth of groove	Width of groove At bottom at top
65 – 70 mm	27 mm	9 mm-12mm
75 – 100 mm	35 mm	11 mm-14 mm
More than 100 mm	lining thickness / 3	11 mm-14 mm

Specification for preparation and application of sealant in the contraction joint is as follows:

i. The sealant shall be prepared from the following materials.
Bitumen (Grade 85/25) conforming to IS 702-1961: 55%
Sand (Finess Modulus 1.0 to 1.5): 43%
Asbestos powder (white): 2%

ii. Heat bitumen and sand in separate containers to 375° Fahrenheit. Mix the heated sand with two-third quantity of heated bitumen first and then add asbestos powder. Add the remaining one-third quantity of bitumen to this mix and stir it thoroughly.

iii. After curing period is over, clean the groove, apply primer (conforming to IS 3384-1986 Table 1) and then pour hot sealant in the groove and finish it with trowel.

To facilitate special condition at structure and where concrete lining placing operations are stopped for the day, interrupted because of break down, or delayed by other causes, transverse construction joints may be placed at spacing that vary from the spacing shown on the drawings. The spacing shall not be less than one half of the spacing shown on the drawings.

The specification for application of sealant for construction joint is the same as for contraction joint

In case the contractor wishes to deploy the concrete paver the contraction joints shall be appropriately provided through netting groovier as per specifications at a spacing specified or as directed by the Engineer in charge.

Concrete sleepers below the joints may be provided as specified in clause 5.9.2 of IS 3873 – 1993

Expansion/ contraction joints should be provided at intersection of every cross masonry structures along the length of the canal and at locations specified in the drawing

8.2.5 POROUS CONCRETE PANELS/ POROUS PLUG

Porous concrete plugs with filter arrangement shall be provided at intervals in the bed and sides of the lining as per the drawings.

The gravel to be used for filter should be non-cohesive type. During execution the properties of sub soil should be ascertained at close intervals for suggesting suitable treatment if any needed.

No fine concrete used for the porous concrete plug shall be composed of 1 part of cement , four part of aggregate of not more than 20 mm size or specified shall be provided at intervals shown in the drawing or as directed

by the Engineer – in –charge. The fines in the aggregates may be permitted up to 10 % of total weight of aggregate

The porous plug shall be so inserted into the lining that their porosity is not lost or reduced when the concrete for the lining is vibrated.

Water curing of plugs should be done for at least 21 days of the porosity of plugs shall be checked.

When precast slab side lining is adopted, the plugs along the slope may be substituted by precast slabs of same size of slab with no fine concrete as specified in the above with filter material at the back of the slab. The porous concrete slabs may be placed directly over the subgrade with filter beneath. The thickness of the porous slabs may be increased by about 18mm so as to be in conforming with overall thickness of lining and base preparation in other areas. This will also increase the structural strength of the no fines concrete slabs.

. The tendered unit price bid for these items of schedule shall be inclusive of the manufacture , handling and installation in position complete and shall be inclusive of all these operations as well as those defined in the nomenclature of the item

8.2.6 MODEL SECTIONS OR TEMPLATES

Model sections or templates shall be constructed upto the of the lining and the templates be of size as shown in drawing or as directed by Engineer in charge at 15 metres intervals in straight reaches and at 7.50 meters intervals in curves as directed by the Engineer – in – charge as to achieve a smooth curved surface free from unsightly units and depressions. the model sections in bed and sides shall be constructed in random rubble masonry in CM1:4(one cement four sand by volume) and top plastered with cement mortar 1:4 (one cement four sand by volume) and in cement concrete with cement level of 250 Kg /cu.m using aggregate of 20 mm size in the case of canal lining. The top level of template will be the top level of lining.

8.2.7. FINISHING OF LINING

The surface of finished lining shall conform to clause5.6 of I.S. 3873- 1993

8.2.8. CURING

Curing of concrete for canal lining both bed and sides either by paver finisher or suitable gantry or by conventional methods has to be carried out by water curing only by providing suitable pipe lines and connected equipments.
Also curing of concrete for protective lining at structures and foundation concrete of structures has to be carried by water curing only.

Curing of Lining for bed & side: Bed lining to be cured through building small height earth bunds and ponding water; double layer of hessian cloth rolls to be placed on the side slopes & kept continuously saturated with water for 28 days.

Water curing for bed & side lining concrete lining to follow strictly according to 5.7 of I.S. 3873- 1993 specification as per clause 13.5 of IS 456 – 2000. The contractor shall also provide Hessian cloth rolls to cover the side's slopes of lined portions and sprinkle water over them to ensure full proof curing. For curing of bed lining he shall construct small earth bunds and impound water.

8.2.9. CORE TESTS

SECURING AND PREPARING TEST SPECIMEN FROM HARDENED CONCRETE

As specified in clause 4.1. of I.S. 1119 – 1959 (Indian Standard Methods of sampling and analysis of concrete). Cores shall be taken at random so as to ascertain segregation / honey combing of concrete; thickness of lining and compressive strength of concrete. In no case shall fewer than 3 cores shall be taken at a section. The contractor shall allow all facilities and cooperation towards collection of cores. The testing cores shall be carried out at the testing laboratories set up at the site by the contractor at his cost or at any other laboratory that the Engineer in-charge may so decide (cost of testing to be borne by the contractor) and the results given there by shall be considered correct and authentic by the contractor.
Final payment shall be made only after 28 days core test results are acceptable to the Engineer in charge as per section 17.4.3 of IS 456 – 2000. Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the core is equal to at least 85% of the cube strength of the grade of concrete is specified for the corresponding age, and no individual core has a strength less than 75%.In case the concrete does not conform to the acceptance criteria for strength. The Engineer-in charge reserves the right to reject the work or accept the same at a reduced rate,

which will be in proportion to the percentage reduction in strength subject to a maximum of 5% provided it does not affect the structural integrity.

8.2.10. TOLERANCES

The intent of this paragraph is to establish tolerance that are consistent with modern construction practice. Yet governed by the effect that permissible deviations will have upon the structural action or operational function of the structure. Deviations from the established line, grades and dimensions shall be permitted to the extent set forth herein, the tolerance set forth herein if such tolerance impair the structural action or operational function of the lining. Concrete forms shall be set so as to ensure completed work within the tolerance limits specified herein.

The permissible tolerance for the canal lining shall be as under

a. Departure from established alignment: 50 mm on tangents, 100mm on curves.

b. Departure from established profile grade : 25 mm

c. Reduction in thickness of lining : 10 % of specified thickness, provided that average thickness is maintained as determined by daily batch, volumes

d. Variation from specified width of Sections of any height : ¼ of 1percent of specified width plus 25mm

e. Variation from established height of Lining : ½ of 1 percent of specified height plus 25 mm

Abrupt departure from the alignment and grade shall not be permitted.

8.2.11 APPLICABILITY OF SPECIFICATION

These specifications along with the accompanying drawings, schedule and other general specifications covering the lining in the reaches specified in the tender schedule and shall be carried out in accordance with or authorized deviations to the Tamilnadu standard specification reprint of 1983 and the relevant Indian Standard specification covering each item of work are also indicated in the bill of quantities and shall be read in conjunction with the special specifications.

8.2.12 MEASUREMENTS AND PAYMENTS.

For preparation of subgrade

1. Measurements for payment for the following items of preparation of foundation for concrete lining will be made.
2 Excavation in slushy soils and silt in canal bed.
3 Excavation up to underside of concrete lining for seating to lining
4 Preparation of sub-grade up to underside of concrete lining filter material duly compacted with power roller in the canal bed.
5 Preparation of sub-grade up to underside of concrete lining in sides and bed curvature with filter material duly watering and tamping.
6 Preparation of sub grade underside concrete lining in bed consisting of rock with rock spells and chips compacted with power roller.
7 Laying no fine concrete panels in concrete lining.

The payment of the above items will be made at the unit price bid therefore for relevant items in the bill of quantities.

No separate payment will be made for performing the test sections.

For concrete lining

Measurement and payment for concrete in lining will be in the units of square metres for the specified thickness of lining. The payment will be made on the relevant unit price per 1 sqm. Bid in the bill of quantities for lining concrete item of the work. The unit price shall include the cost of furnishing all materials and performing all works required for concrete construction

DEVICE FOR CONSOLIDATION OF SUBGRADE AND CONCRETE

1. DIESEL OPERATED NEEDLE VIBRATOR

2. NEEDLE VIBRATOR CLAMPED ON STEEL PLATE

9. PLAIN and REINFORCED CEMENT CONCRETE CONSTRUCTION

SECTION – A

9. PLAIN and REINFORCED CEMENT CONCRETE CONSTRUCTION.

SECTION – A

Cement Concrete Mix. Cement concrete is the most widely used construction material the world over. The concrete mix comprises cement, sand (fine aggregate), coarse aggregate, water and admixtures (whenever added). The last century witnessed huge growth in urbanization and industrialization and, accordingly, it resulted in phenomenal increase in the production of construction materials including cement for the construction of various types of infrastructure. Global production of cement was only about 2 million tons in 1900, which has risen to about 2000 million tons in the year 2010 and its demand is still rising.

Cement. The cement to be used in the concrete mix can be any of the following depending upon the intended use:

Ordinary Portland Cement (OPC). It is classified in various grades in different countries, such as: 40 Grade OPC, 43 Grade OPC, 53 Grade OPC etc. The grade number indicates compressive strength of cement in N/mm2 at 28 days. OPC is used in almost all types of construction, cement concrete lining, shot creting and in concrete structures which do not involve mass concrete.

Portland Pozzolana Cement – PPC (fly ash based). It contains 'pulverized fly ash' blended with OPC as part replacement of Ordinary Portland Cement to the extent ranging from about 20 % to 30 %. PPC manufactured in the factory ensures uniform blending of fly ash with OPC. It is the preferred cement in mass concrete constructions and in the structures located in coastal areas being associated with low heat of hydration & consequently minimized thermal and shrinkage micro cracks, reduced permeability and improved resistance to sulphates and chlorides.

Portland Slag Cement – PSC. It contains 'ground granulated blast furnace slag' as part replacement of Ordinary Portland Cement to the extent ranging from about 50 % to 70 %. It is the preferred cement for use in the construction of structures in the coastal zones. This cement is also associated with low heat of hydration & consequently minimized thermal & shrinkage micro cracks, reduced permeability of concrete and improved resistance to sulphates and chlorides. PSC is more effective than the sulphate resisting cement in its resistance to the sulphate attack.

Rapid Hardening Portland cement; Low Heat Portland Cement and Sulphate Resisting Portland Cement.

Nomenclature of these cements indicate their respective properties. Low heat Portland cement is to be used with adequate precautions with regard to removal of formwork.

Testing of Cement & Storage of Cement: The cement should be tested for fineness, initial & final setting time, soundness and compressive strength.

It is also important to ensure proper storage of cement bags. Cement loses strength and deteriorates in quality on improper and long storage. It is advisable to use cement within 3 months of its bagging. Improper storage of cement for about 6 months causes a loss in its strength to the tune of about 20 %.

Coarse & Fine Aggregates. The aggregates constitute nearly 70 % volume of concrete. These do not take part in the chemical reaction of cement with water, known as 'hydration' which produces Calcium Silicate Hydrate (CSH) gel . The CSH gel gives strength to the concrete mix. Notwithstanding the fact that the aggregates are inert filling material and do not contribute to the 'hydration' process, the quality and grading of aggregates are of vital importance to the production of quality concrete. Both the fine and coarse aggregates should be free from the impurities within the specified tolerance limits. The adhesion of cement paste to the aggregates in the concrete mix is adversely affected by the presence of impurities in the aggregates such as silt, clay, dirt etc. Accepted tolerance level is that the total impurities should not exceed 5 %. The coarse aggregate should be tested for grading, soundness, water absorption, abrasion and impact.

Grading of Coarse Aggregate. The coarse aggregate grading suggested by the *Transport and Road Research Laboratory, U. K.* are given in the following Table:

SUGGESTED COARSE AGGREGATE GRADING

Nominal maximum size of aggregate (mm)	Zone	Percent passing sieve sizes (mm) 40	20	10	4.75
40	A	100	34 – 40	16 – 18	0
	B	100	40 – 45	18 – 20	0
	C	100	45 – 53	20 – 25	0
20	A	100	100	21 – 32	0
	B	100	100	31 – 40	0
	C	100	100	40 - 52	0

Allowance for oversize in the nominal maximum size of aggregate shall be limited to 5 %. *Out of the 3 zones in the above Table, Zone B is considered more suitable than zones A and C.* Sometimes it may be necessary to combine two or more coarse aggregate fractions to obtain a grading approximating to the one required.

Tests on Sand (Fine Aggregate). The sand should be tested for grading, fineness modulus, silt & clay content and presence of any organic impurities. Sand is an important ingredient in the mortar mix and the concrete mix. It greatly influences the strength of these mixes. It is, therefore, of paramount importance that the sand to be used is free from silt and clay within the specified tolerance level of 3 %. It should also be free from organic impurities. In case, moist sand is used, it should be tested for its "bulkage" and adjustment for the bulkage is to be made while batching by volume. There are very simple tests to determine the extent of the presence of silt & clay as well the organic impurities in sand and the bulkage of sand. Only transparent graduated glass or plastic cylinder is needed for determination of silt & clay content and the bulkage of sand . A transparent graduated glass or plastic bottle is required for determination of the presence of any organic impurities in sand. All these 3 tests can be very conveniently done by the project engineers themselves in the field. *These tests are outlined duly illustrated in* ***Sketch No. 15 in Annex-5****.*

Grading of Sand. Well graded sand should be used in the concrete mixes. The Indian Standards classify the sand in 4 Grading Zones, as indicated in the following Table:

Percentage Passing

Sieve Size	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90 – 100	90 – 100	90 – 100	95 – 100
2.36 mm	60 – 95	75 – 100	85 – 100	95 – 100
1.18 mm	30 – 70	55 - 90	75 – 100	90 – 100
600 micron	15 – 34	35 – 59	60 – 79	80 – 100
300 micron	5 – 20	8 – 30	12 - 40	15 - 50
150 micron	0 – 10	0 - 10	0 – 10	0 – 15

Zone IV Grading Sand is not to be used in the reinforced concrete structures. Sand of "Fineness

Modulus" 2.2 to 3.2 is normally used in concrete constructions.

Water. The water used for mixing the concrete mix ingredients as well as for curing of concrete should be clean and free from injurious amounts of oils, acids, organic material or other harm full substances. *Potable water is considered suitable for mixing and curing. PH value of water should be in the range 6 to 8.5 and it should not be less than 6. p*H Meter should be kept at the site of work to measure the *p*H value of water. Further more, solids present in water should also be got periodically checked in the laboratory in order to ensure that these do not exceed the following permissible limits:

(i) Organic = 200 mg/litre (ii) Inorganic = 3000 mg/litre (iii) Sulphates (as SO3) = 400 mg/ litre

(iv) Chlorides (as Cl) = 500 mg/ litre for reinforced concrete and 2000 mg / litre for plain concrete, and (v) suspended matter = 2000 mg/litre.

Grades of Concrete. Concrete Mixes are designated as M 10, M15, M20, M25, M30 and of higher grades up to M90. In the designation of concrete mix, M refers to the *mix* and the number refers to the *specified compressive strength* of 150 mm size cube at 28 days, expressed in N / mm2 , as is indicated in the following Table (1 N/mm2 = 10 kg/cm2 ; 1 kg/cm2 = 14.7 lb / inch2 ; 1 MPa = 1 N/mm2)

Group	Grade Designation	Specified 28-days Compressive Strength of 150 mm Cube
Ordinary	M 10	10 N / mm2
Concrete	M 15	15 N / mm2
	M 20	20 N / mm2
Standard	M 25	25 N / mm2
Concrete	M 30	30 N / mm2
	M 35	35 N / mm2
	M 40	40 N / mm2
	M 45 to M 55	45 N/mm2 to 55 N/ mm2

NOTE: Concrete of Grade M 60 to M 90 is designated as *"High Strength Concrete".*

Proportioning of Concrete Mix ingredients – Volumetric Proportioning. When the works are of small magnitude, volumetric proportioning of concrete mix can be allowed by the Engineer-in-Charge. Such concrete mixes are designated as: 1: 4: 8 (lean concrete – M7.5); 1: 3: 6 (M10 equivalent); 1: 2 : 4 (M15 equivalent); 1: 1.5 : 3 (M20 equivalent). However, proper "Gauge Boxes" should be used for correct volumetric proportioning of cement, sand and

coarse aggregate. Measured quantity of water should be used by deploying calibrated buckets / jars of water to maintain the specified water-cement (W/C) ratio. W/C ratio for most of the works should not be allowed to exceed 0.60 (though 0.55 shall be preferable). As for example, the water content at W/C ratio of 0.55 for one bag of cement in the concrete mix shall be 0.55 x 50 = 27.50 litres. *Many rehabilitation works in the proposed Sri Lanka Climate Smart Irrigated Agriculture Project are of small magnitude, such as* : construction of model sections in the irrigation channels; placement of selective concrete lining in the irrigation channels downstream of irrigation sluices of tank bunds; construction of flow measuring devices (Cut Throat Flumes) in irrigation channels; construction of small drop structures in channels; construction of small bridges / culverts; repairs of surplus weirs etc. Volumetric proportioning of concrete mix ingredients can be allowed in such works. Mechanical mixers should, however, be deployed for the production of concrete. Hand mixing of concrete mix ingredients should be avoided.

Design Mix Concrete. Notwithstanding the above mentioned relaxation to allow volumetric proportioning of concrete mix ingredients for the works of small magnitude, it shall be preferable and desirable to design the respective concrete mixes of grades M 15, M 20, M 25 and of higher grade. These mixes should be got designed from the quality control laboratories of the department or from the engineering colleges well in advance of the commencement of works. Reputed institute can also be engaged to train the quality control personnel of the laboratories in designing the concrete mixes. In the design mix concrete, proportioning of cement, sand and coarse aggregate is all by weight. Water can be added either by volume or by weight (since 1 litre of water weighs 1 kg). It is observed that quantity of cement used in the design mix concrete is less than that used in the volumetric proportioning of the mix. Once the co create mix is designed, volumetric quantities of cement, sand and coarse aggregate can be calculated corresponding to their weights upon determining the bulk densities of sand and coarse aggregate. In respect of cement, one bag weighs 50 kg, which, in volume is 1.20 cubic ft or 0.034 cubic metre. Thereafter, "Gauge Boxes" may be used for the calculated volumetric proportioning of concrete mix ingredients.

Strength of Concrete. The strength of concrete depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching; mixing; placing; compaction and curing. Quantity of cement to be used (minimum quantity) and the water-cement ratio to be maintained (maximum Water-cement ratio) in the construction of concrete infrastructure is also greatly governed by the "*Environmental Exposure Conditions*" to which the concrete

structures would be exposed during their service life. The Indian Standards classify the environment and environmental exposure conditions into 5 levels of severity. These levels are: (i) Mild (ii) Moderate (iii) Severe (iv) Very Severe, and (v) Extreme.

The 'Exposure Condition' against the respective Mild , Moderate, Severe, Very Severe and Extreme environment is broadly listed in the following paragraphs:

Environment	Exposure Condition
(i) Mild …	Concrete surfaces protected against weather or aggressive conditions except those situated in coastal area.
(ii) Moderate …	Concrete surfaces sheltered from severe rain; concrete continuously under water ; concrete sheltered from saturated salt air in coastal area
(iii) Severe …	Concrete surfaces subjected to alternate wetting and drying and severe rains.
(iv) Very Severe ….	Concrete surfaces subjected to sea water spray; concrete exposed to corrosive fumes.
(v) Extreme ….	Concrete surfaces in tidal zone; concrete members in direct contact with aggressive chemicals.

The minimum cement content (kg/m3) and maximum water-cement ratio (W/C) to be adopted in the plain and reinforced concrete constructions corresponding to the respective environment & exposure condition (Mild, Moderate, Severe, Very Severe and Extreme) are tabulated below, *using coarse aggregate of maximum nominal size of 20 mm in the concrete mix:*

Exposure	Plain Concrete			Reinforced Concrete		
	Min. Cement	Max W/C	Min Grade	Min. Cement	Max W/C	Min. Grade
Mild ……	220	0.60	M10	300	0.55	M20
Moderate …	240	0.60	M 15	300	0.50	M 25
Severe …….	250	0.50	M 20	320	0.45	M 30
Very Severe …	260	0.45	M 20	340	0.45	M 35
Extreme …	280	0.40	M 25	360	0.40	M 40

NOTES: (i) Minimum cement content indicated above is *inclusive* of "mineral admixtures", if used (fly ash, ground granulated slag, micro silica). (ii) ***Minimum Grade of reinforced concrete has to be M20***

(iii)*Following adjustments are to be made in the Minimum Cement content* indicated in the above Table in case coarse aggregate of maximum nominal size other than 20 mm is used in the concrete mix:

Nominal Max. Size of Coarse Aggregate	Adjustment in Minimum Cement
10 mm	+ 40 kg / m2
40 mm	- 30 kg / m2

Actual cement content to be used in concrete mixes shall be determined through testing of trial mixes.

