



Department
for International
Development

Climate Resilient Infrastructure Guidelines

BIHAR; CHHATTISGARH; ODISHA

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Infrastructure for Climate Resilient Growth in India (ICRG) Programme

Submitted By:



IPE GLOBAL LIMITED

IPE Global House,
B - 84, Defence Colony,
New Delhi - 110 024, India
www.ipeglobal.com

In association with



The Context

This document is designed as a handbook/guideline for the construction of the most common NRM infrastructures constructed under Mahatma Gandhi NREGA in Bihar, Chhattisgarh and Odisha. The document is meant for the use of MGNREGA functionaries and other agencies involved in design of infrastructure. The MGNREGA Engineers, Technical Assistants and Contractors can use this as a guideline from planning to implementation phase. The content and practical suggestions in this guide are based on the field experiences of the ICRG project, implemented in Bihar, Chhattisgarh and Odisha. The document is an outcome of the need expressed across the states by the Mahatma Gandhi NREGA officials for a standardized design document.

BIHAR

Introduction

Bihar has a high percentage of population dependent on agriculture and is the fourth largest producer of vegetables and the eighth largest producer of fruits in India. Most of this agriculture is rainfed and facing stress because of the unpredictability of the monsoons. Rains are very erratic with intermittent long dry spells. Bihar has recorded 6 to 7 drought years in the recent past with Begusarai district being one of the most affected. Begusarai used to receive around 1200 to 1300 mm of annual rainfall with 1750 mm in 2007 but now it receives less than 500 to 600 mm/annum due to which the productivity of rice and other crops has fallen. The erratic rainfall is coupled with high floods and Bihar is also one of the most flood prone states in the country with under 76 percent of the population living under threat of recurrent flood destruction.

Recommended MGNREGA Works

Given the combination of current vulnerabilities and exposure to long term climate change, the following MGNREGA works have the greatest potential to reduce vulnerabilities and enhance climate resilience of the communities.

- **To address net irrigated area:** earthen field bunding, rehabilitation of minors and sub-minors, community well for irrigation, lining of canals, **community farm ponds**/individual and its repaired and maintenance of drainage line (pyne) waterlogged areas, diversion weir, link drains, deepening and repair of flood/irrigation channels etc.
- **To address low groundwater availability:** Ahar, **pyne construction**, recharge pits, **Check dam, stop dam, de-siltation of farm pond, community and individual line and block plantation.**
- **To address low forest cover:** grassland development and silvipasture, eco restoration of forest, **forest protection, road/canal side plantation, afforestation**, plantation in government premises, plantation, bi drainage, diversion weir etc.

The ICRG programme supported the design of many Ahar Pyne excavation, farm pond, (community /individual) and de-siltation of farm pond, check dam and its repairing – these are the most typical structures that contribute to conservation and management of rainwater in the state.

AHAR-PYNE: Structure Design and Construction

Definition: Ahar pyne's are traditional floodwater harvesting systems in South Bihar and have been the most important source of irrigation in the region. Ahars are reservoirs with embankments on three sides and are built at the end of drainage lines such as rivulets or artificial works like pyne's. Pynes are diversion channels leading off from the ahars/rivers for irrigation purposes and for impounding water from the ahar. The pynes are of various sizes with the smaller ones originating in ahars and carrying the water to cultivable plots. The large ones have their origins in rivers from where water is diverted through these artificial channels by erecting embankment in the riverbeds. These structures are critical for paddy cultivation in south Bihar.



Key use of Ahar Pyne Structures

- Efficient diversion management and flood mitigation
- Soil moisture improvement
- Additional irrigation support (for growing a second crop)

Improved design of these structures ensures an assured availability of water for agriculture and contributes to improving incomes. Improved agriculture has spin offs in allied activities. One of the critical factors for sustainability of these structures is the need for creating user groups to take ownership for maintenance.

Site Selection

The ahar is an impounded pond, constructed at the site of a depression to store water, and ensure its availability all-round the year. This encourages a second crop for those in the command area and inside the Ahar area. The critical factors that need to be kept in mind for site selection are:

- The site selected should be one where storage capacity is high.
- The slope of the nalla should not be higher than 0-2% in ahar side.
- The trench should cut on the lowerside around the ahar and it should not be wider than 3-5 m.
- A core trench at possible seepage points of the Ahar embankment should be excavated and filled with black soil with compaction, so that it can prevent possible soil erosion and water loss by seepage through subsurface cracks or joints.
- Natural drainage should be available on the downstream side for safe disposal of peak runoff in rainy season.
- Provision of outlet/weir should be made according to need of community in ahar without destroying the field crops.

Ridge to valley approach in pyne: The ridge to valley approach should be adopted for the excavation of pyne's. This will allow the structure to receive maximum water accumulated systematically in the ahar to be efficiently used in the fields.

Need base discharge of water: In order to irrigate more agriculture fields and for utilization of accumulated water from the ahar, there should be provision of hume pipe weirs in the main embankment of the ahar at different heights to allow distribution of the irrigation water to fields downstream.

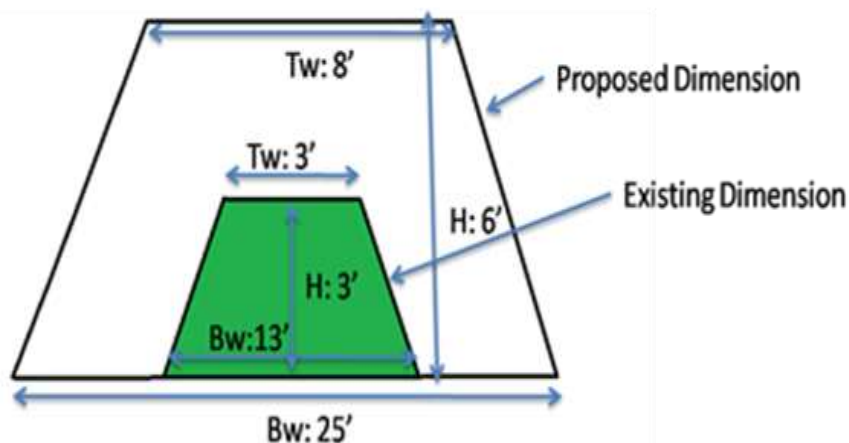
Plantation on Ahar Bunds: In order to protect Ahar bunds from soil erosion and damage, a shallow rooted plant could be suggested on Ahar bunds.

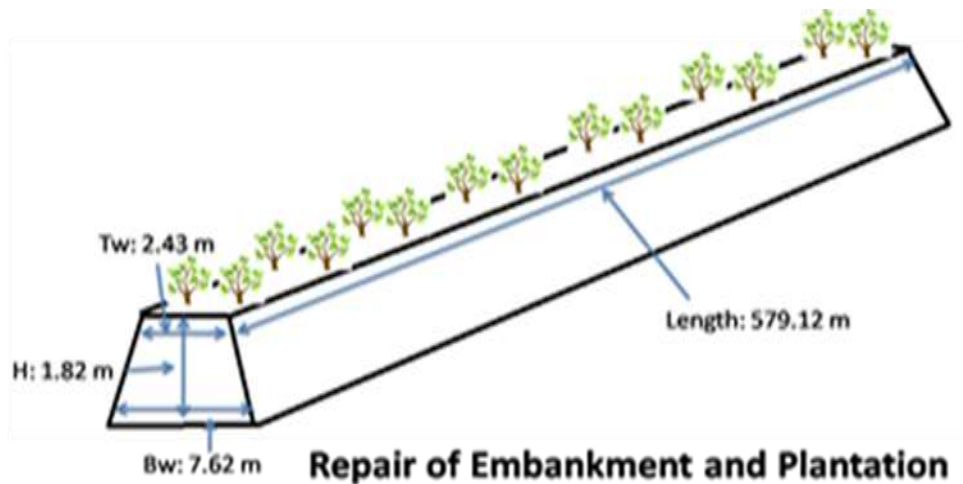
Design of Ahar

The design of 86 ha area, 690 m length, and 118 mm rainfall /day, is illustrated as follows.

Design Of Ahar		Village	Aewa
S.NO	Design aspects of Ahar	Unit	0
1	Catchment Area of the site	Ha	86.00
2	Length of the Ahar to be renovated	m	690.00
3	Existing Height (H) of Ahar	m	0.91
4	Existing Top Width (TW) of Ahar	m	0.91
5	Existing Bottom Width (BW) of Ahar	m	3.96
6	Proposed Height of Ahar (including 0.15 m free board)	m	1.83
7	Proposed TW of Ahar	m	2.44
8	Proposed BW of Ahar	m	7.62
9	Command Area of the Ahar	m	56.00
Total EW required for construction of Ahar		cum	9637.12
Proposed cross-sectional Area of Pyne (a= 1/2 (TW +BW)x		sqm	9.20
12	Rainfall intensity (by using data from climate variability report)	cm/hr	4.32
13	Maximum discharge (Q) from the catchment area	m³/sec	0.41
14	Wetted Perimeter (p) ($p = Bw + 2 \sqrt{(d^2 + (1.5 d)^2)} = Bw + 3.604d$)		16.70
15	Hydraulic Radius $R = a/p$		0.55
	Slope H/L		0.0
	$K = L/\sqrt{S}$,		12029.3
16	Time of Concentration ($T_c = 0.0195K^{0.77}$) where $K = L/\sqrt{S}$, and $S(\text{slope}) = H/L$, $L = \text{Maximum length of travel} = 1050 \text{ m}$, and $H = \text{difference in elevation between most remote point and outlet point} = 8 \text{ m}$	min	27.0
Maximum rain fal intensity for one day =118mm/day		sqmm	261.9
14	Maximum surface runoff water may enter during highest rainfall intensity period from catchment area to the proposed CR site (Using rational method to calculate runoff and volume, $Q=CXRXA$ as per MNREGA guideline	cum	1486080
15	Maximum surface runoff catchment area could be arrested (70 % of the maximum surface runoff)	cum	1040256
16	If we keep 1.5 m average storage depth in all Ahars the maximum	cum	72000

Drawing of Ahar structure





Pyne Design

The Ahar- pyne model system in Bihar is a very successful measure for water conservation since the olden times. Over the years, the systems have fallen into disrepair primarily because of pynes becoming defunct or increase in siltation of the structures. The ICRG programme identified a high demand from the community for revival of the pyne structures to provide irrigation at the critical periods of the agriculture cycle. Some of the pynes are 10 -12 km long and full the irrigation needs for 4-5 villages in south Bihar. The origin of such long pynes are from perennial streams. The community makes barriers on the stream and diverts the water flow into the pyne. The distribution mechanism is such that every field has access to irrigation.

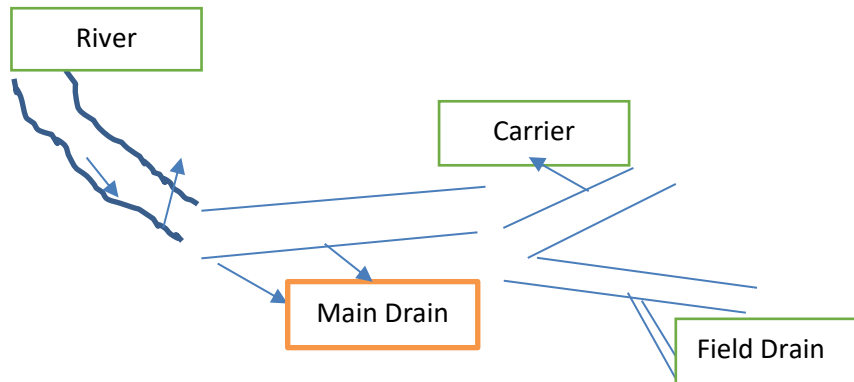


Site selection

- Pynes are always constructed with ridge to valley approach and must originate from either a perennial stream or Ahar.
- Maintenance of the gradient of the slope is a key consideration in the construction of the pyne structure.
- Avoid hill and hillocks during the planning of pyne and ensure that water flows under the influence of gravity.
- Avoid forests and shrubs during the pyne planning. The structures will be overgrown with vegetation in the future.
- Silt trap construction in pyne bed will check the siltation for few years and need continuous repair and maintenance.

Design Procedure

The pyne can also be called as carrier drain from the sub canal or ahar water drain through pyne or carrier drain. A main drain is constructed from the river and is divided into two carrier drains and subsequently into field drains.



Design Criteria

To calculate the catchment area and peak runoff of the rainwater in the rainy season. The surface drainage is dependent on several variable conditions as under:

a) Intensity of rainfall b) Soil characteristics of the catchment c) size and topography of catchment d) vegetative cover and land use in catchment e) Cropping Pattern on catchment f) calculate 24 hr. max rain fall of 5 year frequency and intensity. By using Peak Runoff formulae

Q= 0.0028CIA where q= peak runoff cum/sec, Runoff coefficient, I= is the Intensity of Rainfall mm/hr and A = area of catchment in ha (runoff coefficient varies from (0-1) for different type of Catchment

C= A1C1+ A2C2+A3C3----/A1+A2+A3 ---

Tc = 0.0195(L)0.77(S)0.385 where L = Max Length of flow (m) and S =slope of drainage area(M/minute) and Tc= time of Concentration

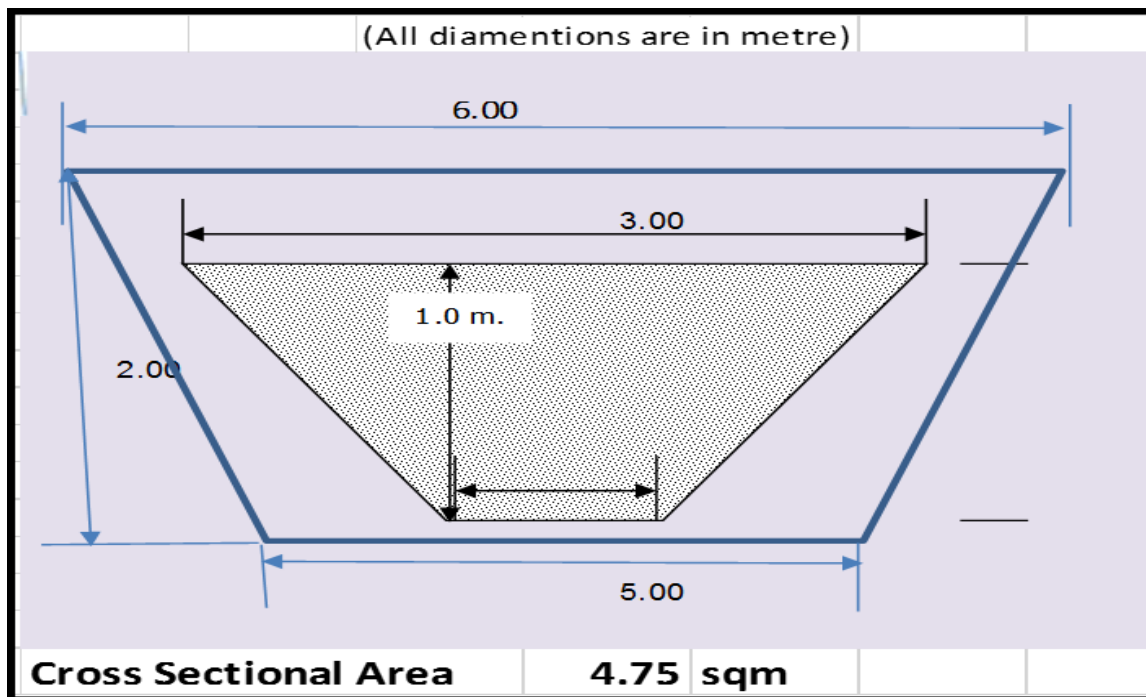
Design Procedure as under

The length of Pyne is 600m, Proposed TW=6.0, Bw=3.5m and depth = 2m

Design of Pyne Work	Length of pyne M	600
Climate Resilient Work	Unit	Water Conveyance structure
Name of Village		
Type of Pyne	Renovation of existing Pyne structure	
Shape of the Pyne		Trapezoidal
Catchment (Ha)	Ha	NA
Fetch length (Max length of Travel)	M	560
Slope of the Area		0-3%
Type of Soil		loam
Existing Depth (d) of Pyne		1.20
Existing Top Width (TW) of Pyne	M	3.00

Exiting Bottom Width (BW) of Pyne	M	5.00
Proposed Depth of Pyne including 0.15 m free board)		2.00
Total depth of channel (existing + proposed)	M	3.20
Proposed TW of Pyne	M	6.00
Proposed BW of Pyne	M	3.50
Proposed cross-sectional Area of Pyne ($a = 1/2 (TW + BW) \times \text{Depth}$)	Sqm	15.20
Catchment Area of the pyne	Ha	42
Fetch length (Max length of Travel)	M	560
Elevation difference from remote point to outlet of discharge		4
Command Area of the Pyne (ha)	Ha	235
Wetted Perimeter (p) ($p = Bw + 2 \sqrt{d^2 + (1.5 d)^2} = Bw + 3.604d$)		15.04
Hydraulic Radius $R = a/p$		1.01
S (Slope) = H/L		0.01
$K = L/\sqrt{S}$,		6626.01
Time of Concentration ($T_c = 0.0195K^{0.77}$) where $K = L/\sqrt{S}$, and S (slope) = H/L , L = Maximum length of travel = 1400 m, and H = difference in elevation between most remote point and outlet point = 8m (minimum)		17.08
Per day maximum rainfall (as per Climate modelling report)		235
Rain fall intensity (I), as per climate variability report (one day max rain fall 150 MM/day)	mm/hr	825.70
coefficient of runoff © as per differnet catchment terrain May vary from 0.3 to 0.5		0.5
Manning's coefficient (n) may varies as per soil type of location		0.02
Discharge from drainage area ($Q = CIA$) Where C = Runoff coefficient = 0.4 for loamy soil arable land and slope rang 5-10%), I = Rainfall intensity (cm/hr), mean rainfall intensity for the design recurrence interval and for a duration equal to the time of concentration, A = Drainage Area (m^2)	cum/sec	48.17
S (Longitudinal gradient slope of channel) varies as per site slope and location (taking $1/6000$)		0.00017
Velocity of water flow ($V = R^{2/3} S^{1/2} / n$) Where R = Hydraulic Radius, S = Longitudinal slope (may be assumed assume $1/6000$ approx.), n = manning's coefficient = 0.02 for ordinary firm loam soil type		0.650
Maximum permissible velocities in non-vegetated canal for ordinary firm loam soil type (Reference table, After Fortier and Scobey, 1926)	Clean water =0.75m/sec Water with Colloidal silt =1.05M/sec Water with sand Gravel =0.68m/sec	
As the designed velocity is within the permissible velocities limit, so we can say that the design of pyne is suitable.		

Drawing of Pyne Structure



Design of Community Pond

Definition

Farm Pond is a dug-out structure with definite shape and size having proper inlet and outlet for collecting the surface runoff flowing from the farm area. It is one of the most important rainwater harvesting structures constructed at the lowest portion of the farm area. Depending on the source of water and their location, farm ponds are grouped into four types: 1) Excavated or Dug out ponds 2) Surface ponds 3) Spring or creek fed ponds and 4) Off stream storage ponds.

Objectives of Farm Pond

1. To arrest maximum runoff in the village area.
2. To increase ground water level in drought prone areas.
3. To increase fish production.
4. Protective/supplemental irrigation to crops.
5. Pisciculture or Duck Farming.
6. Conserve the natural resources like soil and nutrients apart from water and acts as flood control structure by reducing peak flows of given area of catchment.
7. Provide for domestic/livestock use

Prerequisites for Pond

Adequate Water Source: This is an important requisite for pond design and construction. Without availability of water source in nearby area, the construction of farm pond is not possible. For feeding

the farm pond there must be water source, which may be the spring, canal water, overland drainage, ground water, stream flow or the diverted water flow.

Proper Catchment Area: In case, the water source for the pond is rainwater, an efficient design should take into consideration a proper catchment area/drainage. This enables water storage for longer periods. The soil of catchment area should have good runoff producing potential that is least erodible.

Sub-Soil Properties: The sub-soil properties of the construction site also determine the suitability of pond construction. If sub-soil contains impermeable strata, then the loss of stored water due to deep percolation gets checked to a large extent; and storage increases significantly.

Water Supply: In order to feed the farm pond, timely, at fast rate, the water supply source must be adequate. Also, the pond should maintain relatively constant water level round the year. In case of farm pond for fish farming, if water supply rate is very high, then there is possibility of overflow of water from the pond storage, which results into flushing of nutrients, and allowing the fish to escape. A small size stream is always good source of water for ponds, provided that,

- a. The flow is enough to fill the pond and maintain the water level in optimum limit
- b. Stream is not subject to flood occurrence
- c. The watershed is well vegetated, and
- d. The stream carries least amount of silt load, especially during flood occurrence

Components of farm pond

1. Storage area – Area contained by pond that stores the runoff water.
2. Earthen Embankment – A raised structure made of excavated soils and deposited at the sides of the pond.
3. Inlet – A channel constructed along the slope to channelize the runoff water into the pond.
4. Berm – Distance between the pond and earthen embankment.
5. Mechanical Spillway /Outlet – An outlet or waste weir of a pond is designed to remove the surplus runoff above the maximum capacity of the pond.
6. Slit Trap –A chamber to capture the silt carried by the runoff water.

Design of Farm Pond

Design of farm pond consists of following parameters for determining:

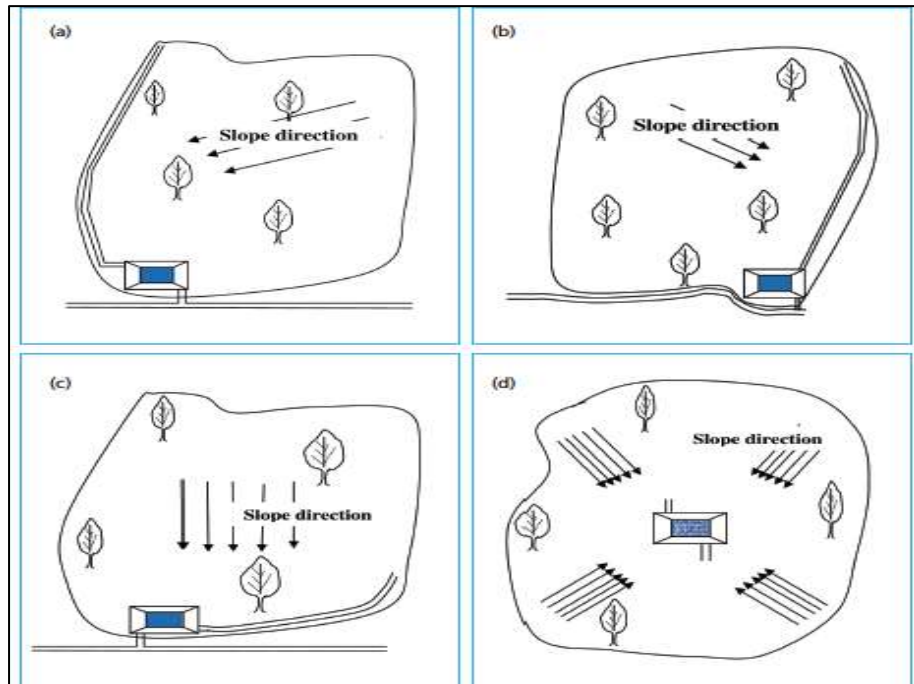
1. Site selection
2. Calculation of pond capacity
3. Design of embankment
4. Design of mechanical spillway
5. Design of emergency spillway, and
6. Arrangements for seepage control from storage area of the pond

1. Site Selection of Farm Pond

A preliminary study of suitable sites is conducted with each site being assessed separately. Some of the important considerations are as follows.

- From an economic point of view, a pond should be located at that site where enough storage volume can be obtained with least amount of earthwork. This condition generally gets satisfied at a site where the valley is narrow and side slopes relatively steep. Such sites have

greater water depth as compared to the exposed surface area, which is very conducive to reduce the evaporation loss. However, such sites must be checked carefully for adverse geologic conditions of the area. According to slope the site should be chosen as under



- If ponds are constructed for the purpose of livestock, then they should be constructed at such a point, from where the transportation distance of water will not be more than one-quarter mile in rough areas. Avoid porous, sandy and saline land for construction of farm pond.
- The pond site should be such that water conveyance from the site is easy.
- For the ponds to be used for fishing or other forms of recreation, the site should be readily accessible by transportation facilities and the soil should be deep (up to 1m) on the site, this provide the longevity of the water in the pond.
- The pond site should be such that, the drainage from farmsteads, feeding lots, corrals, sewage lines, mines dumps and other similar area should not be there. However, if it is not practically possible, then drainage line from the site should be diverted.
- Infiltration rate is the most important factor to be observed at the site, less infiltration increases the possibility of water storage round the year. Therefore, clay soil will be suitable for pond construction. If the clay soil is not available at the site, precautions should be taken to control seepage loss. Some suggestions to control seepage loss include spreading of bentonite, rice bran and cow dung, mulching on the bottom and clay soil up to 6 inches. The Infiltration rates of different types of soil are ----

Sl no	Type of Soil	Infiltration rate (cm/hr.)
1	Coarse sand	2.0- 2.5
2	Fine sand	1.2-2.0
3	Fine Sandy Loam	1.2
4	Silty Loam	1
5	Clay Loam	0.8
6	Clay	0.5

2. Calculation of pond capacity: The ponds capacity depends mainly on catchment size, volume of water requirement, and soil characteristics of the catchment. The catchment size directly affects the quantity of available water for storage. The volume of water requirement may be for crop cultivation, livestock or domestic needs. Only the erosion potential of the soil characteristics is considered. For high erodible soils in catchment, comparatively greater siltation storage is provided in the pond storage. For calculating the catchment area, elevation, slope and soil type under ICRG project, the google earth pro map has added value with the submergence area and lat long being taken from the same map. The capacity of farm ponds can be determined with the help of contour maps of the watershed, contributing to the runoff by using rational formulae.



