Manual on Small Dams in Jharkhand

Water Resources Department

Government of Jharkhand

Govt. of Jharkhand

Manual on Small Dams in Jharkhand

Water Resources Department
Government of Jharkhand

Published by:

Water Resource Department, Government of Jharkhand
Nepal House, Doranda, Ranchi - 834002

© 2012, Water Resource Department, Govt. of Jharkhand

Drafting Committee:

B. C. Nigam (I. F. S), Special Secretary, WRD, Govt. of Jharkhand
Er. Y. N. Mishra, Consultant (MI Works), WRD, Govt. of Jharkhand
Er. Rajesh Kumar, Director, Central Water Commission, Ranchi
Er. B. K. Roy, Superintending Engineer, WRD, Govt. of Jharkhand
Er. Arvind Kumar, Superintending Engineer, WRD, Govt. of Jharkhand
Er. Sachhidanand Sharma, Superintending Engineer, WRD, Govt. of Jharkhand
Er. Ripusudan Prasad, Superintending Engineer, WRD, Govt. of Jharkhand
Er. Shashi Bhusan Sharma, Executive Engineer, WRD, Govt. of Jharkhand

Printed by:

Setu Printers
Morhabadi, Ranchi. Ph :2551356

Sudesh Kumar Mahto
Dy. Chief Minister
-Cum- Minister of
Water Resources Department

Govt. of Jharkhand

Water Resources Department
Government of Jharkhand

Message

It gives me immense joy to know that the department has prepared a Manual on Small Dams in Jharkhand. I have always believed that 'Small is Beautiful'. The topography and precipitation in Jharkhand is ideal for mirco-dams and small water arresting structures. The department and the drafting committee have gone an extra mile to come up with a practical manual for our engineers.

I am sure, this manual would fulfill a practical requirement of the field level functionaries and our farmer's co-operatives in a laudable manner.

(Sudesh Kumar Mahto)

Foreword

Water is essence of life. It is becoming dearer day by day. It is high time, we take steps to conserve water. Since long, a need has been felt for a manual which can act a ready- reckoner for engineers and other functionaries working in the field and entrusted with the task of construction of small check-dams and similar other structures for retaining water in the streams of Jharkhand.

This is a great effort by the drafting committee, who have worked with full devotion to bring out this technical manual in a very short span of time. The manual is a sincere effort to put together all the technical and practical information required for conceiving, executing and maintaining small Check Dams. In our state, engineers and supervisory level technical personnel will now have ready access to technical know-how for undertaking such projects.

Last but not the least, there is an urgent need to involve our people at large in conceiving, execution and maintenance of such Check Dams. Traditionally, engineers are involved in hardware aspects of construction because they are professionals in the field of Civil or Mechanical Engineering, but the need of the hour is social engineering. Our engineers now have to be greatly involved in the software aspects of Participatory Irrigation Management, right from the conceptions of such Check Dams to its maintenance and sustainable usage.

Let this pave the way for the movement of water conservation or "Pani Roko Abhiyan" in our State as we are celebrating 2012-13 as the year of Water Conservation.

(S. K. Satapathy)
Principal Secretary, WRD
Government of Jharkhand

Preface

The 'Manual on small Dams in Jharkhand' presents broad design principles, procedures and standards of small dams for the terrain of Jharkhand. This manual is expected to serve as a ready reference for economical design of small dams and broad implementation procedures including promotion of water user associations under various ongoing and upcoming programs of Water Resource Department.

Small dams under Minor Irrigation (MI) works are generally associated with rivulets, streams, small rivers with smaller drainage area. Considering the scope of MI works and prevailing undulating terrain in the state, the manual focuses on the purpose of small dams at upper, middle and lower ridges of stream section, site selection conditions, design and implementation procedures. Accordingly, it proposes structures (Boulder Check dam, Earthen Check dam, Masonry check dam) for upper to lower ridges, so that water harvesting /storage would be facilitated in the entire length of the stream. Simplified design formulae, values of various design constants, factors, etc. have been placed in tabular forms. However, it does not encourage assumptions of undue responsibility and over-simplifying on the part of designer.

The design principles, formulae, etc. has been taken from books and documents. The experiences of practitioners have been incorporated in texts. Suggestions from practitioners, readers for further improvement of the manual will be appreciated.

We express our sincere gratitude to Shri S. K. Satapathy, Principal Secretary WRD, GoJ who mentored and motivated us to prepare the manual. We thank Engineers of the department for their inputs and suggestions for the manual. The cooperation and understanding of Setu Printers is greatly appreciated.