Durability of Concrete; Water-Cement Ratio; Compaction & Curing: Besides the "Strength" of concrete, more stress is now being given world wide to the "Durability" of concrete. *Durability of concrete is its ability to successfully resist the harmful effects of environment to which it would be exposed during its operational / service life with minimum maintenance.*

Water-Cement Ratio (W/C) is the single most important factor that has the maximum bearing on the strength and durability of concrete. High water-cement ratio reduces both the strength and durability of concrete. High water-cement ratio increases 'porosity' in concrete and higher porosity results in higher "co-efficient of permeability", which makes the concrete highly vulnerable to easy ingress of environmental elements into concrete, such as : carbon dioxide, chlorides, moisture, oxygen, sulphates etc. Such easy ingress of environmental elements makes the concrete vulnerable to premature deterioration. Such ingress into the reinforced concrete structures initiates rusting of steel bars followed by spalling and cracking of concrete, there by, adversely affecting the integrity of these structures. The lower the water-cement ratio, lower would be the permeability of concrete and the concrete of low permeability shall offer strong resistance to the ingress of deleterious elements. **As per USBR Manual,** *relationship between water-cement ratio (W/C) and co-efficient of permeability is graphically depicted in* ***Sketch No. 16 in Annex – 5.*** It clearly shows that the co-efficient of permeability in concrete increases rapidly beyond water-cement ratio of 0.60. *Thus, for the concrete works to be executed under the Climate Smart Irrigated Agriculture Project , the water-cement ratio should be restricted to not exceed 0.60. It shall, however, be preferable and desirable to restrict W/C ratio to 0.55*. These concrete works under the project broadly include: construction of concrete model sections in irrigation channels; placement of selective concrete lining in irrigation channels; construction of flow measuring devices (Cut Throat Flumes) in irrigation channels; repairs to irrigation sluice structures; rehabilitation of

existing surplus weirs through provision of skin concrete; modification of existing surplus weirs; re-construction of damaged surplus weirs with new weirs in concrete; concrete retaining walls; construction of culverts; construction of drop structures in channels; construction of re-charge well structures in the foreshores of selected tanks; construction of concrete drains in the water-shed development works etc. *Engineer-in-Charge should strictly enforce the suggested specification that, for all these works, water-cement ratio in concrete shall not be allowed to exceed 0.60 for the long-term durability of concrete constructions.* Also, for the M20 and M25 mixes, "Design Mix Concrete" be used.

Compaction & Water- Curing. Besides maintaining low water-cement ratio, as suggested above, effective compaction and efficient curing of concrete are also very important requirements for the strength and durability of concrete constructions and the field engineers should strictly enforce implementation of these requirements. They should ensure that the requisite compaction and curing arrangements are in place before the contractor is allowed to commence construction. Concrete surfaces should be kept continuously moist / wet with water for the specified number of days (21 – 28 days). In case, it is felt by the Engineer-in-Charge that fool-proof implementation of this specification by the contractor is not feasible in some works located in the interior, curing of both the plain and the reinforced concrete structures should be got done with "membrane forming curing compound". No compromise, what so ever, is to be made in so far as efficient compaction and curing are concerned.

Curing By Membrane Forming Curing Compound. The curing compound should be white pigmented of approved quality conforming to ASTM -C-309-81 Type -2 (ASTM : American Society of Testing Materials). The compound should meet the requirement of water retention test as per ASTM designation C-156-80. Loss of water in this test is to be restricted to be not more than 0.55 kg / m2 of the exposed surface in 72 hours. When tested with method E-97 of ASTM, it should exhibit a day light reflectance of not less than 60 % of that of Magnesium Oxide. Curing compound should be applied as soon as the bleeding water or shine on the concrete surface disappears leaving dull appearance. This is when there is no longer any evidence of free moisture on the surface. If applied too early, the free moisture present on the surface will prevent the compound from forming a moisture proof film. If applied too late, some of the moisture will have already been lost that should have been retained. The proper time range may vary from 20 minutes to 75 minutes after placement of concrete depending upon humidity and temperature. In hot season, bleeding water / shine

could disappear in just 20 to 30 minutes. The curing compound should be applied on the concrete surface with "power spray" to ensure effective coverage of the full surface. Overall average coverage of about 3. 5 m2 surface area by one litre of curing compound is considered to be adequate and satisfactory coverage.

Corrosion of Reinforcement in Reinforced Concrete Structures – Deterioration /Failure of Structures. Reinforcement corrosion is a serious problem in the concrete structures. It becomes particularly more serious in the concrete structures exposed to aggressive environment e. g. reinforced concrete structures in the coastal area or the structures exposed to sea water spray or the structures exposed to corrosive fumes or the structures in direct contact with aggressive chemicals. Corrosion results in the reduction of effective cross sectional area of reinforcement bars and also causes cracking and spalling of *cover concrete* which leads to serious deterioration of the structure and, finally, failure of the structure. Research has indicated that, on an average, deterioration of concrete structures is to the extent of as much as 49 % due to corrosion of reinforcement and the balance deterioration of 51 % takes place by other causes such as: structural damage; fire damage; Alkali-Silica Reaction; chemical attack; accidental damage. This situation is depicted in **Sketch No. 17 in Annex-5.**

Mechanism of Corrosion : Factors Influencing Corrosion.

Mechanism of Corrosion. The steel reinforcement embedded in concrete gets protection from fresh concrete which offers alkaline environment with pH value of 12.5 – 13. This is known as "passivation" or "passivation layer" from the surrounding concrete which provides a strong shield to reinforcement bars against corrosion. This pssivation gets gradually destroyed through continued ingress of environmental elements (carbon dioxide, chlorides, sulphates, oxygen, moisture etc) into the body of concrete. Concrete not properly proportioned & prepared with high water-cement ratio and not properly mixed, compacted, cured and with inadequate cover thickness offers easy ingress of these elements, there by, accelerating the destruction of passivation. After the destruction of passivation, process of corrosion / rusting of reinforcement steel commences. The volume of corrosion product increases two to three fold of the original volume of steel and the resulting expansive forces cause 'bursting stresses' around the reinforcement leading to cracking, spalling and de-lamination of cover concrete. *This corrosion mechanism is broadly illustrated in* **Sketch No. 18 in Annex-5.**

Factors Influencing Corrosion. Main factors influencing corrosion are listed in the following paragraphs:

(i) pH value of concrete. Chemical reaction of cement with water, called *hydration*, produces C-S-H gel (Calcium Silicate Hydrate gel) which imparts strength to the concrete mix. In the process, Calcium Hydroxide – Ca (OH)2 is also generated as an important by product to the extent of about 15 – 25 % of cement content. This imparts alkaline environment to concrete and, consequently, pH value of fresh concrete becomes about 12.5 – 13 which provides 'passivation layer' to steel reinforcement and protects the reinforcement steel from corrosion. Whenever, this pH value reduces from 12.5 -13 to a low level of 8 - 8.5 , the alkalinity reduces and destroys the passivation layer, there by, making the reinforcement vulnerable to corrosion. *Thus, reduction in the pH value of concrete from 12.5 – 13 to a level of 8 – 8.5 makes the concrete vulnerable to corrosion.* Hydration process is illustrated in **Sketch No. 19 in Annex-5.**

(ii) Carbonation. When CO2 (Carbon Dioxide) from the air finds easy ingress into the body of concrete, it forms Hydro Carbonic Acid in the presence of moisture and water. CO2 + H2 O = H2 CO3 (Hydro Carbonic Acid) Hydro Carbonic Acid reacts with Calcium Hydroxide (generated during hydration process) and produces Ca Co3 (Calcium Carbonate), there by, neutralizing Calcium Hydroxide. H2 Co3 + Ca (OH)2 = Ca Co3 + 2 H2 O Since Calcium Hydroxide (providing alkalinity to concrete) gets neutralized, pH value of concrete reduces gradually to a low level of 8 – 8.5, there by, making it vulnerable to corrosion.

(iii) Penetration of Chlorides. Penetration of Chlorides into the body of concrete destroys the 'passivation layer' and activates corrosion. Source of Chlorides may be the water used for mixing concrete ingredients and for curing or the aggregates might be contaminated with chlorides or Chlorine gas from the environment may enter through pores in concrete.

(iv) Oxygen & Moisture. Oxygen and moisture play significant role in accelerating corrosion.

(v) Permeability of Concrete. The permeability of concrete greatly influences the rate and ease with which the *environmental elements (Co2 , Chlorides, Oxygen, Moisture, Sulphates)* can enter the body of concrete. The permeability depends on how well the concrete has been produced, whether low or high water-cement ratio is adopted and how well it has been placed, compacted and cured. If the concrete

has been well produced duly incorporating cement content corresponding to the relevant environmental exposure condition and with low water- cement ratio, well compacted and adequately cured, it would have very low permeability and would offer optimum resistance to the ingress of environmental elements. Such concrete would not have any thermal or shrinkage cracks. Consequently, such concrete would not be vulnerable to corrosion for a very long period.

(vi) Cover Concrete Over Reinforcement Steel. Extent of the thickness of "cover concrete" over reinforcement steel (termed as 'nominal cover') is an extremely vital factor influencing corrosion since the cover is the length of the path through which the environmental elements travel to reach the steel reinforcement to initiate its corrosion. It is commonly observed that due to slack supervision by the contractors and also not understanding the significance of maintaining the specified "nominal cover to steel reinforcement / cover concrete over the reinforcement" by them, erection of reinforcement is not done properly at all and, on many occasions, the nominal cover is substantially reduced compared to the specified cover. Reduction of 'nominal cover' makes the reinforced concrete structure vulnerable to early corrosion and pre-mature deterioration.

Corrosion Process is depicted and illustrated in **Sketch No. 20 & Sketch No. 21 in Annex – 5. Sketch No. 21** *depicts "causative factors"; "accelerating factors"; "promoting factors" as well as the items associated with the "quality of concrete" influencing corrosion of steel reinforcement for comprehensive understanding by the project engineers and construction agencies and making them conversant with remedial measures for* corrosion control.

Nominal Cover To Meet Durability Requirement. Nominal cover is the design depth of cover to the steel reinforcement. It is the dimension used in design and indicated in the drawings. It shall be ensured by the Engineer-in-Charge that the nominal cover indicated in the drawing is strictly maintained by the contractor during the erection of reinforcement and, that, this is also maintained during the placement of concrete.

The "Nominal Covers" to meet *durability requirement* corresponding to the respective environment exposure condition (mild, moderate, severe, very severe, extreme), as per the Indian Standard Specifications, are outlined below. These nominal covers may also be agreed to and specified by the Designs Organization of the Irrigation Department, Sri Lanka for requisite provision during the execution of reinforced concrete works.

Nominal Cover to Meet Durability Requirements

Exposure Condition	Nominal Concrete Cover Not Less Than
(i) Mild …… …….	20 mm
(ii) Moderate …….	30 mm
(iii) Severe …… …	45 mm
(iv) Very Severe ……	50 mm
(v) Extreme ……	75 mm

`It is of utmost importance that the construction and quality control engineers ensure, through personal checking during the erection of reinforcement, that the specified "nominal cover" is strictly maintained. *Tolerance of up to +10 mm in the nominal cover can be allowed but no relaxation at all is to be allowed for any cover less than the specified one, not even – (minus) 1 mm.* In this context, proper positioning of reinforcement to the specified cover and prevention of its displacement during placement of concrete are of vital importance. The reinforcement should, therefore, be adequately tied and supported. Precast concrete blocks of, say, 75 mm x 75 mm size with due embedment of binding wire should be used for this purpose. These blocks are to be cast in the same grade of concrete as is to be placed in the structure and should be spaced at about 0.90 m interval. It should be understood that any reduction in the nominal cover would cause reduction in the operational / useful life of the structure. *It has been estimated that, other factors being the same, reduction of 5 mm in the nominal cover could reduce the useful life of the structure by some 5 to 7 years due to early corrosion of steel reinforcement.*

Logging Cover Meter - Device To Check Nominal Cover Of Steel Reinforcement. In order to ensure that the contractors erect the reinforcement strictly adhering to the specified nominal cover within the tolerance levels, e.g. up to +10 mm (plus 10 mm) over the specified cover and nothing less than the specified nominal cover, e.g. – zero (minus 0) tolerance and that the reinforcement is not displaced during the placement of concrete, it is suggested to deploy "**Logging Cover Meter**" to check the actual nominal cover after the concrete is placed. The Logging Cover Meter is a very useful device to measure the depth of concrete over the reinforcement. A preset value of the specified cover is entered into the data logger and the head of logging cover meter is scanned over the concrete surface. All values less than the preset value are recorded automatically. Also, whenever the depth of concrete cover above the reinforcement bars falls below the preset value, an audible alarm signal is

given by this device. It is operated by batteries. The data can also be downloaded to any PC-compatible computer for analysis. Deployment of this device / instrument will provide a result-oriented tool for monitoring the actual nominal cover to the reinforcement in the concrete member. In case, scanning of the concrete surface by the Logging Cover Meter indicates the nominal cover to be deficient (less than specified cover), Engineer-in-Charge can (and should) direct the concerned contractor to dismantle the particular concrete 'lift' and the contractor should re - do the work at his own expense . Thus, the Logging Cover Meter will act as meaningful & effective warning tool to the contractor who would remain fully alert to ensure that the specified nominal cover is meticulously maintained by his crew.

The Logging Cover Meter is depicted in **Photo Copy P 13 in Annex -5** along with its specifications and other details. Procurement of at least two such devices is suggested for monitoring of nominal cover in the reinforced concrete works, being considered vital for the long-term durability of these works.

Corrosion Control / Protection Methods. Following corrosion protection and corrosion control methods can be used to enhance the operational life of reinforced concrete structures:

i. *Coating of reinforcement by cement slurry.* This is the simplest and the most economical method of coating of steel reinforcement. The cement slurry coat provides a good barrier against aggressive environment elements like chlorides, carbon dioxide, moisture, gases etc.

ii. *Epoxy coating of reinforcement.* Epoxies have good adhesion properties and offer excellent resistance to chemicals. However, such coatings are costly

iii. *Using stainless steel reinforcement.* Stainless steel is corrosion resistant and contains a minimum of 12 % Chromium. On exposure to air, it forms a thin layer of Chromium Oxide which acts as a protective layer against corrosion. The constraint to its use is its high cost.

iv. *Using TMT steel reinforcement.* The TMT steel (Thermo - Mechanically – Treated steel) is used in the construction of important structures in the areas associated with aggressive environment. It effectively resists corrosion.

v. *Use of corrosion inhibitors.* Certain admixtures like 'Calcium Nitrite' can be used in concrete to inhibit corrosion of reinforcement. Addition of Calcium Nitrite resists corrosion initiation and also reduces the rate of corrosion after it starts.

vi. *Improving concrete.* The best corrosion control method is to adopt sound practices in the production of concrete mix, compaction of concrete and curing of concrete, outlined below:

- Using graded aggregates free from impurities in the concrete mix.
- Adequate cement in the mix duly taking into account the environmental exposure condition.
- Concrete Mix to be of minimum M 20 grade in the reinforced concrete construction.
- Correct proportioning of concrete mix ingredients and, also, "Design Mix" concrete to be used in important works involving substantial quantity of concrete.
- Addition of calibrated / measured quantity of water in the concrete mix.
- Restricting water-cement ratio (W/C) to 0. 60 (however, W/C of 0.55 is preferable). Concrete mix should not be 'harsh' as else its placement & compaction will pose problems. The mix has to be workable to enable proper placement and compaction. At the same time, water-cement ratio has to be kept low for the long term durability of the structure. Chemical admixture (super plasticizer) shall need to be added in the concrete mix to increase its workability and maintaining the specified low water cement ratio without addition of any extra water what so ever. (Refer Section- B for Chemical Admixtures).
- Mixing concrete in a mechanical mixer.
- Using Portland Pozzolana Cement (fly ash based) instead of Ordinary Portland Cement since PPC makes the concrete more impermeable than OPC (Refer Section-B for "Blended Cement").
- Ensuring specified "Nominal Cover" of steel reinforcement duly considering environmental exposure condition.
- Coating steel reinforcement with cement slurry.
- Good and leak proof formwork duly coated inside with form oil.
- Good compaction of concrete and effectively treating honey combs, if any.
- Fool proof curing of concrete.

ANNEX – 5

Enclosed are the following Contents:

Tests on Sand Illustrated in Sketch No. 15

i) Determination of silt & clay content in sand.
ii) Determination of the presence of Organic Impurities in sand.
iii) Determination of bulkage of moist sand

Sketch No. 16 Depicting Relationship between Water-Cement Ratio (W/C) and Coefficient Of Permeability in Concrete (as per USBR Manual).

Sketch No. 17 Depicting Causes of Deterioration of Concrete Structures (in percentage) due to:

i) Reinforcement Corrosion.
ii) Chemical Attack.
iii) Structural Damage.
iv) Alkali-Silica Reaction (ASR).
v) Fire Damages.
vi) Accidental Loads.

Sketch No. 18 Depicting CORROSION MECHANISM in Reinforced Concrete.

Sketch No. 19 Illustrating Hydration Of Cement (Chemical Reaction of Cement & Water).

Sketch No. 20 & Sketch No. 21 Depicting Factors Causing Corrosion of Steel Reinforcement and Detailed Illustration of Corrosion Process in R. C. C. Structures.

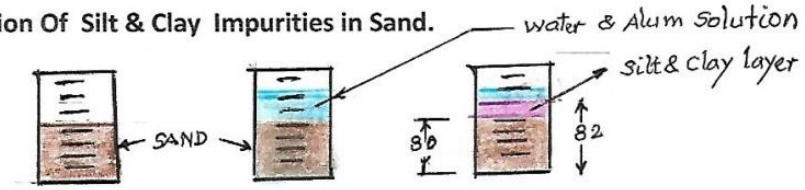
Photo Copy No. 13 Depicting LOGGING COVER METER & Its Specifications (State-of-Art Device for Monitoring "Nominal Cover of Reinforcement").

SKETCH - 15

ANNEX -5

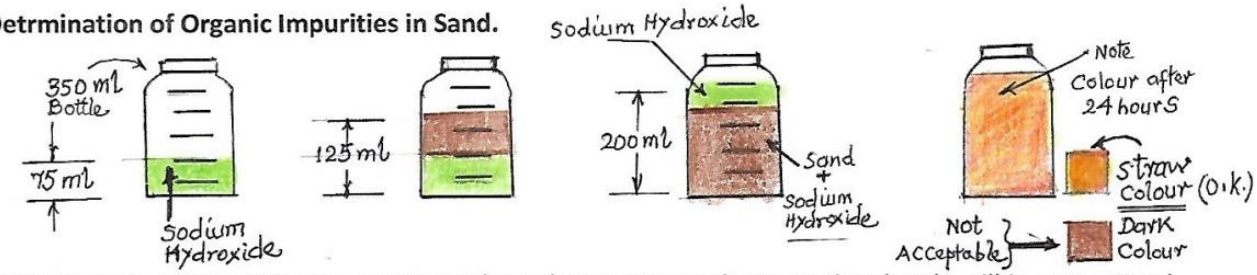
QUALITY CONTROL TESTS ON SAND

1.Determination Of Silt & Clay Impurities in Sand.



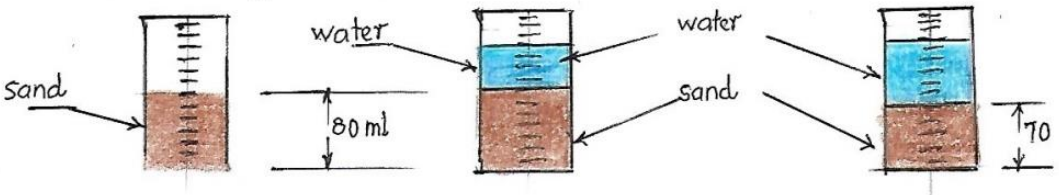
Test procedure. Take certain amount of *air dried* sand in a graduated transparent plastic or glass jar. Add clear water till sand is totally submerged. Then add 10 ml of 5 % alum solution in water and shake the jar. Keep it undisturbed for about 6 hours. A thin layer of silt / clay will be seen deposited at the top. Note the levels. If sand level is at mark 80 and the silt/clay layer is at mark 82, the silt & clay content present in the sand shall be: (82-80)/80 x 100 = 2.5 %. The impurities being less than 3 %, sand is acceptable.

2.Detrmination of Organic Impurities in Sand.



Test Procedure. Take a 350 ml capacity graduated transparent plastic or glass bottle. Fill it up to 75 ml mark with 3 % solution of sodium hydroxide in water (3 % caustic soda + 97 % water). Then pour sand gradually (as received without drying) till the sand reaches 125 ml mark. Add more 3 % solution of sodium hydroxide till 200 ml mark is achieved. Put stopper in the bottle and shake it vigorously and allow it to settle for 24 hours. Thereafter observe the colour carefully. (i) A clear colour indicates nil impurities; so sand is acceptable. (ii) A straw colour indicates 'non objectionable' organic impurity; so sand is acceptable, and (iii) A dark colour indicates presence of 'harmful organic impurities'; so sand should be washed and re-tested.

3. Determination of Bulkage of Moist Sand.



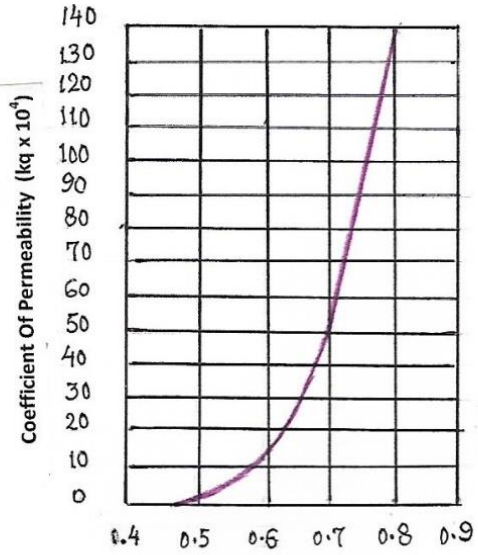
Test Procedure. Take a certain amount of sand from the moist sand sample in graduated glass or transparent plastic jar. Not down the level, say, mark 80. Then pour water to completely submerge the sand, shake it and allow to stand for 3 hours. Note down the new mark level of sand, say, 70 (sand level goes down after submergence. The Bulkage of sand will be = (80 – 70)/70 x 100 = 14.3 %. So, the sand is O. K. since the maximum permissible limit of bulkage of sand is 20 %. However, 14.3 % of extra volume of sand will require to be added in the concrete mix to compensate for this bulkage and the water content will be, correspondingly, reduced.