A) Peak surface Runoff: Using Rational Formulae: **Q=CRA (As per MGNREGS guidelines 2007)**

Where Q= Peak surface runoff in m³

C= Coefficient of Runoff (0.1 to 0.6 for different type catchment)

R = Average Annual Rainfall m

A =Area in sqm (suppose catchment 17.24 ha forest and 2.76 ha cultivable area)

Total surface runoff yield for the monsoon (Q) =0.3*172400+0.5*27600) *1.290=84,520.8 cum, that is enough to fill the WHS. (where rainfall 1290 mm/annum (as per JJAS)

Where C1= Runoff Coefficient for available Silty/Clay loams soil (Forest Land) = 0.3

C2= Rational Runoff Coefficient for available Silty/Clay loams soil (Cultivable Land) = 0.50

R= Max one day Rainfall with CV (historical/projected) whichever is higher =352+(353x31.6) =463 mm/day (as per CCVA study done by IISc, Bangalore)

A1= Catchments area (Forest) = 17.24 Ha

A2= Catchments area (Cultivable) = 2.76 Ha

Peak Run off (Qp) = (0.3*172400+0.5*27600) *463/1000= 30335.8cum/day or 0.35cumecs

Different size and storage Capacity of Pond: table -1

Size of Farm Pond in meter	Storage in TCM (10x10x10 m3)
20x20x3	0.876
20x20x2	0.651
20x15x3	0.621
20x15x2	0.471
15x15x3	0.441
15x15x2	0.341
15x10x3	0.261
15x10x2	0.21
10x10x3	0.156

B) Volume of Earthwork Calculation: From the contour plan of the site, the capacity of pond is computed for different stages, using area estimating formula. Generally, Trapezoidal and Simpson's

formulae are used for the purpose. The Simpson formula gives more accurate estimate than the Trapezoidal formula. For determining the pond's capacity, the area enclosed by each contour line is measured with the help of planimeter and by using Trapezoidal or Simpson rule for calculating the pond capacity.

Or by Prismoidal rule Earth work Measurement = $(Ax + 4Bx + C/6) \times D$ (17.2)

A = Area of upper surface of farm pond in m² (Top surface)

B = Area at the half depth of farm pond in m² (Middle surface)

C = Area of Lower surface of Farm Pond in m² (Bottom surface)

D = Depth of Farm Pond in m. (The Simpson rule is also known as Prismoidal rule.)

C. Side Filling of Farm Pond:

The soil excavated from farm pond is used for constructing bund of width 1-2m with top width putting berm 1-2 m around farm pond and provide slope 1: 1.25 with height of 1m

3.Design of Embankment

For design and construction of earthen embankment in farm pond, the following data are required:

a. **Hydrologic Data:** (i) Stream flow (volume, rate). (ii) Water requirement including various losses such as conveyance, seepage, percolation, evaporation, etc. (iii) In coming flow data including design inflow and outflow to be expected. (iv) Data on sediment flow rate. (v) Ground water-table.

b. **Climatic Data:** (i) Rainfall and storm intensity. (ii) Temperature. (iii) Evaporation rate. (iv) maximum, minimum and mean temperature. (v) sunshine hour. (vi) relative humidity. (vii) Prevailing wind direction. (viii) Wind velocity.

c. **Geologic Data:** (i) Types of aquifer. (ii) Exposed gravel. (iii) Geological cross-sections where necessary.

a) Core Wall:

To check the seepage flow from the foundation of the earthen dam, a core wall of impervious material is provided. The construction of core wall should be started from a certain depth, below the ground surface up to the height of maximum expected water level in the pond. If there exists impervious layer in the soil at the construction site, then core wall should be keyed to the impervious layer for providing complete sealing of seepage flow. For construction of core wall, a trench is dug along the Centre line of the purposed dam site, at least 60 cm deep into the sub-soil. The minimum width of core trench is kept about 120 cm at the bottom with the side slope 1:1. The core trench dug so, is filled in layers using impervious materials (black soil prefers). The filled material is puddled and compacted for better result, and it is done up to 50 to 60 cm above the highest expected water level in the farm pond.

b) Cross-Section:

Cross-section of earthen embankment depends on the foundation and fill materials available at the construction site. The materials used for embankment construction should be fine and impervious in nature to the water.

c) Side Slope:

The side slopes of earthen dam are dependent on the dam height, nature of foundation materials as well as the fill materials used for construction. The side slope which is commonly used for average quality fill material is 3:1 and 2:1 towards upstream and downstream sides, respectively for a dam height of 15 m. In case of relatively coarse fill material that cannot be compacted very well, a flatter

slope, i.e. 3:1 and 4:1 towards u/s and d/s, respectively are provided.

Table II (suitable Site slope for different spoil

Soil type	Slope (Horizontal: Vertical)
Clay	1:1 to 2:1
Clay loam	1.5:1 to 2:1
Sandy loam	2:1 to 2.5:1
Sandy	3:1

Suitable side slopes for different soils (Source: FAO, 2011)

d) Height:

The height of dam is determined after fixing the position of spillway in the dam section. The dam should be extended up to the height ranging from 60 to 100 cm above the spillway. For determining the net height of dam an adequate allowance for settlement and free board is also provided. A newly constructed earthen dam tends to settle down after construction. The height of settlement depends on the method of construction and materials used. It may vary from 20 to 25% when construction is done by drag line method. It could be very small, when the fill materials are thoroughly compacted. However, the following formula can also be used for computing the height of settlement in case of earthen embankment –

$$S = \frac{(e_1 - e_2)}{(1 + e_1)} \cdot Y \quad \dots(17.4)$$

Where, S = height of settlement, meters, e₁ = void ratio before consolidation e₂ = void ratio after consolidation, Y = depth of soil being consolidated, meters.

The free board ranging from 60 to 75 cm is added to the height of dam, after settlement. In bigger size earthen dams, the determination of exact value of free board, is done based on engineering principles.

e) Top Width:

The top width of dam varies. It mainly depends on the height of dam and mode of use of its top surface. However, the following formula can be used for determining the top width of earthen embankment.

$$W = 1.105 H^{1/2} + 0.91 \quad \dots(17.5)$$

Where, W = top width of the dam, meter, H = maximum height of the dam, meter.

Normally, up to 5 m height of embankment the minimum top width 2.5 meters is recommended. If the top of the dam is used as road, then width can be up to 5 meters or more.

f). Earthwork:

For computing the volume of earth work involved under dam construction, the end area method is commonly used, which states that the volume between two successive cross sections is equal to the average of their end areas, multiplied by the distance between them. This is expressed as –

$$V = L \left(\frac{A_1 + A_2}{2} \right) \quad \dots(17.6)$$

Where, V = volume of earthwork, cu.m, A₁ & A₂ = end areas of the respective cross-sections, sq. m, L = distance between the two cross-sections, m

g) Design of Mechanical spillway for inlet /outlet:

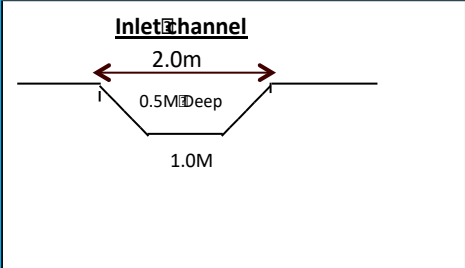
One of the important points in pond construction is to provide a suitable means for disposing the excess water from the pond. The kind of spillway to be used, depends on the size of catchment of surface runoff water coming into the pond.

If the drop height exceeds 4 meter and there is chance of silt accumulation, then drop inlet type spillways are mostly preferred; it should have a box type inlet or an arched type inlet. Arched inlets are more preferred as they provide additional advantage of arch strength in case of masonry structures. The spillway should be constructed on a firm foundation and with the help of durable materials, for providing long life. The drop structure used in embankment of farm pond is also referred by the name of surplus weir.

h) Inlet Channel:

An inlet is designed to channelize the inflow of the runoff water to the pond. The average length of inlet channel is 10m with width 2m and 0.5m depth. The side slope of the inlet channel is kept at 1:1

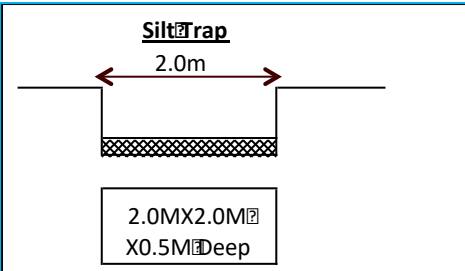
Table- III

	<p>Inlet Channel</p> <p>For diverting the runoff coming from catchments into the farm pond</p> <ol style="list-style-type: none"> 1.Length of Inlet Channel: 10.00M 2.Width of Inlet Channel: 2.00M. 3.Depth of Inlet Channel: 0.50M. 4.Side Slope: 1:1
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Silt Trap Chamber

A silt chamber/ trap is constructed at the inlet chamber to control the flow of silt in the farm pond. The dimension of silt trap is 2mX2mX0.5m. Stone packing of 25cm should be done to reduce/control the velocity of runoff water and aberration. The trapped silt in the silt chamber should be periodically removed.

Table IV

	<p>Silt Trap</p> <p>For checking the silt coming from catchments before entering into the farm pond</p> <ol style="list-style-type: none"> 1.Length of Silt Trap: 2.00M 2.Width of Silt Trap: 2.00M. 3.Depth of Silt Trap: 0.50M. 4.Details: 25cm Stone pitching
---	---

Outlet Channel

Outlet should be proposed in the design when the calculated runoff water is greater than the storage potential of farm pond. Outlet helps to safely dispose of excess water from the farm pond. On an average, the length of outlet is kept at 7m and width is maintained at 1.5m. Stone pitching on the outlet reduces the velocity of discharge water and controls the aberration effect. The width of outlet is 7m in total out of this 1.5m are head wall, 4 m is crest wall apron is 1.25 m and wing wall is 1 m on both the side.

a. **Sample spill way (without scale-width of core wall may vary as per excess flow)**

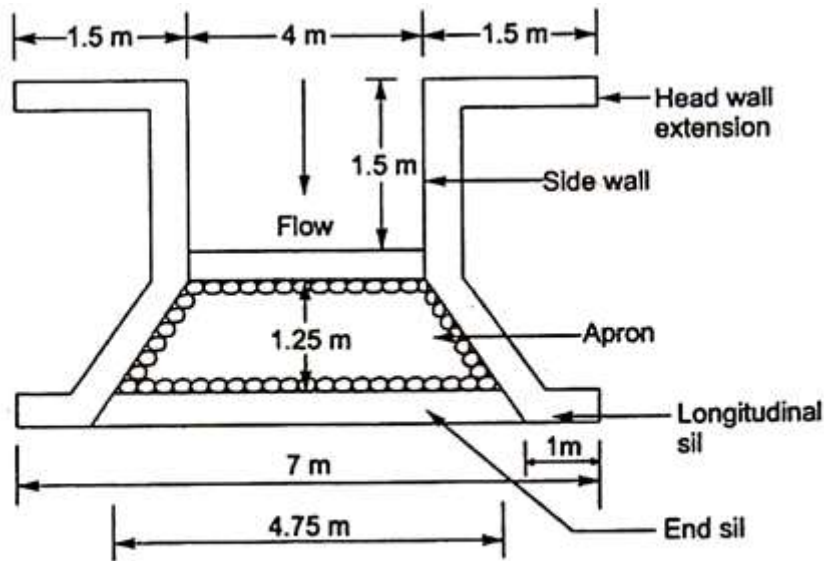


Fig. 17.3. Mechanical spillway in farm pond

4. Design of emergency spillway: Sometimes a drainpipe at the pond bottom is connected to the spillway, so community can lower or empty the pond for repairs, fish harvests, or weed cleanups. The dead storage water can pass out through emergency spill way.

5. Arrangement for Seepage Control: HDPE tarpaulin spread on the bottom up to embankment to control the seepage loss in the pond by skill mason during final construction of pond. At least 2 feet deep the tarpaulin should spread and later the soil will fill over the tarpaulin. The bentonite compound is also used to check the seepage loss in newly constructed pond.

6. Climate Resilient Component of Farm Pond:

1. Treatment of land at the upper ridges to reduce siltation effect (Integrated planning e.g. FB, CCT, SCT, CB and Plantation in the catchment)
2. Selection of farm pond site to harvest and store maximum runoff water
3. Hydrological design to calculate the storage potential of farm pond
4. Provision of "inlet" to channelize runoff water to farm pond
5. Provision of "silt trap" to arrest silt deposition in the farm pond
6. Provision of "outlet channel" to safely discharge excess runoff
7. Compaction of embankment /bund. Grass seeding of Bunds or plantation of leguminous crops.
8. Stone pitching at the inlet and outlet section.
9. Historical and projected rainfall precipitation undertaken during design of Farm Pond

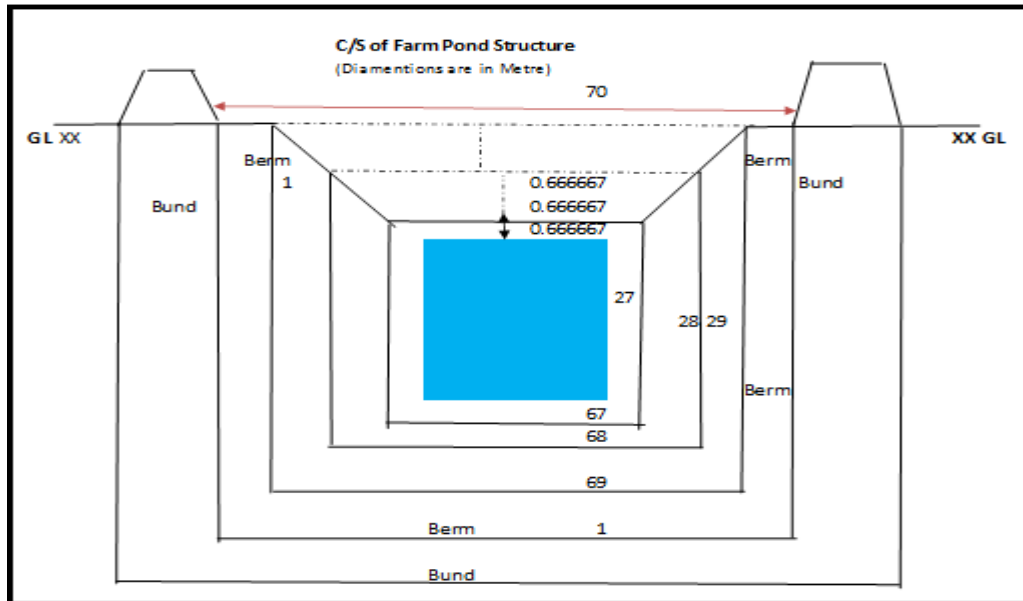


Sample farm Pond with Inlet and Outlet

7. Quality Assurance parameters during construction of farm pond

Parameters to be taken care during implementation	Check list to ensure	Period
Layout for excavation area and from where labour dug the soil step wise (as per drawing) –	Lining by lime-, inner line, steps line, outer line,	Day 1
Layout for Farm bund area and from where labour dump the soil for bunding (as per drawing) –	Lining by lime-, berm line, bund bottom line, bund top with lines, bund center line,	Day 1
Provisioning of Inlet and outlet layout	Lining by lime- inlet and outlet width (Top & bottom) inlet length	Day 1
Excavation of Farm Pond	Excavation with steps of 30 cm,	Weekly
Dumping of excavated soil	Dumping of soil start from center line and must compacted by labour after every 10 cm thickness of excavated soil	Daily
Lining of material thickness (puddling)- clay/HDPE	From where soil to be collected- Check soil type as clay soil and clay puddling thickness- 30cm/15cm, or /HDPE sheet must be 300-500 micron spread on bottom (if require controlling seepage)	In Last week of completion of work
Stone pitching and grass pitching/turfing in inlet/outlet and bunds	Stone/Grass pitching on inlet and outlet as well as on bunds	In 2nd Last week of completion of work
Plantation of Plants outside bunds and leguminous crop in bunds	Plantation in outside bunds and in bunds pulses crops and gross seeding should done,	In the month of June- July (Onset of Monsoon)

Drawing of Community Pond desiltation:



(Cross section of top view of pond)

CULVERT

Culvert is defined as a tunnel structure constructed under a pyne, river, roadways or railways to provide cross drainage or to provide path for domestic and animal crossing or other cables from one side to other. It is totally enclosed by soil or ground. Brick culvert, Pipe culvert, box culvert and arch culvert are the common types used under roadways and railways. Pipe culverts are widely used culverts and rounded in shape. The culverts may be of single in number or multiple. If single pipe culvert is used, then larger diameter culvert is installed; if the width of channel is greater then, multiple culverts are more appropriate – these are also suitable for larger flows. The diameter of pipe culverts ranges from 1 meter to 6m. These are made of concrete or steel.

Front view of Pipe Culvert:



Cost Estimation of hume Pipe Culvert

Abstract of Cost for Construction of Culvert in 4 m wide stream

S. No.	Particulars of Works	L(m)	W(m)	Depth (m)	Qty.	Rate	Unit	Amount (Rs)	Remark
1	Site clearance, cutting of bushes, grasses, for 50mx 4 m etc.				4	274	Mday /day	1096	
2a	Excavation of Earth work in surface soil for foundation and for pipes laying up to 0.5m deep and x4m length and 3m width, in pyne nalla to fix the pipe after making hard strata	4	3	0.5	6	38	cum	228	rate as per M.rate taken
2b	Laying of pebbles/metal for making hard strata with Ratio(1:3:5)	4	3	0.3	3.6	81	cum	291.6	
2c	Cost of hume pipe with 1m dia with 2 m length total 6 RCC pipe require	2	1	1	6	900	per pipe	5400	
2d	Filling of RCC material with (1:3;4) in left space about 100 cft 40 mm metal require				100	80	cum	8000	
3	Cement require for making mixture of PCC(1:3;5),RCC(1:3:4) and plaster (1:6)				400	50	bag	20000	
5	Coarse sand for mixing material and plaster and PCC				40	150	Cft	6000	
6	Provide filter material including filling of fine cement grout mix of suitable mixture and gravel on a side of tube well for filtering the surface water	2	2	2	8.00	712	cum	5696	
7	Mason Charges for construction of Culvert	60			60	294	mt	17613	
8	Labour charges of fitting PVC pipe	120			500	120	m/d	14400	
Total								78724.6	
Add contingencies and miscellaneous charges @ 3.5 % of total cost								2755.36	
Grand Total								81480	

4 Mango plantation one unit in pyne side:

Cost Estimation of Community Plantation on Pyne. (one Unit Plantation)					
Subject/ Operation	Year- 01- Establishment				
	Unit	Qty.	Rate	Description	Amount
A. Maintenance cost					
Maintaining 100 lenior AF/Fruit plant up to 5 year and security of the same plant by 4 no gardeners	No	At least maintenance of 100 Fruit plants up to five year or 60 months based on living plants	7	100*12*5*4*7	168000
Pit Digging of 100 plant	No	100 Big Fruit plants with Pit size 0.60x0.60x0.60= 43.2 cum or 1524.31 cft/108=14 mdays	177	177*14	2478
	NO	100 AF plants with Pit size 0.30x0.30x0.30x200=5.4 cum or 190.56cft/108=2 mdays	177	177*2	354
Purchasing of Fruit Plants for 100 plants	No	100 fruit plants	35	100*35	3500
	No	100 No Agro forestry plants	15	100*15	1500
Installation of hand Pump	No	Two number on the site of fruit and agroforestry plantation @9500/hand pump	9500	2*9500	19000
Insecticide and pesticide treatment on 200 plants	LS	year -1 after two months in 15 days gap LS@ 0.90 p/plant		200*20*0.90	3600
		year - 2 in 30 days gap LS@ 0.90 p/plant		200*10*0.9	1800
		year -3 in 30 days gap LS@ 0.90 p/plant		200*10*0.10	200
		year - 4 in 30 days gap LS@ 0.90 p/plant		200*10*0.11	220
		year - 5 in 30 days gap LS@ 0.90 p/plant		200*10*0.12	3600
Two buckets, Mug, Jhara and clothes etc.		up to 5-year Lump sum Expenditure			4000
Permanent Net Fencing for 5 year and maintenance		400 plant fenced with permanent fencing @350/fencing		200x350	70000
		Total cost			278252
Miscellaneous expenditure		2 % of estimated cost			5565.04
		Grand Total			283817.04

CHHATTISGARH

Introduction

Chhattisgarh receives an average rainfall ranging from 1200 to 1600 mm with over 94% of the precipitation-taking place during July-October, the peak being spread over two months. The Climate of Chhattisgarh is mainly tropical, humid and sub-humid. The climate is hot because of its positioning on the tropic of cancer. May is the hottest month and December-January are the coldest ones.

The Chhattisgarh government announced a scheme Suraj Gaon Yojana- "Narwa, Garuwa, Ghurwa, and Baadi;,which means "collective action to ensure water conservation, livestock development, use of compost and cultivation of vegetable and fruit backyard". It is proposed to achieve the four objectives through an integrated approach to the primary sector with the best use of native resources along with the benefits of government's modern schemes in agriculture, water resources, energy, forest, and rural development.

Narwa (rivulets and streams) focuses on low-cost water conservation structures such as check dams, gully controls, underground dykes at strategic locations on water streams in order to ensure harvesting of surface water and recharge of subsoil as well as groundwater. In Chattisgarh, 69% of irrigation is dependent on groundwater, the absence of surface water conservation can lead to fast depletion of the precious resources. Therefore, Narwa is a scientific initiative started by state government with eco-friendly without displacing zero percent local flora and fauna.

Issues in Chhattisgarh

- Erratic and Inadequate rainfall during the monsoon
- Reduction in number of water flow days in rivers and dry spell period
- Overexploitation of groundwater for various purposes had caused the depletion of groundwater
- Siltation in river caused the base flow instead of surface flow.
- Undulating topography and high slope

Recommended Package for Chhattisgarh

The soil water conservation measures designed based on land type and the land can be divided in 3 broad area centered on their position in state 1. Non arable land 2. Arable land 3. Drainage line treatment. Based on land slope, rainfall and present land use/problem- different type of structure and vegetative measures can be used as under

Non-Arable treatment (Ridge line)	Arable treatment (Middle)	Drainage line treatment (nalla/stream)
Diversion drain	FB/CB/GB/Conservation Ditches	Earthen Dam
Contour trenching (CCT/SCT)	Bench Terracing/30x40 model,5%model	Check Dam/Stop Dam
Loose boulder bund (LBB)	Tanks/well/Khadis/LBC	Underground Dyke
Springs /Creeks	Gabions/EGP	Gabion Structures
Percolation tank/Pond	CAD -development	Pond with Inlet /outlet
Forestry plantation	Water courses- Minor/Major/Collector Drains, Fruit plants	River Lift Irrigation, Fruit plants

The most common structure for Chhattisgarh state to conserve the soil and water are as follows

1.Sub surface Dyke

Definition

Sub surface dyke or under-ground wall is a subsurface barrier across stream which retards the base flow and stores water in upstream below the ground surface. By doing so, the water levels in upstream rises saturating on the dry part of aquifer. The sub-surface dykes have been proved to be effective for ground water conservation structures in undulating/ hilly terrain. They are found suitable for providing sustainable drinking/irrigation water supplies for local communities, without any loss of cultivable land and without affecting the local river ecology. The series of Dyke construction in river results the surface flow of river in long stretch. The site where sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow outlet.

Objectives of sub surface Dyke

- The primary objective of a subsurface dyke is the creation of subsurface storage reservoir with suitable recharge conditions and low seepage losses.
- To conserve the runoff through subsurface base flow of stream or Nalla.
- To rejuvenate the surface flow of river or nalla and create the moisture in subsoil on upstream of river side and recharge the well also which lying in upstream.
- Recharge the aquifer due to retardation of base flow on the river.

Site selection parameter of Dyke

Valley shapes and gradients are used for site identification. Optimally, a valley should be well-defined and wide with a very narrow outlet (bottle necked). This reduces the cost of the structure and makes it possible to have a comparatively large storage of water volume. This indicates that the gradient of the valley floor should not be high since that would reduce the storage volumes behind a barrier of given height.

The limitations on depth of underground construction are that the unconfined aquifer should be within a shallow to moderate depth (down to 10 m bgl) and have a well-defined impermeable base layer. Such situations occur in hard rock areas and shallow alluvial river fine deposits. The dyke is ideally constructed across narrow ground water valleys, generally not exceeding 150 to 200 m in width. Based on a thorough study of a water table contour map of the area, a narrow ground water valley section where the flow lines tend to converge from up gradient direction, usually coinciding with a surface drainage line, should be identified. The requirement of narrow flow section is usually fulfilled in watersheds in hard rock terrain having rolling topography where relatively narrow depressions separate hard rock spurs.

Size of Subsurface Dyke

The size of subsurface dyke depends on the site location and width of the river. After selection of suitable site, a trench of 1-2.5 m wide is dug across the breadth of the stream and excavated deep up to impermeable bed. The trench may be filled with clay or brick/ concrete wall up to 0.5m. below the ground level.