B. C. Nigam

Y. N. Mishra

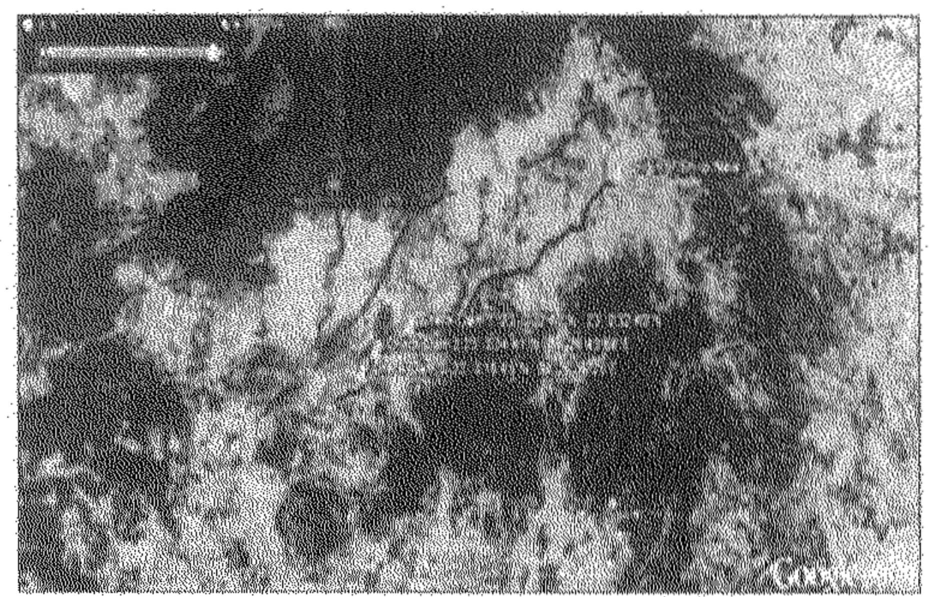
July-August, 2012

Contents

1. Introduction

Water Resource Department, Government of Jharkhand has been planning, implementing, supervising and monitoring various programs and projects in the state of Jharkhand. These plans and projects have wide range of diversity in terms of their purpose, resources required, effect on ecology and habitations, completion time, accrued benefits and so on. Such diversities are being addressed by Major and Minor Irrigation wings in the department. The minor irrigation wing has designed and implemented a number of irrigation schemes under Million Wells Schemes, Bihar Plateau Development Project and other schemes to augment irrigation potential in the state. Currently, series of check dams are being planned and implemented under the guideline of Accelerated Irrigation Benefit Programme (AIBP) supported by Ministry of Water Resources, Government of India and Government of Jharkhand.

Under AIBP series of check dam have been planned and implemented generally in the lower part of the streams. A sample Google map[1] shows that 3 check dam has been built in the lower 20% length of the stream. However, there may be some exceptions to this. The upper part of the stream being at higher elevation can offer great potential for gravity irrigation if rain water harvested and allowed to flow under gravity in farmers field. Contrary, if not treated, they would bring heavy load of silt from upper catchment in the impounding area of dams built in lower part of the stream making the dams less useful. The topography of the state provides unique opportunity of conservation and harvesting of rain water in upper and middle ridges, making the water flow under gravity to crop fields. Such planning, design and implementation of water conservation, harvesting structures would facilitate longer period of availability of water throughout the length of the stream for domestic, irrigation and other purposes. The manual proposes to use appropriate structures and mechanism for utilizing such untapped potential.



Map: Dams in lower part of stream

[1] Stream under Raidih block of Gumla district

2. Scope and Applicability

This manual is designed for practitioners engaged in water conservation and irrigation promotion with understanding of water conservation measures, dams and irrigation planning in Jharkhand. It is expected to provide a practical understanding of the principles and procedures used in irrigation planning under the broad framework of AIBP in the state. The proposed structures are suggestive for conservation and harvesting of rainwater and sub surface flow for the promotion of gravity flow and micro lift irrigation system. Description of community participation and process of building their ownership into the project for operation, maintenance and future sustainability have been incorporated in the manual, keeping the Participatory Irrigation Management (PIM) in view.

3. Objectives of Check Dams:

The purpose of check dam construction in minor irrigation sector may vary with type of dam, size of dam, location and requirement of government and local community. Considering the topography, width of water courses, possible detention or storage or diversion structures, broadly the purpose may be classifies into following two categories:

In upper part of stream, harvesting rain water and run off during monsoon to

- i. Minimize peak run off volume and velocity in stream, reducing soil erosion,
- ii. Create an impounding of water in upstream,
- iii. Facilitate infiltration of water into sub surface and recharging ground water,
- iv. Increase sub surface flow and increased months of availability of water in the stream,
- v. Promote gravity flow irrigation by diverting water into farmer's field either by underground PVC pipeline or diversion channels.

In middle or lower part of stream, harvesting stream flow and sub surface flow to

- i. Harvest surface flow of stream going out of catchment and command area during monsoon and off monsoon period,
- ii. Create impounding of water in upstream of dams for irrigation, domestic and other use,
- iii. Increased months of availability of water in the streams,
- iv. Facilitate Gravity Flow irrigation and Community Managed lift irrigation system for enhancing cropping intensity and crop productivity.

4. Site conditions for small Dams:

Following are the preferred site condition for small check dams in upper or middle or lower part of the stream:

- i. A narrow, U – shaped, straight section in the stream,
- ii. Availability of space for impounding water in upstream,
- iii. Availability of minimum width of waterway of the stream,
- iv. Prevalence of high firm embankment
- v. Site for spillway or diversion channel on either side of the dam in upper part of the stream (if required);
- vi. Adequate Cultivable Command Area on either / both side of dam
- vii. Minimum submergence of cultivable area
- viii. Community accessing and using that section of the stream for their current uses

Considering the topography, rainfall pattern in the state, broad framework of AIBP and requirements of the state and local community, three structures namely Boulder Check dam, Earth dam and Masonry check dam are proposed to be constructed in upper, middle and lower parts of the stream respectively. The details of each structure have been dealt in subsequent pages.

5. Boulder Check Dam

The boulder check dam is a small check dam made of boulders locally available and considered as a method for drainage line treatment. These are made in series on seasonal streams in ridge area of the stream. It arrests silt fully, water temporarily and allows water to flow at a deaccelerated velocity through and over the dam section.