SKETCH – 16

ANNEX -5

Relationship Between Water – Cement Ratio (W/C) & Coefficient Of Permeability

(as per USBR Manual)

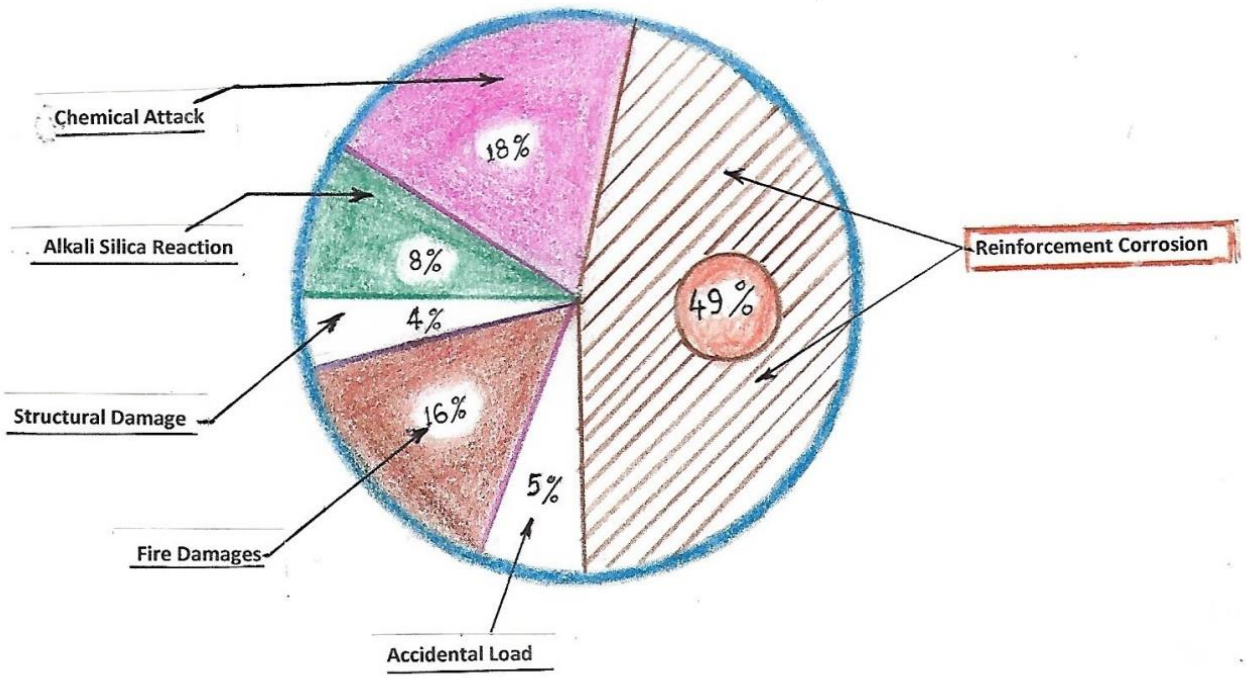


Kq is the relative measure of the flow of water through concrete In cubic ft /year/sq ft of area for a unit hydraulic gradient

Coefficient Of Permeability increases rapidly for W/C higher than 0.60

Broad Causes Of Deterioration Of Concrete Structures (In Percentage Causes)

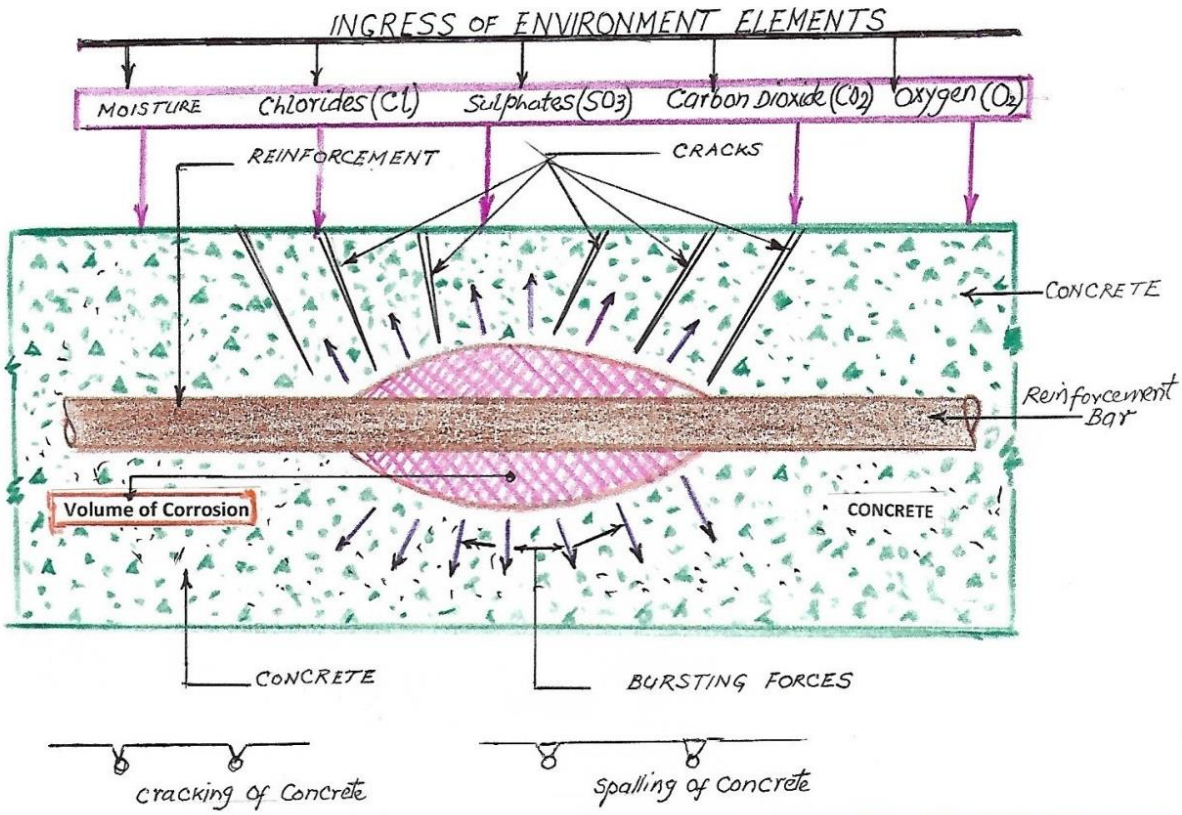
SKETCH – 17



ANNEX -5

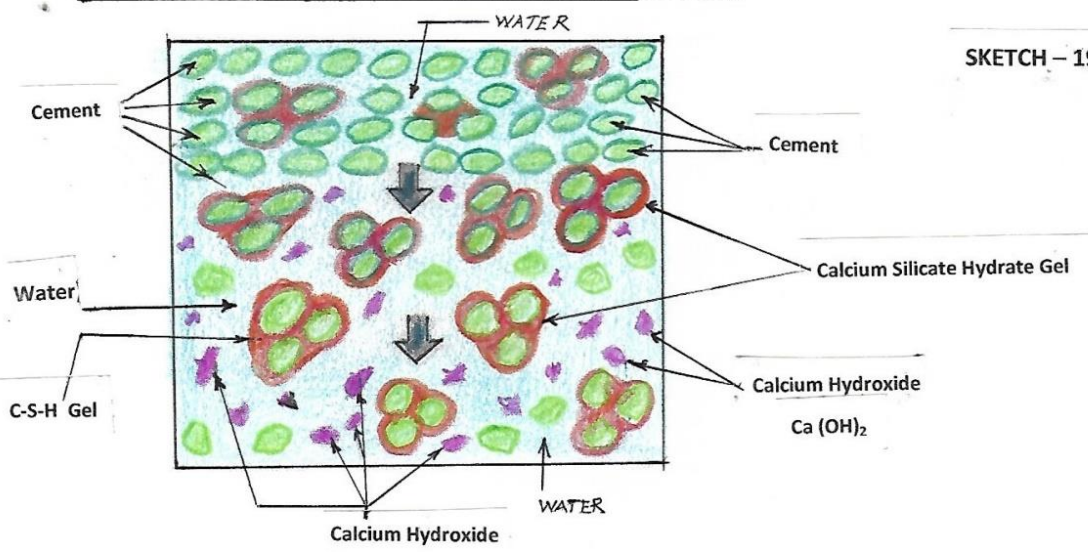
CORROSION PROCESS Of REINFORCEMENT BARS IN CONCRETE

SKETCH – 18



HYDRATION PROCESS (Chemical Reaction Of Cement and Water)

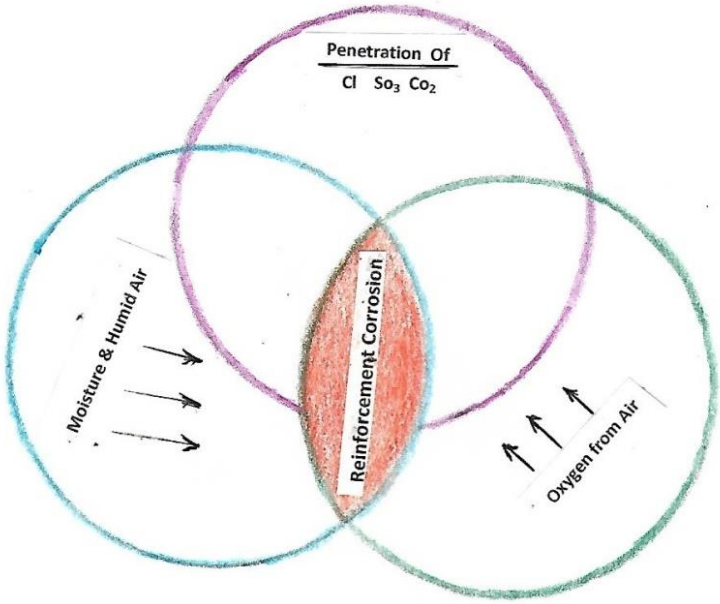
SKETCH – 19



REINFORCEMENT CORROSION MECHANISM IN CONCRETE

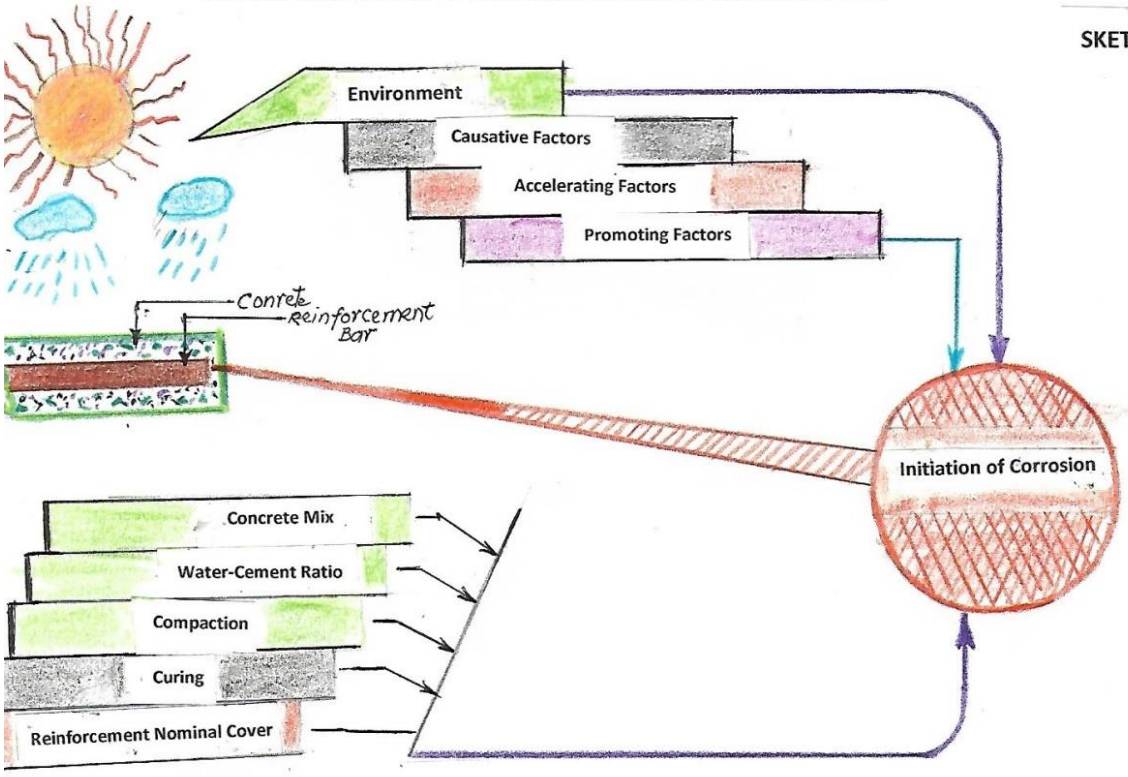
ANNEX -5

SKETCH – 20



DETAILED ILLUSTRATION OF CORROSION PROCESS IN R. C. C. STRUCTURES

SKETCH – 21



- Causative Factors ..... Ingress of Cl, So_3, Co_2, Moisture
- Accelerating Factors ..... Temperature, Humidity, Oxygen
- Promoting Factors ..... Cracks, Crack Width

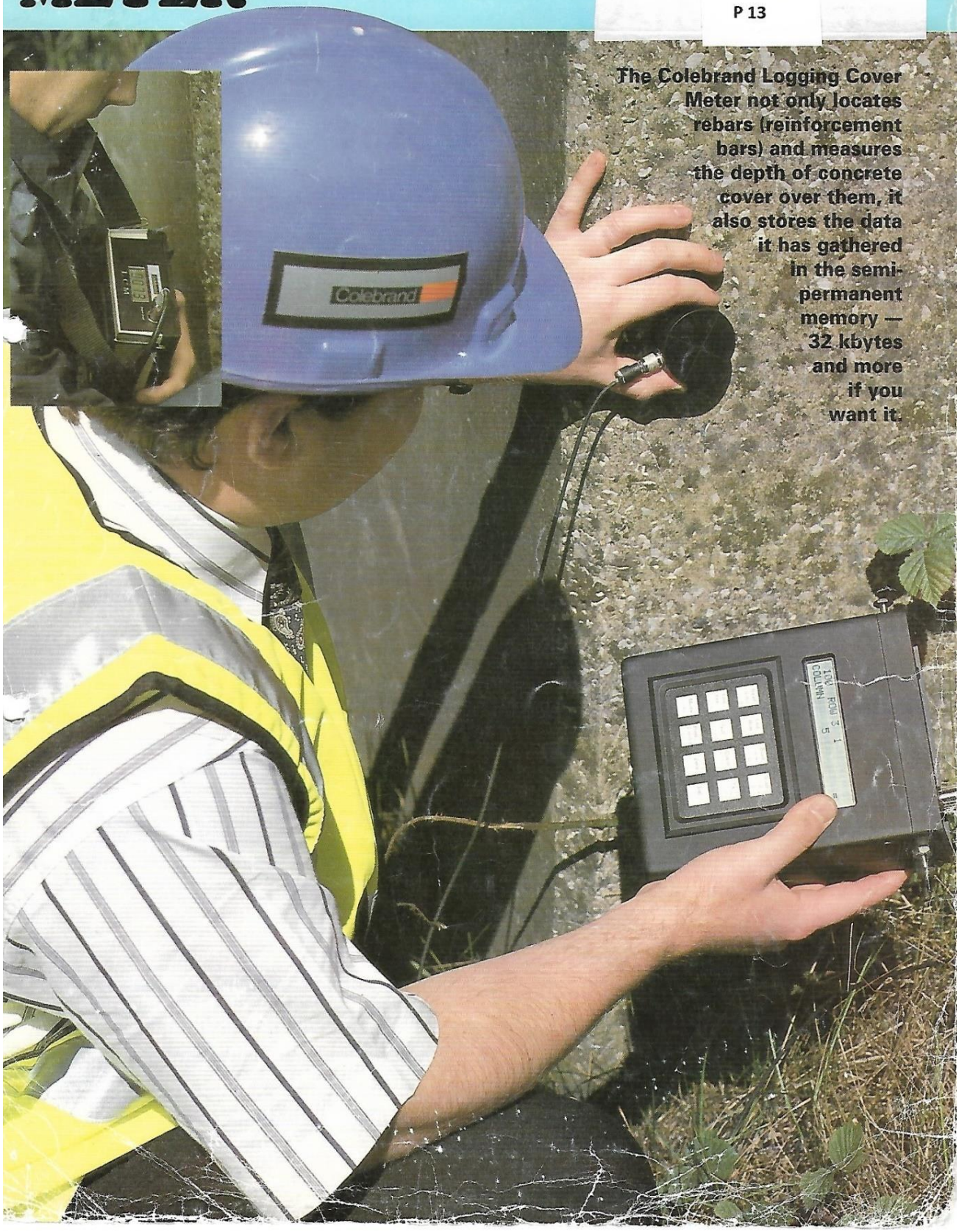
ANNEX -5

LOGGING COVER METER

Colebrand

Instrumentation

P 13



The Colebrand Logging Cover Meter not only locates rebars (reinforcement bars) and measures the depth of concrete cover over them, it also stores the data it has gathered in the semi-permanent memory — 32 kbytes and more if you want it.

COLEBRAND LOGGING COVER METER

Features:
The many features include:

- Scanning for minimum cover which allows the user to find the minimum cover automatically.
- Automatic surveying — a preset minimum value is entered into the data logger and the head is scanned over the concrete surface, all values less than the preset minimum are recorded automatically.
- Minimum cover alarms — whenever the depth of concrete cover above the rebars falls below a value preset by the user, an audible alarm signal is given.
- Traveller to carry a search head which automatically measures and logs the distance between cover readings.

Data Handling:
When a survey is completed the data can be printed out on site using any standard bubblejet, portable printer (Colebrand recommends the Diconix printer). An example of data printed out on a Diconix printer: The readings show the depth of concrete cover above the rebars in mm.

```
FILE NUMBER 010                          Nulls
024 037 034 037 034 036 025 048          /
033 037 050 039 044 039 026 029            031 040 043 035 037 016 020 012
035 045 047 041 047 038 029 038 038 036 036 037 041 041 042 011 017 011
036 043 038 032 040 051 036 042 037 024 030 027 034 036 028 006 022 014
035 043 038 030 033 045 039 046 032 027 038 038 027 036 035 018 018 010
040 052 037 027 027 043 042 045 031 025 045 044 023 035 043 021 026 026

FILE NUMBER 011

038 035 049 032 035 039 031 034 021 016 029 033 034 033 036 038 057 022 035 038 019
```

Sample printout from the Diconix printer, including spaces for nulls.

Also the data can be downloaded to any PC-compatible computer for archiving and analysis. Software and connecting leads are supplied with the Logging Cover Meter.

Specification:

Resolution: (concrete cover)	Small head	1, 3, 5mm at 60mm depth
	Standard head	1, 3, 5mm at 100mm depth
	Medium head	1, 3, 5mm at 140mm depth
	Large head	1, 3, 5mm at 200mm depth
Resolution: (distance measurement)	10mm	
Range for concrete cover measurement:	Small head	60mm
	Standard head	100mm
	Medium head	140mm
	Large head	200mm

Calibrated for bar sizes up to 40mm, in both metric and Imperial bar sizes; to BS 1881 part 204.

Maximum distance measurable:	54cm
Memory, semi-permanent:	32 Kbytes
Serial interface:	RS232 8 data bits 1 stop bit no parity 1200 baud
Audio signal: (headphones)	4mm jack plug on front panel; frequency increases as cover decreases.
Zeroing:	Hold search head away from metallic objects and press Zero.
Range:	High-tensile and mild steel bars in the following metric diameters: 6, 8, 10, 12, 16, 18, 20, 25, 32, 40mm.
Power:	Four AA-size batteries, giving approximately 8 hours continuous use. low battery warning given when approximately 2 hours' use remaining.
Packed dimensions:	460mm x 340mm x 160mm Weight 6.0 kg
Temperature:	operating 0-45°C storage –25-60°C humidity 20-85% non-condensing

Contents of Kit:
Two search heads
Data logger
Cable (for connecting either search head to the data logger)
Cable (for connecting the data logger to the Diconix Printer, if ordered)
Cable (for connecting the data logger to a PC)
File transfer software
Spacer Block
Comprehensive user manual
Carry Case

Extras: Diconix Printer, Headphones, Calibration Block, Extension Stick (5m, telescopic stick to take all sizes of head), Traveller to measure the distance moved over the concrete surface as cover readings are taken, Directional Head, customised software.

Colebrand and you . . .

Colebrand is efficient and responsive to customer needs. If you have a specific requirement then please discuss it with us, we can adapt the software to meet your needs or design a special head. Colebrand also takes great pride in providing a thorough and complete after sales service.