Material for Dyke construction

For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength at 400 to 600 gauge or low-density polythene film of 200 gauges can also be used to cover the cut-out dyke faces. The clay soil

puddling fill into the trench to control the hydrological seepage cut off line flowing above the impervious layer. The trench may also be filled with brick masonry or reinforcement concrete to check the seepage of sub surface. Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no siltation in the reservoir takes place. The potential disaster risk like collapse of the barriers can also be avoided due to beneath of subsurface.

Construction of Dyke

A trench should be dug out across the ground water depression (streambed) from one bank to the other. In case of hilly terrain in hard rocks, the length of the trench generally may be less than 50 meters. In more open terrain, the length may be usually less than 200 m but occasionally even more. It should be wide enough at the bottom to provide space for construction activity. In case of shallow trenches down to 5 m depth, the width at the bottom should be 2 m. For deeper trenches down to 15-20 m, deployment of mechanical equipment may be required. In such cases, width of 5 m at the bottom is recommended. The side slopes within alluvial strata should be 2: 1 to make the structure stable.

The cut-out dyke could be either of stone or brick masonry or an impermeable clay barrier. For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength and 400 to 600 gauge or low-density polyethylene film of 200 gauge is also used to cover the cut-out dyke faces. In the case of relatively shallow trenches within 5 m depth, where good impermeable clay is available within an economic distance (3 km), the cut-out dyke could be entirely be made of clay. In case good impermeable clay is not available, a stone masonry wall of 0.45-meter thickness or a brick wall of 0.25 m thickness may be constructed on a bed of concrete. Cement mortar of 1: 5 proportion and cement pointing on both faces is considered adequate. In the case of very long trenches, for economic considerations, it may be necessary to provide masonry wall only in the central part of dyke and clay dyke suitably augmented by tar felting, PVC sheet etc. on the sides.

In the case of clay dyke, the width should be between 1.5 and 2m depending on the quality of clay used. The construction should be in layers and each fresh layer should be watered and compacted by plain sheet or sheep foot rollers of 1 to 2 ton capacity. In absence of roller, the clay should be manually compacted by hand ramets. Where the core wall is a masonry structure, the remaining open trench should be backfilled by impermeable clay. The underground structures should be keyed into both the flanks of stream for one-meter length to prevent leakage from sides. The underground structures top should be located between 1 to 1.5 m below the streambed to permit overflow in high water table stage for flushing of salinity of ground water stored behind the dyke. The alignment of the dyke should be shown by fixing marker stones on bank and whenever there is change of alignment in between. Before back filling the subsurface trench, piezometric tubes should be installed on both the faces of the dyke for measuring water levels.

Sample design and estimate

Name of The Work - Underground Dyke

Village				
Gram Panchayat				
Stream -				
District				
		GPS position Latitude	N 23056' 30.3"	
		Longitude	E 740 49' 07.5"	
	S.no	Particulars	Measurement	unit
	1	Width of Nala	6.0	meters
	2	Length of Dyke	7.0	meters
	3	Top width of Dyke	1.8	meters
	4	Bottom Width of Dyke	1.05	meters

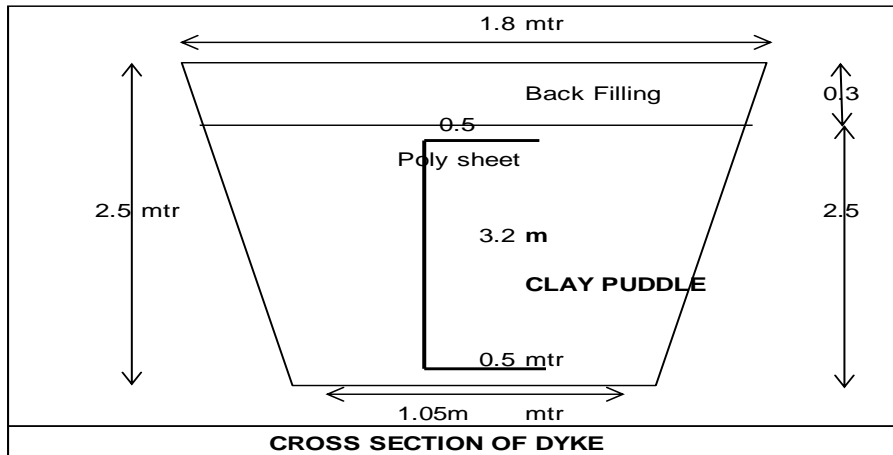
5	Depth of dyke	2.5	meters
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Bill of Quantity

Name of Work- Underground Dyke								
Name of The Village								
Name of The District								
	GPS position Latitude		N 23056' 30.3"					
		Longitude	E 740 49' 07.5"					
	S.no	Particulars	Measure ment	unit				
	1	Width of Nala	6	m				
	2	Length of Dyke	7	m				
	3	Top width of Dyke	1.8	m				
	4	Bottom Width of Dyke	1.05	m				
	5	Depth of dyke	2.5	M				
Sl No	SOR. no	Particular of Work	No	Length	Width	Height/ Depth	Quantity	Unit
1	2	3	4	5	6	7	8	9
1	101	Site Cleaning, Grass Cutting, Making heap and displacement from site	1	7.0	2.8		19.6	sqm
2	317	Marking On site						
	(d)	Marking on single spade at least 75 mm deep marking	2	9.8			19.6	RM
3	301	Earth work excavation (30 cm deep, width 1.5m and area 10 sqm) displacement of excavated soil up to 50 cm away from site with 50 m height including spreading of soil and levelling work.						
			1	7.0	1.425	2.5	24.9375	Cum
4	322	Additional lift up to 1.5m charges	1	7.0	1.25	1.0	8.75	Cum
	¼[½	b) Cohesive and hard soil					8.75	Cum
5	2305 + 230 7	In foundation of trench - refilling of black soil, puddling, mixing of soil with water and ramming in trench with carrying material from 50 m distance.	1	7.0	1.425	2.2	21.945	Cum
6	1901 +19 02+ 190 4	Transportation of material from mine to site lead up to 3 km (lead chart enclosed)	1	7.0	1.425	2.2	21.945	Cum
		Puddle soil	1	7.0	1.425	1.9	18.9525	Cum
		Water					18.9525	Cum
		Total					59.85	Cum
7	LMR	LDP Plastic sheet of 100-micron thickness for center layering	1	8.0		3.0	24	Cum
8		Pit of pillar digging and lifting soil from pit with						

		spreading of soil layer up to 20 cm deep and refilling.						
		a) Cohesive and hard soil	1	7.0	1.8	0.5	6.3	Cum

Drawing of the Dyke Structure



Dyke – sample

1. Check Dam construction

Climate Resilient Check Dam Design

Check dam is a drainage line treatment structure, created in seasonal or perennial tributaries to control the water flow velocity. It dissipates the hydraulic energy into static energy after stroking a flow of water from the core wall barriers. Series of check dam can control the soil erosion during the rainfall by surface runoff. "Check dams" are small barriers built across the direction of water flow on shallow rivers and streams for the purpose of water harvesting. The small dams retain excess water flow during monsoon rains in a small catchment area behind the structure. Pressure created in the catchment area helps force the impounded water into the ground. The major environmental benefit is the restoration of nearby groundwater resources and wells. The water captured by the dam, surface and subsurface, is primarily intended for use in irrigation during the monsoon and later during the dry season but can also be used for livestock and domestic needs. Check dams are built in a range of sizes

using a variety of materials, including clay, stone and cement. Earthen check dams, or embankments, can easily be constructed by the farmers themselves. Masonry and reinforced cement concrete (RCC) structures, on the other hand, require some degree of advanced construction experience and monetary inputs. Earthen dams do not allow for overflow of water, in compare to masonry and RCC structures which allow excess water to flow over the spillway.

Site Selection

Prior to the construction of any check dam, the following criteria are to be considered with respect to site selection.

1. The stream should be straight where site is going to be selected.
2. The embankment should be firm on both the side of river/stream
3. The structure should be able to store a high volume of rainwater
4. The check dam should provide a long length of stored water
5. There should be a high percentage of cropped area, or potential crop area, on either side of the length of the stored water.
6. Risk of submergence of cropped lands during flash floods should be minimal
7. Check dam should have a high cost-benefit ratio.

Instrument for planning & monitoring

Surveying – Dumpy level, levelling staff, prismatic compass, plane table, clinometer, Roto meter, plany meter and chain.

Soil characteristics for land classification- Soil augur, PH meter, Clinometer, Infiltrometer, pressure plane apparatus.

Rain gauges – Ordinary -Non Recording Type and automatic or recording Type

Stream flow Measurement- V-notch, Partial flumes, Current Meters, Staff Guage, Automatic stage level recorder.

Ground water Measurement -Automatic water Level Indicator and Piezometer Tubes

Soil Moisture Measuring Instruments -Tensiometer, Neutron Probe and Infiltrometer

Meteorology Equipment's: Anemometer, Wet and Dry Bulb thermometer, Minimum and Maximum thermometer, Sunshine Recorder, Pyranograph, Pan Evaporimeter, Automatic Weather station.

Objective of Check dam

- Recharging groundwater reservoirs, wells, tube well and increase the availability of water for agricultural/domestic purposes
- Increasing soil moisture surrounding the area
- Promoting growth of surface vegetation on the riverbank
- Capture surface runoff and silt in rainy season

Check dams reduce poverty through additional income

The check dams have helped to reduce the poverty by providing additional surface and underground water leading to:

- Increased agricultural yield
- Increased income from the sale of crops
- Income from the sale of fish
- Increased revenues from livestock
- Increased growth of fodder
- Increased availability of water for processing sun hemp (a forest fiber)

Factors to be considered

- Hydrological factors such as surface runoff, Rainfall intensity, fetch length, catchment area & Type, vegetative coverage, slope and depth- width of the stream/river.

- People's participation.
- Availability of manpower and construction materials.
- Other local peculiarities etc. need to be taken into consideration during the planning and designing of check dams.
- Use of google earth pro map for calculating the slope, area, lat- long and fetch length will be used to design the structure
- Bhuvan and CLART app will support to get the actual suitable site, morphology, lithology, erosion mapping and drainage pattern of catchment area.

Steps for Design of Check Dam

The technical staff when wants to design the check dam structure the under-mention parameter to be consider as stepwise.

Step I: Calculate peak discharge, $Q = C*(A/100)^{3/4}$ Here, Q = Peak discharge in cusec

A = catchment in hectares, C = coefficient of runoff, the value of C is 11.45 for the areas with annual rainfall of 600 to 1200 mm and for Central India the value is 14.

Step II: Calculate peak runoff per running meter $q = Q/L$, where L is the length of the dam

Step III: Calculate depth of the flow considering peak discharge $h = (q/1.71)^{2/3}$

Step IV: Calculate the hydraulic head "HL" $HL=H+h$, where H is height of the dam

Step V: Calculate the top width of the dam "a"

$a = [HL/ (G+1)]^{1/2}$, where G is specific gravity of construction material

Step VI: Calculate the bottom width of the dam "b"

$b = [HL/ (G-1)]^{1/2}$, where G is specific gravity of the construction material

Step VII: Calculate the length of the downstream apron (La)

$La = 1.45 * K * (HL/13)^{1/2}$, here K is coefficient of hydraulic gradient

Step VIII: Calculate the thickness of the downstream apron (t) = $1.33 * [h/ (G + 1)]$, where G is specific gravity of the construction material

Sr. No.	Construction material	Specific gravity (G)
1	Plain cement concrete (PCC)	2.24
2	Reinforced cement concrete (RCC)	2.40
3	Stone masonry in cement mortar	2.54
4	Dry stone masonry	2.08
5	Random rubble masonry	2.32
6	Brick masonry	1.92
7	Reinforced brick masonry	2.00
8	Plum cement concrete	2.24

Hydraulic Gradient Table:

Sr. No.	Situation of drain bed	Safe hydraulic gradient (K)
1	Coarse sand	12
2	Fine sand + mu	8
3	Sand + Boulder	5 to 9
4	Fine Sand	15
5	Boulder	5
6	Big Boulder	3.5 to 4.5

Step IX Design of Baffle wall

The downstream drain bed may get damaged by the water falling over the top of the dam, it is thus necessary that a baffle wall be constructed at the end of the downstream apron, so that an additional water cushion may be provided at the scour.

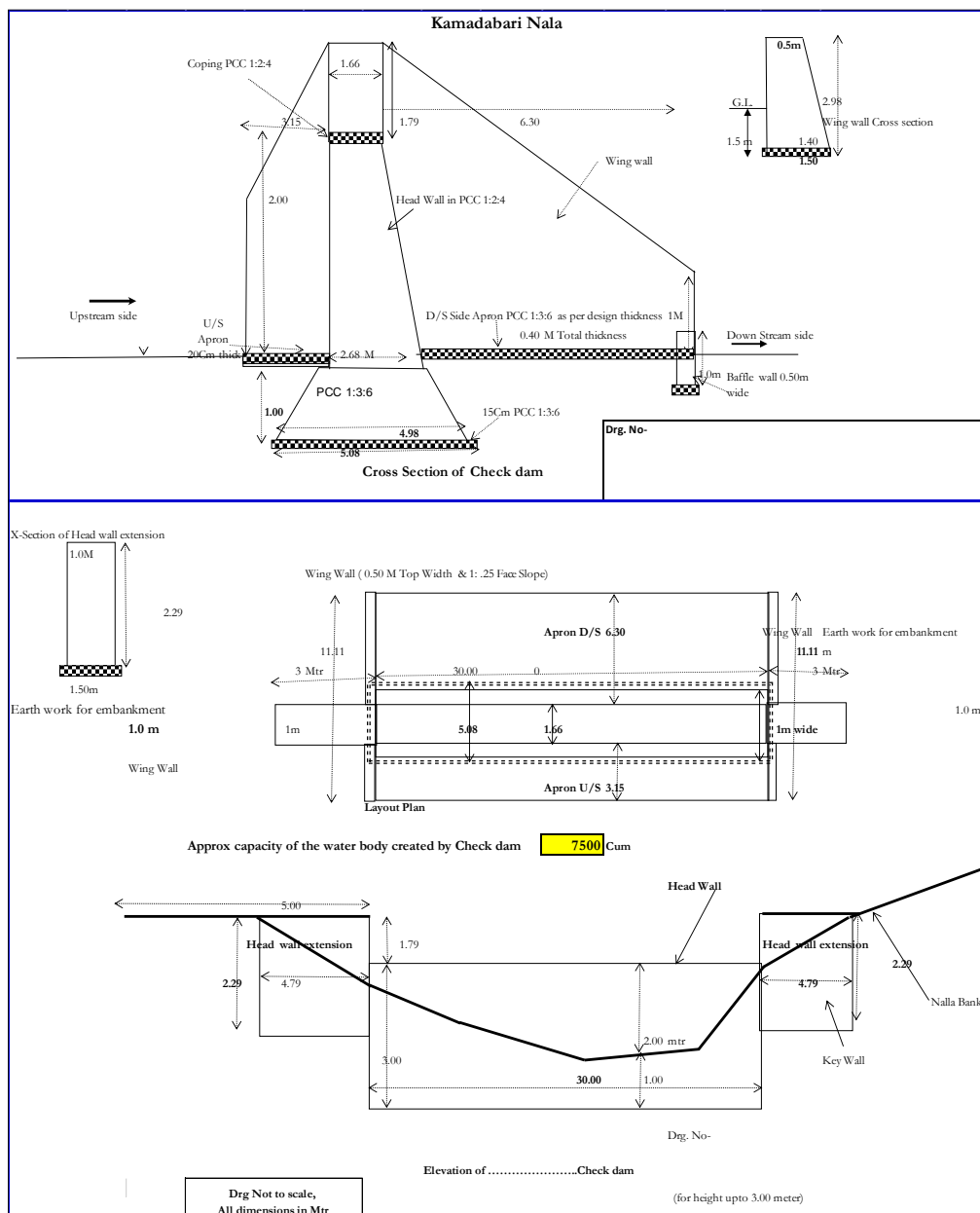
Calculate height of the baffle wall (h_b), $h_b = y_c - y_1$ Here y_c is critical depth, $y_c = (q^2/g)^{1/3}$, where g is acceleration due to gravity, which is 9.81. And y_1 is pre-jump depth, $y_1 = 0.183 * q^{0.89} * HL^{-0.35}$, If the $y_c - y_1$ is less than 0.30 m then $h_b = y_c$ Thickness of baffle wall " t_b " = $2/3 * h_b$

Distance of baffle wall from head wall (L_b) $L_b = 5.25 * h_b$

Step X: Design of sidewall, key wall and wing-wall

These are constructed for protection of the structure, especially where the banks are weak. Weep holes should be provided in the wing wall for the drainage of excess water. Foundation depth of the sidewall and wing wall depends on the soil strata of foundation bed. It is an expensive measure, and thus it should be constructed only where it is necessary, but the design formulae given in the case of Check dam construction of Kamdabari village of Kabirdham district at Chhattisgarh.

Sample Cross section -Drawing of Check Dam





(Fig.of check dam Construction)

Do and don't in farm Pond construction

- The storage capacity of check dam should not too large or too less in relation to runoff estimation
- The firm side of stream should protect the structure from overturning and sliding
- The upstream slope should be lower than the downstream slope.
- All the component of dam must be design as per design calculation to avoid the structure for rapturing, sliding and overturning during the full reservoir level (FRL)
- Rock toe must be provided on the downstream to drag the seepage line
- Don't use the high erodible material like clay soil on the outer faces
- Don't raise the core wall over the FRL of structure, it should always be below approx. 40-50 cm.
- The surface weir should not be very steep or have a sharp curve

2. Gully Plug – Earthen Check Dam

Earthen Check dam is a gully plug structure mainly built on a seasonal nalla to prevent erosion and to settle sediments and pollutants. Furthermore, it is possible to keep soil moisture due to infiltration behind the water of earthen check dam. The broad use of ECD are i) Storing water during the rainy season to be used for irrigation in the post-monsoon period and ii) Providing protective irrigation during dry spells within the rainy season. Depending on the topography, amount of precipitation, material and financial resources available, there are several kind of gully plugs structure e.g. vegetative gully plug, earthen gully plugs and loose boulder gully check.

Advantage of Earthen Check Dam

- Dissipate the water speed, which reduces erosion and prevents unwanted gully formation during a flood in rainy season.
- No trench design is required, just uses existing gully drainage pattern
- Can assist recharge of shallow wells
- Can reduce salinity in groundwater
- Allows groundwater recharge and sediment to settle out (reduces sediment transportation)
- Cost effective – these dams can use locally available materials
- Harvest surface runoff in series of ECD and create moisture surround the area
- Increase vegetative coverage on the site.

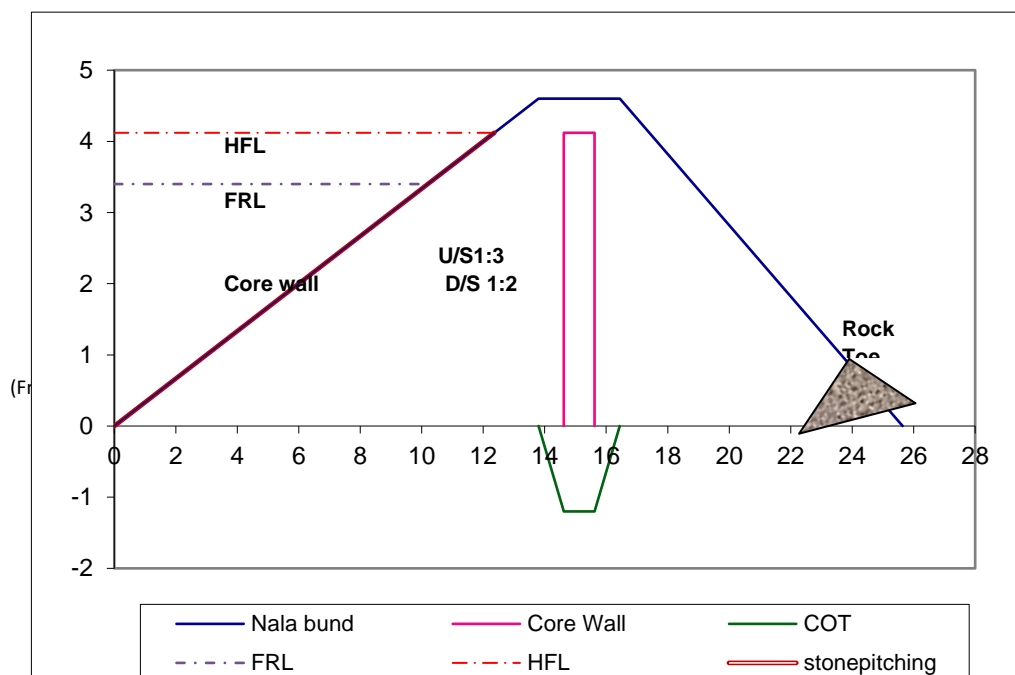
Disadvantage of Earthen Check Dam

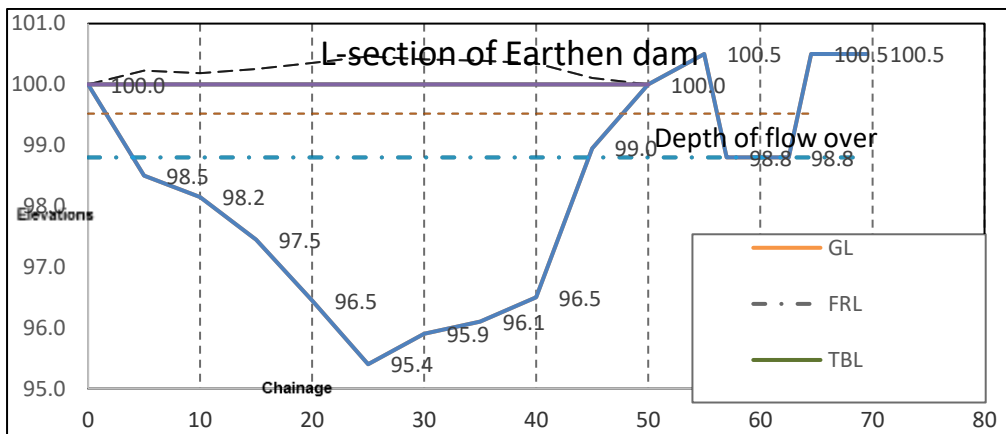
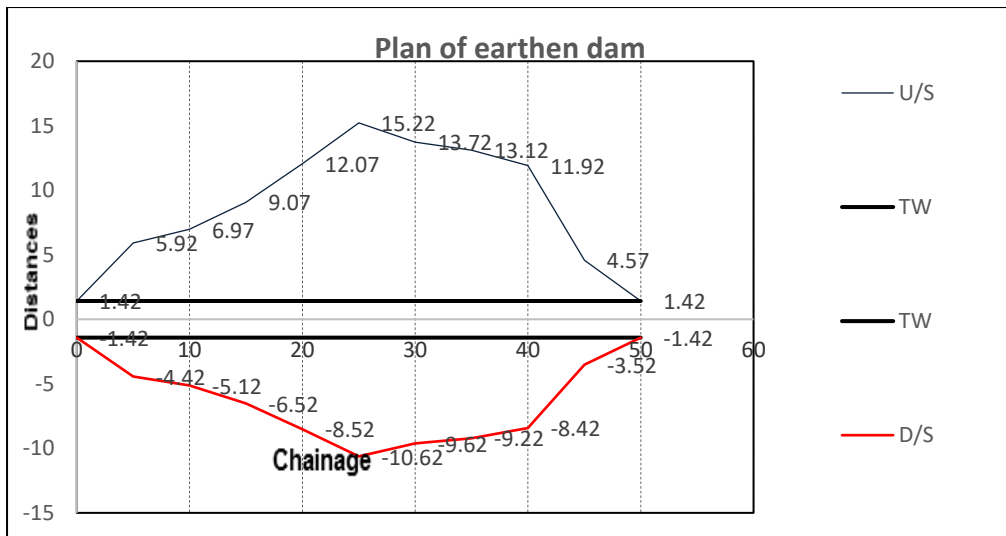
- Earthen check dam silts up and will need maintenance
- Levels of infiltration can be slow due to silt build-up in the submergence area
- Unclear land tenure can result in ownership of the structure
- If designed incorrectly, the surface runoff may block the structure in heavy rain
- When only focusing on gully plug construction, the main cause of gully development is missed.