5.1 Technical and Site Considerations:

- i. Suitable in upper ridges, where the stream section has depth up to 3 meters and width up to 6 meters,
- ii. Stream bed slope less than 20%,
- iii. Availability of firm embankment on both the sides of the stream,
- iv. Availability of boulders in the vicinity
- v. Distance[2] between two successive boulder check dam 30 to 50 meters, one series is effective for catchment area less than 50 hectares,

[2] Depends on the slope of the bed of the stream

Functions of Boulder Check Dam:

i. Reduces the speed of run off during monsoon peak flow,

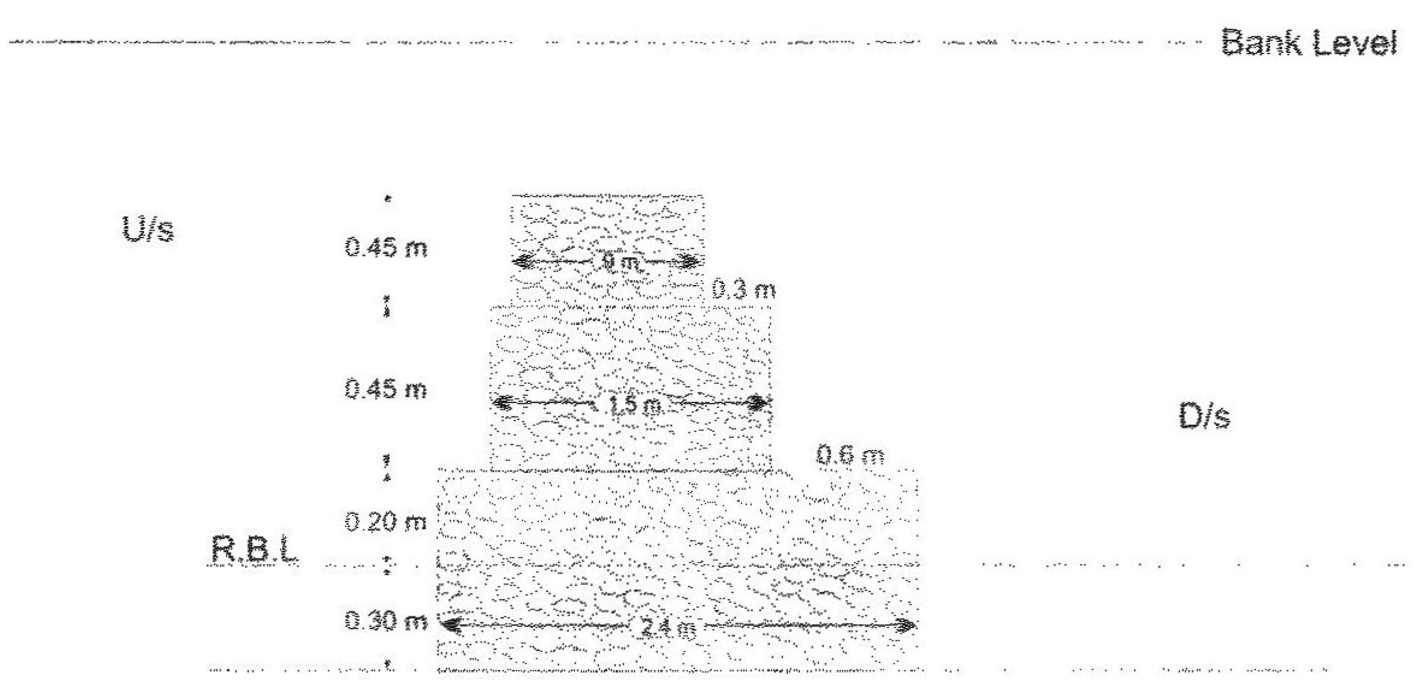
ii. Checks soil erosion,

iii. Checks silt of flowing water and reduces siltation in the downstream reservoirs,

iv. Rejuvenates water flow, increases duration of surface flow in the stream and thereby prolonging the recharging time in downstream wells and other water bodies.

5.2 Design and Layout:

The boulder check dam, not being the harvesting structure, it's height above the gully is generally kept between 1.2 to 2.5 meters. The length of the check dam shall be equal to the water ways plus 0.50 meter on both sides, embedded in the embankment. The depth of foundation below the stream bed is provided between 0.30 to 0.75 meters. The top width is kept 0.6 to 0.9 The slope in downstream is kept more gradual so as to minimize the impact of water which flows over the dam. The height of dam embedded in the embankment is always more than the height of dam in the middle of the stream, so as to provide a gradual slope which facilitates safe flow of water over the dam without harming the embankments. Additionally on downstream side sufficient (1.5 times of the height of the fall) length and width of stone apron needs to be provided to prevent scour. An illustrative sample section is presented as following :



The distance between two successive check dams shall be governed by the gradient /slope of the stream. If the slope is flat, the distance would be more and vice versa. The maximum water stored by one boulder check may reach up to toe of the upper boulder check dam. Any distance lower than this, would be uneconomical.

Since the boulder check dam is small structure, allows water to flow through and above it; if designed as per above mentioned dimension and specifications, check for safety against sliding, overturning is not generally required. In order to provide further safety, the surface of the dam may be anchored in the foundation and embankments with the help of wire mess.