Colebrand

FM10561

Colebrand Limited
Colebrand House, 18-20 Warwick Street
Regent Street, London W1R 6BE
Telephone 071-439 1000
Telefax: 071-734 3358 or 071-287 1544

10. ALLOWABLE LIMITS FOR CONSTRUCTION MATERIALS

Sl. No.	Test	Frequency	IS	Allowable Limits
1.	**CEMENT** a) Chemical i) Alkalies ii) Minor, major oxides by Calorimetry iii) Chloride	For each consignment	a) 269-1989 b) 1489-1976 c)IS-4032-1985	OPC < 0.60% PPC < 0.70% PPC/OPC < 0.05%
	b) Physical i) Fineness ii) Soundness (Le Chatelier) iii) Consistency iv) Setting time Initial v) Final vi) Compressive Strength vii)Heat of Hydration viii)Drying shrinkage	For each consignment	a) 269-1989 b) 1489-1976 4031-1988	Not < 2250 cm2/gm Not > 10 mm Penetration upto 5 to 7 mm from base IT-Not < 30 min FT-Not > 600 min 3 days - 160 kg/cm2 7 days- 220 Kg/cm2 28 days-330 Kg./cm2 PPC 7 days - 65 Cal/gm OPC 28 days - 75Cal/gm <0.15%

Sl. No.	Test	Frequency	Purpose	IS	Allowable Limits
1.	**FINE AGGREGATE** i) Screen Analysis (Fineness modulus)	One test for every 150 m3 of sand used in concrete	To know grain size and the fineness modulus of sand	IS 2386 Part-I 1963	2.2 to 3.2
	ii) Unit Weight and Bulkage of sand	-As above- (also once in a shift or for every consignment)	To utilize data for mix design computation	IS 2386 Part III 1963	Allowable limit of Bulkage of sand is 20%
	iii) Organic impurities	-As above-	To assess the quality of sand	IS-2386 Part II 1963	As explained in Sec. 4.2.2
	iv) Soundness	One test for every 150 cum of sand used in concrete	To assess the quality of sand	IS 2386 Part II 1963	Loss Not > 10% after 5 cycles of immersion in Na2 So4
	v) Silt Content	One test for every 150 cum of sand used in concrete	To assess the silt content present in the sand	IS 2386 1963	Not greater than 3% for natural FA and Not grater than 5% for crushed FA.
	vi) Specific Gravity, moisture content and absorption	One test for every 150 cum of sand used in concrete	To utilise the data for mix design computations	IS 2386 part III 1963	
2.	**COARSE AGGREGATE**				
	i) Sieve Analysis	One test for every 150 m3 or less	To know gradation and percentage of various size	IS 2386 part I 1963	
	ii) Specific Gravity, Bulk	-do-	To utilize data for mix design	IS 2386 part III	Not > 2.6 Not more than 5%

	Density, Moisture content, Absorption & Silt Continent		computation	1963	by weight Not > 3%
	iii) Soundness test (Sodium Sulphate method)	-do-	To assess the quality of course aggregate	IS 2386 Part V 1963	Loss Not > 12% after 5 cycles of immersion in Na2 SO4
	iv) Abrasion, Impact & Crushing Value	-do-	-do-	IS 2386 part IV 1963	Wearing Surfaces: Loss Not > 30% Non Wearing Surface Not > 45%
	v) Organic Impurities (Mica content)	-do-	-do-	IS 2386 part II 1963	Less than 1%
	vi) Alkali reactivity (Alkali-Aggregate reactivity)	Twice in one working season	To know the `innocuous' or `deleterious' nature of aggregate	IS 2386 part VII 1963	* Falling in left side of Sc/Re curve. `Innocuous' *Falling in right side of Sc/Re curve. `Deleterious'
	vii) Petrographic Examination	Twice in one working season	To know the deleterious constituents and silt in aggregate	IS 2386 part VIII 1963	Deleterious constituent plus silt shall not exceeds 5%

Sl. No.	Test	Frequency	IS	Allowable Limits
1.	**GRAVEL** i) Size of Gravel ii) Liquid limit iii) Plasticity Index	For each stack	IRC 19-1977	Not larger than ¾" < 20% <6%
2.	**WATER** i) pH value ii) Organic	Two samples for each source	3025 Part II Part XXIV	6 to 8 Not greater than 200mg/lit

	iii) In-organic iv) Sulphate v) Chloride vi) Suspended Solids		Part XXXII Part XVII	Not greater than 3000mg/lit Not greater than 400mg/lit Plain Concrete : Not greater than 2000mg/lit RCC Work : Not greater than 500 mg/lit Not greater than 2000mg/lit
3.	**RR STONE** i) Abrasion value ii) Crushing strength iii) Specific Gravity iv) Water Absorption v) Durability	For each quarry	1124-1974 1121-1974 1124-1974 1126-1974	Not to exceed 6% Granite -1000 Kg/cm2 Basalt-400 kg/cm2 2.60 Not to exceed 5%
4.	**REINFORCEMENT** Weight Diameter Ultimate Test Strength Yield Stress Elongation	For each consignment	1786-1985 432-1966	Dia ≤ 8mm ± 4% Dia ≤ 8mm ± 2.5% Dia ≤ 25mm ± 0.5% Refer the table below for allowable limits.

Allowable limits for Reinforcement Bars

Types of reinforcement	Characteristic strength (yield stress of 0.2% proof stress) N/mm2	Ultimate tensile stress, N/mm2	Minimum elongation on gauge length of 5.65√ Cross - sectional area (%)
Mild steel of grades I II	255 236 231 211	412 373	20-23 20-23
Medium tensile steel	353 348 323	538	17-20

Types of reinforcement	Characteristic strength (yield stress of 0.2% proof stress) N/mm2	Ultimate tensile stress, N/mm2	Minimum elongation on gauge length of 5.65√ Cross - sectional area (%)
Cold worked deformed bars	415	15% more than the actual 0.2% proof stress	14.5
	500	10% more than the actual 0.2% proof stress	12
Hot Rolled	412	15% higher than the yield stress	14.5
SAIL-MA of grades 300 HY 350 HY 410 HY	300 350 410	440-560 490-610 540-660	20 20 19

Sl. No.	Test	Frequency	IS	Allowable Limits
1.	Cube Test for concrete	Qty. (m3) / Samples 1 to 5 / 1 6 to 15 / 2 16 to 30 / 3 31 to 50 / 4 50 & above / 4 + one addl. For each 50 (m 3)	456-2000	
2.	Cube test for cement mortar in masonry	3 tests per each grade of mortar per day	2250-1981 Appendix A	
3.	Permeability test on cement mortar	Once in a week	3085-1965	Not greater than 2.5x10-8 mm per sec. for rich mortar & 4.8x10-8 for lean mortar.
5.	Slump test	One test in each shift on at frequent intervals to checked workability	IS 1199	As per Mix design.

11. FREQUENCY OF TESTING OF CONSTRUCTION MATERIALS

Name of test, purpose of test and frequency of test

Testing of construction materials for quality control is a continuous process to ensure quality control during the entire period of construction. The tests have to be conducted periodically on the materials at intervals as stipulated by the Indian Standards. The results of the tests have be within the limits prescribed by the relevant IS codes. The allowable limits for various construction materials used in TN IAM Project are as per IS codes.

The following tables give the name, purpose of test and the frequency at which the tests should be conducted on the various materials. These tables also give the details of Indian Standards related to the tests.

Table - Frequency of testing for Soil and Filter Materials

Sl. No.	Test	Frequency of Test	Purpose	Test Designation
1.	Grain size analysis For classification and Atterberg limits	For every 3000 m3	To know the classifications of soil actually put in the embankment	As per IS-2720-IV-1975
2.	Field Density and Moisture content	One test for every 1500 m3 of earth work and at least one test in each layer laid on embankment.	To determine the placement density and moisture content.	IS-2720-XXVIII-1974 IS-2720-XXIX-1966 IS-2720-XXXIII-1971
3.	In-situ permeability Test	One test every 3m of embankment height or for 20,000 m3	To determine permeability characteristics of the fill material	IS-2720-XVII-1966
4.	Triaxial Shear Test	One test in every 3m of embankment height or for 20,000 m3	To know the shear characteristics of fill material (in-situ)	IS-2720-XII-1975
5.	Consolidation Test	1 set of 3 samples in every 6m height of embankment or for 30,000 m3	To know the settlement rate and its magnitude	IS-2720-XV-1965

6.	Standard Proctor Test	For every 10,000 cum of compacted earth or where there is change in the borrow area or change of soil texture, limited to minimum three samples and maximum 10 samples.	To determine MDD and OMC of the soil and compare the results with Laboratory value	IS-2720-VII-1970
7.	Moisture content	One test in each sample	To know the moisture content of the sample	IS-2720-II-1975
8.	Shrinkage Factor	One test in 5 mtrs of embankment height.	To determine shrinkage limit	IS-2720-Part-VI-1972
FILTERS				
9.	Grain Size Analysis	One test for every 200m3 of filter (sand) One test for every 200 m3 of filter (Aggregate)	To find % of the D10, D15, D30, D50, D60 and D85 grain sizes of materials	IS-2385-Part –I
10.	Clay lumps and organic impurities	One test for every 200 m3 (sand) One test for every 200 m3 (Aggregate)	To find out clay lumps & Organic impurities level	IS-2386-Part II

Sl. No.	Test	Frequency	IS	Allowable Limits
1.	**CEMENT** a) Chemical i) Alkalies ii) Minor, major oxides by Calorimetry iii) Chloride	For each consignment	a) 269-1989 b) 1489-1976 c)IS-4032-1985	OPC < 0.60% PPC < 0.70% PPC/OPC < 0.05%
	b) Physical i) Fineness ii) Soundness (Le Chatelier) iii) Consistency iv) Setting time Initial v) Final vi) Compressive Strength vii) Heat of Hydration viii)Drying shrinkage	For each consignment	a) 269-1989 b) 1489-1976 4031-1988	Not < 2250 cm2/gm Not > 10 mm Penetration upto 5 to 7 mm from base IT-Not < 30 min FT-Not > 600 min 3 days - 160 kg/cm2 7 days- 220 Kg/cm2 28 days-330 Kg./cm2 PPC 7 days - 65 Cal/gm OPC 28 days - 75Cal/gm <0.15%

Sl. No.	Test	Frequency	Purpose	IS	Allowable Limits
1.	**FINE AGGREGATE** i) Screen Analysis (Fineness modulus)	One test for every 150 m3 of sand used in concrete	To know grain size and the fineness modulus of sand	IS 2386 Part-I 1963	2.2 to 3.2
	ii) Unit Weight and Bulkage of sand	-As above- (also once in a shift or for every consignment)	To utilize data for mix design computation	IS 2386 Part III 1963	Allowable limit of Bulkage of sand is 20%
	iii) Organic impurities	-As above-	To assess the quality of sand	IS-2386 Part II 1963	As explained in Sec. 4.2.2
	iv) Soundness	One test for every 150 cum of sand used in concrete	To assess the quality of sand	IS 2386 Part II 1963	Loss Not > 10% after 5 cycles of immersion in Na2 So4
	v) Silt Content	One test for every 150 cum of sand used in concrete	To assess the silt content present in the sand	IS 2386 1963	Not greater than 3% for natural FA and Not grater than 5% for crushed FA.
	vi) Specific Gravity, moisture content and absorption	One test for every 150 cum of sand used in concrete	To utilise the data for mix design computation s	IS 2386 part III 1963	
2.	**COARSE AGGREGATE**				
	i) Sieve Analysis	One test for every 150 m3 or less	To know gradation and percentage of various size	IS 2386 part I 1963	
	ii) Specific Gravity, Bulk	-do-	To utilize data for mix	IS 2386 part III	Not > 2.6 Not more than 5%

	Density, Moisture content, Absorption & Silt Continent		design computation	1963	by weight Not > 3%
	iii) Soundness test (Sodium Sulphate method)	-do-	To assess the quality of course aggregate	IS 2386 Part V 1963	Loss Not > 12% after 5 cycles of immersion in Na2 SO4
	iv) Abrasion, Impact & Crushing Value	-do-	-do-	IS 2386 part IV 1963	Wearing Surfaces: Loss Not > 30% Non Wearing Surface Not > 45%
	v) Organic Impurities (Mica content)	-do-	-do-	IS 2386 part II 1963	Less than 1%
	vi) Alkali reactivity (Alkali-Aggregate reactivity)	Twice in one working season	To know the `innocuous' or `deleterious' nature of aggregate	IS 2386 part VII 1963	* Falling in left side of Sc/Re curve. `Innocuous' *Falling in right side of Sc/Re curve. `Deleterious'
	vii) Petrographic Examination	Twice in one working season	To know the deleterious constituents and silt in aggregate	IS 2386 part VIII 1963	Deleterious constituent plus silt shall not exceeds 5%

Sl. No.	Test	Frequency	IS	Allowable Limits
1.	**GRAVEL** i) Size of Gravel ii) Liquid limit iii) Plasticity Index	For each stack	IRC 19-1977	Not larger than ¾" < 20% <6%
2.	**WATER** i) pH value ii) Organic	Two samples for each source	3025 Part II Part XXIV	6 to 8 Not greater than

	iii) In-organic iv) Sulphate v) Chloride vi) Suspended Solids		Part XXXII Part XVII	200mg/lit Not greater than 3000mg/lit Not greater than 400mg/lit Plain Concrete : Not greater than 2000mg/lit RCC Work : Not greater than 500 mg/lit Not greater than 2000mg/lit
3.	**RR STONE** i) Abrasion value ii) Crushing strength iii) Specific Gravity iv) Water Absorption v) Durability	For each quarry	1124-1974 1121-1974 1124-1974 1126-1974	Not to exceed 6% Granite -1000 Kg/cm2 Basalt-400 kg/cm2 2.60 Not to exceed 5%
4.	**REINFORCEMENT** Weight Diameter Ultimate Test Strength Yield Stress Elongation	For each consignment	1786-1985 432-1966	Dia ≤ 8mm ± 4% Dia ≤ 8mm ± 2.5% Dia ≤ 25mm ± 0.5% Refer the table below for allowable limits.

Allowable limits for Reinforcement Bars

Types of reinforcement	Characteristic strength (yield stress of 0.2% proof stress) N/mm2	Ultimate tensile stress, N/mm2	Minimum elongation on gauge length of $5.65\sqrt{}$ Cross -sectional area (%)
Mild steel of grades I II	255 236 231 211	412 373	20-23 20-23
Medium tensile steel	353 348 323	538	17-20
Cold worked deformed bars	415	15% more than the actual 0.2% proof stress	14.5
	500	10% more than the actual 0.2% proof stress	12
Hot Rolled	412	15% higher than the yield stress	14.5
SAIL-MA of grades 300 HY 350 HY 410 HY	300 350 410	440-560 490-610 540-660	20 20 19

Frequency of Testing Cement Mortar, Masonry and Concrete

<table>
<tr><th>Sl. No.</th><th>Test</th><th>Frequency</th><th>IS</th><th>Allowable Limits</th></tr>
<tr><td>1.</td><td>Cube Test for concrete</td><td><table><tr><th>Qty. (m3)</th><th>Samples</th></tr><tr><td>1 to 5</td><td>1</td></tr><tr><td>6 to 15</td><td>2</td></tr><tr><td>16 to 30</td><td>3</td></tr><tr><td>31 to 50</td><td>4</td></tr><tr><td>50 & above</td><td>4 + one addl. For each 50 (m3)</td></tr></table></td><td>456-2000</td><td></td></tr>
<tr><td>2.</td><td>Cube test for cement mortar in masonry</td><td>3 tests per each grade of mortar per day</td><td>2250-1981 Appendix A</td><td></td></tr>
<tr><td>3.</td><td>Permeability test on cement mortar</td><td>Once in a week</td><td>3085-1965</td><td>Not greater than 2.5x10-8 mm per sec. for rich mortar & 4.8x10-8 for lean mortar.</td></tr>
<tr><td>5.</td><td>Slump test</td><td>One test in each shift on at frequent intervals to checked workability</td><td>IS 1199</td><td>As per Mix design.</td></tr>
</table>

The actual frequencies shall be determined by the Engineer-in-charge to suit the nature and variability of material placed and the rate of fill placement with the objective of ensuring best quality control and quality construction.

The extract of pages from IS 456-2000 for acceptance criteria for concrete cube compressive strength is as follows.

However, when adequate past records for a similar grade exist and justify to the designer a value of standard deviation different from that shown in Table 8, it shall be permissible to use that value.

Table 8 Assumed Standard Deviation
(Clause 9.2.4.2 and *Table* 11)

Grade of Concrete	Assumed Standard Deviation N/mm²
M 10, M 15	3.5
M 20, M 25	4.0
M 30, M 35, M 40, M 45, M 50	5.0

NOTE—The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate gradings and moisture content; and periodical checking of workability and strength. Where there is deviation from the above the values given in the above table shall be increased by 1N/mm².

9.3 Nominal Mix Concrete

Nominal mix concrete may be used for concrete of M 20 or lower. The proportions of materials for nominal mix concrete shall be in accordance with Table 9.

9.3.1 The cement content of the mix specified in Table 9 for any nominal mix shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio as specified is not exceeded.

10 PRODUCTION OF CONCRETE

10.1 Quality Assurance Measures

10.1.1 In order that the properties of the completed structure be consistent with the requirements and the assumptions made during the planning and the design, adequate quality assurance measures shall be taken. The construction should result in satisfactory strength, serviceability and long term durability so as to lower the overall life-cycle cost. Quality assurance in construction activity relates to proper design, use of adequate materials and components to be supplied by the producers, proper workmanship in the execution of works by the contractor and ultimately proper care during the use of structure including timely maintenance and repair by the owner.

10.1.2 Quality assurance measures are both technical and organizational. Some common cases should be specified in a general Quality Assurance Plan which shall identify the key elements necessary to provide fitness of the structure and the means by which they are to be provided and measured with the overall purpose to provide confidence that the realized project will work satisfactorily in service fulfilling intended needs. The job of quality control and quality assurance would involve quality audit of both the inputs as well as the outputs. Inputs are in the form of materials for concrete; workmanship in all stages of batching, mixing, transportation, placing, compaction and curing; and the related plant, machinery and equipments; resulting in the output in the form of concrete in place. To ensure proper performance, it is necessary that each step in concreting which will be covered by the next step is inspected as the work proceeds (*see also* **17**).

Table 9 Proportions for Nominal Mix Concrete
(*Clauses* 9.3 *and* 9.3.1)

Grade of Concrete	Total Quantity of Dry Aggregates by Mass per 50 kg of Cement, to be Taken as the Sum of the Individual Masses of Fine and Coarse Aggregates, kg, *Max*	Proportion of Fine Aggregate to Coarse Aggregate (by Mass)	Quantity of Water per 50 kg of Cement, *Max* l
(1)	(2)	(3)	(4)
M 5	800	Generally 1:2 but subject to an upper limit of 1:1½ and a lower limit of 1:2½	60
M 7.5	625		45
M 10	480		34
M 15	330		32
M 20	250		30

NOTE—The proportion of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of fine aggregates becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregate shall be used.

Example

For an average grading of fine aggregate (that is, Zone II of Table 4 of IS 383), the proportions shall be 1:1½, 1:2 and 1:2½ for maximum size of aggregates 10 mm, 20 mm and 40 mm respectively.

600 mm and so on.

The amount of grout to be sent down shall be sufficient to fill all the voids which may be either ascertained or assumed as 55 percent of the volume to be concreted.

14.2.5 To minimize the formulation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

15 SAMPLING AND STRENGTH OF DESIGNED CONCRETE MIX

15.1 General

Samples from fresh concrete shall be taken as per IS 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS 516.

15.1.1 In order to get a relatively quicker idea of the quality of concrete, optional tests on beams for modulus of rupture at 72 ± 2 h or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength test. For this purpose the values should be arrived at based on actual testing. In all cases, the 28 days compressive strength specified in Table 2 shall alone be the criterion for acceptance or rejection of the concrete.

15.2 Frequency of Sampling

15.2.1 *Sampling Procedure*

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested that is, the sampling should be spread over the entire period of concreting and cover all mixing units.

15.2.2 *Frequency*

The minimum frequency of sampling of concrete of each grade shall be in accordance with the following:

Quantity of Concrete in the Work, m^3	*Number of Samples*
1 - 5	1
6 - 15	2
16 - 30	3
31 - 50	4
51 and above	4 plus one additional sample for each additional 50 m^3 or part thereof

NOTE—At least one sample shall be taken from each shift. Where concrete is produced at continuous production unit, such as ready-mixed concrete plant, frequency of sampling may be agreed upon mutually by suppliers and purchasers.

15.3 Test Specimen

Three test specimens shall be made for each sample for testing at 28 days. Additional samples may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing, or to check the testing error. Additional samples may also be required for testing samples cured by accelerated methods as described in IS 9103. The specimen shall be tested as described in IS 516.

15.4 Test Results of Sample

The test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than ±15 percent of the average. If more, the test results of the sample are invalid.

16 ACCEPTANCE CRITERIA

16.1 Compressive Strength

The concrete shall be deemed to comply with the strength requirements when both the following condition are met:

a) The mean strength determined from any group of four consecutive test results compiles with the appropriate limits in col 2 of Table 11.

b) Any individual test result complies with the appropriate limits in col 3 of Table 11.

16.2 Flexural Strength

When both the following conditions are met, the concrete complies with the specified flexural strength.

a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.

b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2.

16.3 Quantity of Concrete Represented by Strength Test Results

The quantity of concrete represented by a group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches.

For the individual test result requirements given in col 2 of Table 11 or in item (b) of **16.2**, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified the maximum quantity of concrete that four consecutive test results represent shall be limited to 60 m^3.

16.4 If the concrete is deemed not to comply persuant to **16.3**, the structural adequacy of the parts affected shall be investigated (*see* **17**) and any consequential action as needed shall be taken.

16.5 Concrete of each grade shall be assessed separately.

16.6 Concrete is liable to be rejected if it is porous or honey-combed, its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the engineer-in-charge.

17 INSPECTION AND TESTING OF STRUCTURES

17.1 Inspection

To ensure that the construction complies with the design an inspection procedure should be set up covering materials, records, workmanship and construction.

17.1.1 Tests should be made on reinforcement and the constituent materials of concrete in accordance with the relevant standards. Where applicable, use should be made of suitable quality assurance schemes.

17.1.2 Care should be taken to see that:

a) design and detail are capable of being executed to a suitable standard, with due allowance for dimensional tolerances;
b) there are clear instructions on inspection standards;
c) there are clear instructions on permissible deviations;
d) elements critical to workmanship, structural performance, durability and appearance are identified; and
e) there is a system to verify that the quality is satisfactory in individual parts of the structure, especially the critical ones.

17.2 Immediately after stripping the formwork, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before concrete has thoroughly hardened.

17.3 Testing

In case of doubt regarding the grade of concrete used, either due to poor workmanship or based on results of cube strength tests, compressive strength tests of concrete on the basis of **17.4** and/or load test (*see* **17.6**) may be carried out.

17.4 Core Test

17.4.1 The points from which cores are to be taken and the number of cores required shall be at the discretion of the engineer-in-charge and shall be representative of the whole of concrete concerned. In no case, however, shall fewer than three cores be tested.