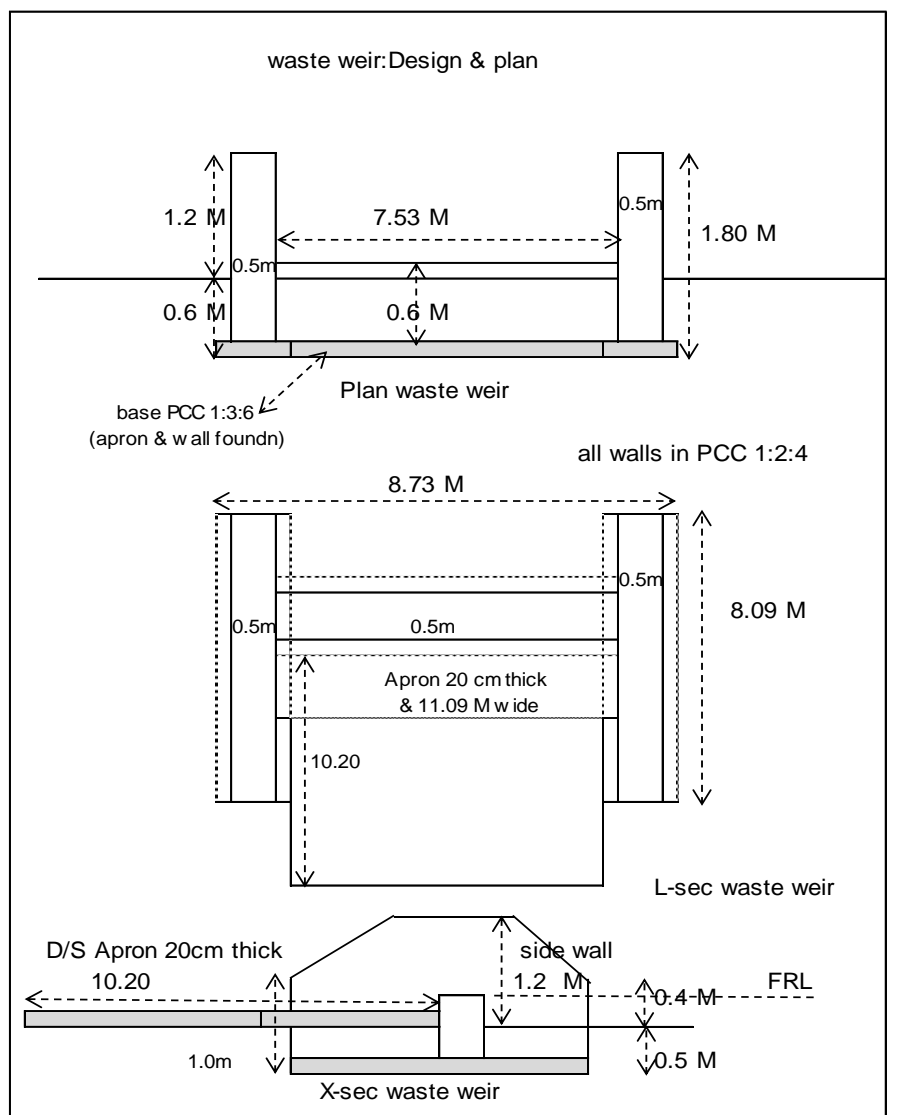
Drawing of Earthen Check Dam

According to the area of catchment and amount of rainfall, C varies from 11.37 to 22.04 as given in Table 5.1.

Region	Value of C
North India	11.37
Central India	11.77–19.28
Western India	22.04







3. Recharge Pit for bore well

Surface and sub surface water is the clear source of irrigation for Chhattisgarh farmers through bore well, deep well and farm pond. The depletion of underground water is the matter of great concern for farming communities and human life is affected in most of the districts. Large scale in pumping out of underground water and negligible recharging in surrounding, has affected a havoc problem in these bore well by deep-water table or aquifer become dry in the region. Therefore, an urgent need is required to enhance the ground water potential through artificial recharging technique.

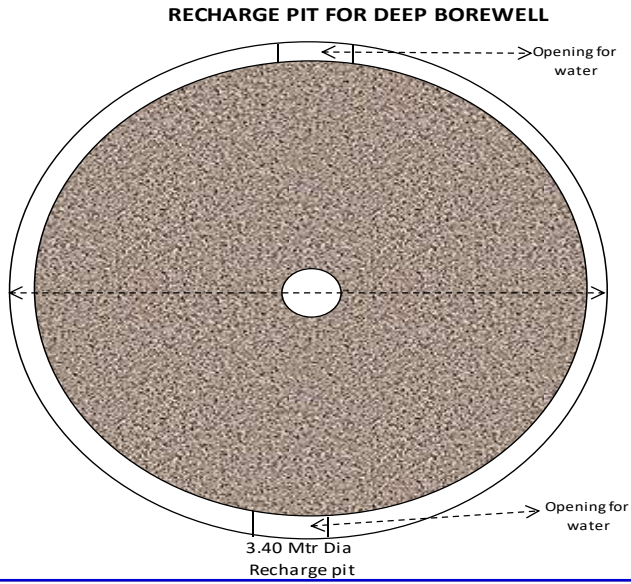
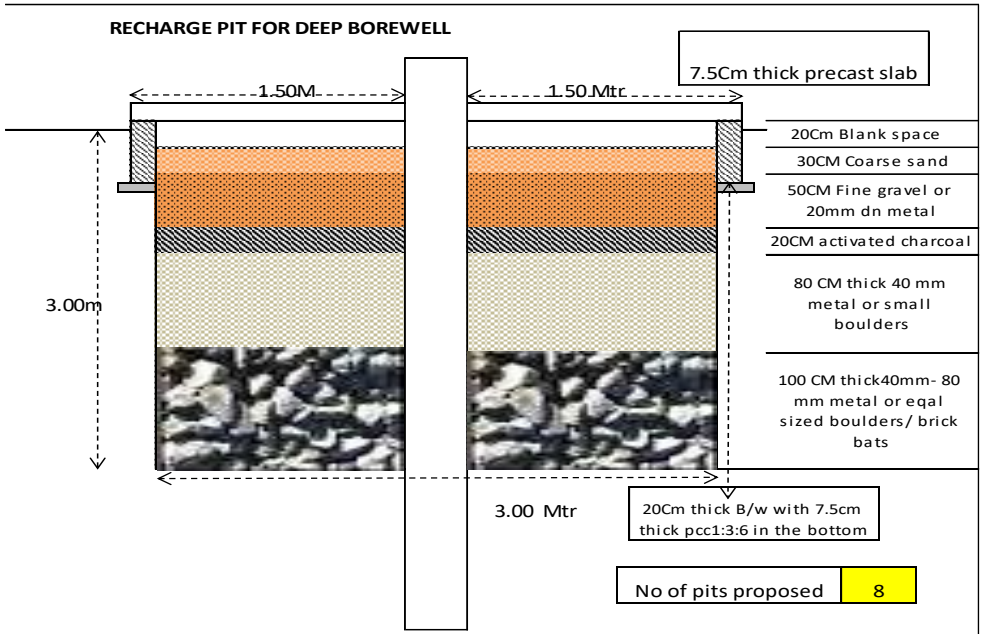
Objectives of Bore well Recharge

- Conserve surface runoff water and increase the water table
- Minimize drinking water scarcity and domestic use in summer
- Permit farmers to take up rabi and summer crops
- Mitigate the risk of crop failure due to water scarcity in critical period

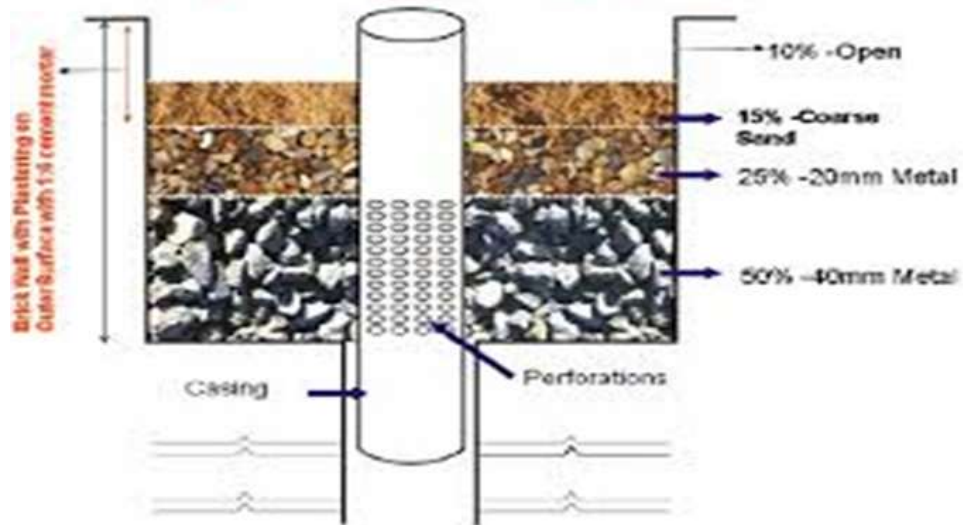
Diagrammatic representation of recharge pit construction

Filter material	Thickness of Layer
Fine coarse sand	30 cm
Fine Gravel or 20 mm metal	50 cm
Activated Charcoal	20 cm
Small Boulders	80 cm
Boulders 40-50 mm	100 cm

The first step is to mark out the recharge pit spot. The dimensions of the recharge pit around the bore well were 10ft x 10ft x 8ft. Then a water storage pit of dimensions 18ft x 12ft x 6ft is marked 2 feet away from the recharge pit. At the time of excavation of these pits, a 3-foot wide and 5-foot deep block is excavated between these pits in order to make the storage wall. After excavation, the recharge pit is filled with stones up to 1.5 feet from the bottom. Small holes are made on the casing pipe and the net is wiped with the help of coir rope around the casing. Four cement rings are placed around the tube well covering the tube well all the way up to ground level. Now the recharge pit is filled with stone, crashed stones, sand and again with crashed stones in that order up to ground level. Finally, a concrete mixture is used to cover the boundaries of the recharge pit. This prevents rainwater from directly pouring into the recharge pit.



RECHARGE THROUGH INJECTION (BORE) WELL



Bill of Quantity of Recharge Bore well

BOQ for Recharge pit for bore wells						
Sr. No.	Particulars	A/U	L	B/W	D/H	Qty
1	Excavation around the bore well for recharge pit i/c disposal of mud and dressing(soft and Hard soil)	Cum	3.14X1.9X1.9		0.5	5.67
			3.14X1.5X1.5		1	7.07
2		Cum	3.14X1.5X1.5		1.5	10.60
3	(B) Cohesive /Hard Soil/Hard Moorum	Cum	3.14X1.5X1.5		1.5	10.60
4	PCC 1;3:6 for foundation of side wall	Cum	3.14X3.4	0.25	0.075	0.151
5	Labour for 413	Cum				0.151
6	20cm Thick Brick work with CM 1:6	Cum	3.14X3.4	0.2	0.5	1.005
7	Labour for 614					1.005
8	7.5 cm Thick precast slab all complete with 6mm dia reinforcement @10cm c/c	sqm	3.14X1.6X1.6			8.04
9	Collection and stacking of filter media as per drawing	cum	3.14X1.5X1.5		0.3	2.12
10	Supply of coarse sand	cum	3.14X1.5X1.5		0.3	2.12
11	Supply of garvel 20 mm dn	cum	3.14X1.5X1.5		0.5	3.53
12	Supply of activated charcoal 20 mm dn	cum	3.14X1.5X1.5		0.2	1.41
13	Supply of garvel 40 mm dn	cum	3.14X1.5X1.5		0.8	5.65
14	Supply of garvel 80 mm dn or boulders or brick bats	cum	3.14X1.5X1.5		1	7.07

4. Gabion Structure

Gabion structure is kind of loose boulder check dam constructed across small stream to conserve stream flows with practically low submergence beyond stream course with a catchment area of 30-150 ha. Small bund across the stream is made by putting locally available boulder in a steel mesh wires boxes of 1cum. It acts as a single unit that can withstand a high velocity of runoff. The height of such structures is around 1 to 2 meter and is normally used in the streams with width of about 10 to 20 m. Gabion structures have a long life (20-25 years) almost like cement masonry permanent structures.

Objectives

The main aim of constructing gabion structure is to reduce the velocity of water flowing through the drainage line. By reducing the velocity of runoff, gabion structures help in

- Trapping silt, which reduces the rate of siltation in water harvesting structures in the lower reaches of the watershed.
- Soil conservation
- Creating a hydraulic head locally which enhances infiltration of surface runoff into the groundwater system.
- Increasing the duration of flow in the drainage line. Therefore, the capacity of the water harvesting structures created downstream on the drainage line is utilized fully as they get many more refills.

Site Selection

The site of gabion structure selected where local available material easily available and the desired condition should as under.

- Straight stream flow.
- Stream bed should not be with loose material
- Stream banks should be stable and should have enough height on both sides.
- For maximizing storage in the structure, the bed slope of the upstream portion should be low. The flatter the upstream slope, the more will be the storage.
- Structures should be at right angles to the stream flow.
- On the downstream of the structure at least 2m level land should be available for apron work.

Spacing of the Gabions

Most of the common thumb rule is bottom of the upstream structure should be in the same level with top of downstream structure. If there is very mild slope say around 1% then spacing between two structures must be 50 m horizontally. In steep slopes spacing should be 5 to 10 m vertical interval or 10 to 20 m horizontal interval.

Description & Material of Gabion Construction

Good quality galvanized wire of gauge 12-14 must be used for constructing gabion structures. Ready-made mesh with a single twist is commercially available. In these meshes the gap should not be more than 7.5cm x 7.5cm. The prepared mesh should be combined with 14-gauge wires. Box size of 1m length x 1 wide x 1m height is required to prepare and all the boxes must be joined as a whole unit. After filling the box with rocks or boulders of the local material the top cover mesh is to be folded and all the corners are to be tightened with binding wire of 14 gauge. Acceptable stone for gabion construction shall be hard, durable, equally graded, angular in shape, and shall not be less than 4" in any given dimension and no larger than 8" in any given dimension. The specific gravity required for the stone fill shall be determined by the design and specified by the design engineer. Specific gravity for stone fill shall be no less than 2.5. To increase the impermeability of the structure, a reverse filter should be constructed on its upstream face. This is made up by placing layers of small boulders, gravel, sand and mud against the structure. The boulders are placed adjacent to the structure, with gravel, sand and mud being placed successively away from it.

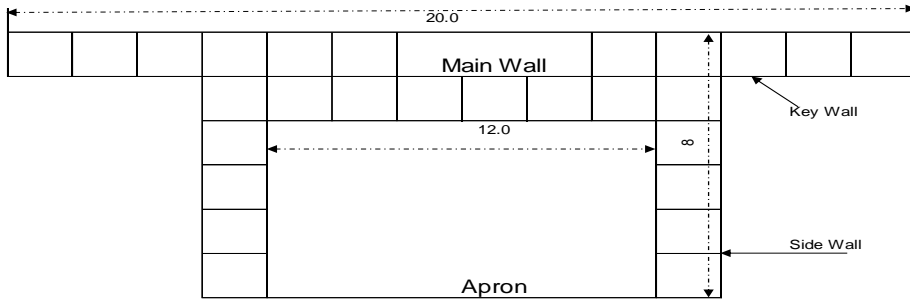
Gabion structure plan



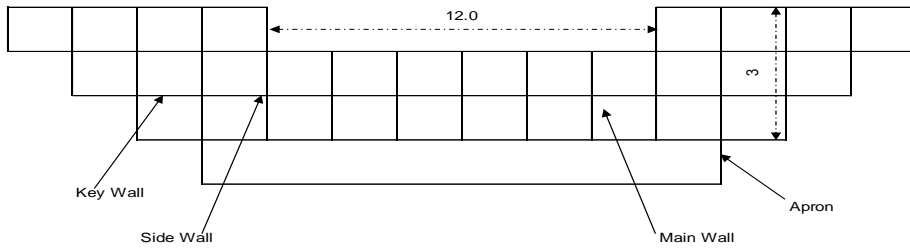
Sample Drawing of gabion structure (yellow is input data cell)

Name of the work - Gabion Structure			
Name of Village			
Name of Gram Panchayat			
Name of Block			
District/ State			
GPS position	Latitude		
	Longitude		
Dimension for Construction & Costing of Gabion Structure			
S.no	Particulars	Measurement	unit
1	Length of Head Wall	12.0	meters
2	Height of Head Wall	2.0	meters
3	Top Width of Head Wall	1.0	meters
4	Bottom Width of Head Wall	2.0	meters
5	Width of Apron	6.0	meters
6	Thickness of Apron	0.6	meters
7	Length of Side Wall	8.0	meters
8	Height of Side Wall	3.0	meters
9	Thickness of Side Wall	1.0	meters
10	Length of Key Wall	3.0	meters
11	Total Length of Structure	20.0	meters
12	Steps (V:H)	1	:1
Summary : cost of structure			
1	Total cost of structure in Rs.	181183	100%
2	Labour Cost in Rs.	132460	73.11%
3	Material cost in Rs.	48723	26.89%

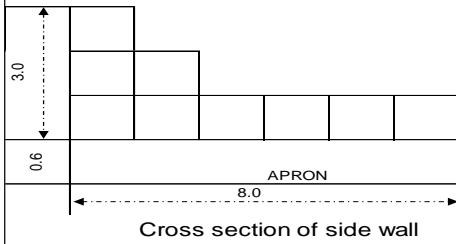
Name of Village 0
 Detail Drawing of Gabion Structure



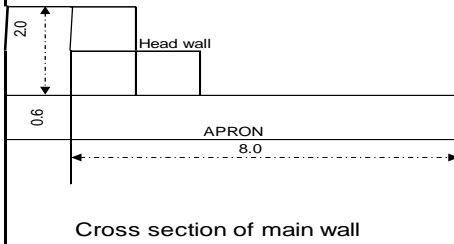
Plan view of Gabian Structure



Longitudnal section of Gabion



Cross section of side wall



Cross section of main wall

Notes :- All Dimension Are in Metres

Not to Scale

ODISHA

Introduction

In Odisha there is about 2 lakh hectares of cultivated land of which 27 lakh hectares are upland/highland, 19 lakh hectares are medium land and 16 lakh hectares are low land. The upland/highland and medium land are mostly situated in the interior area of the state. Most of these upland and medium land areas are non-irrigated and under rainfed agriculture. Most of these areas are unbunded and have little chance of percolation of rain water into the soil. As a result, when there is a small dry spell, drought occurs. To mitigate this frequent drought situation, in-situ moisture conservation measures should be taken up for which land development activities are most beneficial. Almost all the land development activities are permissible under MGNREGS. Given the topographic condition of Odisha, the land development activities like Field Bunding, Contour Bunding, Contour Trench, Staggered Trench, 30X40 model, 5% model, Guide Bund, Gully Control structure etc. are most important activities that can be taken up under MGNREGS. The advantages of these activities are:

- It requires very less technical knowledge
- Most of these activities are short term activities
- These are labour intensive work
- This will help recharge ground water
- This will help in conservation of soil and moisture
- This will act as mitigation strategy to droughts

Different estimates have found that around 47% of rain water goes to the sea. Under the geographical condition of Odisha, rainwater is a major responsible factor for the soil loss. It is estimated that the tolerance limit of erosion (soil loss) is 4.5 tonnes/hectare whereas, it is around 16.35 tonnes/hectare at present. Out of a total soil loss, 29% goes directly to the sea, 10% deposited in surface reservoirs causing storage capacity loss upto 1-2% and 61% displaced and transported to another location. This soil loss will cause some hazardous conditions in future if not checked. Hence immediate steps should be taken to control this soil loss. If the velocity of runoff is controlled, the major portion of soil loss will be checked. For this field bunding should be done in almost all the barren/uplands with proper spacing to check the erosion. Bunding is important to intercept the rainwater before it attains the erosive velocity. The spacing of bunds depends on slope, soil, rainfall, conservation practices, cropping pattern.

The following sections describe the various types of structures under land development that are common in Odisha.

Design of Primary bund

The runoff velocity has a direct relation with slope, soil type & cover. As the primary bund generally constructed just at the foothill, hence slope is always more and thus the velocity is high. Therefore, a strong bund is required to sustain the runoff velocity. Though the trench excavated just ahead of the bund in upstream side, it checks some amount of runoff forces, but if the trench is already filled then the impact of runoff may directly hit the primary bund. Hence, the dimensions of the primary bund need to be design as per the peak runoff. To construct this bund, we also need to maintain the height of the bund in same elevation means a same contour. Thus, of bund height may differ place to place, however during design, an average height needs to be considered.

Description of primary bund design with an example from Patna block of Keonjhar district: The length of the catchment area is 570m and average slant surface width is 80m, hence the total catchment area for primary bund is 4.56 ha. The one-day maximum rainfall for Patna block is 178mm with a project CV is 27.2%. Though the projected mean monsoon rainfall for Patna block is showing a decreasing trend of 6% from historical mean of 1113mm, however, to calculate the peak runoff we have to take the one-day maximum rain fall with the projected CV. Hence one-day maximum rainfall would be 226.4mm. Considering rational formula of calculation of runoff, $Q = CRA$ cum per day.

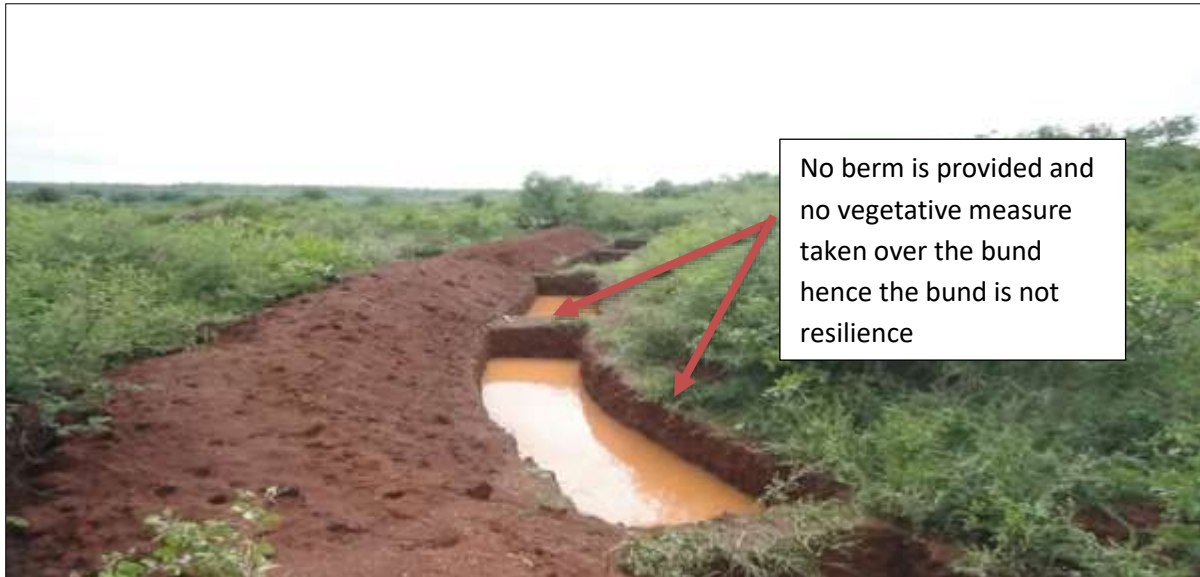


Figure 1: Image of Primary bund and water absorption trench

As the catchment characteristic is stony and tree coverage with an average slope of 9% the coefficient of runoff (C) is 0.35. hence the

$$Q = 0.35 \times 0.226 \times 45600 = \mathbf{3613} \text{ cum/day}$$

Now considering the size of primary bund as below:

Average height: 1.35m

Top width (TW)=1.0m

Bottom with (BW) with side slope (1:1)= 3.7m

Cross section area of bund=3.17sq.m, length=600m, volume=1904 cum.

This is the loose volume, hence deduct 30% from the bund volume to get trench volume=1904-1904x.30=1332 cum

Trench size: L-600m, Area=1332/600=2. 22sq.m, considering width of trench 3.05m (10feets), the depth of the trench would be 0.75 m say 3 ft.

After deducting settlement allowances of 25%, the final bund height would be=1.35m-(1.35x0.25) =1.01m, if we keep outlet crest level a 0.5m of primary bund height from bottom then we get an additional water storage area above the trench and that would=0.5x5x600=1500 cum (0.5m height of storage above trench due to bund, 5 m width of storage and 600 is the bund height).

Now in completely dry situation, when there would be 226mm one-day rainfall then, the primary bund and trench will be hold $1332+1500=2832$ cum of water

But we have a volume of runoff 3613 cum which is higher than our storage volume and it is 781 cum. As we have to dispose this 22% of total volume of runoff, we need outlet to safely dispose this amount of water to the downstream plots. To dispose this, we need a stone outlet as per following specification;

Average velocity of flow=1.2m/sec. Considering a crest height=0.3m, crest length of 2m, $Q=AxV=0.3 \times 2 \times 1.2=0.72$ cum per sec). This volume of water will be disposed by the outlet in one second, hence in an hour the outlet will discharge a volume of $=0.72 \times 60 \times 60=2592$ cum per hour. Which is more than our surplus runoff volume 781 cum.

As the above assumptions are made on completely dry situation when there is no storage in trench and bund hence one single outlet of the estimated size will not solve the purposes. There may be same amount of rainfall in a situation when the trench and bund is already filled up to the crest level of outlet, in this case we need one more such outlet to dispose the whole volume of runoff. However as per the situation of site and need at the downstream plots, more outlets can be constructed. But at least two outlets with above dimensions are required as per projected rainfall in future mentioned in the climate modelling study done by IISc, Bangalore. Please find below figures as engineering drawing of primary bund and water absorption trench. The engineering drawing of stone outlet is shown in figure 2.