5.3 Construction procedures:

I. Layout (foundation, height, top width, upstream/ downstream slopes, apron) of the boulder check dam as per dimensions and specification provisioned in design

ii. Excavate the foundation, embedded into both the embankments

iii. Built the profile of the boulder check as per lay out with the following precautions:

   a. Avoid using round stones strictly, use angular stone in the construction so that they develop grip among each other,

   b. Small stone weighing less than a kg should not be used, as they wash away easily,

   c. Larger boulders placed on outer side of the profile,

   d. Check for the embedding of the section into the embankments,

   e. The check dam should be raised in horizontal layers, care must be taken for maintaining the downstream and upstream slopes as per design,

   f. Keep the embankment higher than that of middle section of the boulder check dam, If the section is leveled, water will cut through the embankments and the check dam will collapse. The construction of the boulder check dam shall complete before the onset on monsoon.

iv. Provide anchorage with wire mess and suitable pitching for water cushion in downstream

v. Small maintenance may be required after the monsoon and farmers shall encouraged to do it

6 Masonry Check Dam

Masonry check dams are being built across streams by various departments in the state. Of late, masonry check dams in series are being planned and implemented under AIBP by the Department of Water Resources Development, GoJ and more such work is expected to be taken up in the coming future. In Jharkhand context, such dams broadly, are envisaged to fulfill the following objectives:

a. Harvest water flowing through the stream, which are going out of catchment and command area during monsoon and off monsoon period,

b. Create impounding of water in the upstream of dam, to be used for irrigation, domestic, animal and other purposes,

c. Facilitate infiltration of water into sub surface strata and recharging of ground water,

d. Increased months of availability of water in the streams,

e. Promote Gravity Flow Irrigation and Community Managed micro lift irrigation system for enhancing cropping intensity and crop productivity.

To fulfill the above objectives; planning, design, implementation and monitoring procedures are in place for the series of check dam in the department. However, the department has identified few dimensions in the design of check dam such as site considerations, length and height of weir, protection work in downstream, provision of gravity flow irrigation or community managed micro lift irrigation system, etc., which requires to be fine tuned over the prevailing design and practices. Accordingly, these are emphasized in the subsequent sections.

6.1 Site Selection:

Following are the preferred general site condition for check dams to be constructed in upper, middle or lower part of the stream:

a. Availability of adequate catchment area, at the axis of check dam,

b. Availability of straight and narrow firm bank of stream; any curve or meandering portion of stream shall be avoided,

c. Prevalence of high firm foundation condition at axis of proposed dam, rocky or hard soil makes the designed section of dam economical

d. Availability of space for impounding water in upstream,

  i. Fetch generally be more than 300 meters; i e river slope1: 150 or should have good storage - perennial sub surface flow

  ii. High flood level (HFL) should not inundate private /cultivable land; flatter upstream or below a junction of 2-3 tributaries provides such sections in general,

e. Adequate Cultivable Command Area[3] on either / both side of dam,

f. Community accessing and using that section of the stream for their current uses

g. Submergence of forest land, cultivable area, displacement should be negligible

6.2 Design of check Dam:

Design data required :

- o Latitude and longitude of dam site
- o Catchment Area at the axis of check dam (by Survey of India Topo sheet map or Drainage GIS map of JSAC)
- o Type of soil (silt, clay, rocky or combination)
- o Cross section of stream at axis, 100 m in u/s and 50 m d/s
- o Longitudinal section of stream up to one km (for storage & velocity of flow)
- o Reduced level (RL) of River bed level and RL of highest point in command area (Water requirement for 2" depth of irrigation per irrigation per hectare during Rabi season is approximately 500 m^3, accordingly live storage and discharge inflow in the impounding area shall be taken into account)
- o Observed highest flood level of stream by local enquiry
- o Command Area

Determination of peak flood discharge

The peak flood discharge may be determined by the following methods:

By Dicken's formula

$Q_p = C A^{3/4}$

(Where Q_p = Peak discharge in cumec,

A = Catchment area in square km,

C[4] = a constant, depending on nature of catchment and intensity of rainfall)

Value of Dicken's 'C'	
Indian Region	Value
Northern India	11.50
Central India	14 to 19.50
Western Ghats	22 to 26

[3] A guidance from GIS map of JSAC or Google earth map may be taken

[4] Value of 'C' is taken 12 to 14 for calculation in Jharkhand. However, it's value increases for hilly catchment and higher Intensity of rainfall and vice- versa.

Slope Area method :

Mannings formula may be used, considering the stream in 'regime'[5] state,

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

(Where V= velocity of flow in m/s,

R[6] = Hydraulic radius in meter,

S = Slope of the bed and

n = Rugosity coefficient[7])

Value of Manning's coefficient	
Condition of channel	Value of n
Very good	0.0225
Good	0.0250
In different	0.0275
Poor	0.0300

After getting V, cross sectional area of the stream may be obtained and the discharge may be calculated by multiplying V by A (cross sectional area) of the stream.

Q = A x V

The maximum value of discharge obtained by above two methods may be used for further design and calculations.

The discharge, which is 1.5 times of minimum but not more than maximum by the above methods, may be taken for further design and calculation.

Length of waterways :

Length of waterways may be calculated by Lacey's regime width formula

P[8] $\approx L = 4.75 \sqrt{Q}$ (Where, Q = discharge of stream in cum/sec)

[5] Flow of water is non silting or scouring in the stream

[6] R = A/P (where, P= perimeter of the stream, A = area of cross section of stream at weir section)

[7] The value of n may be taken as 0.025

[8] Wetted perimeter of stream, can be considered equal to width for wider stream on flatter slope or alluvial soil

As the check dam would be behaving like Broad Crested Weir, the length may be further worked out using Broad crested weir as below

$L = Q / 1.71 \times H^{3/2}$

(Where, Q = discharge of stream in cum/sec,

H = Head over crest in meter)

Value of H may be kept as high as possible; in order to keep waterways lower to have economic design. Head over crest and height of check dam should be such that water does not over top the u/s bank. Generally, it should be kept 0.6 -1.0 meter lower than the u/s banks height on both the sides

The length of waterways should be as kept as low as possible for economic design. The length may be equivalent to the width at HFL of the stream plus embedded portion on both the sides of the embankment. Generally, it should not be more than be 1.20 times (so as to contain the afflux and the flow remains within the designed waterway)) of the width of at HFL river /stream. For length of check dam more than 50 meter on alluvial soil, detailed investigation is required