17.4.2 Cores shall be prepared and tested as described in IS 516.

17.4.3 Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has a strength less than 75 percent.

17.5 In case the core test results do not satisfy the requirements of **17.4.3** or where such tests have not been done, load test (**17.6**) may be resorted to.

17.6 Load Tests for Flexural Member

17.6.1 Load tests should be carried out as soon as

Table 11 Characteristic Compressive Strength Compliance Requirement

(*Clauses* 16.1 *and* 16.3)

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm²	Individual Test Results in N/mm²
(1)	(2)	(3)
M 15	≥ f_{ck} + 0.825 × established standard deviation (rounded off to nearest 0.5 N/mm²) or f_{ck} + 3 N/mm², whichever is greater	≥ f_{ck} − 3 N/mm²
M 20 or above	≥ f_{ck} + 0.825 × established standard deviation (rounded off to nearest 0.5 N/mm²) or f_{ck} + 4 N/mm², whichever is greater	≥ f_{ck} − 4 N/mm²

NOTE—In the absence of established value of standard deviation, the values given in Table 8 may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

12. Duties of Field and Quality Control Staff In Relation to Quality of Works

Sl. No.	JE / AE / AEE CONSTRUCTION	JE / AE / AEE QUALITY CONTROL
1.	• Shall see that the mark out of the area to be tackled is properly given, shuttering, centering, reinforcement are done as per drawing and technical specifications, to record the Pre levels/ foundation levels. • To see that mark-out for canal excavation is perfectly given as per drawings. Pre-levels, classification levels and final levels of canal shall be taken as per specification.	• Shall check the mark out of foundation and centering/shuttering reinforcement arrangement and inform the Assistant Engineer construction to rectify the defects if any.
2.	• Shall see that the construction equipment like mixers, vibrators, compaction equipment, pumping arrangements for curing/watering are arranged before starting of any work.	• Shall check the adequacy of the construction equipment and curing/ watering arrangements before start of work and during execution.
3.	• Shall see that sufficient quantities of input materials as per agreement specifications are made available at site of work. • To arrange testing equipment, men and material required for conducting field tests. • Sending samples of input materials for testing to central lab, regional laboratories as per norms.	• Shall conduct / get conducted by different laboratories, the field tests on input materials and record the results. • To inform the Assistant Engineer construction to rectify the defects if any.
4.	• Shall write O.K. Cards after area is ready to start the work and to inform the Assistant Engineer Quality Control and Executive Engineer construction and take permission to start the work. • Shall also permit OK in case quality control A.E. is not available.	• Shall check and write the O.K. card and record the deviations, defects if any or otherwise to record the final OK. • To inform Executive Engineer quality control and to permit to start the work.
5.	• Shall supervise and ensure that correct quantities of input materials as per mix design communicated by the central laboratory are fed into the mixers/batching plants etc., and	• Shall make regular checks of the feeding of input materials, mixing time and suggest the quantity of water depending on the moisture content of sand as and when

	shall ensure specified mixing time. (minimum 2 ½ minutes)	required.
6.	• Shall ensure proper vibration, rolling etc., during course of day to day work. • Shall conduct D.B.D test of earth work, gradation of material, slump test, and core drill test. • To extract field samples of material and finished products to be sent to different laboratories. • To provide men and material required for extracting samples of finished product for quality control staff.	• Shall ensure slump test, core tests, proctor density etc., conducted as per norms by the construction and quality control staff. • To extract field samples of finished product to be sent to central/Regional laboratory later.
7.	• Shall ensure proper curing of samples extracted till the curing time is over. • To make arrangements to send the samples to central lab or other suitable lab.	• Shall assist the Assistant Engineer in proper handling/transport of samples to central / Regional lab.
8.	• Shall ensure timely green cutting of concrete with proper air - water gun; nicking & chipping (wherever so warranted) so as to prepare the surface for next concrete lift for effective bond at the lift/construction joints.	• Shall check and see that the preparation of the surface is adequately done for starting the next lift.
9.	• Shall ensure proper curing/watering and allow removal of shuttering only after the time limit prescribed in the specifications and to see that the surface are finished to the plumb/ straight lines etc., after removal of shuttering.	• Shall check the adequacy of curing/ watering and see that the final surfaces are finished neatly plumb/straight lines etc.
10.	• Shall maintain (1) mark-out register (2) OK Card files (3) Load Register.	• Shall maintain registers of field tests conducted.

DUTIES OF EXEUCTIVE ENGINEERS

Sl. No	EXECUTIVE ENGINEER CONSTRUCTION	EXECUTIVE ENGINEER QUALITY CONTROL
1.	• Shall supervise, check, advise, and instruct the J.E./A.E. Construction regarding discharge of their functions properly.	• Shall supervise, check, advise and instruct the A.E. Quality control regarding discharge of their functions properly.
2.	• Shall intimate the Executive Engineer quality control regarding signing of agreement for starting of any new work, duly endorsing a copy of work order. • Shall supply copies of contract documents, drawings construction programme etc., to Executive Engineer Quality Control.	• Shall maintain copies of approved Designs, reports, contract document, drawings, construction programme, extracts of inspection notes etc., • Shall see that his subordinates go through the above documents.
3.	• Shall get all ingredients of concrete, masonry got tested before use. • Shall see that the soils are tested for various properties like OMC, MDD, etc., before starting of Embankment work.	• Shall remind and verify whether test results are available or not before starting up of any new work and during execution of work.
4.	• Shall see that all the Machinery / Equipment being used by the contractor is got periodically calibrated.	• Shall guide in upkeep and calibration of equipments.
5.	• Shall see that OK Cards are written and kept at site of work before starting of any work. • Shall ensure rectification of work before releasing payments.	• Shall inspect and sign on O.K. Cards during field visits. • Defects of construction will be pointed out and remedies suggested for achieving good quality construction.
6.	• Shall order the suspension of work if any defects are noticed or reported by quality control staff and resume the work only after rectification of defects in the presence of quality control staff.	• Shall order the stopping of work if major defects are noticed or reported by quality control staff and intimate his counter part to see that defects are rectified. • Defects noted during construction are to be reported to the E.E. and S.E./Quality Control & construction.

7.	• Foundations and reinforcement, shuttering, centering where heavy reinforcement is involved is to be checked by Executive Engineer invariably before starting the work.	• Foundations and reinforcement, shuttering, centering where heavy reinforcement is involved is to be tallied by Executive Engineer invariably before starting the work, during his field visits.
8.	• Shall personally see that the samples to the laboratories are sent regularly, obtain the results and communicate the same to Executive Engineer quality control	• Shall pursue and keep track of sending of samples various laboratories and to keep record of results received.
9.	• Shall take the help of quality control Executive Engineer whenever a dispute is referred.	• Shall co-ordinate with the Executive Engineer Construction and render assistance in resolving the issues referred to him.

General Duties

I. Duties of Executive Engineers

1. Verifying the pre levels and final levels taken for bund
2. Inspecting the work site frequently and signing the OK. Cards with observations.
3. Verifying the rectification of remarks if any pointed out by Quality Control personnel
4. Monthly review on Project Implementation Plan of the sub basin & uploading the monthly progress report in Web portal by 5th of every month.
5. Conducting subcommittee meeting
6. Bill payment to contractors should be made only after verification of OK. Cards & connected registers showing the satisfactory quality parameters & authentication by Quality Control Engineers.

II. Duties of Superintending Engineers

1. Conducting Contract Management Meeting every month
2. Monthly Progress Review Meeting
3. Technical Meeting at Work Site Twice a Month including the Quality Control Engineers during the review.
4. Review of Quality Control aspects and progress monthly

13. SALIENT POINTS TO BE FOLLOWED IN IAMP WORKS

I. Before commencement of Work:-

1. Take photographs of important structures which are to be dismantled and tank bunds
2. Jurisdiction Map and Location Map should be available at site
3. Water source origin details
4. Surplus course feeding details
5. Tank / Anicut hydraulic particulars
6. Necessary Estimates, drawings and agreement copy should be available at site
7. Working drawing for earth work, concrete structures and progress chart (PERT chart)

II. Quality Control tests:-

1. Water Test
2. Soil suitability Test (with classification of soil and Maximum dry density of soil)
3. Steel Test (with permissible limits)
4. Cement (Factory test report and QC Test reports should be enclosed)
5. Fine aggregate and Coarse aggregate tests.

Note : Permissible Limits enclosed in annexure I

III. During Execution:-

1. TBM & LF Book entry should be made and kept available
2. Photos/Videos should be taken during execution at different levels and after completion of work
3. Maintenance of registers (List of Registers enclosed in annexure II)
4. O.K. cards (Tamil version) with WUA consent signature duly inspected by higher officials along with their remarks.
5. Observations of the Quality Control Engineers shall be recorded in the O.K. Cards maintained by site Engineers and validation of compliance shall also be recorded in the subsequent visits.

6. Points to be considered during execution works

6.1) Form work

a) Centering stability should be checked

b) Cleaning and oiling of centering sheets should be ensured before laying concrete.

6.2) Reinforcement

Double binding wires should be provided and over lap should be binded at the ends.

6.3) Concrete

a) "No vibrator No concrete" policy should be adopted

b) Alignment and verticality of structures should be checked

c) Water cement ratio should be strictly controlled

d) Supervision by Assistant Engineer / Junior Engineer in batching plant locations with proper load Register

e) Sufficient curing should be ensured

f) Proper splay should be provided in the U/s wing during sluice construction

7. Earth work

7.1) Short width drum vibratory power roller should be used for compaction in smaller width portions.

7.2) Side plate compactor (approx plate dimension 1.00x 1.60m x 0.02m) should be used for compaction of u/s and D/s slopes

7.3) Watering to optimum moisture content should be ensured

7.4) Side slopes (U/s & D/s) should be properly maintained

7.5) Excavated earth at the sides of sluice should be compacted effectively using rollers.

7.6) Roots and dead woods should be removed then and there

7.7) All the excavated earth pits should be linked to the sluice points

7.8) Take necessary earth cores for every layer and Core Bore details drawing (annexure II & IV) should be updated with test results.

14. Package Details & Documents to be kept at site

1) Name of sub basin :

2) Package Details :

a) Package No :
b) Agreement Value :
c) Name of Contractor :
d) Date of Commencement :
e) Probable date of completion :

3) Details of infrastructure works considered in the package

	Taken up for Rehabilitation in IAMP	Completed	In Progress	Balance to be taken up
No . of Tanks				
No. of Anicuts				
Length of Supply Channel in KM				

4) Documents to be kept at site

a) Index plan / Flow Diagram :
b) Design & Drawing with authentication By the Chief Engineer :
c) Expenditure statement (Progress Report) :
d) Bar Chart :
e) Photographs (Before, During After) :
f) Success Stories :
g) List of Registers to be maintained at site :

5) a) Mile Stone

No. of Milestone	I	II	III
Date of Completion			

b) Target & Achievement (for completed Milestone)

	Tanks		Anicuts		Supply Channel		Others	
	Nos.	Amount	Nos.	Amount	Nos.	Amount	Nos.	Amount
Target								
Achievement								
Short Fall								

c) Reason for short fall (if any) :
d) Action taken for makeup of the short fall :

6) Quality Control

a) O.K. Cards (should
Details of materials tested
Proctors compaction test,
Concrete tests done, etc with
Signature of Engineers &
WUA representatives) :

b) Machineries working at site :

7) Inspection of SE/CE
(Site Order Book should contain the following details)

i). Date of inspection :
ii). Remarks, if any pointed out /
site order given if any :
iii). Follow up action taken :

15. O.K. Cards

An OK Cards is a condensed form of specifications and an essential requirement for achieving specified workmanship and quality level of output. Each work is sub-divided into various construction activities in proper sequence/order of construction. Such activities are listed in chronological order in the OK Cards. The OK Cards contain important entries / information relating to execution at all stages of work and are liable to be referred/perused at a later stage as well, particularly during the Internal Quality Audit of works.

It provides a systematic approach towards assuring quality construction and has proved to be a practical mechanism for enforcement of technical specifications. The cards are maintained in different colors to be operated by construction and quality control units separately. During execution of work, both cards should be operated simultaneously and will be kept on record by the Executive Engineer concerned.

Maintaining O.K. Cards to ensure Quality Control

The O.K. Cards System shall be followed for various stages of construction activities where laboratory tests or checks with reference to drawings and specifications are required from quality control unit. The O.K. Cards should be made available on the site in regular manner. Approval of the competent authority of work in progress should be recorded in the O.K. Cards by the inspecting officer at the time of his inspection. The O.K. Cards, relating to any particular work, shall be put in a steel rack and placed at the construction site. Senior officers shall also check the O.K. Cards during the field inspections to ensure that those are being maintained and proper/genuinely filled.

Items of activities entered in the O.K. Card will depend upon the nature of work and the type of activities to which the work can be divided. The O.K. Card for raising and strengthening of earthen embankments/fill placement and compaction, for example, may consist of activities like initial preparedness, requisites, fill placement, commencing compaction and placing subsequent layer. The activities may again be divided into sub-activities like (i) lay out/demarcation/fixing and checking Temporary Bench Mark, (ii) removal of debris, vegetation and site

clearance and (iii) benching and stripping of base. Sample O.K. cards appended to this chapter may please be referred in this regard.

Against each sub activity, the remark of the construction agency/contractor or his representative as to the readiness for commencing the sub activity, recording test results, if any will be entered with his dated signature.

Permission granted by the Construction Engineer and/or Quality Control Engineer for carrying out each item of activity/sub activity will then be recorded by the engineer with dated signature. Wherever Water Users Association are actively involved in the project, his remarks will also be entered in the O.K. card, against each activity/sub activity, since the work being carried out is ultimately for the benefit of the water users, like farmers.

IF QC/QA Engineer is not available at site then O.K. given by Construction Engineer will be treated as final, if anything otherwise is not observed. Should anything otherwise be found, the O.K. Card shall not be signed by him and he should ask the Construction Engineer/Agency for necessary rectification. Subsequently, O.K. Card should refer to the defects removed, if pointed out previously in O.K. Card and counter reference to the previous check and should be signed or okayed.

It must be borne in mind that work cannot be held up unduly for disposal of O.K. Card. The Assistant Executive Engineer, Quality Control/Construction will be okaying the concerned work like dam, spillway, head regulator, etc and Assistant Engineer/Junior Engineer Construction will be okaying the scattered works like canals and small structures. Such permissions given by the officers should be brought to the notice of competent authority and take ex-post-facto approval. Random checks by the supervising officers should be recorded on O.K. Cards at site. Weekly report of O.K. Cards maintained by construction unit should be submitted to Executive Engineer concerned who has to monitor and ensure that adequate check is being maintained by field staff. After processing through various levels and entering observations and rectification, O.K. Card will be closed at the time of taking measurements. Photocopy of the O.K. Cards will be kept at site and the original will be sent to the Division Office for record. Specimens of O.K. Cards for various works such as embankment, concrete, masonry etc are enclosed.

O.K. CARD

Form: O.K. Card No: 1

FOR RAISING/STRENGTHENING OF EARTHEN EMBANKMENTS/FILL PLACEMENT & COMPACTION (PART-I)

Name of the Work:

Agency: Contract/Package No:

Location: Date:

Description of activities	Remarks and dated signature of Construction Agency	Remarks and Dated Sign. Of Construction Staff		Remarks & Dated Sign. OF QC/ Inspection Engineer	Signature of WUA
		JE/AE	AEE		
Initial Preparation					
(1) Layout / Demarcation / Fixing & Checking T.B.M					
(2) Removal of Vegetation, debris & Site clearance					
(3) Benching, stripping of base (+20 cm)					
Pre-requisites					
(1) Proctor's density of borrow area					
(2) Designation of borrow area & checking of required moisture					
(3) Excavation and shaping of rain cuts and its refilling					
(4) Whether key trench made and / or plowing of old embankments done if required					
(5) Watering base					
Ok for fill placement					
(1) Thickness of loose layer (cm)					
(2) Removal of oversize (more than 7.5 cm size) layer					
(3) Moisture content (%) initial					
(4) Moisture content (%)					

final (OMC=%)					
(5) Whether soil laid as per profile					
Ok for commencing compaction					
(1) Checking of Type of Compaction Equipment/Roller					
(2) Checking of In place density (D.B.D.)					
(3) Compaction Efficiency (%)					
(4) Specified Compaction (%) of Proctor					
(5) Re-Rolling /Re-compaction if required					
(6) D.B.D. after Re-Rolling					
Ok for next layer					
Removal of extra / loose earth from US & D/S faces					

O.K. CARD
Form: O.K. Card No. 2
FOR SUPPLEMENTARY O.K. CARD FOR SUBSEQUENT LAYERS (PART II)

Name of the work:
Agency: Contract/Package No:
Location: Date:

Description of activities	Remarks and dated signature of Construction Agency	Remarks and Dated Sign. Of Construction Staff		Remarks & Dated Sign. OF QC/ Inspection Engineer	Signature of WUA
		JE/AE	AEE		

O.K. CARD

Form: O.K. Card No. 3

FOR SUB-GRADE PREPARATION FOR PLACEMENT OF LINING (PART I)

Name of the work:

Agency: Contract/Package No:

Location: Date:

Description of activities	Remarks and dated signature of Construction Agency	Remarks and Dated Sign. Of Construction Staff		Remarks & Dated Sign. OF QC/ Inspection Engineer	Signature of WUA
		JE/AE	AEE		
Chainage					
Removal of vegetation, debris					
Completion of dewatering					
Filling of over excavation, depressions/pockets in sol/rocky strata as per spees.					
Water of sub-grade					
Compaction of sub-grade (bottom & sides) through slope compaction / Pneumatic rammer / power roller to specific density (%)					
Final lip cutting & checking sub-grade surface to ensure within permissible tolerance (up to 6.5 mm on sides, upto 12.5 mm on bed)					
Laying of under-drainage arrangements (a) Porous Plugs (b) Longitudinal & transverse Drains (c) Porous Panels					
Final wetting of sub-grade to 15 cm depth					
Checking of quantity and quality of material stacked at site: Cement, Aggregate, Sand, Water					
Checking of mixer, vibrator & power					
Checking of form work/shuttering true to line and grade					
O.K. Placement of lining					

Form: O.K. Card No. 4
FOR PLACEMENT OF CAST-IN-SITU CONCRETE LINING (PART II)

Name of the work:
Agency: Contract/Package No:
Location: Date:

Description of activities	Remarks and dated signature of Construction Agency	Remarks and Dated Sign. Of Construction Staff		Remarks & Dated Sign. OF QC/ Inspection Engineer	Signature of WUA
		JE/AE	AEE		

Form: O.K. Card No. 5
FOR PCC SLAB CANAL LINING

Name of the work:
Agency: Contract/Package No:
Location: Date:

Description of activities	Remarks and dated signature of Construction Agency	Remarks and Dated Sign. Of Construction Staff		Remarks & Dated Sign. OF QC/ Inspection Engineer	Signature of WUA
		JE/AE	AEE		
A. Material Suitability i) Cement ii) Aggregate 40mm. 20mm iii) Sand iv) Water v) Treatment of soil if any					
O.K. for Materials					
B. Formation of Canal Banks i) Stripping/Removal of vegetation					

ii) Cutting Canal bed & sides to the geometric section/shape iii) Consolidation iv) Trimming					
C. Casting of PCC Slabs i) Mix, Measurement by weight ii) Mixing, consistency iii) Slump iv) Water Cement Ratio v) Casting of PCC Slabs vi) Casting of cubes of concrete mix vii) Providing sub base if necessary viii) Laying / Placing in position PCC Slabs ix) Construction Joints x) Contraction Joints xi) Pointing with CM xii) Curing xiii) Pressure Relief Hole xiv) Flexural Strength of PCC Slabs					
Final OK					

Form: O.K. Card No. 6
FOR PLAIN & REINFORCED CEMENT CONCRETE

Name of the work:
Agency: Contract/Package No:
Location: Date:

Description of activities	Remarks and dated signature of Construction Agency	Remarks and Dated Sign. of Construction Staff		Remarks & Dated Sign. OF QC/ Inspection Engineer	Signature of WUA
		JE/AE	AEE		
Material Suitability i) Cement ii) Steel iii) Aggregate 40mm, 20mm iv) Sand v) Water vi) Admixture					

O.K. for materials					
Form Work & Centering i) Tightness, Stability, Smoothness ii) Cleaning, Oiling, perfectness of form work iii) R.L. of Centering iv) Checking of reinforcement					
O.K. for reinforcement					
Tool & Plants i) Mixers & Vibrator Adequacy of concrete production / transportation placement, consolidation					
O.K. for Placement					
i) Design mix, measurement ii) Mixing/Consistency iii) Slump iv) Compactions of Concrete v) Joints vi) Finishing vii) Casting of Cubes viii) Curing ix) Comprehensive strength at 28 days					
Final OK					

Note: Before pouring of concrete the reinforcement should be got checked by the Q.C. unit. Working standby vibrator & Mixer should be kept at site before start of concreting.