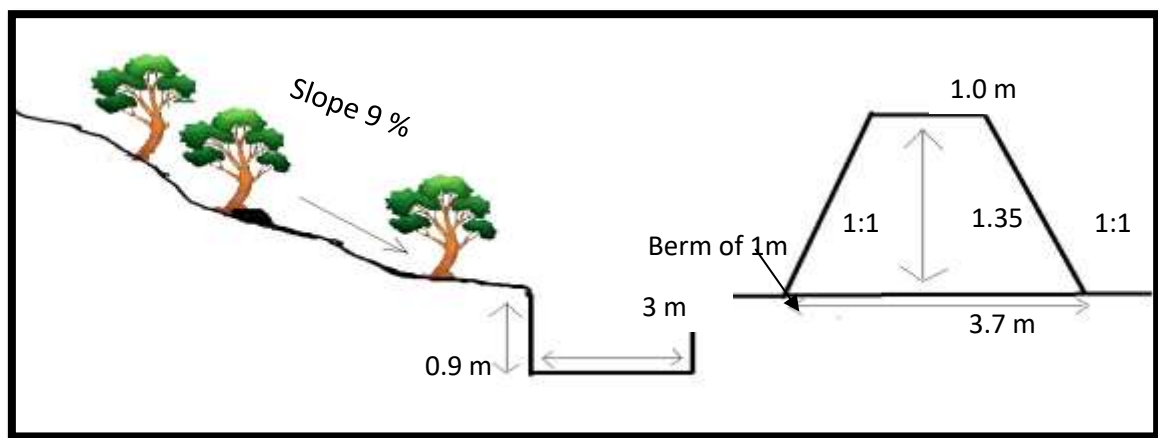


Figure-2: Design of Primary bund and water absorption trench

Secondary bunds

Secondary bunds are constructed in the downstream of the primary bund across the slope. The objective of the bund is to again conserve soil, water and soil moisture. These bunds are either constructed following a contour if the patch is a common land, otherwise constructed following the revenue boundary of a plot. However, sometimes it is required to divide a plot if the plot size is huge to check the technical feasibility and to maintain stability of the bund.

As primary bund uses to check the runoff forces at the top, these bunds mostly get the surplus water release by the primary bund and the runoff generated in the plots itself during a storm. As the large plots are divided into small plots, the final slope of the plots reduced and hence the force of runoff, so a medium size bund needs to be constructed along with an outlet for each plot to check runoff and store water and soil. The outlets are arranging in zig zag way so that the surplus water should not create a gully or a drain rather it spreads over the downstream plot passes from one to another till the velocity reaches to a safe level. A proposed bund design is given in the figure 3.

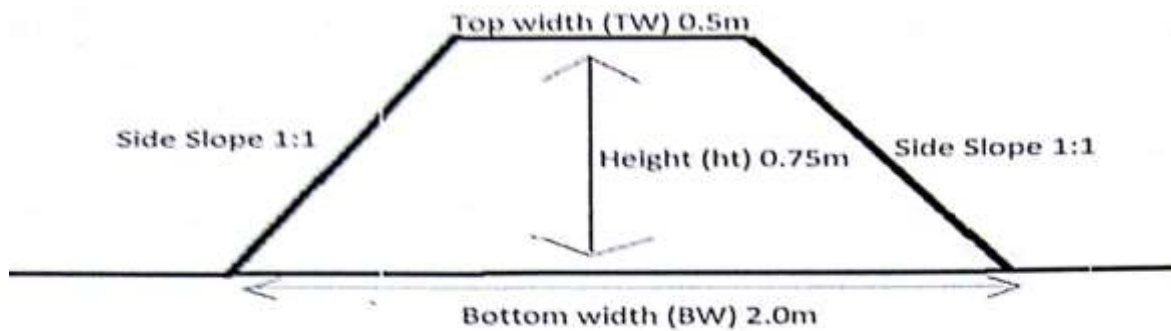


Figure-3: Cross section of a secondary bund

Stone outlets in primary bunds

As mentioned in the primary bund and water absorption trench part, outlets are very important

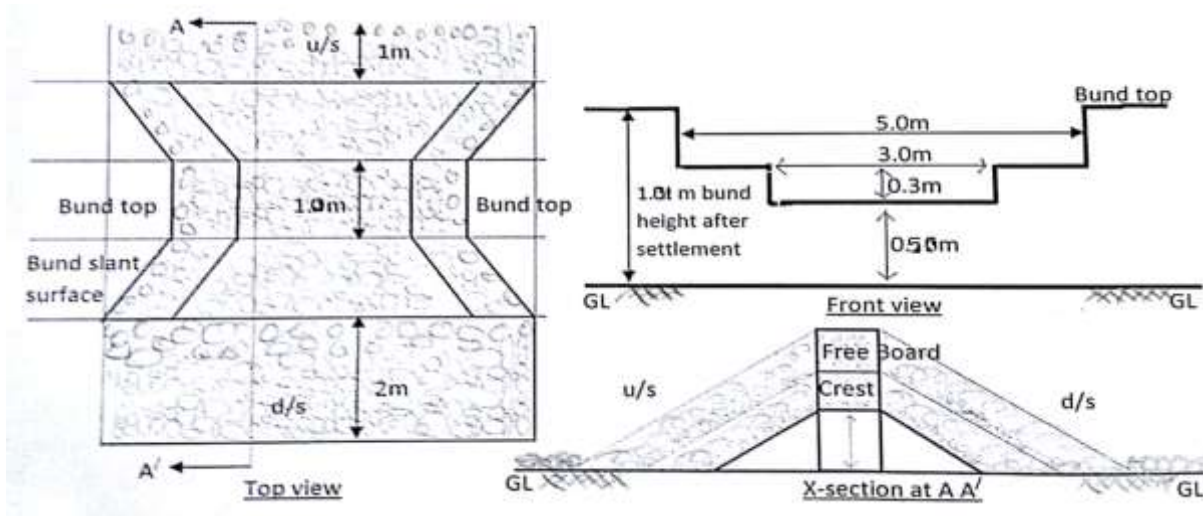


Figure 4: Design drawing and dimensions of Stone outlets

to dispose excess water safely to downstream plots. As stone are locally available, after consultation with community and block officials, stone outlets are proposed. The design as well as numbers of outlets required has been done based on the volume of water to be disposed for a peak runoff hour in a day. The design drawing and dimensions are provided in figure 4.

Cashew Plantation

After a brief discussion with the community and block MGREGA staff, it was found that cashew plantation would be best in the treated area. Since the soil quality is good, people are having two choices, some wanted to go for kharif paddy and some wanted to go for cashew plantation.

Example of cashew plantation of Patna block of Keonjhar district: It was found that 1.5 ha area would be covered under cashew plantation. The following are the specification and cost of the cashew plantation. As this part of the activity is decided after the approval of the Rainwater management part, hence approval has to be taken as additional work for the site. After discussion with block official it is decided that they will assign this work to PD, Watershed to implement the plantation part. Rainwater management work will be implemented by Block MGNREGA cell.

The spacing of plants –row to row is 7m and plant to plant is 7m. Hence approximately 200 plants will be planted in a ha area. The pit size is 0.6m \times 0.6m \times 0.6m. There would be fencing provision along with other plant protection measures (organic only). Total cost per ha is Rs 2.9 lakh including intercropping cost and three years maintenance cost, i.e. the project would be for three years period. The cost also include gap filling in 2nd and 3rd year if there is any mortality. The labour and material ratio is 64:36. Hence for 2 ha area total cost would be 5.8 lakh. Layout is given in figure-6

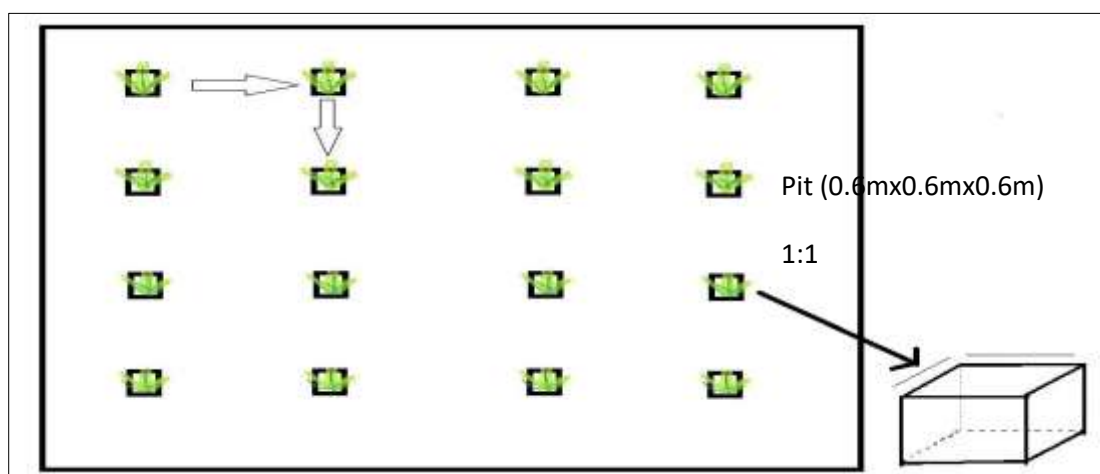


Figure 6: A layout of cashew plantation with specification

Diversion canal

Example of diversion canal design of Ghatagaon block of Keonjhar district A diversion canal generally constructed to divert surface runoff of hills/upland to either agricultural plots or to any water body. The canal may be a lined or unlined or pitching with boulder to check the canal from erosion due to water velocity. In this case a boulder pitching canal has been proposed. The canal length would be 190 RM and shape would be trapezoidal. Design is shown in figure 7. The canal carrying capacity would be 0.522 cum per sec. The canal will divert water from a catchment area of 3 out of 6.52ha of total catchment area for primary bund with a runoff volume of 3388 cum.

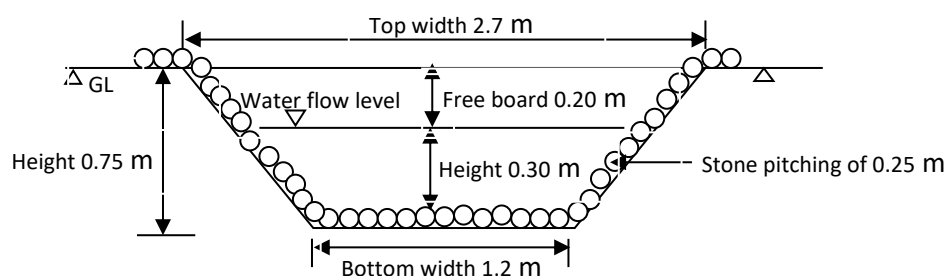


Figure 7: Section of diversion

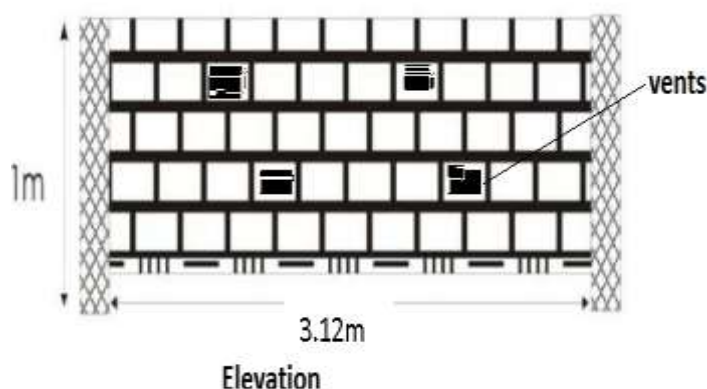
Nadeep compost pits

Compost pits are one of the individual category works under MGNRGA. It is constructed to



Figure 8: Plan and elevation of a Nadeep compost pit

convert the cow dung and households waste into useful organic manure. These helps waste material and cow dung decompose in an open chamber, thus during rainy season there is no leaching of its use full nutrient. Generally, brick and cement mortar are used to construct the pits. The unit cost is Rs 14000 out of which 78% is material cost and 22% is labour cost. There are 12 compost pits have been proposed for the beneficiaries of land development with an objective to increase soil nutrition and to



aware farmers to use organic manure. It also increases the cleanliness of the HHs as well as village by managing solid and liquid waste. A standard design has been shown in the below figure 8 an example from Jashipur block from Mayurbhanj.

1. Design of earthen bund

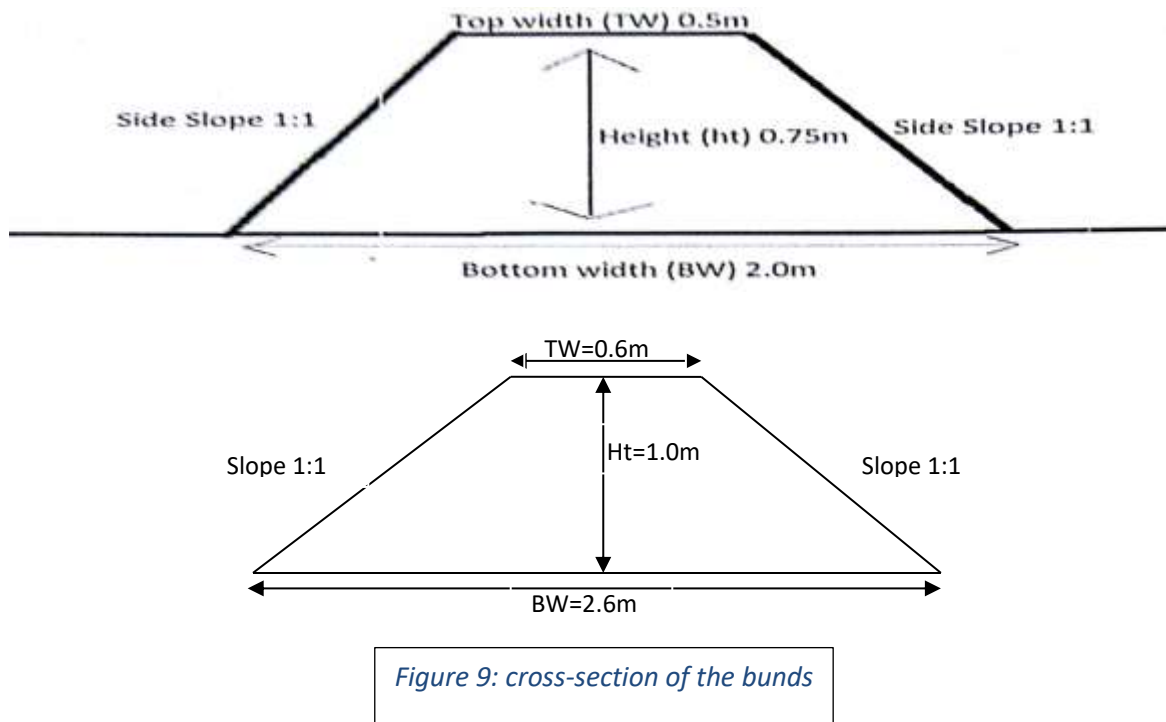
Explaining the concept and design of Earthen bund using an example from

Saharpada block of Keonjhar district: The runoff velocity has a direct relation with slope, soil type & cover. The total catchment area is 12 ha equal to the treatment area. The average slope of the area is 2.68 5% hence the runoff coefficient would be 0.30 for the catchment area as per SPS MGNREGA manual published in 2007.

The one-day highest rainfall for Saharpada block is 265mm in 30 years historical period (1984-2014) with a historical CV of 22.35% and project CV of 18%. Though the projected mean monsoon rainfall for Shaharpada block is showing an increasing trend of 18% (217mm) from historical mean monsoon rainfall of 1180mm, however, to calculate the peak runoff we have to take the one-day highest rain fall with the projected CV or historical CV whichever is higher in value. Hence, one-day maximum rainfall would be 324.2mm. Considering rational formula of calculation of runoff, $Q = CRA$ cum per day and all above data, the total runoff volume would be **13,618** cum per day.

As slope is varies and to keep a target to conserve more than 50% surface runoff, we need two different types of bunds. Following are details about both bunds:

- a) Bunds for barren patch: Total length of the bund is 3000 RM. Average height: 0.75m Top width (TW)=0.5m, Bottom with (BW) with side slope (1:1) = 2.0m Cross section area of bund=0.937 sq.m, volume=2812.5 cum. trench volume=1968.75 cum (70% of cut or loose volume). Figure 9 below has shown the cross section of the bund.
- b) Bunds in periphery and where slope is high: Length 1200 RM, TW=0.6m, BW=2.6m, Height=1.0m, cross section area=1.6 sq.m, total volume =1920cum, Trench volume =1344 (70% of total bund volume). Figure-2 below has shown the cross section of the bunds.



The trenches or borrow pits of the field bund will conserve 3313 cum. However, we have total runoff volume of 13,618 cum. As we know all earthen bund also work as earthen dam/embankment, hence each bund will also hold some water in front of the bund spreading water on each plot. The water spreading area or storage area in front of each bund (across the slope only) will depend upon the slope of the plot. The present slope varies from 1.37-3.54%, however when entire patch is covered with bunds, then each plots slope will have reduced to 1-2%. Considering a plot of 50m width and 50 m length and maximum of 2% slope, a bund will store water= $(0.5 \times 17.5 \times 0.3 \times 50) = 131.25 \text{ cum}$ considering for type (a) bund mentioned above.

- a. Total bund height is 0.75m, after settlement it would be 0.6m. We can allow 0.30m maximum water height at bund as remaining 0.3m would be free board. After 0.3 m height of water storage in front of bund rest will be dispose through outlets (either stone or vegetative hedge). Vegetative hedge are commonly used by farmers in their paddy field to safely dispose the excess runoff water after keeping a certain height of water in the plot as per the height of paddy plant.

- b. In 2% slope while the height of water would be 0.3m then the spread length of water in 50 m length plot would be 17.5m. Calculated using right angle formula. Please see details in figure 10 and figure 10.1 below.

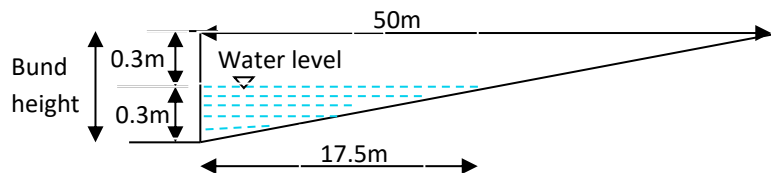


Figure 10: section of water storage in front of

Similarly, for bund type (b), considering above factors, the water storage length in the plot 50 x 50 m plots would be 26 m if we keep outlet at 0.5 m of a 1 m ht bund (keeping 25% settlement allowance, after settlement bund height would be 0.75m. if we keep outlet at 0.5 m height still we have a free board of 0.25m). Hence, the water storage volume in front of the bund type (b) of 50x50 plot would be (using triangular formula)= $\frac{1}{2} \times 0.5 \times 26 \times 50 = 325$ cum of water. Please figure-4 below for the details:

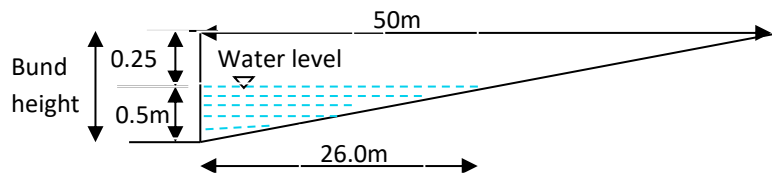


Figure 10.1 : section of water storage in front of

Now each 0.25 ha plot will additionally store water of 131.25 cum for (a) type and 325 cum for (b) type. Total treated area is 12 ha out of which 8.5 ha for (a) type bund area and 3.5 ha for (b) type bund area. While we construct bund there is a loss of area ranges from 5-7% of total area depending upon the bund size. Considering maximum area loss of 7%, we have total area to harvest water (excluding borrow pits) for bund (a) type is 7.91 ha and (b) type is 3.26 ha after deducting 7% area loss due to constriction of bund. So, total volume of water would be harvest by the bunds = $(131.25 \times 4 \times 7.91) + (325 \times 4 \times 3.26) = 8391$ cum. Now, borrow pits and bunds would harvest = $1969 + 1344 + 8391 = 11,704$ cum of water, which is 86% of total runoff volume 13618 cum. This is on the basis of maximum one day rainfall as per future climate projections. However, the present mean annual monsoon rainfall is 1180 mm. If 86% of the mean rainfall is harvested then we can harvest a total amount of $(111600 \times 0.86 \times 1.180) = 113252$ cum i.e. 11.32 crore litres of water. This is only total of monsoon rainfall (JJAS), hence it may be more if we considered the total mean annual rainfall.

Farm ponds

Farm ponds are small size pond constructed in the lowest elevation corner or point of a plot to harvest the runoff of that plot or plots above and then reuse the store water to irrigate the crop in the plot. As water store in the pond, small amounts of water percolate down the earth and join with ground water. Some places where the soil type is highly permeable, if we construct farm pond there then we may call it percolation tank. But as we have objective to harvest water for irrigation, we need to see the underground soil strata while we construct a farm pond, so that there would be minimum seepage from the pond. Where there is high scarcity of water and need assured irrigation, farm ponds are lined

with cement concrete or polythene sheets to make 100% seepage proof. But it needs extra cost. Farm pond also needs inlet and outlets depending upon the soil type and runoff volume. Looking the soil type in our proposed area there will be both inlets and outlets in the proposed ponds however those will be very small in size with loose boulder as proposed in the Primary bund. The design drawing and dimensions of stone outlet are provided in figure 11. Inlet's shape will also be same but the dimensions will be less and in some places inlets may not be required if there is sufficient vegetation is there. The side bund of the farm ponds those will be constructed by excavated soil would be compacted well and there would be grass tarping to protect them from erosion.

Design of a farm pond: Considering a one-acre plot, and other data used for calculation of runoff in above section of land development and the plot average slope of plot 2%, the one day maximum runoff= $0.5 \times 4000 \times 3.22 = 644$ cum per day. However, the total availability of water through monsoon rain is 1183mm (historical data, here we are not considering the predicted as there is only 1% decreases in mean rainfall). Then total Q for one acre= $0.5 \times 4000 \times 1.183 = 2366$ cum. This is the total availability or supply of water but, it will not receive in one go, it will be received by the farm pond in four months period (JJAS). Hence the pond may fill much time and due to evaporation and percolation it may dry or water level may go down.

Now if we calculate the demand considering paddy crop that need an irrigation during a dry spell in the monsoon season. We found that the area needs **625** cum of water considering 20cm of irrigation depth and an area of 3125 sq.m (this area is 4000 sq.m minus the farm pond and bund area). As there will be always evaporation, percolation and other losses, hence our storage volume should be 15-20% more than the demand volume of 625 cum. Hence a **750** cum volume of farm pond would serve the purpose. Now, considering average length of 18m and width of 14 m, we need a depth of 3m to get the required volume of 750cum. However, the dimensions of farm pond will be very as per the plots size and availability of land and soil depth, but the total volume must keep rain same else the pond may not able to meet the demand.

To reduce the chances of the bank erosion of the pond, rather keeping a 1:1 slope of the bank, step of 0.6 depth (total 5 steps from GL) will be provided. Figure -3 below shows the details engineering drawing of farm pond.

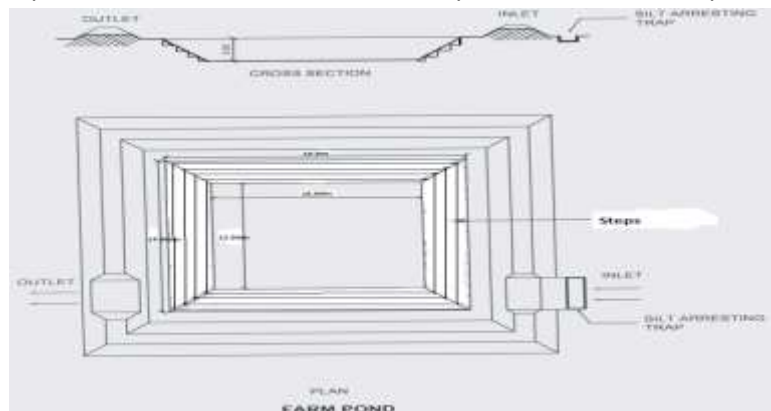


Figure 11: Engineering drawing of farm pond.

As we have an accumulated volume of water of 2366 cum that will receive in a four-month period with different intensity, we need outlet

to dispose surplus water. However, the design of outlet is always done with highest one day or one-hour rainfall intensity. Assume that the pond is full and pond received the one-day highest rainfall of 644 cum in day (as per predicted future rainfall scenario), then we need to dispose this 644 cum of water in day or even in few hours. Considering an out let with crest length of 2 m and height of 0.3m and velocity of 1.2m/sec, we get 0.72 cum of water will be dispose by the outlet in one second of

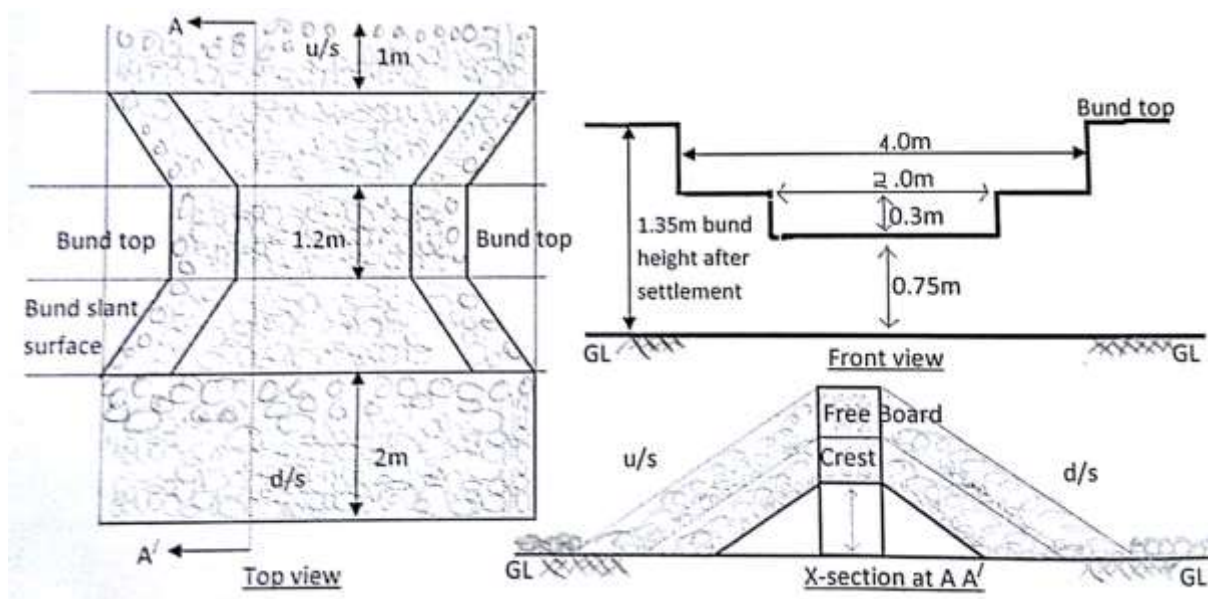


Figure 12: Design of stone outlet in farm pond

time. Hence in an hour it will dispose $(0.72 \times 60 \times 60) = 1592$ cum that is far more than the one-day maximum runoff of 644 cum. The design of stone outlet is shown on the figure 12.