Check wall:

Top width of the Check wall:

According to Bligh's formula

$B' = H_L / \sqrt{(G-1)}$

Generally, top width of the check wall is taken 0.9 to 1.2 meter with d/s side slopes 0.6: 1 to 1:1

B'= Top width of Check wall

H_L = Difference in water level /head loss between U/s and D/s[9]

G = Specific gravity of material

[9] Afflux (U/s HFL – D/s HFL), the value for alluvial soil and rocky soil may be taken maximum 1.0 and up to 2.5 respectively

Bottom width 'B' of the check wall:

Bottom width of the check is obtained by adopting suitable downstream slope, generally taken as 0.6: 1 to 1:1. However, Bottom width should not be less than

$B = (H + \text{Height of Weir}) / \sqrt{(G-1)}$

Where H = head of water at weir wall at the time of maximum flood

M10 in foundation and in check wall (where sized boulders are not available) may be adopted Further, 100 mm thick RCC Jacketing in M15 is suggested over check wall and D/s floor.

Length of floors :

According to Bligh, percolating water follows the outline of base of the foundation of hydraulic structure, i. e. water creeps along the bottom contour of the structure. Accordingly, the safety against piping can be ensured by providing sufficient Creep length, given by

$L = C H_L$

(Where,

C = Bligh's coefficient for the soil,

H_L = Static head or height of check dam from U/s floor to crest of check dam)

Value of Bligh's C

SL	Soil Type	Value of 'C'	Safe hydraulic gradient
1	Fine micaceous sand (North India)	15	1/15
2	Coarse grained sand (Central & south India)	12	1/12
3	Sand with boulder, gravel, loam soil	5-9	1/9 - 1/5
4	Light sand and mud	8	1/8

$L_2 = 2.21\, C \sqrt{(H_L/10)}$

$L_2 + L_3 = 18\, C \sqrt{(H_L/10 \times q/75)}$

$L_4 = L_3/2$

q = Discharge intensity (cumec/meter)

L_2 = Length of downstream floor

L_3 = Length of downstream loose boulder talus

L_4 = Length of upstream talus (nominal)

Length of upstream floor

L_1 = Total creep length – (2 x U/s cut off + B + 2 x D/s cut off), nominal value 2 to 3m may be kept

Floor length may also be calculated from Khosla's Exit Gradient Curve

Safe Exist Gradient = $G_E = (H_p / d) \times 1/\pi \sqrt{\lambda}$

Where H_p = Static head

d = downstream cut off depth

$\lambda = (1+\sqrt{(1+\alpha^2)}/2$

$\alpha = b/d$

b = total floor length

Value of G_E	
Shingle	1/4 to 1/5
Coarse sand	1/5 to 1/6
Fine sand	1/6 to 1/7

Total floor length can be calculated from Khosla's exit gradient curve

= U/S floor Width + 2 x U/s cut off + Weir width + D/s floor width + 2 x D/s cut off,

Depth of cut off:

Find Scour depth [10]

$R = 1.35 (q^2/f)^{1/3}$

Where q = discharge per unit length of weir (Q/L)

f = lacey's silt factor

Value of Lacey's silt factor	
Soil Type	'f' Value
Silt (fine)	0.61
Silt (standard)	1.00
Sand (medium)	1.25
Sand (course)	1.49
Gravel (medium)	4.72
Gravel (heavy)	8.94
Boulder	12.38 to 24.00

Provide upstream cut off = 1.2 x R

Downstream cut off = 1.5 to 1.75 x R

(These scour depths are calculated from u/s and d/s HFL)

[10] Applicable only for permeable / semi permeable foundation

The thickness of the floor is designed by equation

$t = \{h/(G-1)\}$

(Where h = Ordinate of Hydraulic Gradient line above the top of D/s floor i.e. uplift pressure at that point

G = Sp. Gravity of the concrete)

For small check dam (1.5 to 3 m height), since water falls more or less vertically on D/s floor, a water cushion of depth 0.5 m may be provided. When the discharge intensity /m is less than 5 cumec/m, concrete block is not required, only boulder pitching of 2.5 times of D/s scour depth having 0.6 m thick may be provided. Friction block is provided when Froud number $F = V/\sqrt{(g\, d_1)}$ is more than 2.0

Gates in Weir :