Form: O.K. Card No. 6
FOR RANDOM RUBBLE STONE MASONRY Date:
Name of the work: Agency:
Location: Contract/Package No:

Description of activities	Remarks and dated signature of Construction Agency	Remarks and Dated Sign. of Construction Staff		Remarks & Dated Sign. OF QC/ Inspection Engineer	Signature of WUA
		JE/AE	AEE		
Stone – Quality Size					
Suitability of Cement Sand Water					
Mortar Mix, measurement Mixing, Consistency					
Pointing, thickness of joints, staggering of joints, laying of stones, hearting stones, bond stones spacing.					
Whether Samples of Mortar Collected in Cubes for testing					
Green cutting, with proper air water gun/sand blasting					
Adequacy of curing for masonry work					
Verticality of structure check by using plumb bob					
Embedded Materials					
Final OK for masonry work					

16. On Farm Development Works by Water Users Association

Broad Illustrative Rectification Guidelines

by Andhra Pradesh Community Based

Tank Management Project

(As a Model to be adopted in our Project)

ఆంధ్రప్రదేశ్ సమాజ ఆధారిత చెరువుల యాజమాన్య పథకం

ANDHRA PRADESH COMMUNITY BASED TANK MANAGEMENT PROJECT

నీటివినియోగదారుల సంఘం నిర్వహణ ఒ.కె. కార్డుకు అనుబంధం

Attachment to WUA Maintenance O.K. Card

సుధీర్ఘ సచిత్ర సవరణతో కూడిన మార్గదర్శకాలు

Broad Illustrative Rectification Guidelines

నీటివినియోగదారుల సంఘమునకు తగినంతగా నిర్వాహణ మరియు భద్రతకు సంబంధించిన అంశాలలో శిక్షణ ఉండాలి. సరియైన శిక్షణ, సమయము ప్రాముఖ్యమైన అంశము అయినప్పుడు నీటివినియోగదారుల సంఘము అపద పరిస్థితులను త్వరితముగా గుర్తించడానికి వీలు కలిగి అలస్యము చేయకుండా ఉపశమన చర్యలు ఆరంభించడానికి సహాయపడుతుంది.
The WUA should be adequately trained in the aspects of maintenance & safety of tanks Proper training shall help WUAs in quick identification of distress situations and initiation of remedial measures without delay when time is the critical factor.

నీటివినియోగదారుల సంఘము ద్వారా క్లిష్ట పరిస్థితులలో అన్ని చెరువు వ్యవస్థల నిఘాను పెంచుతూ నిర్వహించాలి: పరివాహక ప్రాంతంలో అధికమైన వర్షపాత పరిస్థితులు మరియు "వరద సమయాలలో" మరింత మేలుగా ఈ క్లిష్ట పరిస్థితులలో 24 గంటల నిఘా నిర్వహించబడాలి. మరియు రాత్రి గస్తీ సమయాలకై కాంతివంతమైన టార్చి లైట్లు కలిగియుండాలి.
Increased vigilance by WUAs must be maintained on all Tanks Systems during the critical periods: "periods of intense rainfall in the catchment" & "periods of floods" Rather round the clock vigilance should be maintained during these periods and the WUAs should have powerful torches for night patrol.

కట్ట కుంగిపోవడం, దిగిపోవడం, లీకేజీలు, పగుళ్ళు ఏర్పడుట మరియు వాలులు జారిపోవుట అనవాలులు ఉన్నప్పుడు అత్యవసర చర్యలు ప్రారంభించడానికి నీటివినియోగదారుల సంఘము జాగ్రత్త పడాలి. ఈ పరిస్థితులను నీటివినియోగదారుల సంఘాలు త్వరితంగా కార్యనిర్వాహణ అధికారిగారికి తెలియజేయాలి.
Evidence of any subsidence, settlement, leakages, cracks formation and slipping of slopes must alert them to initiate emergent measures. WUAs should immediately inform the Executive Engineer.

అత్యవసర పరిస్థితులలో త్వరితంగా వినియోగించుకోవడానికి వీలుగా ఈ క్రింద తెలిపిన నిర్మాణ సామాగ్రిని చెరువు ప్రదేశములలో నిల్వ చేసుకోవడం చాలా ఉపయోగపడుతుంది.
It shall be very useful to stockpile the following materials at the tank site for immediate use during emergency conditions.

1. ఇసుకతో నింపిన ఖాళీ సిమెంట్ బస్తాలు Empty cement bags filled with sand
2. మొరముతో నింపిన బస్తాలు Murum filled in empty bags
3. గుళకరాళ్ళు / కంకర (40 మి.మీ. పరిమాణం) Gravel / metal (40 mm size)
4. గుండ్రాళ్ళు / రాళ్ళు (100 మి.మీ నుండి 250 మి.మీ. వరకు పరిమాణం) Rubble / stones (100 mm to 200 mm size)

ఈ రీతిగా నిల్వ ఉంచిన సామాగ్రిని క్రుంగినప్పుడు కట్టను ఎత్తుగా చేయుట, లీకేజీలు, పైపింగ్, బుడగలు కనిపించినప్పుడు, ఇన్‌వర్టెడ్ ఫిల్టర్‌లు, క్రమక్షయాన్ని అరికట్టడం / పెద్ద లీకేజీలను మూసివేయుట మొ॥ వాటికి ఉపయోగించవచ్చు
The stock- piled material would be used for : Raising embankment in case of settlement, laying inverted filter on leaks, piping, boils, erosion protection/closing large leaks etc.

పెద్ద చెరువు కట్టలలో 10 ఘ.మీ. ఇసుక, 10 ఘ.మీ. గుళకరాళ్ళు / కంకర మరియు 20 ఘ.మీ. గుండ్రాళ్ళు నిలువ చేయాలి. ఇసుక. గుళకరాళ్ళు, మొరములను గోనెపట్టాలలో నింపి ఉంచుకొవాలి. దీనికి అదనంగా దాదాపుగా 1000 ఖాళీ సిమెంట్ బస్తాలను నిల్వ ఉంచుకోవాలి.
In large tank bunds, stock – piling of about 10cum of sand, 10cum of gravel / stone metal and 20cum of rubble may be considered. Sand gravel, murum can be put in gunny bags. In addition, about 1000 empty cement bags be also stored.

గేట్లు కలిగిన స్పిల్‌వేలలో ఋతుపవనాల కాలమునకు ముందు గేట్లను ఎత్తి దించాలి. మరియు వరద కాలంలో డ్యామ్ భద్రత కొరకు గేట్ల సున్నితమైన అపరేషన్‌ను నిర్ధారించుకోవాలి.
In gated Spillways, "Dry Run" of gates (Operation of gates) must be done during pre – monsoon season to ensure smooth operation of gates during flood season for dam safety.

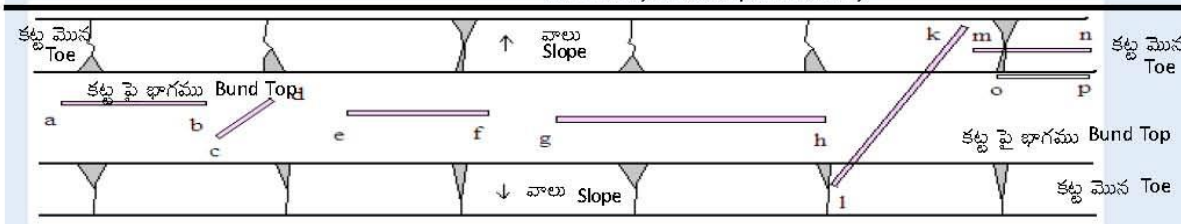
గుంతలు/ఎత్తుపల్లాలు సరిచేయుట

Rectification of Depressions/undulations

ఎత్తుపల్లాలు ఉన్నచోట 7.5 సెం.మీ లోతుకు మరియు ప్రక్కవాలుకు 1.5 (అడ్డం) 1.0 (నిలువు) తవ్వాలి.

Cut the undulation to 7.5 Cm depth & side slopes of 1.5 (H) : 1.0 (V)

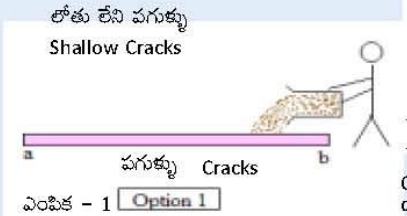
సబ్‌గ్రేడ్‌పై నీటిని చల్లి దాని మీద మట్టిని రెండు పొరలుగా వేసి చానిని చేతి పరికరాల ద్వారా బాగా దట్టించాలి. Moisten the subgrade with water and place good soil in 2 layers & compact manually.



చెరువు కట్ట మీద ఉన్న పగుళ్ళను సరిచేయుట

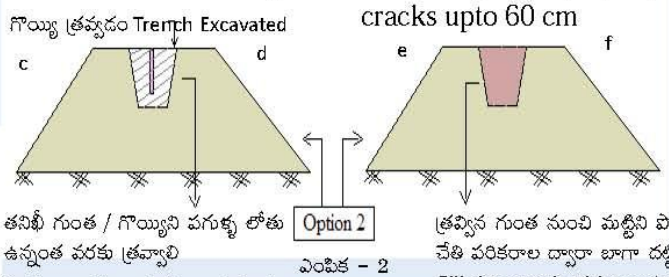
Treatment of Cracks on Tank bund

నీరు మరియు ఇసుక (5:1) మిశ్రమ ద్రవం పొయాలి
Pour Slurry of water & Sand (5:1)



పొడవుగా ఉన్న పగుళ్ళు (ఎ-బి, సి-డి, ఇ-ఎఫ్) 60 సెం.మీ వరకు

Longitudinal Cracks (a-b,c-d,e-f) depth of cracks upto 60 cm



తనిఖీ గుంత / గొయ్యిని పగుళ్ళ లోతు ఉన్నంత వరకు త్రవ్వాలి

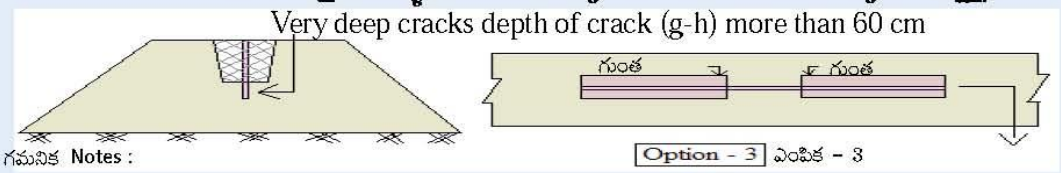
Cut inspection pit / trench to the depth of crack

త్రవ్విన గుంత నుంచి మట్టిని పొరలుగా వేసి చేతి పరికరాల ద్వారా బాగా దట్టించాలి.

Fill the trench with good soil in layers and compact manually

చాలా లోతైన పగుళ్ళ (జి-హెచ్) యొక్క లోతు 60 సెం.మీ కంటే ఎక్కువగా ఉన్నట్లైతే

Very deep cracks depth of crack (g-h) more than 60 cm



గమనిక Notes :

1. అడ్డంగా ఉన్న పగులు (ఎల్-కె)ను సరి చేయాలంటే కట్టను పూర్తిగా త్రవ్వేసి, మట్టి పని అంతా మరలా చేయాలి

1. To treat transverse crack, L-K, excavate the embankment completely and re-do the earth work

60 సెం. మీ లోతు గల 2 లేదా 3 గుంతలను త్రవ్వి వాటిని నీరు, బెంటోనైట్ (14:1) మిశ్రమ ద్రావణంతో నింపాలి. ఇది పగుళ్ళను నింపివేస్తుంది.

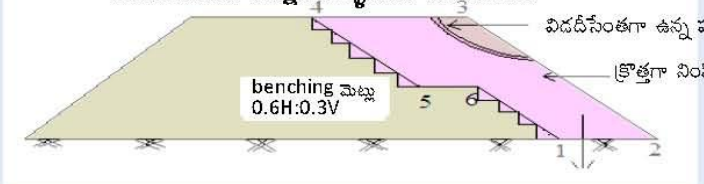
Excavate 2 or 3 trenches of 60 Cm depth & fill with a solution of water & bentonite (14:1). This will fill the cracks

2. కట్టను విడదీసేంతగా ఉండే పగుళ్ళు (యం-యన్, ఒ-పి) లను సరిచేయాలంటే ఆ భాగంలో మట్టిని తీసివేసి, మరల అదే మట్టిని నింపి దృఢపరచాలి.

2. For treat 'seperation cracks' m-n, o-p, remove the earthfill and replace it duly compacted.

విడదీసేంతగా ఉన్న పగుళ్ళను బాగు చేయుట

Treatment of separation Cracks

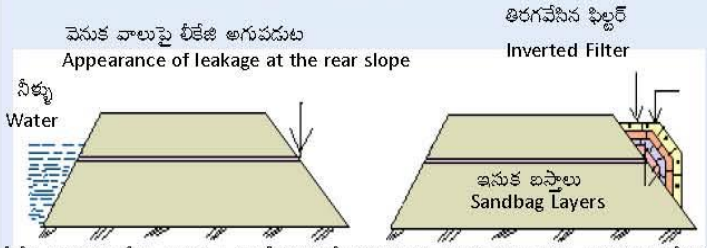


మట్టిని పొరలుగా వేసి మరియు గట్టిపరిచే పరికరం (రామర్)తో దృఢపరచాలి.

The earthfill is to be placed in layers & compacted by earth rammer.

విడదీసేంతగా ఉన్న పగుళ్ళు / జారిపోయే ప్రదేశం వెనుక భాగానా ఉన్న మట్టిని త్రవ్వేసి (1-2-3-4-5-6) ఆ ప్రదేశంలో క్రొత్త మట్టిని వేసి చేతి పరికరాల ద్వారాదృఢపరచాలి Cut Open the Earthfill well beyond the seperationcrack / slippage plan. The place new earht fill in the portion (1-2-3-4-5-6) and manually compacted

అత్యవసర పరిస్థితుల పరిష్కారంలో
Tackling Emergency Situations

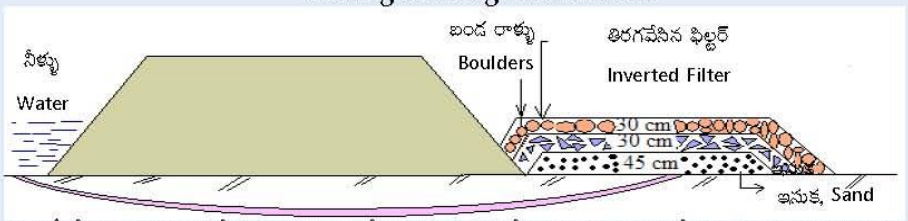


వెంటనే వేయాలి : Place Promptly

1. క్రింది భాగములో ఇసుక బస్తాలను 2 పొరలుగా వేయవలెను
1. 2 layers of sand bags at the bottom
2. దాని పైన ఒక వరుసలో 40 మి.మీ పరిమాణం గల కంకర బస్తాలను వేయాలి.
2. then one layer of 40 mm metal bag.
3. గులక రాళ్ళను (12 సెం.మీ – 22 సెం.మీ పరిణామం) మరొక పై పొరగా వేయాలి.
3. then one layer of pebbles (Size of pebbles 12 to 22cm) at the top.

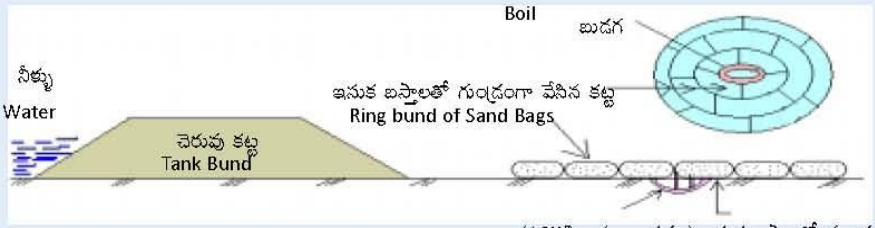
లీకేజి అవుతున్న నీరు బురదగా ఉంటే (మట్టి రేణువులను మోస్తున్న) తక్షణ చర్య అక్కడ తిరగవేసిన ఫిల్టర్ వేయాలి. (పైపింగ్ మరియు తెగిపోవడం అరికట్టవచ్చు)
If leakage water is turbed (carrying soil particles), immediate action should be taken to place inverter to filter. (to avoid piping & breach)

పునాదుల ద్వారా లీకేజి
Leakages through foundations



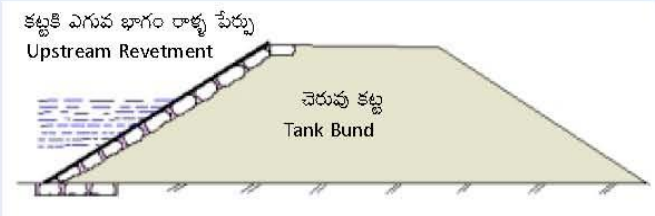
గోనెసంచులలో వేయాలి. : 45 సెం.మీ ఇసుక, 30 సెం.మీ కంకర (40 మి.మీ) మరియు 30 సెం.మీ పరిమాణం గల బండ రాళ్ళను పైన వేయాలి
Dump or place in Gunny bags : 45cm sand, 30 cm metal (40mm & place 30 cm boulders on top)

బుడగలాగ కనిపించడం (డి అను వ్యాసంతో)
Appearance of "BOILS" (of diameter say d)

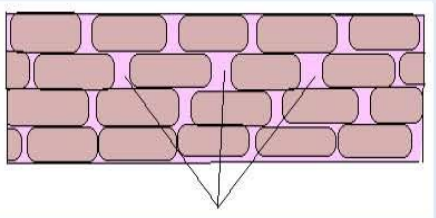


(10Xడి అను వ్యాసము) ఇసుక బస్తాలతో గుండ్రంగా వేసిన కట్ట
Place Ring bund of Sand Bags of 10Xd diameter

బుడగలాగ కనిపించడం (డి అను వ్యాసంతో)
Appearance of "BOILS" (of diameter say d)



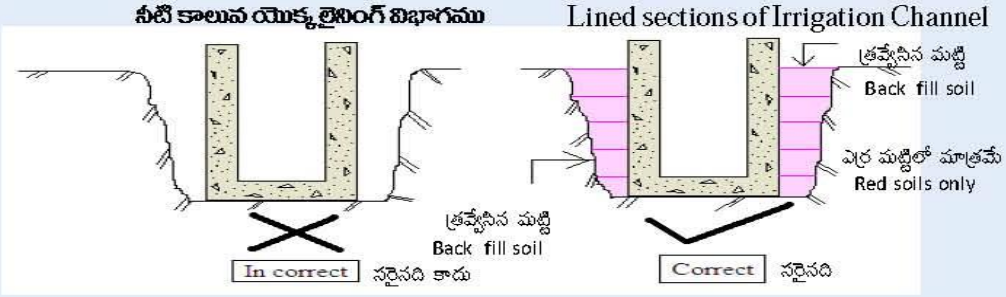
రాళ్ళ పేర్పులోని రాళ్ళ మధ్యన పెద్ద ఖాళీలు
Big gap between stones of revetment



రాళ్ళ పేర్పు యొక్క రాళ్ళ మధ్యన పెద్ద ఖాళీలను కోణీయ చిన్న రాళ్ళతో నింపి వాటిని ఖాళీల లోనికి సుత్తితో కొట్టాలి

Big gaps between stones of the revetment should be filled with angular small stones & hammer wedged into the gaps

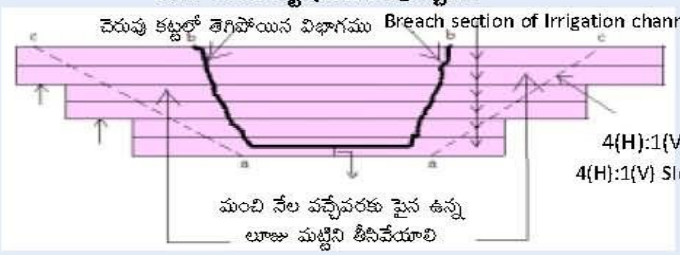
నీటి కాలువ యొక్క లైనింగ్ విభాగము — Lined sections of Irrigation Channel



ఎందుకంటే త్రవ్వేసిన మట్టిని తిరిగి నింపలేదు
Because back fill soil is not placed

త్రవ్వేసిన మట్టిని తిరిగిపొరలుగా వేసి చేతి పరికరాల ద్వారా దట్టించాలి
Because back fill soil is placed in layers and tamped manually

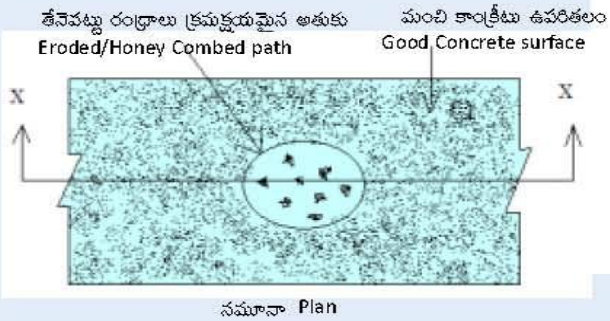
తెగిపోయిన కట్ట భాగము పూడ్చడం — Closing a Breach in a Bund



ఎ-బి-సి భాగములో ఉన్న మట్టిని తీసివేసి, వాలును 4(H):1(V) గా చేసి, మెట్లు చేయాలి

Remove earthfill in the portion a-b-c, Cut the slope to 4(H):1(V) and make benches

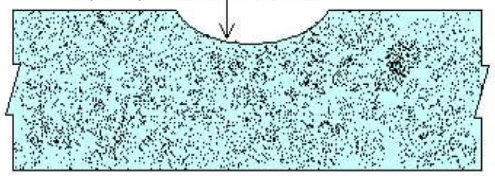
కాంక్రీటులో తేనె పట్టు రంధ్రాలను కాక్రీటు కొట్టుకు పాయి ఉన్న అతుకులను సరిచేయుట — Rectification of "Honey-combed Eroded concrete patches"



నమూనా Plan

తేనెపట్టు రంధ్రాలు క్రమ క్షయమైన భాగమును +/- 25 మి.మీ లోతు వరకు ఉలి మరియు సుత్తితో త్రవ్వవలెను

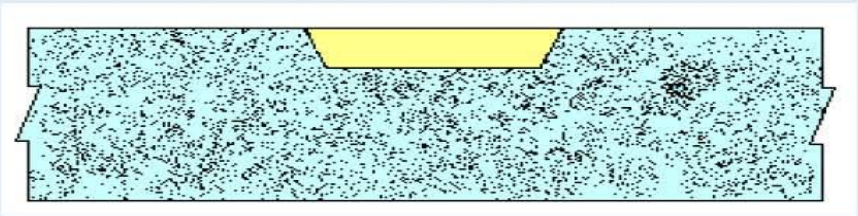
Cut Open eroded / honey combed Portion to +/- 25 mm Depth by a Chisel & Hammer