Design of the Check Dam (CD)

Length and the foundation depth of a CD is depending on the width of the nala and soil depth on nala where the CD has to be constructed (shown in figure 13, 3.18 km away at downstream from the nala origin). However, the width and height of the dam need to be design as per the peak flow (Q_p) of the nala after calculation of total catchment area from where the nala get runoff water. We also need to see the characteristics of the catchment area such as soil type, cultivable and non-cultivable land, soil coverage and slope.

Explaining the concept and design of check dam using an example from Karlamunda block of Kalahandi district: After measuring the catchment area in the selected site, we found it is approximately 630 ha for where water contribute to the point of the nala where check dam has proposed. Almost more than 90% of the catchment area is cultivable and soil type is silt loam/clay. The catchment is not so undulating also. The Average slope is though only little more than 1% however it varies in all directions taking Nala is a centre point. Hence the slope range is 0.53% to 4.3%. Hence as per SPS guidelines for MGNREGA, 2007, runoff coefficient can be considered for whole catchment as 0.5.

Now, to calculate the peak flow of the nala at CD point, we need rainfall data. As per climate modelling study by IISc, Bangalore, the mean monsoon rainfall for Karlamunda is 1236mm and predicted CV is 31.5%. The predicted data is showing an increasing trend of 25% mean rainfall for the block in next 30 years (2021-2050). The maximum one-day rainfall is 246mm. Now to calculate the peak runoff at the point of CD at nala we have to consider the historical mean plus the predicted variation, so the possible maximum one-day highest rainfall could be $= 246 + 246 \times 0.315 = 323.49$ mm. So, $Q_p = C_x R_x A = 0.5 \times 0.3235 \times 630 \times 10000 = 1018994$ cum/day. $Q_p = 1018994 / (24 \times 60 \times 60) = 11.79$ cum/sec (figure 13).

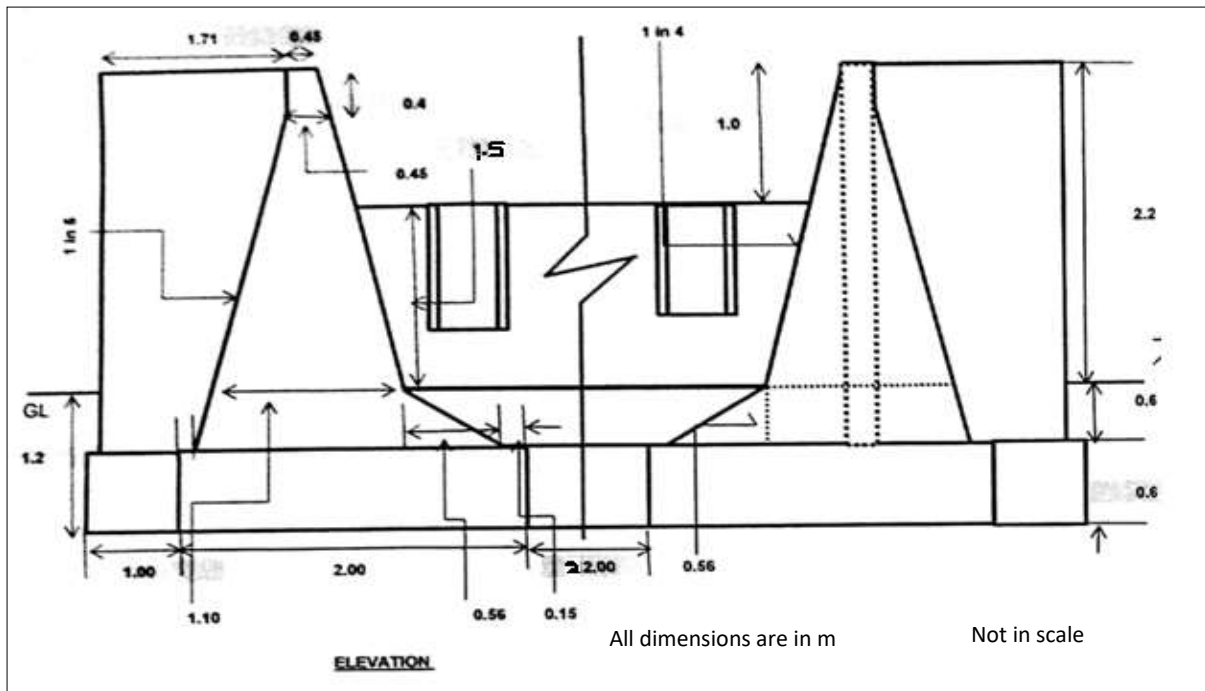


Figure 13: The engineering design of the Check Dam.

The crest of the CD is required design on the basis of the Q_p . After field survey it is found that the nala width is 24m and the depth is 2.5m. The foundation depth required is 1.2m. As per villagers demand they want height of CD is 1.5m. Hence, we have a crest of 1m height, and 22m width (considering side wall and apron will take 1 m of length of CD in each side). Nala flow (velocity) is generally varies from 0.9 to 2 m/sec. Considering an average velocity of 1.45m/sec and a free board of 30% of crest height of 1m, we have water flow height of $1-0.3=0.7$ m. Now the area of crest through where excess water will flow $=22*0.7=15.4$ sq.m. As we know $Q_p=AxV$ (A =area of crest, V =velocity in m/sec) $=15.4*1.45=22.33$ cum/sec, that is almost double of the Q_p we have calculated above (11.79) considering one day highest rainfall on project climate change scenario. Beyond these there would be also two small MS steel gates of size (0.9m(D)x0.6m (W)), to minimize further risk of damage of the Cd due to water pressure and also these keep open if there is siltation found in upstream and silted water comes to the nala to reduce the chances of siltation in storage area of the check dam. Silt deposition in the upstream of the CD will reduce the storage volume. Else these gates will be keeping closed. Other dimensions are shown in the engineering design below in figure 13.

Field Line Channel

Explaining the concept and design of field line channel using an example from Golamunda block of Kalahandi district: The east side plots of the Bindermunda nala, are little higher in elevation (upland) mostly undulated, poor soil quality hence generally either rainfed cotton, maize of other crops is grown in kharif, however, the west side, low land with good quality soil and plots are having bunds to cultivate kharif paddy. Most of the plots are in lower elevation than the nala embankment. As the elevations of these plots are decreasing north to south direction similar to the nala gradient, during monsoon water flows from upper plot to lower plot. Some places farmers cut the west side nala bank and divert the water to their field. Hence community raised demand that if CDs are constructed along with field channel more water can be diverting to irrigate more area and mainly any dry spell during monsoon, due to check dam, water level in nala will be raised and can be diverted to these plots. So

as per the proposed command area situation during field visit we found there would be total of 380m length of can required to cover 7 ha of command area in two different patched by proposed 3 CDs. A lined field channel of dimension shown in the figure 14 is proposed. 0.25m thick masonry walls will be constructed for lining. Considering a velocity 1.2m/sec channel flow and a free board of 0.15m, the field canal will have capacity to carry 0.243 cum/sec, i.e. 243 liters per sec, so it can easily irrigate 7 ha of land in a day or two for paddy crops. The canal will be constructed over the bunds already existed in the field maintaining a gradient and length so that all upper elevated plots can get water and from those plots, the lower plots will get water. Else constructing lined canal for each plot will be costly and not economical as plots sizes varies and mostly they are small.

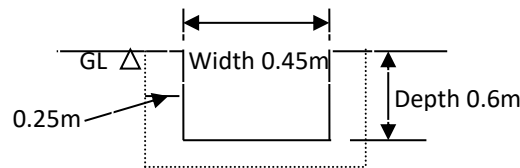


Figure 14: Section of the lined field

Gully control measures

- a) Vegetative measures by planting grass saplings of vertiver and other grass seed on heads and banks of gullies along with peripheral bunds (size of peripheral bund would be same as a) type bund mentioned in land development section and length also considered there). Image 1 shows the vertiver grass.



Vertiver grass

nest

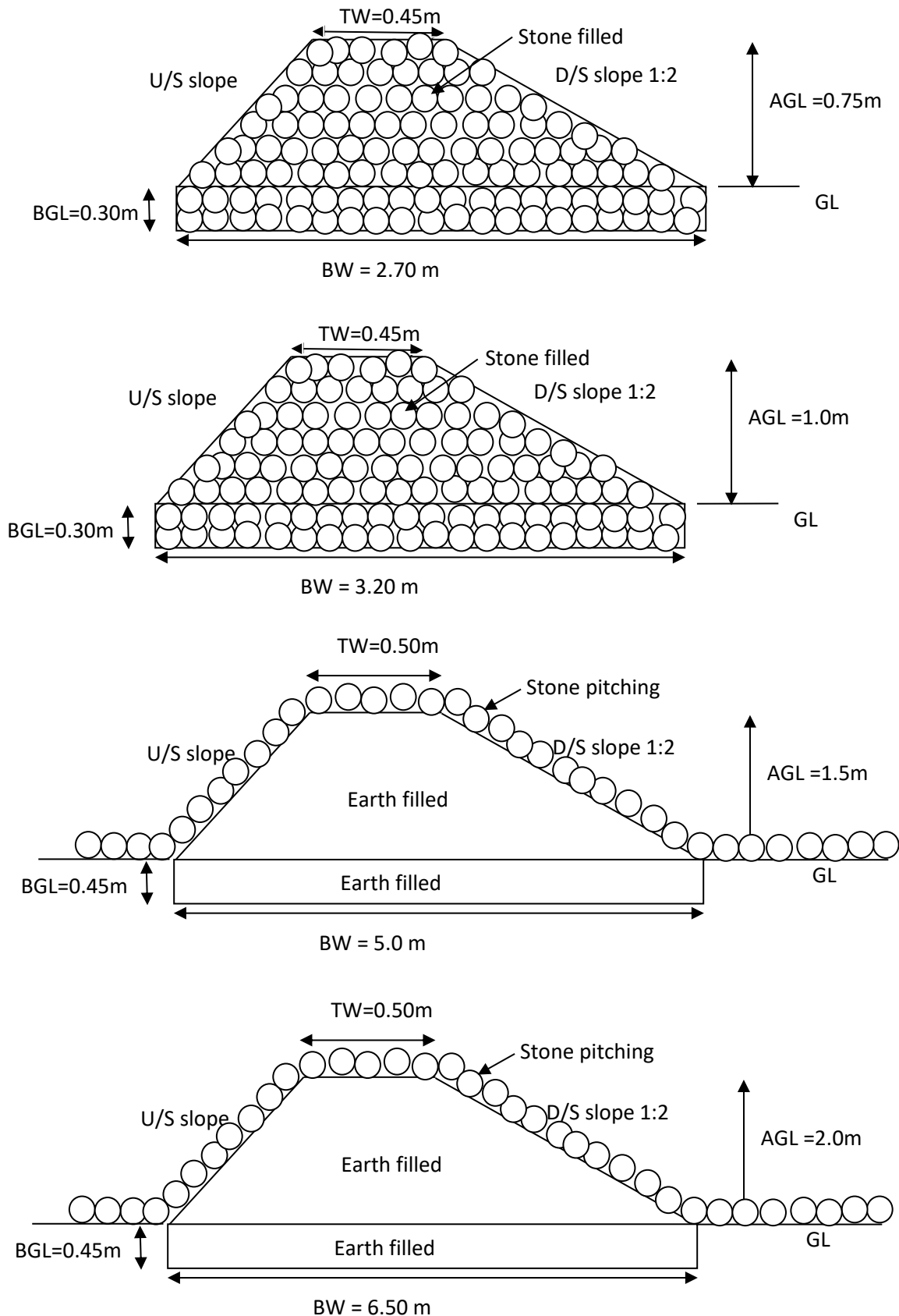
- b) LBCD: Loose boulder check dams to control runoff intensity and check soil erosion. LBCDs are very efficient to stabilize gully by retaining the eroded soil in front of them if constructed in series and over passes of time, land converted in cultivable land. The approach adopted is that the bottom of the upstream LBCD level (RL) should be same as the top of LBCD of downstream. However, it has limit in height as loose boulders are just arranged above the ground on gully bed with 0.30 m depth foundation, hence more height may cause collapse of the LBCD. As per requirement we need almost 20 LBCDs with two different heights 0.75m and 1.0m.

- c) Earth filled and stone pitched check dams: As the gully height here is more than even 3m, hence we have to go with this type of arrangement where we need a LBCD more than 1.2 to 1.5 m height. In this type, there would be foundation then earthen bund/dam with required size would be constructed and then pitching will be done on the earthen bund/dam keeping a small and along apron in upstream and downstream respectively so that the water over topping from the dam will not scour the soil in the downstream. This also make cost effective and constructed almost at the downstream part of the gully where gully depth and width is

more. **Example from Saharpada block from Keonjhar district:** As per site requirement we need 10 such structures with two different heights 1.5 m and 2.0m.

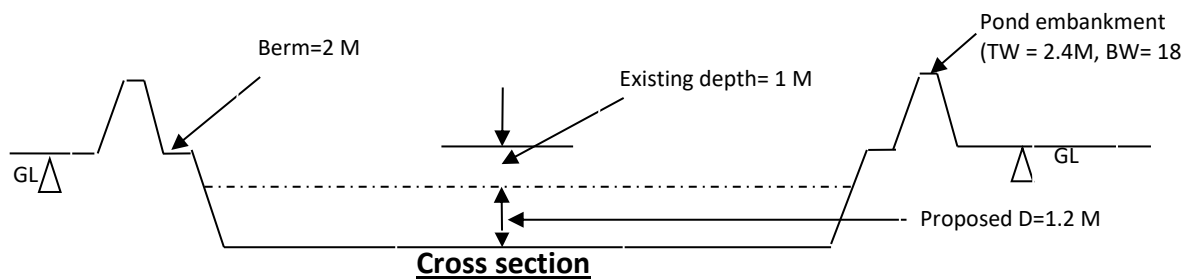
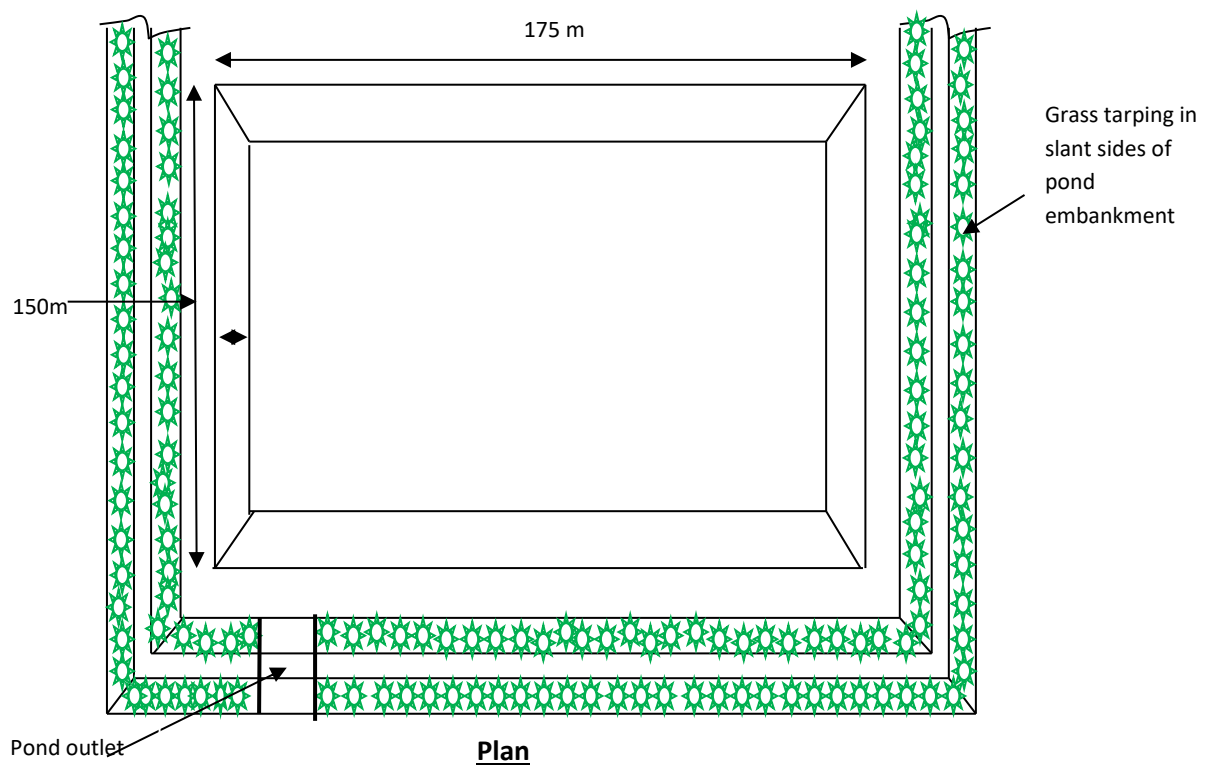
The cross section of all gully plugging activities (types of LBCDs/check dams) are shown in figure 15 below. All LBCDs/check dams suggested here are only to stabilize gullies and control runoff intensity to checks gullies from further augmentation of gully heads, wide and depth.

Figure 15: Cross section of suggested types of LBCD/Check dams as gully control measures:



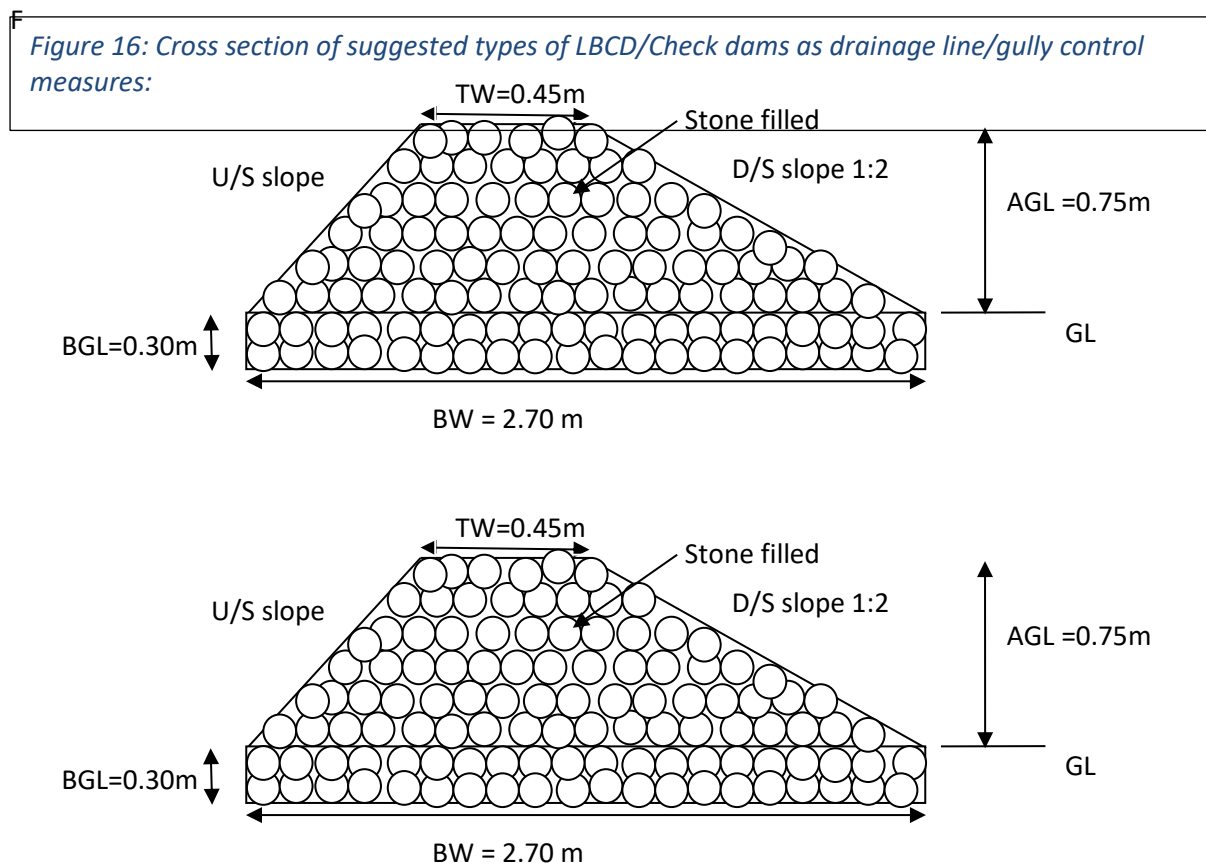
Deepening of the tank:

Description of primary bund design with an example from Narla block of Kalahandi district: At the selected site, the tank has embankment in two sides and other two sides are covered with hills. The total storage area of the tank is approximately 3 ha. As the work had been done in many phases, though excavation has been done in a huge area but it has shallow depth and also due to steep slope of the hill and many drainage lines discharge into tank, there is siltation found in the tank bed. Hence de-siltation, i.e. deepening of the pond has been proposed by the community. Deepening is also required in the area where the sluice is constructed to release the water for irrigation. As the deepening is required in many places where there is undulation and more situation has happened. Hence, there is no such design can be prepared for tank renovation. But an approximate volume has been calculated and that is 3,500 cum. Hence a capacity of storage volume of 3,500 cum of water i.e. 35,00,000 liters of water.



Construction and design of Loose Boulder Check Dam (LBCD)

An Example of the use and the design of LBCD from of the site in Narla block of Kalahandi district: 24 ha of and is there where there is lower density of trees those are not in lined, hence taking other activities such as contour bunding and trenching are not feasible as forest department will not allowed due to cutting of trees. However, drainage line treatments by LBCD are allowed and can be done there to check runoff intensity and check soil erosion. The drainage lines are distinct slope of these drainage lines also feasible to construct moderate size LBCDs. LBCDs are very efficient to stabilize gully by retaining the eroded soil in front of tem if constructed in series and over passes of time, land converted in cultivable land. The approach adopted is that the bottom of the upstream LBCD level (RL) should be same as the top of nest LBCD of downstream. However, it has limit in height as loose boulders are just arranged above the ground on gully bed with 0.30 m depth foundation, hence more height may cause collapse of the LBCD. As per requirement we need almost 30 LBCDs as per dimension mentioned in the figure 16.



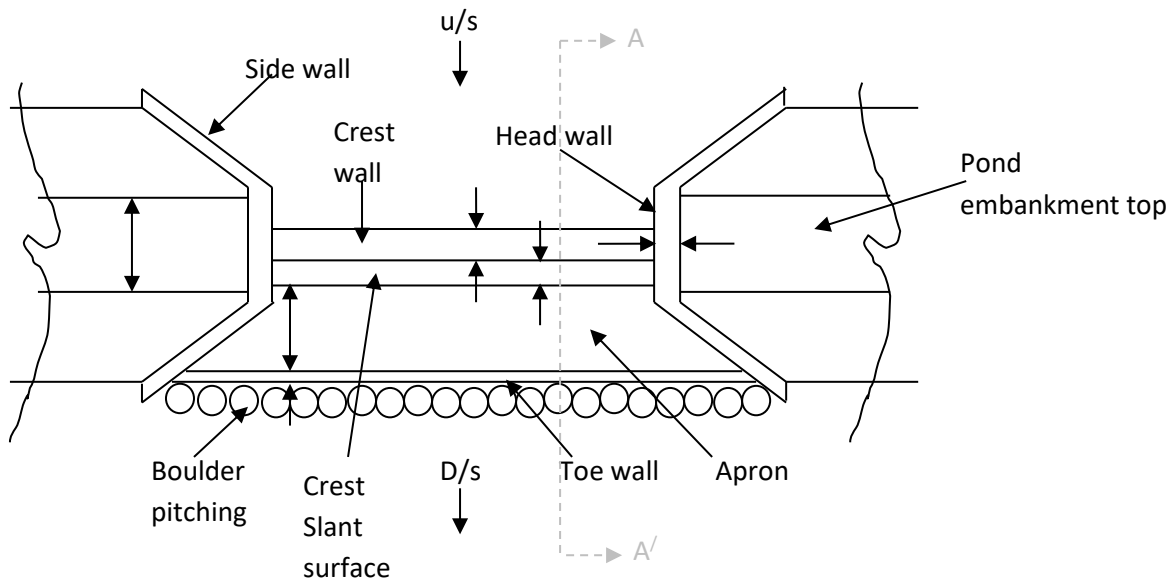
Construction of waste weir:

Example of the design & plan from Deogan Block of Balangir district: Waste weir is an important part of a WHS/tank. It is design on the basis of peak discharge Q_p , that has already been calculated and mentioned above. Now if the WHS is already in full tank level (FTL), then the waste weir would have capacity of dispose whole volume of runoff.