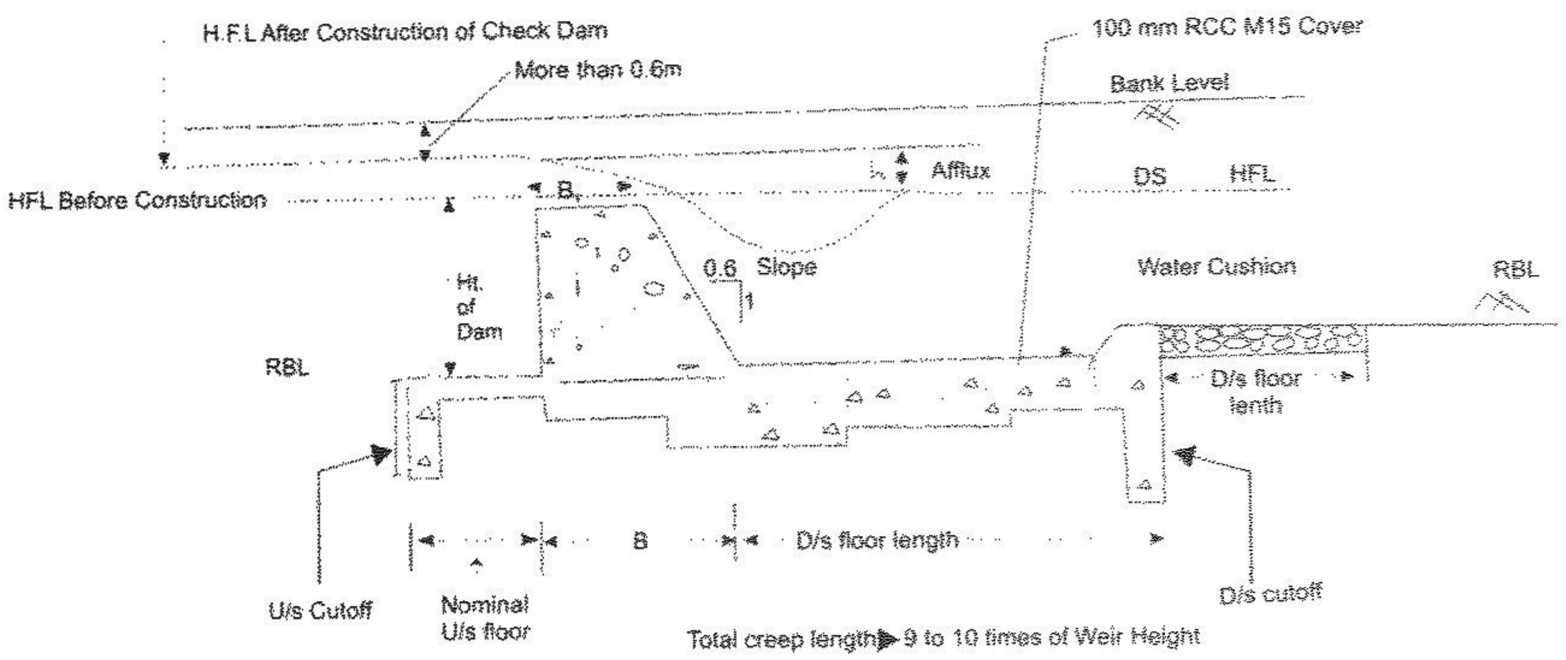
The provision of small gates (1' x 1') @ 10-15 meter weir length is recommended to exclude silt in the lower level of the dam. Operating these gates during flood and after monsoon becomes difficult and many a times it attracts community conflicts for water sharing. Water User Association should be made strong enough to handle such conflicts, otherwise, gates remain open after monsoon and no ponding would be available.

Wing walls :

The upstream wing wall should be extended up to upstream floor end. It should be projected / embedded into the river bank and tied to the firm strata, so as to avoid bypassing of the stream through the embankment. Similarly, downstream wing wall should be made up to the end of downstream pucca floor and it should be tied with the firm bank as in the case of upstream wing wall. The height should be at least one meter above the Maximum Water Level (MWL) at dam section and should be gradually sloped down from the toe of the weir. However, a provision of at least one meter above the maximum downstream tail water level shall be made. Boulder pitching of side slopes of river bank, if required, may be provided.

The sample section of check dam is presented below:

Not for scale



Typical Cross Section of check dam on Alluvial Soil

6.3 Structural stability of masonry check dam :

The designed check dam shall be checked for safety against below mentioned failures:

Safety against overturning: If the resultant of all the forces acting on any section of the dam, passes outside the toe, the dam shall rotate and overturn about the toe. The factor of safety against overturning i.e. ratio of righting moment about toe (anti clockwise) to the overturning moment (clockwise) about toe shall be more than 2.

Safety against compression or crushing: A dam may fail by the failure of its material i.e. the compressive stress produced, may exceed the allowable stress, and the dam may get crushed. The vertical direct stress distribution at the base is given by p = Direct stress + Bending stress. When the reservoir is full, the resultant would be at toe and hence, the maximum compressive stress would be produced at the toe. In reservoir empty case, the resultant would be nearer to heel and the maximum compressive stress would be produced at heel. The total stress, in any case, shall not exceed the allowable compressive strength of dam material (generally taken as 30 kg/cm^2 for concrete), otherwise the dam may fail by crushing.

Safety against tension: Masonry dams shall be designed in such a way that no tension is developed anywhere, because these material don't withstand the sustained tensile stress. If subjected to such stress, these materials finally crack. The maximum permissible tensile stress under worst condition of loading may be taken as 5 kg/ cm^2. In order to ensure that no tension is developed anywhere, the maximum value of eccentricity that can be permitted on either side of the centre is B/6 (B = base width of dam) i.e. the resultant must lie with in the middle third of the base.

Safety against sliding: Sliding failure occurs when the net horizontal force at the base or above any plane in the dam exceeds the frictional resistance developed at that level. For no sliding condition, the external horizontal forces ($\sum H$) must be less than the shear resistance i.e. $\mu \times \sum V$

$$\Rightarrow \quad \sum H < \mu \sum V$$

$$\Rightarrow \quad \mu \sum V / \sum H > 1$$

(Where, μ = Coefficient of friction, value ranges between 0.65 to 0.75)

The above ratio i.e. $\mu \sum V / \sum H$ represents factor of safety against sliding and its value must be greater than one.