అడ్డుకోత XX Section XX

త్రవ్విన భాగాన్ని పొడి ప్యాక్ మొర్టార్‌తో నింపి చక్కగా సమం చేయాలి

Fill the cut portion with Dry pack mortar and level it nicely



పొడి ప్యాక్ మొర్టార్ ఒక భాగము సిమెంట్ మరియు 2 భాగములు ఇసుక సరిపడినంత నీటితో కలిపి చేతితో కొద్దిగా పట్టుతూ ఒక బంతి లాగా తయారు చేయాలి

Dry pack mortar : One part of cement & two parts of sand mixed with just enough water to mould the cement - sand mixture into ball with slight pressure of hand

ఆంధ్రప్రదేశ్ సమాజ ఆధారిత చెరువుల యాజమాన్య పథకం
Andhra Pradesh Community Based Tank Management Project
నీటి వినియోగదారుల సంఘం - నిర్వహణ ఒకె కార్డు - చెరువు వ్యవస్థ అభివృద్ధి
WUA - Maintenance OK Card - Tank System Improvement (Part-I)

చెరువు పేరు Name of Tank		గ్రామం Village		మండలం, జిల్లా Mandal, District	
పరిశీలన కాలము Period of Inspection Tick టిక్ చేయండి	ముందు Pre Monsoon మార్చి – మే March -May ☐	వరద కాలం Flood Season జూన్–అక్టోబర్ June -Oct ☐	తరువాత Post Monsoon నవంబర్–ఫిబ్రవరి Nov-Feb ☐	పరిశీలన తేదీలు Dates of Inspection	నవరణలను పూర్తి చేసిన తేది Completion of Rectifications

వ. నం Sl.	తనిఖీ చేసిన అంశాల వివరణ Description of Items inspected	అవును/ కాదు/సంఖ్య Yes/No/ Num	సవరణ Rectification అయినది Done	కాలేదు Not Done	సంబంధం లేదు N.A.	రిమార్కులు Remarks
A ఎ	చెరువు కట్ట Tank Bund					
1.	కట్ట పై భాగము రూపకల్పన స్థాయిలో మరియు మంచి స్థితిలో ఉందా? Is the bund top at designed level and in good condition?					
2.	కట్ట పై భాగములో గుంతలు / ఎత్తు పల్లాలు ఉన్నాయా? ఉన్నచో సరి చేయాలి. Are there pockets of depressions / undulations on the bund top? If yes, these are to be rectified					
3.	కట్ట పై భాగములో కట్ట వెంబడి ఏమైనా పగుళ్ళు ఉన్నాయా? ఉన్నచో సరి చేయాలి. ప్రతి పగులు లోతు, పొడవు జాబితా వ్రాయాలి. Are there any longitudinal cracks on the bund top? If yes, these are to be treated; location, depth and length of each crack be listed					
4.	మట్టి కట్ట (నింపబడిన మట్టిలో), పొడవు వెంబడి ఏమైనా విడదీసే పగుళ్ళు ఉన్నయా? ఉన్నచో వాటిని పగుళ్ళు ఉన్న ప్రదేశం జాబితా వ్రాయాలి. Are there any longitudinal separation cracks in the earth fill? If yes, these are to be treated; location of crack be listed					
5.	కట్టపైన ఏమైన అడ్డపగుళ్ళు ఉన్నాయా? ఉన్నచో వాటిని సరి చేయాలి. పగుళ్ళ యొక్క ప్రదేశము మరియు లోతు జాబితా వ్రాయుము. Are there any transverse cracks on the bund? If yes, these are to be treated; location and depth of the cracks be listed.					
6.	కట్టను అడ్డంగా విడదీసే పగుళ్ళు ఉన్నాయా? ఉన్నచో వాటిని సరి చేయాలి. పగుళ్ళ సంఖ్య ప్రదేశముల జాబితా వ్రాయుము. Are there any transverse cracks cutting across the bund? If yes, these are to be treated; no. of such cracks and locations be listed.					
7.	కట్టకు రెండువైపుల ఉన్న వాలులు రూపకల్పన వాలులకు నిర్ధారించబడి ఉన్నాయా? లేనిచో వాలు సరిగ్గా లేని వాటిని రూపకల్పన చేయాలి. Do the water and rear sides of bund confirm to designed slopes? If not, deficient slopes be brought to designed ones.					
8.	కట్టకు రెండువైపుల ఉన్న వాలులపై మట్టిని గట్టిగా సాంద్రీకరించారా? Is the earth fill on the rear & water side slope well consolidated?					
9.	కట్టకు రెండువైపుల ఉన్న వాలులపై పొదలు, దట్టమైన చెట్లు చేమలు కట్టవాలు స్థితిని గమనించడానికి అడ్డంగా ఉన్నాయా? ఉన్నచో అలాంటి అడవిమొక్కలను తొలగించాలి/కత్తిరించివేయాలి. Is there growth of wild bushes & dense vegetation on side slopes which obstruct the view of these slopes to know their condition? If yes, such wild growth is to be suitably cut/trimmed					
10.	కట్ట ఇరువైపుల 30 సెం.మీ. అంతకంటే ఎక్కువ కాండము చుట్టుకొలత గల చెట్లు ఎన్ని ఉన్నవి? వాటిని తొలగించకుండా జాగ్రత్తపడాలి. What are the no. of trees of girth 30 cm and more growing respectively on the water & rear slopes? These are not to be cut.					
11.	కట్ట ఇరువైపుల 30 సెం.మీ. అంతకంటే తక్కువ కాండము చుట్టుకొలత కంటె తక్కువగా పెరుగుతున్న చెట్లు ఎన్ని ఉన్నవి? అట్టి చెట్లను ప్రభుత్వ అనుమతితో దశల వారిగా తొలగించాలి. (వాటి మధ్య దూరం 14 మీ.తక్కువ ఉంటే). What are the number of trees of girth less than 30 cm growing respec tively on the water & rear slopes? Such trees may require to be cut in phases (if distance between trees is less than 14 M) upon approval from GOAP.					
12	కట్ట పైన/వాలులో కొత్త చెట్లు నాటకుండా నిర్ధారించుకోవాలి. కట్టవెనుక వాలుపై పచ్చగడ్డి పెంచాలి. Ensure that no new trees are planted on tank bund / tank slopes. Provide grass turfing on rear slopes.					

వ. నం Sl.	తనిఖీ చేసిన అంశాల వివరణ Description of Items inspected	అవును/ కాదు/సంఖ్య Yes/No/ Num	సవరణ Rectification			రిమార్కులు Remarks
			అయినది Done	కాలేదు Not Done	సంబంధం లేదు N.A.	
13.	కట్టకు నీరు ఉన్న వాలు వైపు రాళ్ళపేర్పు దృఢంగా జరిగిందా? Is the stone revetment firmly in place on water side slopes?					
14.	రాళ్ళపేర్పులో రాళ్ళ మధ్య ఖాళీలు/రంద్రాలు ఉన్నాయా? ఉన్నచో అలాంటి ఖాళీలను చిన్న కొనపు రాళ్ళతో నింపి సమ్మెటతో కొట్టి సరిచేయాలి. Are there gaps / voids between the stones of the revetment? If so, such gaps are to be filled with small angular stones, duly hammered.					
15.	రాళ్ళపేర్పులో రాళ్ళ మధ్యలో ఉన్న రాళ్ళను ఎక్కడికైనా తీసివేయడం జరిగిందా? అయినచో ఆ రాళ్ళను దాని వరుసలో తాకించిన మట్టిపై మరల పేర్చాలి. గమనిక : పెద్దచెరువులలో ఎక్కడైతే గ్రేడెడ్ ఫిల్లర్స్‌పై రాళ్ళను పేర్చడం జరిగిందో అక్కడ జారిన ఫిల్టర్‌ను మరల వేసి తగినంత తడిగా చేసి దట్టించిన తరువాత రాళ్ళను మరల పేర్చాలి. Have stones from the revetment got dislodged at some places? If yes, the stones are to be re-set properly on the sub grade duly tamped. ***Note** : In large tanks, where stone revetment is placed on graded filter, the stones are to be re-laid after the slipped filter is re-laid , moistened and tamped.*					
16.	రాళ్ళపేర్పులో నుండి రాళ్ళు జారిపోకుండా రాళ్ళపేర్పుకు మొదలు, చివరన కీ-ట్రెంచ్ ఏర్పాటు చేయడం జరిగినదా? Have key trenches been provided at the commencement and at the end of revetment to properly "key" the revetment to avoid its slippage?					
B బి	**అత్యవసర పరిస్థితులు Emergency Situations**					
17.	1) కట్టకు వెనుక వాలుపై ఇంకుడు రంద్రాలు/తడి అచ్చుల ఆనవాలులు ఉన్నాయా? (i) Is there evidence of sink / wet patches on the rear slope?					
	2) కట్టకు వెనుక వాలు నుండి గుర్తించదగిన రీతిలో తేట నీరు కారుతుందా? (ii) Is significant leakage of water (clear water) coming out of the rear side slope?					
	3) కట్టకు వెనుక భాగం నుండి మరియు క్రింది భాగం నుండి మట్టి కలిసి నీరు కారుతుందా? అయినచో అత్యవసర చర్యలలో భాగంగా ఇన్వర్టెడ్ ఫిల్టర్‌ను ఏర్పరచాలి. దీర్ఘకాల నివారణ కోసం సి.ఇ. (లిన్నునీటి పారుదల) గారిని సంప్రదించాలి. (iii) Is turbid water coming out of the leak from rear side slope/toe? If yes, emergent treatment is required through placement of "inverted filter"; C.E (MI) be consulted for long-term treatment.					
18.	కట్టకు వెనుక వాలు క్రింది భాగంలో నీటి మడుగు గమనించారా? ఉన్నచో సి.ఇ.(చిన్న నీటి పారుదల) గారికి, అన్ని వివరాలను (నిలువ ఉన్న నీటి బొడవు, వెడల్పు మరియు లోతు వివరాలను చెరువులో నీటి మట్టం పెరిగినప్పుడు/ తగ్గినప్పుడు) ఇచ్చి దానిని సరిచేయు విధానమును తెల్సుకోవాలి. Is standing pool of water observed beyond the toe of rear side slope? If yes, C.E. (MI) be informed with full details (length & width of pool as well as depth of pool during rise / fall of water in the tank) to evolve treatment method.					
C సి	**నీటిపారుదల తూములు Irrigation Sluices**					
19.	ప్రతీ తూము దిగువ భాగములో ఎంపిక చేసిన కాంక్రీటు పూత వేసిన భాగం పూడిక లేకుండా మంచి ఆకారంలో ఉందా? Is the selective concrete lined section in the reach downstream of each Irrigation Sluice in good shape and clear of silt?					
20.	లైనింగ్ వేసిన సైడ్ వాల్స్‌కు ప్రక్కన నింపిన మట్టిని గట్టిగా దట్టించారా? Is the back-fill soil against the concrete side walls of lining properly tamped?					
21.	మట్టి కాలువలు రూపకల్పన చేసిన దానికి అనుగుణంగా నిర్వహించుచున్నారా? Have the unlined reaches of irrigation canals been maintained to designed sections?					
22.	తూము నీటి పారుదల కట్టడాన్ని ఆనుకుని ఉన్న మట్టి విడిపోయినట్లు ఆనవాలు ఉన్నదా? అయినచో అచ్చటి భూమిని వాలు వెంబడి వెడల్పు, లోతులకు +/- 60 సెం.మీ. కొలతలతో కోసి తీసివేయాలి. అనంతరం కొత్త మట్టితో తడిచేసి గట్టిగా దట్టించి సార్థకమైన బంధాన్ని నిర్ధారించుకోవాలి. Is there evidence of separation of earth fill adjoining an Irrigation Sluice structure? If yes, the earth fill be cut to a depth and width +/ - 60 cm along the slope and new soil be placed duly moistened and compacted manually to ensure effective bond.					
23.	చెరువు లోపల తూము కట్టడాల వైపు కట్టిన కాలువలు, తూముల నుండి బయలుదేరు కాలువలు సరిగా నిర్వహించబడుతున్నాయా? సాధారణంగా ఈ కాలువల పక్కవాలు1.5 (అ) :1(ని) గా ఉంటుంది. (ఎగువభాగంలో నల్లరేగడి భూముల్లో 2 (అ):1(ని) గా ఉంటుంది. (తూము కట్టడం నుంచి 3-4 మీటర్ల బొడవునా నీటి కాలువ భాగాన్ని రాళ్ళతో తాపడం చేయాలి). Are the approach channels / leading channels to sluice being properly maintained? Normally, channels should have side slopes of 1.5 (H) : 1.0					

వ. నం Sl.	తనిఖీ చేసిన అంశాల వివరణ Description of Items inspected	అవును/ కాదు/సంఖ్య Yes/No/ Num	సవరణ Rectification			రిమార్కులు Remarks
			అయినది Done	కాలేదు Not Done	సంబంధం లేదు N.A.	
	(V). In black cotton soils, the cotton soils, the channel slopes should be 2.0 (H) : 1.0 (V). (The channel sections in some 3 to 4 m length immediately U/S of sluice structures be, preferably, lined with dry stone pitching)					
24.	తూము బ్యారెల్ దగ్గర దిగువ భాగములో నీరు ఇంకిన ఆనవాలు ఏమైనా ఉన్నాయా? ఉన్నచో ఈ పరిస్థితిలు తొలగించడానికి తగిన నివారణ చర్యలు తీసుకోవాలి. Is there evidence of seepage on the D/S in the immediate vicinity of Sluice Barrel? If yes, remedial action is to be taken eliminate this situation.					
Dడి	**యాంత్రిక భాగాలు Mechanical Fixtures**					
25.	తూము గేట్లు మరియు వాటిని ఎత్తే పరికరాలు సరిగా నిర్వహించబడుతున్నాయా Are the sluice gates and hoisting arrangements being properly maintained?					
26.	వాటికి తుప్పు పట్టకుండా నూనె గ్రీస్‌లు పద్ధతిగా పూస్తున్నారా? Is the oiling / greasing methodically done to avoid rusting?					
Eఇ	**నీటి కొలతల పరికరములు - కట్ త్రోట్ ఫ్లూమ్‌లు (సి.టి.ఎఫ్) Measuring Devices - Cut Throat Flumes (CTF):**					
27.	నీటి కొలతల కట్టడాలు (సి.టి.ఎఫ్) లు పూడికలు లేకుండా నిర్వహింపబడుతున్నాయా? Are the CTF structures being properly maintained and free of silt?					
28.	నీటి కొలతల పరికరాలు (సి.టి.ఎఫ్)పై ఉన్న కొలతలు కనిపించునట్లుగా రంగులతో వ్రాసి నిర్వహిస్తున్నారా? Have the gauges on CTF structures been properly painted?					
29.	ప్రతి కాలువలో (సి.టి.ఎఫ్) లలో నీటి ప్రవాహ పరిణామాలు కొలుస్తూ సరిగా రిజిస్టర్‌లో వ్రాస్తున్నారా? Are the flow discharges being measured in each channel, CTF- wise and properly recorded in the Registers?					
Fఎఫ్	**నీటిపారుదల కాలువ Irrigation Channels**					
30.	కట్ త్రోట్ ఫ్లూమ్ నిర్మాణాలపై కాంక్రీటు ఒరుసుకుపోయిన / తేనెపట్టు రంధ్రాలు ఉన్న ఆనవాలు ఉన్నాయా? ఉన్నచో వాటిని సరిచేసి మరింత చెడిపోకుండా చూడాలి. Is there evidence of erosion/honey-combing in concrete of CTF structure? If yes, eroded / honey-combed concrete be treated to avoid progressive damage.					
31.	నీటి పారుదల కాలువలలో మట్టి, పొదలు, దట్టమైన చెట్లు, చెత్త లేకుండా రూపకల్పన చేసిన విధంగా నిర్వహించబడుతున్నాయా? Are the feeder channels being regularly cleared of silt, bushes, dense vegetation and debris and well maintained to designed sections?					
Gజి	**అలుగు మరియు స్పిల్‌వే Weir**					
32.	**s & Spillways** ప్రమాదకరమైన ప్రదేశాలలో రాతిగోడలు, రాళ్ళ పేర్పు వంటి అధికారికంగా అనుమతించిన రక్షణ చర్యలతో వాటి పరిపూర్ణతను కాపాడుచున్నారా? Are protective measures (provision of dry stone walls; stone revetment etc) as warranted, are taken in vulnerable reaches to maintain their integrity?					
33.	అలుగు మరియు స్పిల్‌వే కట్టడాలు మంచి స్థితిలో చేడిపోకుండా ఉన్నాయా? Are the weirs and spillway structures in good condition & free of any damage?					
34.	రాతి గోడల ద్వారా నీరు కారే (చెమ్మ రూపంలో) ఆనవాలు ఉందా? ఉన్నచో అలాంటి చెమ్మగోడ ప్రదేశాన్ని కొద్దిగా చెక్కి సిమెంట్ ఇసుక మోర్టార్‌తో నింపి మొనలు వచ్చేటట్లు చేస్తూ సరిచేయవలెను. Is there evidence of any leakage (in the from of wet spots) through masonry body wall? If yes, the body wall in the portion associated with wet patches is to be treated through raking of joints and filling and pointing of joints in cement-sand mortar.					
35.	రాతి గోడల నుండి దిగిన నీరు బయటికి ధారగా కారుతున్న ఆనవాలు ఉందా? ఉన్నచో వాటిని స్కిన్ కాంక్రీటు వేసి అరికట్టాలి. దీనికి సి.ఇ. (లిన్ననీటి పారుదల) గారిని సంప్రదించాలి. Is there evidence of significant leakages (in the from of oozing of jets) through masonry body wall? If yes, it is treated through provision of "skin concrete" in consultation with C.E (MI)					
36.	అలుగు/స్పిల్‌వే పునాదుల గోడల ద్వారా నీరు కారే ఆనవాలు ఉందా? ఉన్నచో సి.ఇ. (లిన్ననీటి పారుదల) గారిని సంప్రదించి గోడ ఎగువ భాగంలో 'కటాఫ్' నిర్మాణం చేయాలి. Is there evidence of leakages through the foundation of weir / spillway body wall? If yes, C.E (MI) be consulted for the provision of cut-off in the U/S of body wall					
37.	కాంక్రీటు అడుగు రాతి కట్టడం (ఆప్రాన్) మంచి స్థితిలో ఉందా? Is the concrete apron in good condition?					
హెచ్ H	**స్పిల్‌వే గేట్లు మరియు వాటిని పైకి ఎత్తే పరికరాలు Spillway Gates & Hoisting Arrangements**					
38.	సిల్ మరియు గేట్‌గైడ్స్ వద్ద మట్టి, చెత్త లాంటివి అడ్డు లేకుండా ఉన్నాయా? ఉన్నచో వాటిని పూర్తిగా తొలగించాలి.					

వ. నం Sl.	తనిఖీ చేసిన అంశాల వివరణ Description of Items inspected	అవును/ కాదు/సంఖ్య Yes/No/ Num	సవరణ Rectification			రిమార్కులు Remarks
			అయినది Done	కాలేదు Not Done	సంబంధం లేదు N.A.	
	Are the sill and gate guides free of choking with silt, debris, grout etc.? If not, the sill and guides be fully cleared.					
39.	గేటు సీల్స్ లీకేజి లేకుండా మంచి స్థితిలో ఉన్నాయా? Are the gate seals in good condition and there is no leakage?					
40.	గేట్లు బాగా పేయింట్ చేశారా? త్రుప్పు పట్టిన ఆనవాలు లేకుండా ఉందా? (గేట్లు మరియు వాటికి సంబందించిన పరికరాలను కనీసం 3సం॥ లకు ఒకసారి రంగు వేయాలి) Are the gates well painted and there is no evidence of rusting? (Gates & associated fixtures are to be normally painted once in 3 years)					
41.	గేటు సీల్స్ గుండా ఏమైనా లీకేజిలు ఉన్నాయా? ఉన్నచో క్రొత్త సీల్స్ వేయాలి. Are there significant leakages through the seals of gate / gates? If yes, the seals are to be replaced with new seals.					
42.	గేట్లు ఎత్తే పరికరాలు గ్రీజు పట్టించి పని చేసే స్థితిలో ఉన్నాయా? లేనిచో గ్రీజు పట్టించాలి. పని చేసే స్థితికి తీసుకురావాలి. Are the hoisting arrangements in working order and are well greased? If not, these be brought to working order and kept well oiled / greased.					
43.	రుతుపవనాలకు ముందు గేట్లు ఎత్తడం / దించడం సక్రమంగా జరిగినదా? లేనిచో డ్యాం భద్రత కోసం గేటెడ్ స్పిలొవేతో చేయాలి. (డ్యాం భద్రతలో భాగంగా దీనిని రికార్డ్ చేయాలి). Has the "dry run" of gates (viz raising & lowering of gates) been successfully carried out before the monsoon / filling season? If not, must be done for ensuring safety of dams with gated spill ways.					
	ఏమన్న ఇబ్బంది ఉన్నచో సి.ఇ. (లిన్ననీటి పారుదల) గారికి సమాచారం తప్పనిసరిగా తెలియజేయాలి.. (Compliance of this dam safety-related aspect should be specifically recorded, and in case of any problem, C.E (MI) be promptly informed.)					

నీ.వి.సం. కోడ్ నెంబర్
WUA Code Number

నీ.వి.సం. అధ్యక్షుని పేరు
WUA President Name

సంప్రదించవలసిన నెంబర్
Contact Number

N.B. WUA should keep a copy of this OK Card for its records. A copy should be send to the project director.

గమనిక : నీ.వి.సం. ఒక ఒ.కె. కాపిని రికార్డుల కొరకు వారి వద్ద ఉంచుకొనవలెయును. మరొక కాపిని జిల్లా ప్రాజెక్ట్ అధికారికి పంపించవలెను.