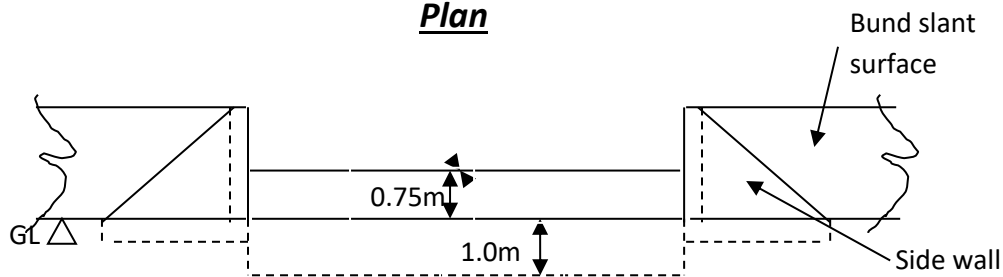
The crest of the waste weir should be same elevation as FTL. If in future it is found that there is scope to store more water after settlement of the WHS and still is strong then by increasing height of the crest of the waste weir we can increase the storage volume of the dam. Considering a crest length of

9 m and crest height of 0.75m with 0.21m as free board (as after settlement of the WHS, we have only 0.8 m elevation difference from crest level and the WHS top level) (please refer to figure-1), and considering flow velocity as 1m/s the discharge will be 6.75 cum/sec, that is more than the $Q_p=1.27$ cum/sec mentioned above. The length of crest could be keep less but it is better to keep more if there is space and area as some time frequent rainfall may occur continuously for few days and accumulation of runoff may be more, hence a free board and bit larger size waste weir are kept for safety purposes as the structure is earthen.

Figure 17: Design of waste weir



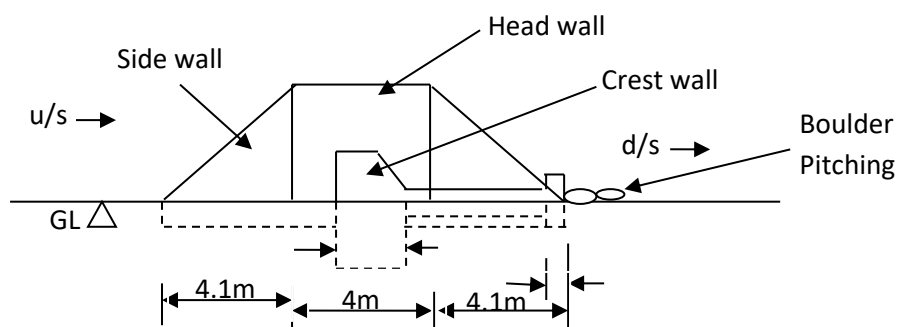
Plan



Side wall foundation D=0.5M

Crest foundation D=1M

Elevation from u/s



Section at AA'

Retaining wall:

Retaining wall is constructed perpendicular to the water flow in a stream to store some water in front of the wall. In general retaining wall also constructed to retain landslides in hilly area. But in this context, it is constructed to retain water only. The main pipeline will be inserted in the bottom of the wall to carry water to the agricultural field and in the village.

Example of the design of one of the site in Udala block of Mayubhanj district: From the site visits and measurement, the details dimensions and design of the retaining wall is shown in the figure 18.

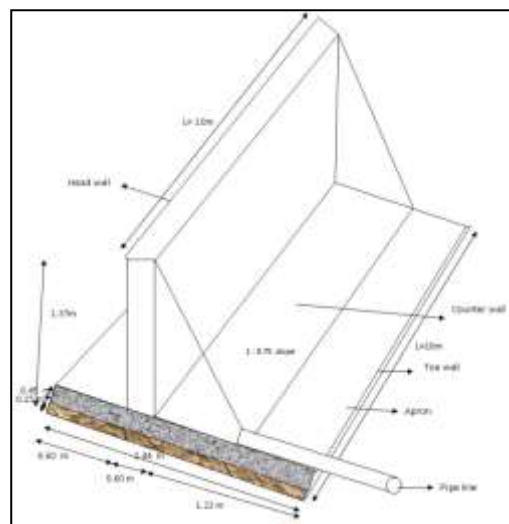


Fig 18: Example of Retaining wall from Udala block of Mayurbhanj district

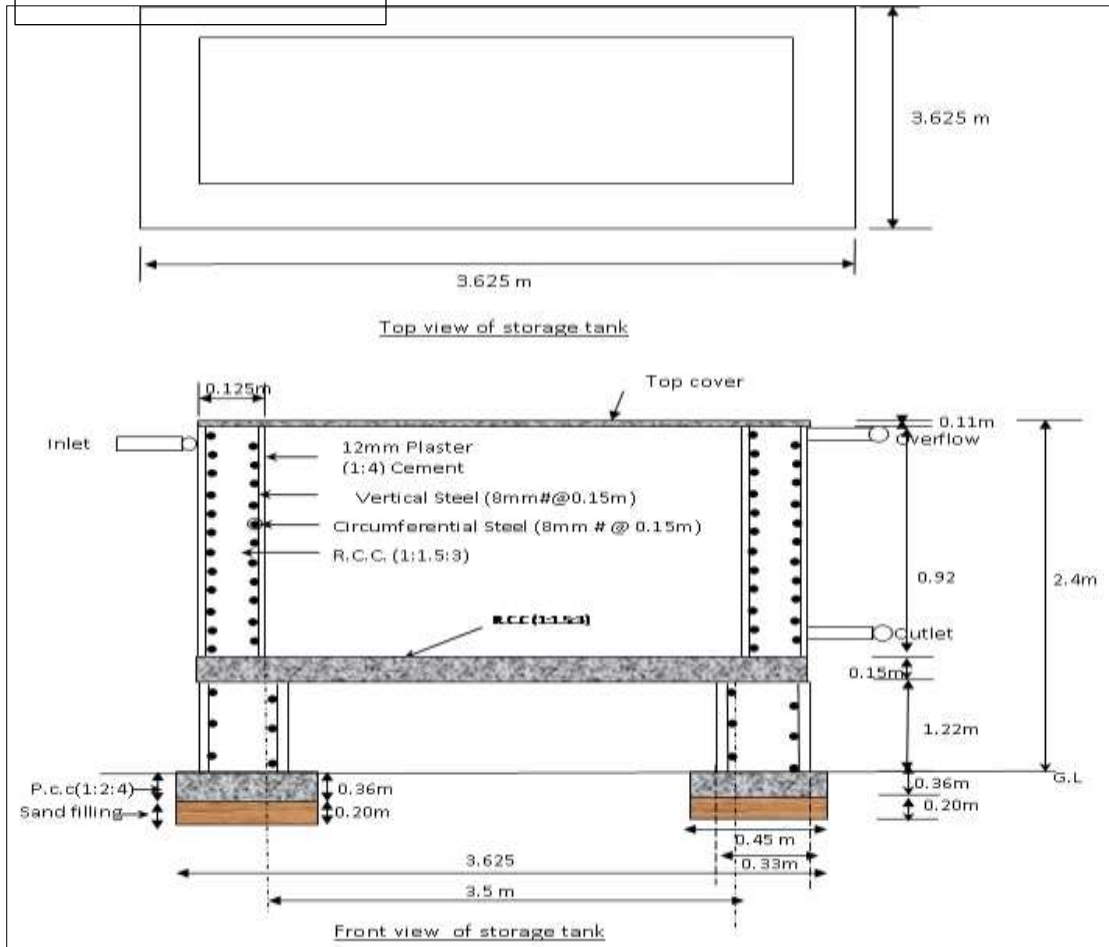
HDPE pipeline

This line will be connected from the source (at retaining wall) to the storage tank at village for domestic supply. **Description and the use of the HDPE pipe line from one of the site in Udala block of Mayubhanj district:** As the agricultural plots (command area) fall in the middle of the village and the source (stream), so, 9 raised outlets will be constructed in the main line with closing and opening valves to irrigate water. Due to outlets in intermediate section of the pipeline, various diameter pipes will be used such 110mm, 90mm and 75mm (from source to storage tank). Just when the pipeline reaches the foothills, another 100m length of pipe will be connected with main pipeline to divert water to another plots situated north side with an area of 1 ha. Hence total length of the main pipeline would be 1150m out of that 690 m 110mm, 350m 90mm and 110m 75mm pipes.

Storage tank

Description and the use of the Reinforced concrete water storage tank design from one of the site in Udala block of Mayubhanj district: A Reinforced Concrete Water tank (RCC) of 10,000 litres capacity would be constructed on the main village roadside (shown Figure 18) to store water and supply 24 hrs to all 35 HHs. The design dimension of tank has been considered as per the peak demand hour supply. There is approximately 200 populations in the hamlet. In peak hours if we consider 50 litre per head then we need a 10,000 litres capacity tank with an additional storage of 1270 litres as free space. Hence the tank inter size is 3.5m x 3.5m x 9.2m. The tank would be constructed in an elevated plant form shown in figure 19 to main the pressure head of water supply through 15 taps.

Figure 19: RCC Storage tank



Domestic water supply pipeline network

Description and the use of the Domestic water supply pipeline from one of the site in Udala block of Mayubhanj district:

Another pipeline or pipe network would be connected from the storage tank to doorsteps of 2-3 households. A tap with stand will be provided for 2-3 HHs so that they can collect water from that tap for 24 hours. A 40mm diameter PVC main pipe (500m length) would pass through the side of the village kuccha road. From that main pipe there would be connecting pipe to connect with each tap. The connecting pipe would also be of PVC; however, MS pipes would be used as riser for taps. A cement concrete platform would be constructed for each tap with provision of drain so that each tap site would remain clean.

Trenches for lying of pipelines: There would be two types of trenches dig for laying pipes for irrigation and for domestic uses. As the pipe diameter is higher of irrigation pipelines and it also passed through agricultural land hence the depth and width of this pipeline would be more. However, as the diameter of the domestic pipeline is less and it will pass along the roadside hence its size would be less. Below figure (Figure 20) shows the average dimensions of both types of trenches. Length of irrigation pipelines is 1150m and domestic supply is 500m.

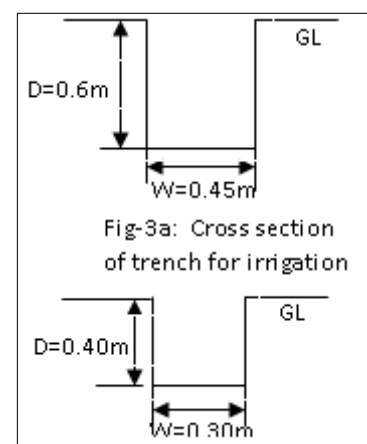


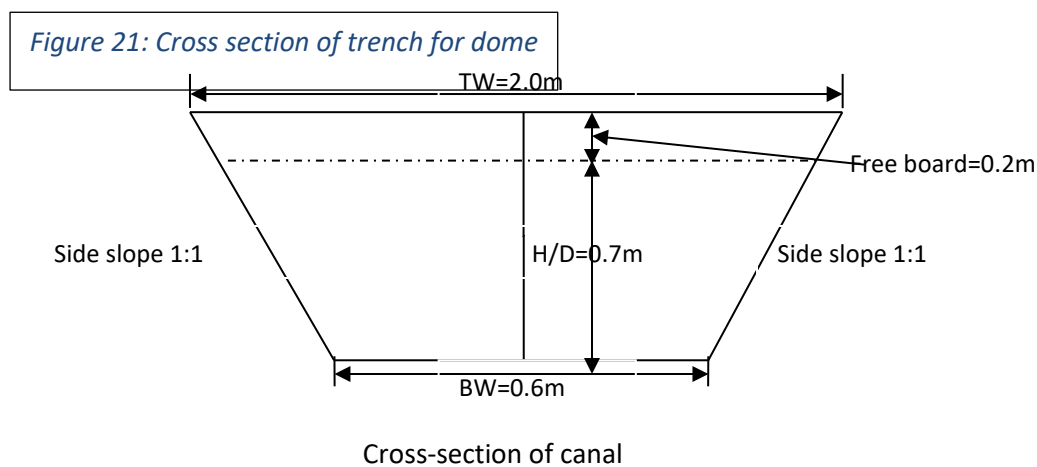
Figure 20: Cross section of trench for domestic

The excavated earth during excavation would be kept aside and will be used to refill the trench after laying pipes with proper alignment and compaction.

From above it is obvious that there are many sub activities in CRW with different longevity. However, as most of the work are RCC, cement concrete, HDPE, PVC and MS pipes hence it can be assumed that the life of the CRWs would be or more than 20 year (20-30 years). However, it required little maintenance like cleaning in front of the retaining wall, cleaning of tank and also cleaning of irrigation outlets (though those would-be L shaped). As it is not required any mechanical or electrical devices to lift the water, hence maintenance and running cost is low and life would be more. All proposed interventions need three major types of materials- earth, stone, brick and cement, sand, stone chips, HDPE, PVC and MS pipes. Except HDPE pipe all are available in the local market, however HDPE pipe has to procure from outside as per government norms. As the design has been made according to the needs and also climate indicators such as volume of stream flow of work has been calculated as per technical feasibility; hence interventions are neither oversized nor under sized. So, the costs are effective.

Canal Designing

An explanatory example from Gudvela block of Balangir district: As the site demands and a small line is passed from the catchment area to the WHS we want to construct a canal lining there so that water could be able to flow continuously from the catchment to the WHS without any obstruction in a continuous parallel line. As the total runoff for the catchment area i.e. 30336cum/day so that we have to design the canal such that the total runoff could pass in it without damaging the canal.



Discharge Calculation through the Field Canal (Q) = $A \cdot V = [\frac{1}{2} \cdot (2+0.6) \cdot 0.7] \text{sqm} \cdot 1 \text{m/s} = 0.65 \text{cum/sec}$ which is much sufficient than the runoff. Hence the design is safe.

Construction of new dug well

An explanatory example from Gudvela block of Balangir district: Dug well will be constructed to provide assured irrigation in the command area. As through WHS, field recga and other proposed activities, it is expected that there would be enhance ground water recharge, hence dug well has been proposed to provide assured irrigation to provide water to mango plantation so that there would be survival of plant and increased productivity (Fig 22.).

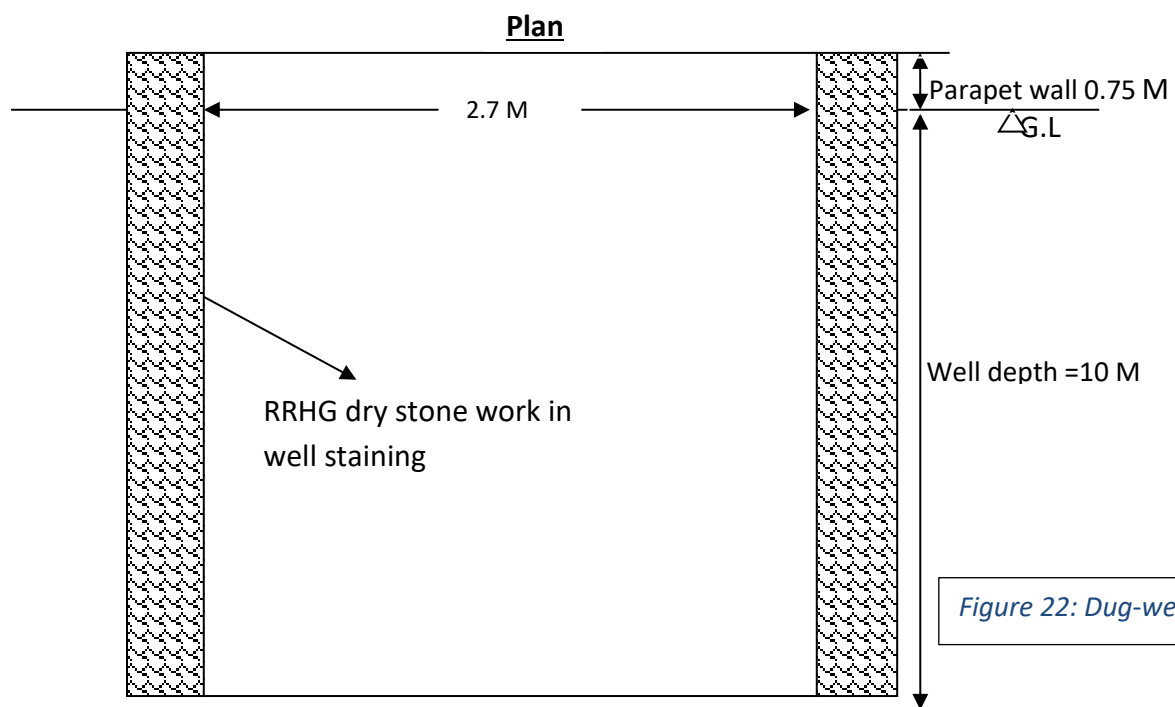
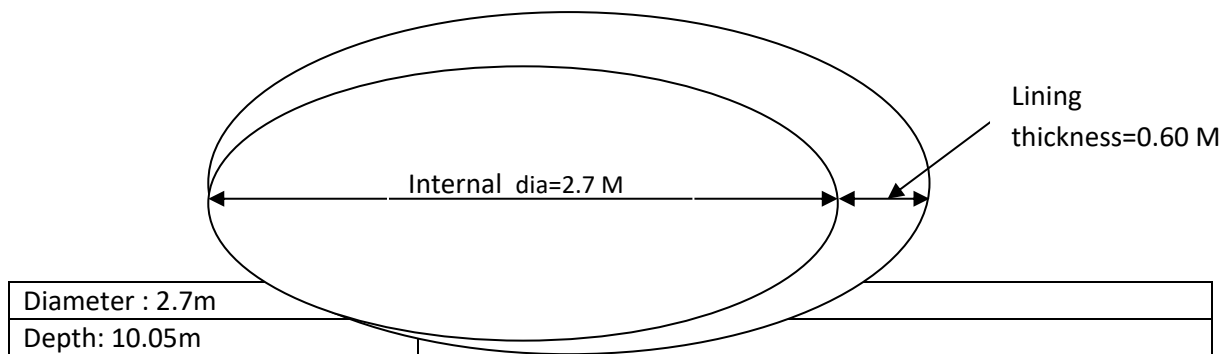


Figure 22: Dug-well design

Water harvesting structure for Pond

An explanatory example from Gudvela block of Balangir district: The site condition of farm pond seems to be flat & undulating topography and water table may not be too close to the ground level. The site of pond could achieve the high-water storage through rain fall precipitation and may be permissible to create flora & fauna, surrounding the bank site and command area.

Pond capacity

Pond capacity could be measured by the total water requirements which are as follows:

Pond capacity = Total irrigation requirement + 20 % of the sum of the other losses.

Mustard Crop: - water requirement: if we grow the Mustard crop in 6 hectare the total no. of irrigation required = 2 Nos. Depth of irrigation must be 10 cm. below the ground at root zone depth.

$$= 6 \times 10000 \times 0.10 \times 2 = 12000 \text{ cum.}$$

Domestic Purposes: domestic cum livestock water requirement is taken as 10% of the total water requirement for irrigation purposes.

$$= 12000 \times 10 / 100 = 1200 \text{ cum}$$

Other Loses: Under the other loses we consider the water requirement in term of transpiration, Evapotranspiration, and vaporization etc. Taking 10% of the above amount for water requirement (5-10%).

$$= 13200 \times 10 / 100 = 1320 \text{ cum.}$$

Dead Storage:

Dead Storage is the water which stored round the year into the pond can be calculated as follows. = Area of the Pond x Ht. of water will store.

$$= 7200 \times 0.90 = 6480 \text{ cum.}$$

Total Water Requirement for Different Head = 12000 + 1200 + 1320 + 6480 = 21000 cum

Capacity of the pond (volume Content): Volume of the Pond Calculated as follows

$$= AV.Ht \text{ of water stored} \times \text{Area of the Pond}$$

$$= 7200 \times (1.0 + 2.0) = 21600 \text{ cum.}$$

Excess water for safe disposal from the Weir of the Pond is = 6880 cum/day or 0.08 cum/sec which is able to be checked as per the design of Waste weir given below.

Recommendation: Collecting all hydrological information regarding above pond and physical investigation, it is calculated that actual crop water requirement from several purposes is lower than the pond capacity. Viewing the above fact the site of pond seems to be Climate resilient, technically feasible, economical and viable.

(ii) The crop water requirement + ET crop + other losses are lesser than the pond storage which will enhance the dead storage capacity of water for round the year.

(iii) The excess run of water can drain through weir in rainy season for safe disposal of water

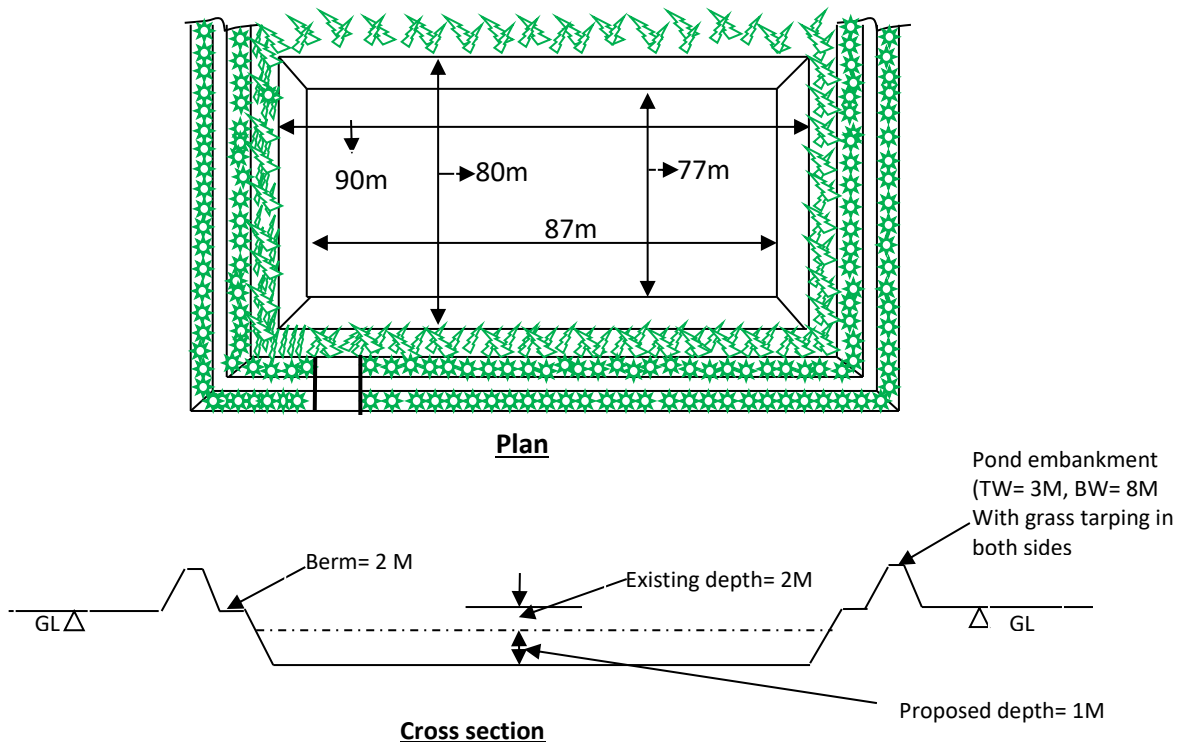


Figure 23: Cross section of Pond WHS

Design of Guard wall

An explanatory example of Construction of Guard Wall in Jhumpura block of Keonjhar district: A masonry Guard wall of $1 \times 30 \text{m} \times 0.3 \text{m} \times 1.8 \text{m} (1.2 + 0.6 \text{m})$ is to be constructed in front of the existing check dam of 24m to check the seepage of water and to arrest silt.