7 Community managed micro lift irrigation

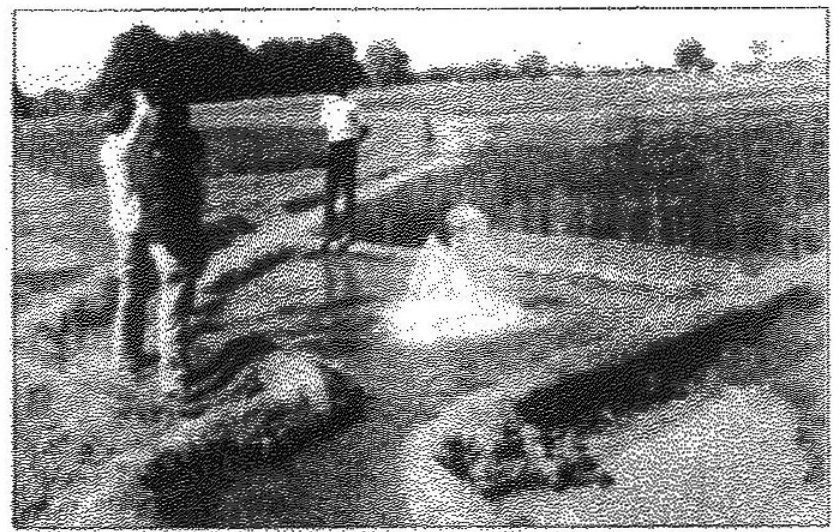


Fig: Water coming out of an outlet of micro LI system

Agriculture is the major occupation of the rural community in villages. The terrain is undulating and the agriculture, by and large, has remained rain-fed. Crop yields are not merely low but uncertain as well. The common practice is to grow kharif paddy with minimum investment on inputs and leave the land uncultivated during rest months. Outputs from such subsistence agriculture, are meager at the best of time and the crops altogether fail in drought years. To overcome the situation, secure irrigation with their ownership over the irrigating system has been the unfulfilled dreams of farmers. Oflate, there has been a focus on creation of irrigation potential in the state under various programs including AIBP. Under AIBP, series of check dam is being constructed and water is stored during off monsoon period. The stored water is envisaged to be lifted through a 'model' micro lift irrigation system, by farmers. However, farmers find it difficult to take the responsibility of operation and maintenance of micro lift irrigation system primarily due to

- Using diesel as only source of energy to run the engines and pump
- Low or negligible know – how at farmers level to go for irrigated farming and
- Lack of institutional mechanism /community organization to take on the responsibility of common asset created by the appointment

7.1 Site conditions and components of micro LI system :

The micro lift irrigation system would be installed at pre decided site i.e. where the check dam has already been constructed. Accordingly, while selecting site for check dam, following factors need to be considered in view of technical and social feasibility of micro lift irrigation system:

i. The command area for Micro Lift Irrigation Schemes should be cultivable land and priority shall be given for covering majority of families in the hamlet/village

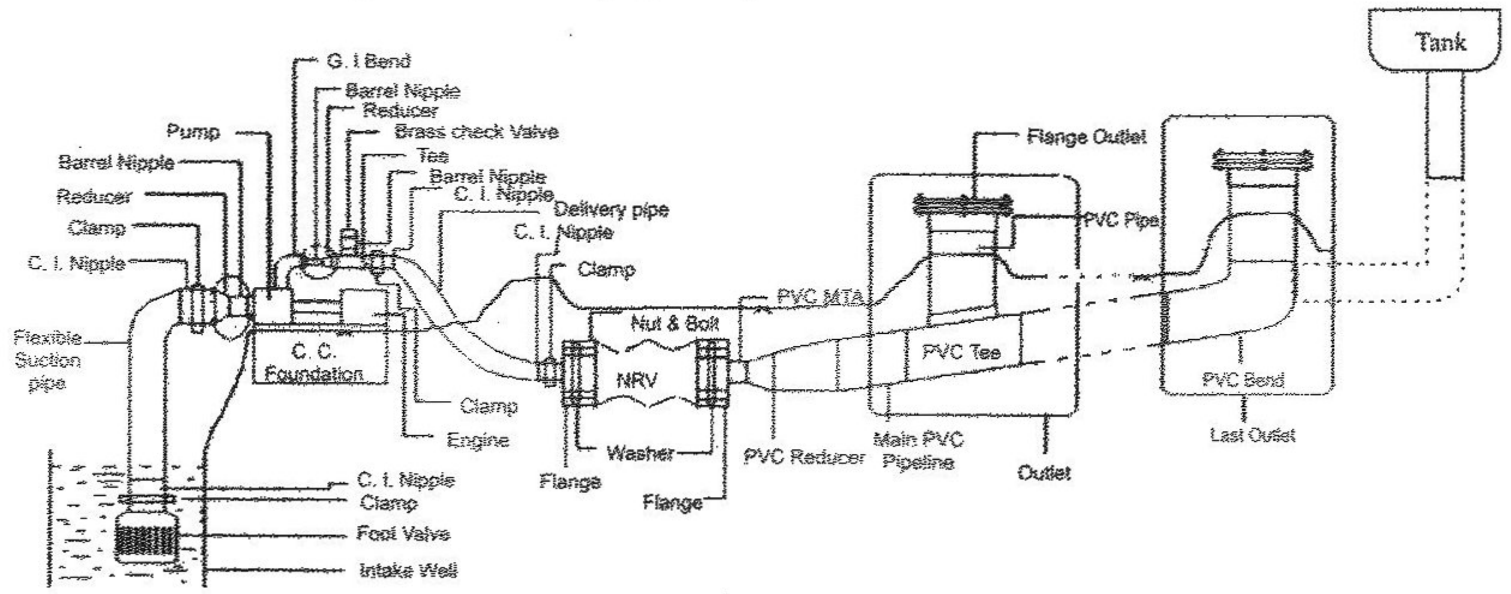
ii. The command area should be within a kilometer from the water source

iii. The static head i.e. elevation difference between water level in the stream and highest point on the command area shall be within 16 meter, if the engine to be operated by diesel

iv. The stream should be accessible for farmers

Major Components of micro Lift Irrigation system:

- o Underground PVC pipeline fitted with QRC outlets and Non return valve
- o Water lifting device (one diesel and one electric engine fitted with suction and delivery hose) with transformer, if electric engine provided
- o Pump protection device (pump house 12' x 16' size with tiled roof to minimize the cost)
- o R. C. C Storage tank[11] at the highest point in the command area



Tower, currently used as a component of LI system, strictly avoided in order to minimize losses in water conveyance system from suction point to field.