The above broad illustrative rectification guidelines and WUA Maintenance Card-Tank Improvement (Part I) was shared by Mr. R.K. Malhotra prepared for the Andhra Pradesh Community Based Tank Management Project.

పార్ట్ - II PART - II

WUA SELF REPORTING (INSTITUTION ALASPECTS)

నీ.వి.సం. అధ్యక్షుని పేరు Name of WUA President		సంప్రదించపల్సిన నెంబరు (నీ.వి.సం.) Contact No.	

A/ఎ. ఆర్థిక వ్యవహారాల నిర్వహణ FINANCIAL MANAGEMENT

సంవత్సర/అర్ధ సంవత్సర ఆదాయ వివరాలు (ఆర్థిక సంవత్సరం) : Annual/Half year Income Details (Financial Year)			సంవత్సర/అర్ధ సంవత్సర ఖర్చుల వివరాలు (ఆర్థిక సంవత్సరం): Annual/Half year Expenditure Details (Financial Year)		
నెం Sl.	అంశము Item	మొత్తము Amount (Rs.)	నెం Sl.	అంశము Item	మొత్తము Amount (Rs.)
1	ప్రారంభ నిల్వ (ఏప్రిల్ 1/ అక్టోబర్ 1) Opening Balance (1st April, 1st October)			**ఖర్చుల వివరాలు EXPENDITURE DETAILS**	
2	నివేదిక కాలంలో చేసిన పొదుపులు Savings from previous year		**A ఎ**	**చెరువు వ్యవస్థ నిర్వహణ TANK SYSTEM MAINTENANCE**	
3	వసూలు చేయబడిన నీటి పన్ను నుండి నీ.వి.సం. నకు రావాల్సిన మొత్తం Plough back of water tax		1	చెరువులో పూడిక తీసివేయుటకు For silt removal from tank bed	
4	సభ్యత్వ రుసుము Membership fees		2	చెరువుకు నీరువచ్చే కాలువలలో పూడిక తీయుటకు For silt removal in feeder channels	
5	వినియోగదారుల సమూహాల నుండి వసూలు చేయబడిన రుసుము Fees collected from user groups ఎ) జెండర్ సి.ఐ..జి Gender C.I.G బి) షెడ్యూల్డ్ తెగల సి.ఐ.జి Tribal C.I.G సి) మార్కెట్ సి.ఐ.జి Marketing C.I.G డి) పి.జి.యం సి.ఐ.జి P.G.M. C.I.G		3	చెరువు ఆయకట్టు కాలువలు శుభ్రం చేయుటకు Cleaning of field channels in ayacut	
6	ఫిక్స్‌డ్ డిపాజిట్ల వడ్డీ Interest from fixed deposits		4	ముళ్ళ పొదలు తొలగించుటకు Jungle clearance	
7	కార్పస్ నిధుల నుండి ఇచ్చిన అప్పుల ద్వారా వచ్చిన వడ్డీ Interest earned from rotation of Corpus Fund		5	చెరువు కట్టకు మరియు అలుగుకు చిన్న మరమత్తులు చేయుటకు Minor repairs to tank bund & weir	
8	అగ్రి బిజినెస్ నిధి నుండి వచ్చిన ఆదాయము Income earned from Agri Business fund(CIF)		6	తూముల నిర్వహణ (గ్రీజు.. మొ॥వి) Maintenance of Sluices (greasing etc.,)	
9	చేపల పెంపకం ద్వారా వచ్చిన ఆదాయము Income from Fisheries		7	కాలువ గోడలు, ఇతర కట్టడలకు అవసరమైన చిన్న రిపేరు చేయుటకు Minor repairs to guide walls and other structures	
10	చెరువు శిఖము కౌలు ద్వారా తక్కువ కాలపరిమితి గల పంటల నుండి వచ్చిన ఆదాయము Income from use of tank bund lease for short duration crops		8	అనుకోని ఖర్చులు Any unforeseen expenditure	
11	కూరగాయలు, గడ్డి పెంపకం కొరకు చెరువు శిఖము కౌలు ద్వారా వచ్చిన ఆదాయము Income from use of tank bed for vegetables/grass cultivation		**B బి**	**పరిపాలన ADMINISTRATION**	
12	ఉమ్మడి వ్యాపారం ద్వారా వచ్చిన ఆదాయం Income from collective marketing		1	నీ.వి.సం. కార్యాలయ నిర్వహణ (అద్దె, కరెంటు, పుస్తకాలు మొ॥వి) కొరకు WUA office maintenance (rent, electricity, stationary etc.)	
13	చెరువు మట్టిని వేలం వేయుట ద్వారా వచ్చిన ఆదాయం Seignerage charges for silt transportation		2	సామాగ్రి మరియు పరికరాల కొనుగోలు Purchase of furniture and equipment	
14	విరాళములు Donations		3	పారా వర్కర్ల గౌరవ వేతనం చెల్లించుటకు Remuneration to Para Workers	
15	రిసోర్సు ఫీజులు Resource fees		4	నీరడి/నీరుగంటి గౌరవ వేతనం చెల్లించుటకు Honorarium to Neeradi/Neeruganti	
16	ఇతరములు Any others...		5	నీ.వి.సం. పుస్తకాలు, రికార్డుల నిర్వాహణకు Maintenance of WUA books & records.	
			6	నీ.వి.సం. సర్వసభ్య సమావేశాల నిర్వహణకు For WUA general body meetings	
			7	యాజమాన్య కమిటీ సమావేశాల నిర్వహణకు For Managing committee meetings	
			8	జాయింట్ అజమాయిషి చేయుటకు For Joint Ajmoish	
			9	నీటి పన్ను వసూలు చేయుటకు For Water tax collection	
			10	కార్పస్ నిధిని పెంపొందించుటకు Corpus fund generation	
సంవత్సర/అర్ధ సంవత్సర ఆదాయ వివరాలు (ఆర్థిక సంవత్సరం) : Annual/Half year Income Details (Financial Year)			సంవత్సర/అర్ధ సంవత్సర ఆదాయ వివరాలు (ఆర్థిక సంవత్సరం) : Annual/Half year Income Details (Financial Year)		

నెం Sl.	అంశము Item	మొత్తము Amount (Rs.)	నెం Sl.	అంశము Item	మొత్తము Amount (Rs.)
	మొత్తము ఆస్తులు TOTAL FINANCIAL ASSETS		11	సీజన్ వారి నీటి వినియోగ ప్రణాళిక తయారు చేయుటకు For preparing Water use plans (season wise)	
	నిర్వహణ మరియు యజమాన్య ఖాతాలోని వివరాలు Balance of O&M account		12	నీటి వినియోగదారుల హిహెచ్‌యం సంఘం ఆస్తుల నిర్వహణకు (వీడర్, మార్కర్, పరికరాలు మొ॥వి). For maintenance of WUA assets (Roto weeder, weeder, maker, PHM equipment etc.,)	
	ఫిక్స్‌డ్ డిపాజిట్లు Fixed Deposits		18	సాంవత్సరిక ఆడిట్ ఫీజులు చెల్లించుటకు Annual Audit fees	
	రివాల్వింగ్ నిధులు Funds of rotation		14	రుణాల చెల్లింపు Repayment of loans	
	బకాయిలు Outstanding loans		15	గతంలో చెల్లించుటకు / చెల్లించవల్సిన అప్పులు Repayment of debts from previous year	
	ప్రస్తుత ఆస్తుల విలువ Value of current financial assets Rs.		16	ఇతరములు Miscellaneous	
			C సి	**సామర్థ్య పెంపుదల CAPACITY BUILDING**	
			1	సంబంధిత శాఖ సమావేశముల నిర్వహణకు To organize meetings with line departments	
			2	విజ్ఞాన యాత్రలకు, అవసరమైన శిక్షణలు Need based training / Exposure visits	
			8	ఇతరములు Others	
				ప్రస్తుత మొత్తము ఖర్చు Total current expenditure Rs.	
	ప్రస్తుత మొత్తము నిల్వ Current total balance				

B/బి. నిర్వహణ మరియు యాజమాన్య ప్రణాళిక OPERATION AND MAINTENANCE PLAN

B1/బి1.తరువాతి పంటకాలానికి తయారు చేసిన రాబడి మరియు ఖర్చుల పట్టిక మొత్తం సంవత్సరం..... రూపాయలు.....

Value of O&M plan prepared for the next season (Year.....) (Rs.....)

B2/బి2. ప్రతిపాదించిన పనులు వివరాలు DETAILS OF WORKS PROPOSED

నెం. Sl.	ప్రతిపాదించిన కార్యక్రమము Activity Proposed	పని విలువ Value of Work Rs.	నీ.వి. సం. సమావేశ తేది Date of WUA meeting	నీ.వి. సం. తీర్మానం ఆమోదం తేది Date of Resolution/ Approval of the WUA	సంబంధిత సాంకేతిక అధికారి ఆమోదం Approval by the Technical Officer concerned		కార్యక్రమము అమలు నీ.వి. సం./ ఇతరులు Execution by the WUA/ Others	పని నాణ్యత బాగా వుంది/ సంతృప్తికరం / బాగాలేదు Quality of work good/ Satisfactory/ Poor)	రిమార్కులు Remarks
					నెంబరు /No	తేది Date			
1									
2									
8									
4									
5									

C/సి. సంస్థాగత అభివృద్ధి INSTITUTION DEVELOPMENT

C1/సి1. సత్సంబంధాల అభివృద్ధి LINKAGES DEVELOPED

అంశము Item	సంస్థ/శాఖ/ఆర్గనైజెషన్‌తో With Agency/Dept/Org	కార్యక్రమము Activity
ఆర్థిక Financial		
సాంకేతిక Technical		
సామర్థ్య పెంపుదల Capacity Building		

C2/సి2. పారావర్కర్‌లు / నీరుగంటి PARAWORKERS/NEERUGANTI

పారావర్కర్‌లు / నీరుగంటి Para workers/Neeruganti	పేరు Name	నివేదిక కాలములో చేయబడిన సేవలు Service provided during the reporting period	నివేదిక కాలంలో వేతనాలు Remuneration during reporting period (Rs)
వ్యవసాయ పారావర్కర్ Agriculture Para worker			
కమ్యూనిటి పారావర్కర్			

Community Para worker			
నీటి యజమాన్య పారావర్కర్ Water Management Para worker			
నీరుగంటి 1 Neeruganti 1			
నీరుగంటి 2 Neeruganti 2			

C3/సి3. నివేదిక కాలంలో కార్పస్ నిధి అభివృద్ధి CORPUS FUND DEVELOPMENT DURING REPORTING PERIOD

నెం. Sl.	గ్రూపు/వ్యక్తి (పేరు)కి అప్పు Loan to Group/ Individual (Name)	అప్పు మొత్తము(రూ) Loan Amount (Rs)	ఉద్దేశ్యము Purpose	చెల్లింపు పద్ధతి (సీజన్/నెలవారి) Repayment mode (season/ monthly)	తిరిగి చెల్లించిన మొత్తం (రూ) Amount Repaid (Rs)	రిమార్కులు Remarks
1						
2						
3						
4						
5						
	మొతము TOTAL					

C4/సి4. యాజమాన్య పరమైన సమస్యలు MANAGEMENT ISSUES ADDRESSED

నెం. Sl.	గుర్తించబడిన సమస్య Issue Identification	సమస్య ప్రస్తుత స్థితి Status of Issue		ఒక వేళ పరిష్కరింపబడినచో If Resolved		పరిష్కరింపబడనిచో కారణాలు If not resolved reasons
		పరిష్కరింపబడినది Resolved	పెండింగ్‌లో ఉన్నది Pending	పరిష్కరించిన వారు Resolved by whom	ఎప్పుడు When	
1						
2						
3						
4						

C5/సి5. నివేదిక కాలంలో ఏర్పాటు చేసుకున్న సమావేశాలు MEETINGS CONDUCTED DURING THE REPORTING PERIOD

నెం. Sl.	సమావేశపు వివరాలు Type of Meeting(GB,MC Other)	సమావేశాల హాజరు Meeting Attendance		చర్చించిన అంశాలు Topics discussed	తీసుకున్న నిర్ణయాలు decision taken	హాజరైన ఎ.ఇ /ఎ.ఇ.ఇ పేరు Name of the AE/AEE who attended
		హాజరైన వారు Attended	మొత్తము సభ్యులు Total members			
1						
2						
3						
4						

C6/సి6. నీటి వినియోగదారుల సంఘం రికార్డుల అప్‌డేషన్ పరిస్థితి STATUS OF WUA RECORDS UPDATING

నెం Sl.	రికార్డు Record	చివరసారిగా అప్‌డేట్ చేయబడిన తేది Last update on date	ప్రస్తుత నిల్వ (రూలలో) ఏప్రిల్ 1/ అక్టోబర్ 1 Current Balance (Rs) as on 1st April, 1st October
1	క్యాష్‌బుక్ (నిర్వహణ మరియు యజమాన్యము) Cash Book (O&M)		
2	క్యాష్‌బుక్ (పనులు) Cash Book Works		
3	బ్యాంక్ పాస్ బుక్ (నిర్వహణ మరియు యజమాన్యము) Bank pass book (O&M Account)		
4	బ్యాంక్ పాస్ బుక్ (పనులు) Bank pass book(Works Account)		
5	మినిట్స్ బుక్ Minutes Book		
6	ఆయకట్టుదారుల రిజిస్టారు Ayacutdars Register		సంబంధము లేదు NA
7	పంటల విస్తీర్ణము మరియు నీటి పన్ను రిజిష్టరు Crop Extent and Water tax Register		సంబంధము లేదు NA

8	మంజూరిల రిజిష్టరు Sanctions Register		సంబంధము లేదు NA
9	సందర్శకుల రిజిష్టరు Visitors Register		సంబంధము లేదు NA
10	ఇతరములు Others…		సంబంధము లేదు NA

D/డి. వ్యవసాయ మరియు నీటివినియోగ ప్రణాళిక AGRICULTURAL AND WATER USE PLAN

నెం No	అంశము Item	సంవత్సరము Year	పంట కాలము Season	అవును/కాదు Yes/No	సమాచారం Data
1	గత పంట కాలానికి నీ.వి.సం. నీటి వినియోగ ప్రణాళికను తయారు చేసుకున్నారా? ఎన్ని ఎకరాలకు ప్రణాళిక తయారు చేసుకున్నారో సమాచార కాలంలో తెలియజేయండి (అవును/లేదు) Did the WUA prepare a water use plan for the previous cropping season? Indicate the extent of ayacut in the data column (Yes/No)				
2	నీటి వినియోగ ప్రణాళికలో ఎన్ని ఎకరాలు సాగు చేయబడినది? How much area was to be irrigated per water use plan (Acres)?				
3	ప్రణాళిక అమలులో మార్పులకు కారణాలు ఉన్నట్లైతే? What are the reasons for changes in adoption, if any?				
4	నీ.వి.సం. తర్వాత పంట కాలానికి నీటి వినియోగ ప్రణాళికను తయారు చేసుకొన్నారా? (అవును/లేదు) Has the WUA prepared its water use plan for the next season?(Yes/No)				
5	ఎంత మంది రైతులు సూక్ష్మ సేద్యపు పద్ధతులు అవలంబిస్తున్నారు? How many farmers are practicing any micro-irrigation methods?				
6	ఎంత విస్తీర్ణంలో సూక్ష్మ సేద్యపు పద్ధతులు అవలంబిస్తున్నారు ?(ఎకరాలలో) What is the extent of micro-irrigation? (acres)				
7	శ్రీ వరి విధానాన్ని ఎంత మంది రైతులు అవలంబిస్తున్నారు?(నం) How many farmers are practicing SRI paddy?				
8	శ్రీ వరి సాగు చేయబడిన విస్తీర్ణం (ఎకరాలలో) What is extent of SRI paddy cultivation? (acres)				

E/ఇ. ప్రత్యేక అంశాలు SPECIAL COMPONENTS

నెం No	విభాగము Component	అంశము Item	సంవత్సరము Year	అవును/కాదు నెంబరు Yes/No/No	మొత్తము (రూ.లలో) Total (Rs)
1.1	పి.జి.యం PGM	ఆయకట్టు బయట ఉన్న పి.జి.యం సభ్యులు చెరువు వ్యవస్థ నిర్వహణలో సహాయపడుతున్నారా? అవును/కాదు. అవును అయితే రూ..... ఎకరాకు/సీజన్‌కు ఎంత మొత్తము చెల్లిస్తున్నారు? Are PGM Members/outside the ayacut making any contribution to tank system maintenance? Yes/No. If Yes, how much? (Rs..... per acre / per season) Give Total			
2.1	చేపల పెంపకం Fisheries	ప్రాజెక్ట్ ద్వారా మత్స్యశాఖవారు ప్రవేశపెట్టిన చేపల పెంపకం పద్ధతులను ఎఫ్.సి.యస్ వారు అమలు చేస్తున్నారా? అవును/కాదు. Is the Fisherman cooperative society (FCS) continuing with fish culture practices introduced by the Project/Department? Yes/No			
2.2	చేపల పెంపకం Fisheries	ఎఫ్.సి.యస్ వారు చెరువు వ్యవస్థ అభివృద్ధికి తన వంతు ఆర్థిక సహకారాన్ని పెంచినదా అవును/కాదు అయినచో ఎంత? Has the FCS Increased its contribution to tank system maintenance? Yes/No If Yes, How much (in Rs.)?			
3.1	అగ్రి బిజినెస్ Agri -business	అగ్రి బిజినెస్ కార్యక్రమాలను కొనసాగిస్తున్న సి.ఐ.జి.ల సంఖ్య (సి.ఐ.జి.ల సంఖ్య) How many CIGs continuing with Agri-Business Activities? (Number of CIGs)			
3.2	అగ్రి బిజినెస్ Agri -business	ఏ రకమైన అగ్రి బిజినెస్ కార్యక్రమాలను సి.ఐ.జి.లు చేపట్టుచున్నాయి? వివరాలు తెలుపండి. What are the Agri-Business Activities CIGs are engaged in? Give details			

అధ్యక్షుడు, నీటి వినియోగదారుల సంఘం
పేరు మరియు సంతకం
President, WUA
Name & Signature

తేది:
Date:

The above WUA Maintenance Card - Tank Improvement (Part II) was prepared by SPMU of Andhra Pradesh Community Based Tank Management Project.

17. Annexures
Permissible Limits

Concrete Works:

1. Water	Limit
Ph value	6 to 8
Organic	Not greater then 200mg/lit
In – Organic	Not greater then 3000mg/lit
Sulphate	Not greater then 400mg/lit
Chloride	Plain Concrete : Not greater then 2000mg/lit
Suspended Soilds	Not greater then 2000mg/lit

2. Cement	Limit
Initial setting time	Not < 30 Min
Final setting time	Not > 600 Min
7 days Compressive strength	22 N/mm2

3. Fine Aggregate	
Fineness Modulus	2.20 to 3.20
Silt content	Not Greater than 3%

Sieve Analysis:

IS Sieve	Zone I	Zone II	Zone III	Unreinforced Masonry Work
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	100
2.36 mm	60-95	75-100	85-100	90-100
1.18 mm	30-70	55-90	75-100	70-100
600 Micron	15-34	35-59	60-79	40-100
300 Micron	5-20	8-30	12-40	5-70
150 Micron	0-10	0-10	0-10	0-15

4. Coarse Aggregate: Sieve Analysis

IS Sieve	Single Size Aggregate	
	40 mm	20 mm
63 mm	100	--
40 mm	85-100	100
20 mm	0-20	85-100
10 mm	0-5	0-20
4.75 mm	--	0-5

5. Steel:

Mild Steel :	Ultimate Tensile Stress	Minimum Elongation (%)
Grade I	412 N/mm2	20-23
Grade II	373 N/mm2	20-23
Medium Tensile Steel	538 N/mm2	17-20
SAIL – MA of grades		
300 HY	440-560 N/mm2	20
350 HY	490-610 N/mm2	20
410 HY	540-660 N/mm2	19

6. Cube Test for Concrete

Grade of Concrete	28 days Compressive Strength Limit
M 7.50 Grade (CC 1:4:8)	7.50 N/mm2
M 10 Grade (CC 1:3:6)	10 N/mm2
M 15 Grade (CC 1:2:4)	15 N/mm2
M 20 Grade (CC 1:1:5:3)	20 N/mm2

Annexure II

Registers to be maintained at site

1	Cement	Cement Register with consignment details along with factory test certificates
2	Aggregates	Sieve Analysis for fine and coarse aggregate and bulkage test registers
3	Concrete Materials	Load Register
4	Concrete	Details of slump and compression strength of concrete register
5	Mortar	Jar Test, Mortar cube test registers
6	Soil	Suitability of soil, field moisture & density Test results register
		Machinery Register involved in earthwork
7	Works	Contractor Site Engineer Register

Colour Patern of OK Cards:

1	Foundation	White
2	Plain/R.C Concrete	Yellow
3	RR Masonry	Blue
4	Earth Embankment	Pink
5	Rough Stone Dry Packing	Light Green

Bund Jungle clearance

Benching

Compaction by Rollers

Finished top of bund

Side compaction by Vibratory power roller

Side compaction by Plated Poclains

Top of bund with Model sections

Dismantling dilapidated Sluice

Reconstruction of Sluice

Benching along Longitudinal Section

Benching along Cross Section

Compaction by Hand operated compactor at Sluice junctions

Finished Sluice

Lining of Channels below Sluice

Reconstructed Weir

Repairs to Weir

Construction of Check Dam

Lining of Canals – Gravel backing

Lined Canal

Bed Concrete with Pavers

Side lining with precast slabs

Slip Form Steel Gantry

Finished Sluice

Lining of Channels below Sluice

Reconstructed Weir

Repairs to Weir

Construction of Check Dam

Lining of Canals –
Gravel backing

Lined Canal

Bed Concrete with Pavers

Side lining with precastslabs

Slip FormSteel Gantry