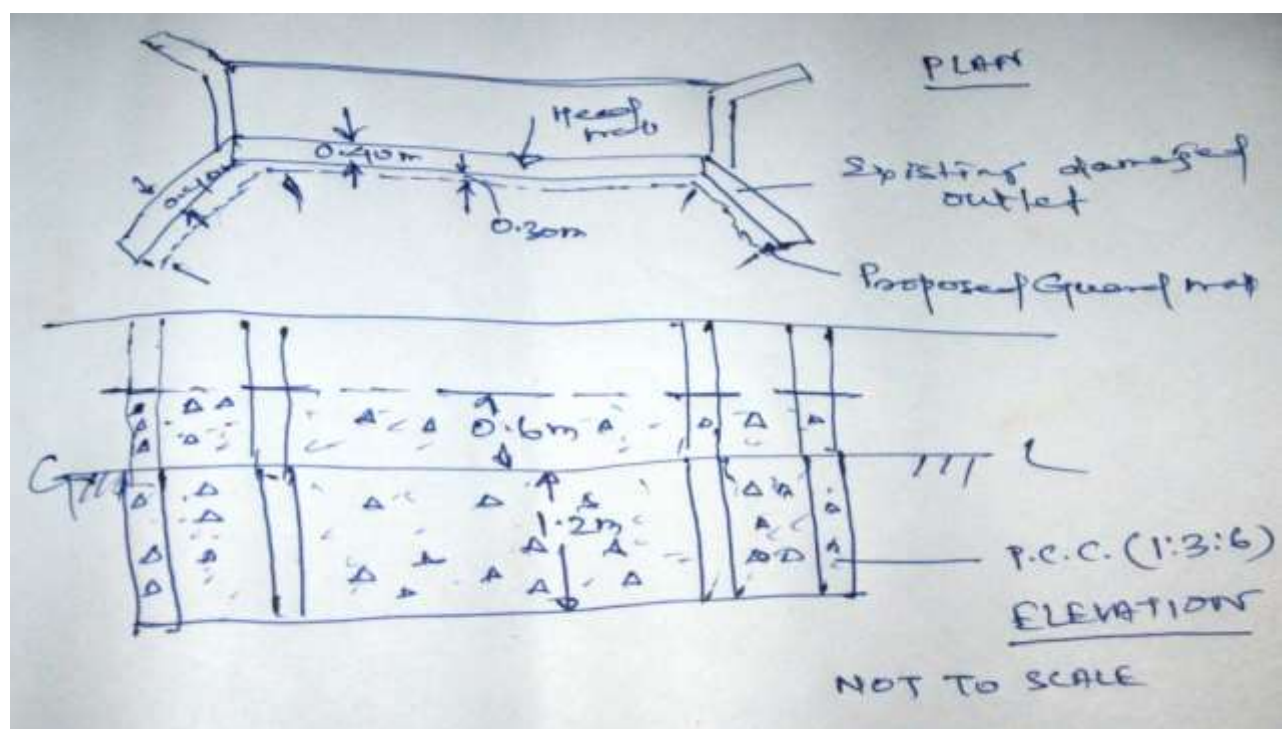
Length of Guard Wall:-30m

Foundation Depth-1.2m

Breadth:-0.3m

Height above ground level:-0.6m

Figure 24: Diagram of the guard wall design



Design of Earthen Embankment (Dam).

An explanatory example from Jashipur block of Mayurbhanj district: Earthen dams are constructed in a depression points to connect (straightly or slightly curved) to joined two higher elevation on both sides of the depression points (left and right, if stand faced toward upstream side) with large command area. Earthen dams are bit cheaper than concrete dams if compared with length. Clay soil is a must requirement material to construct earthen dam to reduce water losses due to seepage. During field visit we found there is clay soil and all abovementioned parameters are fulfilled the proposed site (Figure 25).

The storage area of the earthen dam is calculated as the excavated volume of earth in upstream to construct the embankment and the storage that will be created by the embankment up to the crest level of the outlet. The total excavated volume is 613 cum and the average depth of the storage by the embankment is 1.8m and area is 3800 sq.m, hence the storage volume= $1.8 \times 3800 = 6840$. So, the total storage volume is $613 + 6840 = 7453$ cum i.e. .74 ha-m or 0.8 ha-m that is sufficient to provide lifesaving irrigation of almost 10 ha of land. Following is a cross section of the embankment at maximum height

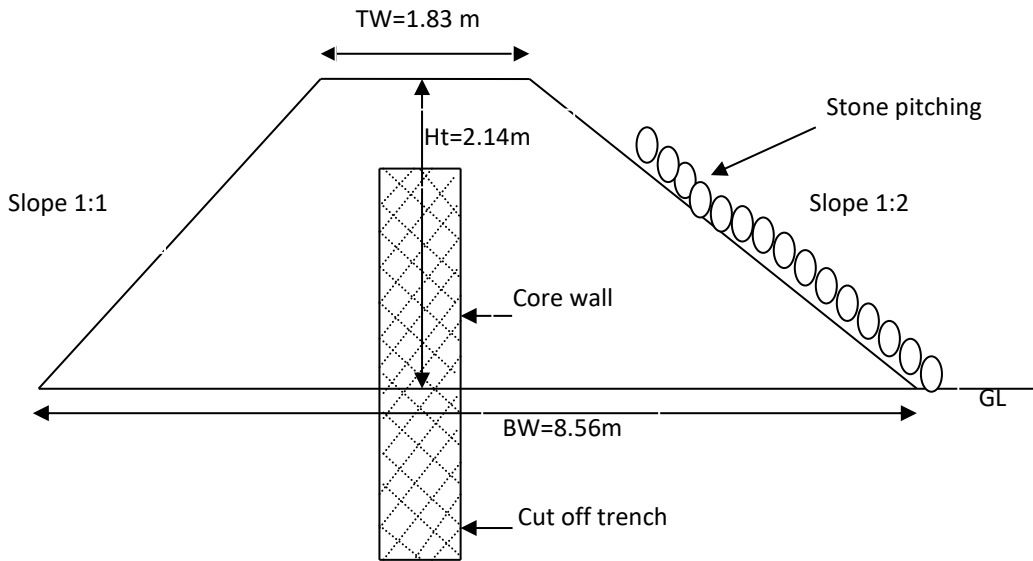
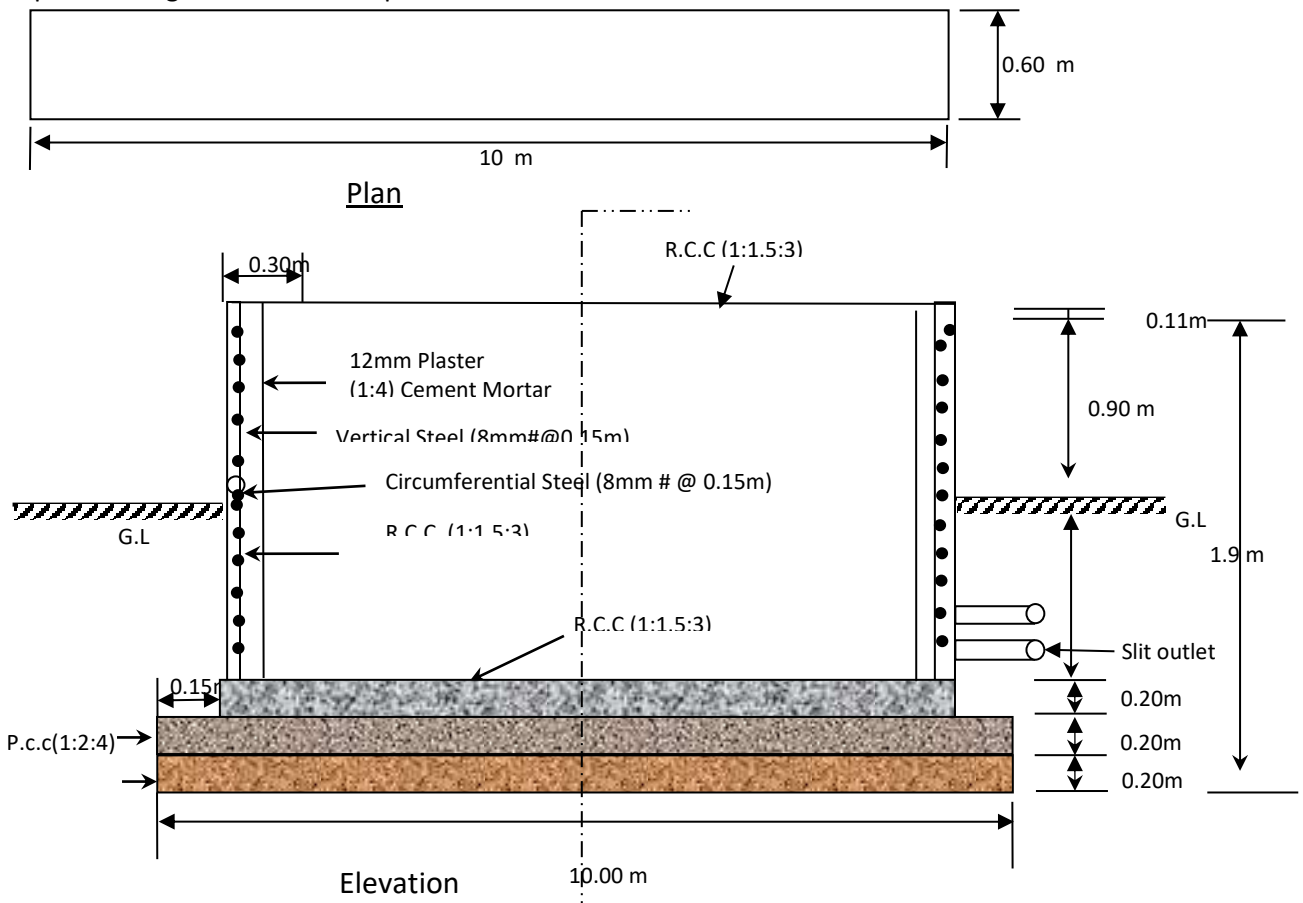


Figure 25: Cross section of the ED at maximum width

Diversion Weir

An explanatory example from Jashipur block of Mayurbhanj district: 10m length diversion weir provided at the downstream of the catchment area to divert maximum water directly to the agriculture field. In above diagram details of the diversion weir provided. Gate provision is provided at the diversion weir to provide irrigation for two sides. example when main gate is off water divert directly to agricultural field. When it opens it requires to pass some distance by earthen canal to provide irrigation to the land present at other end.



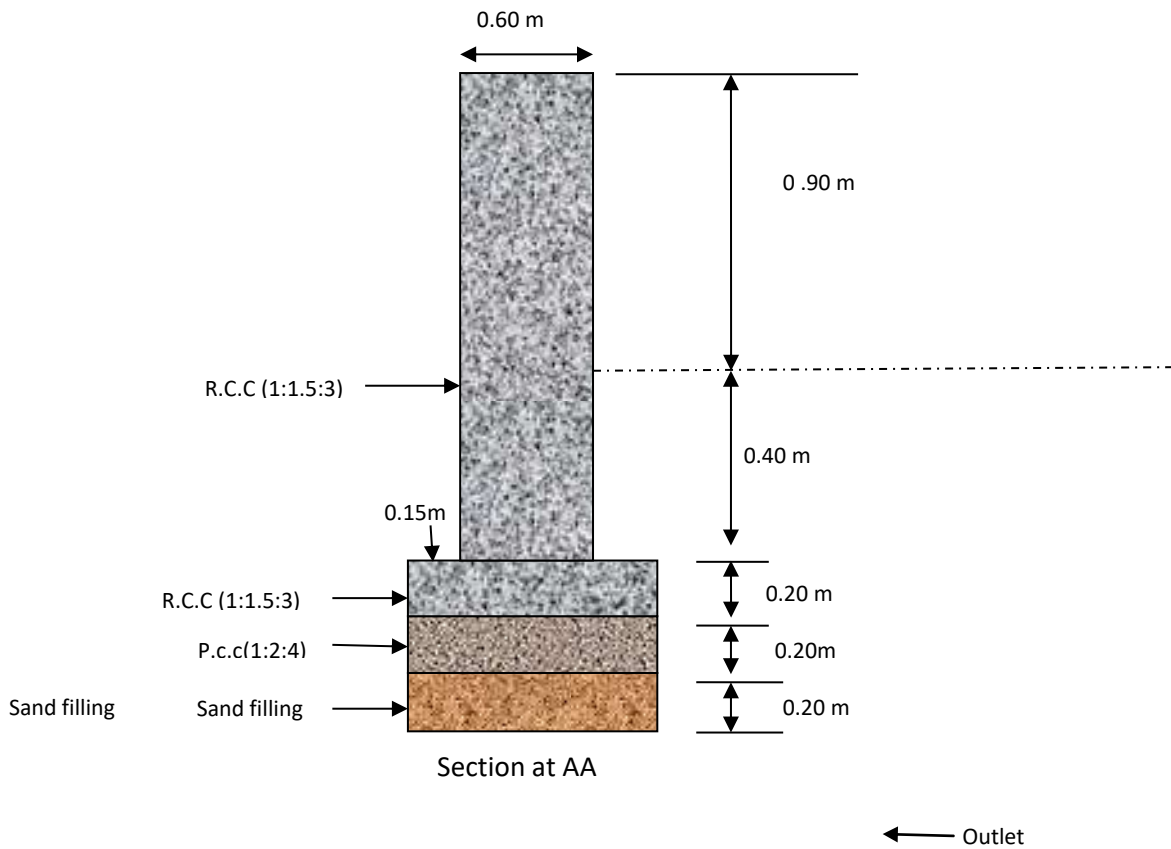
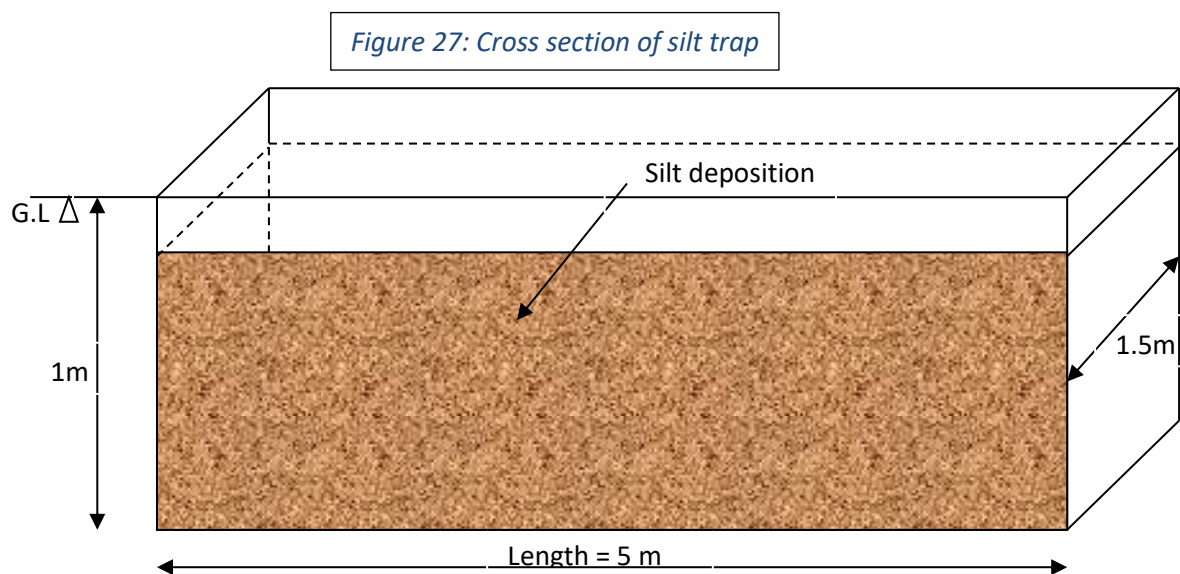


Figure 26: Design of diversion weir

Silt Trap:

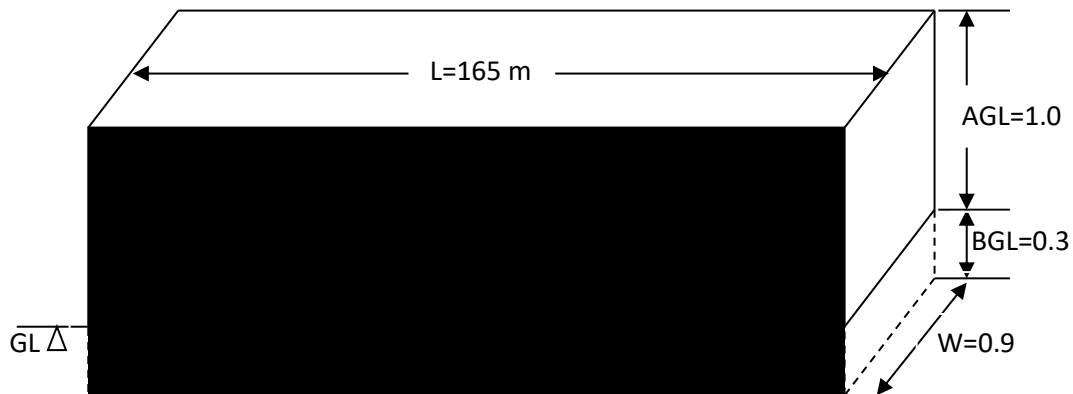
An explanatory example from Thakurmunda block of Mayurbhanj district: Numbers of silt traps will be constructed in the upstream side of the pond to collect water first in the silt trap to retain silt and then silt less water will flow to the pond. An engineering drawing of the silt traps is shown in figure 26



Stone Bunds:

An explanatory example from Thakurmunda block of Mayurbhanj district: Stone bunds will be constructed in the catchment area to check the high runoff intensity almost 100m away toward upstream side of the pond. It will also check some amount of silt. Total length of the bund s 165m. Shape and sizes are shown in the below diagram.

Figure 28: Cross section of stone bund

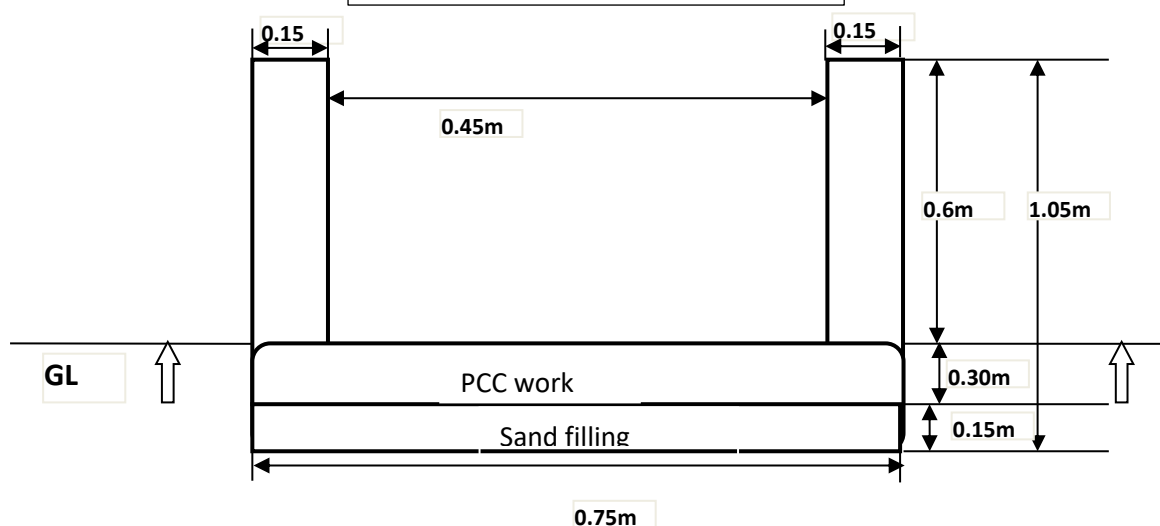


Cement concrete canal:

An explanatory example from Bisoi block of Mayurbhanj district:

A canal of length 694 m would be constructed to carry the tank water to the command area through gravity flow. This will increase the irrigation efficiency and reduce the chances of unequal use of tank water by the community. Thus, it will increase equality and ensure water to the command area beneficiaries as per the calculated water demand and requirement the detailed design and cost estimate are given below.

Figure 29: cement concrete canal

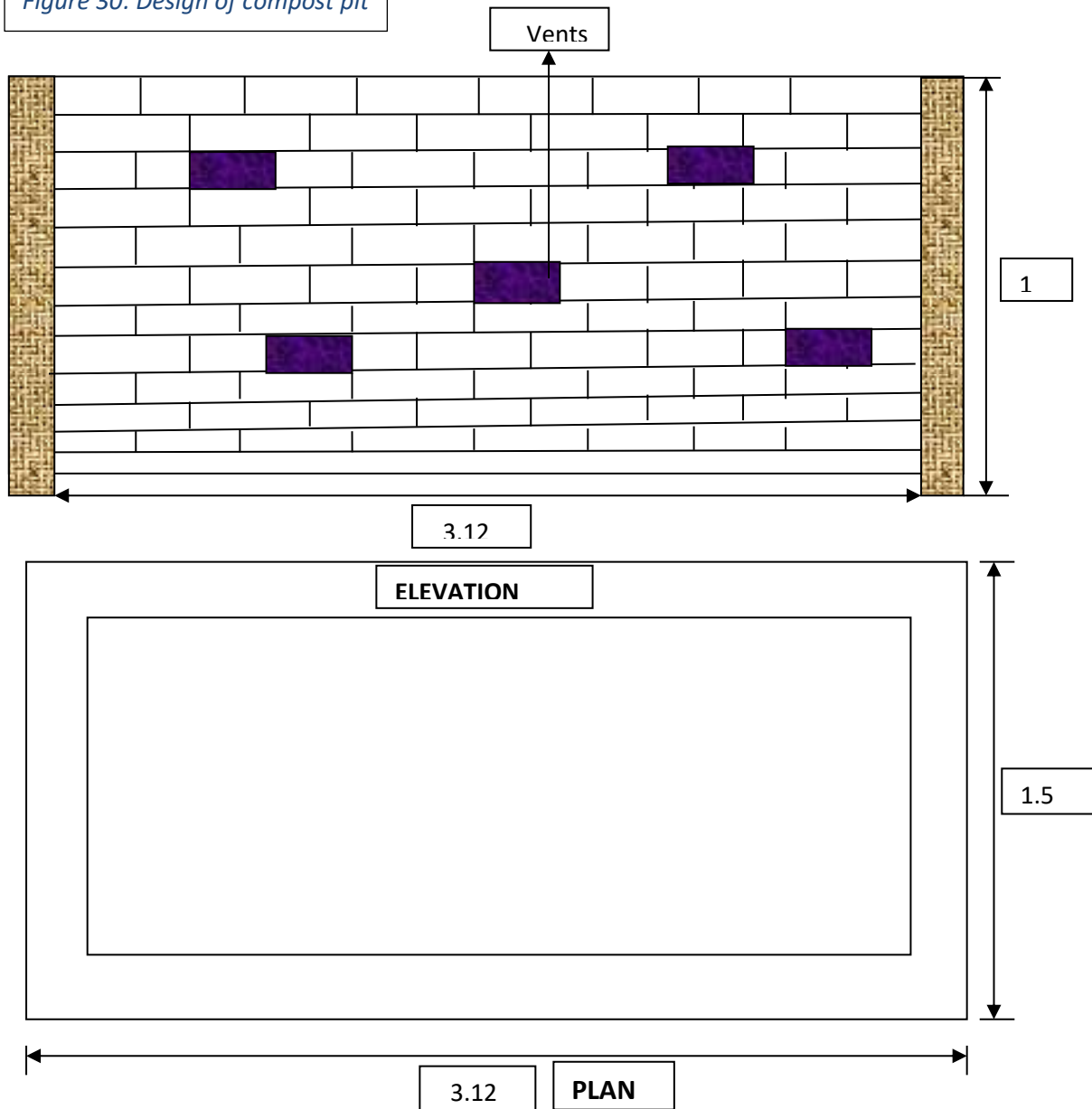


Cross-section of canal

Compost Pit:

An explanatory example from Jamda block of Mayurbhanj district: Looking the livestock availability and scope of construction of compost pits along with the demand of the beneficiaries, 19 compost pits are proposed for all beneficiaries. The model design and estimate has been provided below. Details about the compost pits, process, size, its filling procedures and turning mechanisms are provided in CRW-1.

Figure 30: Design of compost pit



Earthen Embankment:

An explanatory example from Jamda block of Mayurbhanj district: Earthen dams are constructed in a depression points to connect (straight or slightly curved) to joined two higher elevation on both sides of the depression points (left and right, if stand faced toward upstream side) with large command area. Earthen dams are bit cheaper than concrete dams if compared with length. Clay soil is a must require materials to construct earthen dam to reduce water losses due to seepage. During field visit we found there is clay soil and all abovementioned parameters are fulfilled the proposed site.

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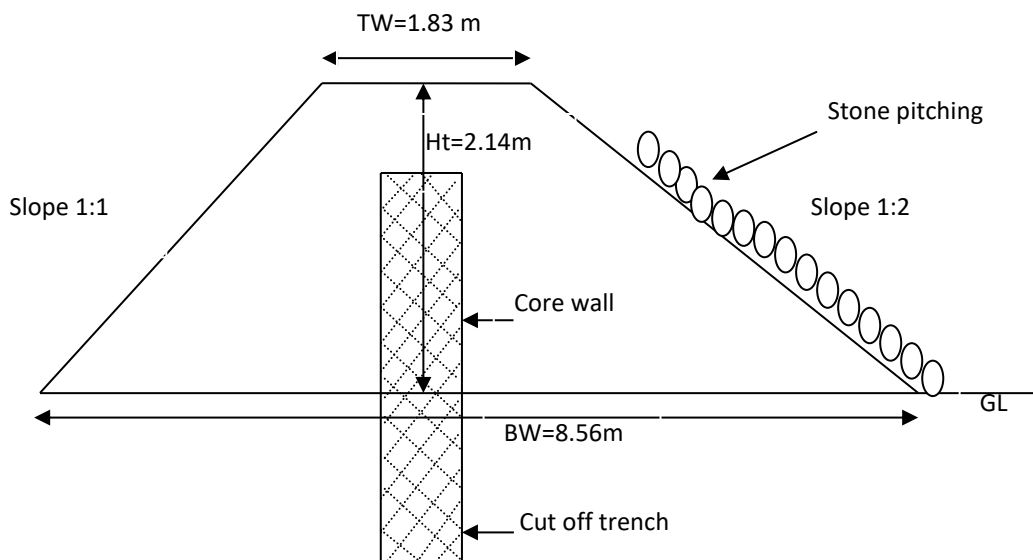


Figure 31: Cross section of the ED at maximum width

Intake storage tank:

An explanatory example from Khunta block of Mayurbhanj district: The intake tank with below design would be constructed in stream to divert water to the pipeline when construction of retaining wall is done.