7.2 Design and implementation procedures :

The design of micro lift irrigation system is govern by the total head between water level at source to highest lifting point and discharge required for the irrigating the command area. The total head and required discharge calculation may be as following:

o Total head calculation

- ➤ $H_{total} = H_s + H_f + H_m$
- ➤ Conduct survey to get the level difference between water level in the stream and highest point on the command area (static head = H_s)
- ➤ Work out friction loss, $H_f = 0.5\%$ of the pipe length (Measure the length between lifting point and highest point on command area for getting the length of pipeline)
- ➤ Work out misc head loss $H_m = 10\%$ of $(H_s + H_f)$ (for losses in joints, bends, expansion and reducing points)

Design data required:

- o Command area in ha
- o Static head of lift system
- o Length of pipeline
- o Assumed value of pumping hour, depth and frequency of irrigation

[11] Tank with capacity of 5 to 8 m^3

- o Determine the discharge required for the command area

$$Q\,(lps) = \frac{A \times 10000 \times D \times 1000}{I \times T \times 3600 \times \eta}$$

Where,
Q = Discharge required in litre per second
A = Command area in ha
D = Depth of irrigation in meter
I = Interval of irrigation in days (15 days)
T = Puming hours per day (Av. 10 hr.)
η = Irrigation efficiency (taken as 0.7)

Fig: QRC outlet, easy to connect with other pipes

- o For the given discharge, select PVC pipe diameter in such a way that the friction head loss shall be within 0.5% of the pipe length using friction chart (Annexure-I)
- o For the designed head and discharge, select the engine and type of pump using performance chart (Annexure -II)
- o Provide QRC (Quick Release and Connector) outlets[12] as per the requirement of farmers
- o In warrant cases, branch pipeline may be provided

Design steps and implementation procedures :

i. Organize village meeting, share about techno-managerial aspects of community managed lift irrigation system, demarcate command area, prepare farmers lists whose land would come under command area and would be irrigated

Fig: Trench digging by farmers in progress

[12] It may vary from 2 to 6 in numbers as per site condition

ii. Conduct transact walk in the command area to demarcate the position for laying of pipeline, outlets, pump house and mark the same on cadastral map, start the procedure of promotion of Water user association

iii. Conduct survey, workout the total head and discharge required, accordingly design
   a. Length of pipeline,
   b. Pipe diameter
   c. Engine h_p and pump type,
   d. Number of QRC outlets

iv. Prepare the list of items to be procured, place the order, initiate process for getting electric connection, if required

v. Start construction of pump house and trench (for pipeline laying) digging. Trench shall be of 1.5 feet wide and 3 feet deep Any sharp bend in pipeline should be avoided, in warrant cases, smooth curve may be provided

vi. Procure materials, Commission the schemes in association of farmers and hand it over to the WUA and get ask howledgement from the WUA.

Recommendations for community managed micro LI :

- **Command area:** 6-15 hectares
- **Length of pipeline:** Up to 1000 meters including branch pipeline ,
- **Diameter of PVC pipe:** 140 mm to 160 mm
- Mix diameter pipeline should be used to reduce the cost and friction loss Bigger diameter pipe may be used in initial 50 -60 % length of pipeline and rest could be smaller i.e. 140 mm diameter, keeping the overall friction loss head within 0.5% of the length of pipeline,
- **Engine** : 5 to 8 hp for diesel operated and 5 to 15 hp for electric operated
- **Pump Type:** Low head or Medium head or High head
- **Storage tank:** RCC tank with 5-8 m^3 capacity at highest elevation in the command area
- **Budget:** Below Rs. 10 lakhs

With the availability of electricity in village, one electric motor of equivalent hp to be provided

Such micro LI is feasible in any streams having surface flow (2' wide & 1" deep) in the month of March

7.3 Promotion of Water User Association (WUA)

The promotion of Water User Association (WUA) requires close engagement of promoter and farmers of WUA for a period of 2 to 3 years. The promoter needs to be well versed with the socio-economic situation of village concerned, promotion processes and growth path of WUA. Understanding of envisaged complexities at various stages of growth of WUA would help the promoter to be aware about the probable conflicts and ways to facilitate the WUA, so that after 2-3 years or two Rabi crop cycles, the WUA would not require any facilitation support from the promoter and the WUA would be functioning at their own.

- The promoter gives an overview pertaining to the roles and responsibilities of the farmer in operation and maintenance of irrigation system for future sustainability,
- Facilitation of farmers for developing basic operating principles for operation and maintenance of the schemes of the WUA. This includes
  - Finalization of norms for meeting (frequency and time)
  - Selection of officer bearers and pump operators,
  - Preparing resolution for opening of a bank account in the name of WUA,
  - Hourly water tariff fixation and collection procedure of the same,
  - Processes for account and book keeping (accounts, minutes, etc) of WUA
  - Mode of payment for repairs, if any, and payment to operator/s
  - Other issues, if required
- The above operating procedures and system would evolve in 8-10 meetings of farmers. In such meetings, the presence of promoter is essential. Very often, the vested interested people would like to make things in their favor and if that happens, WUA would never be functional in practice.
- After formation of such norms and procedures of WUA, implementation of the same and adherence to it by all farmers sometimes becomes a conflicting, however, the WUA resolves it with proper facilitation of promoter

Documents to be maintained by WUA:

- LI scheme details (beneficiary list, scheme design and estimate)
- Bye laws and resolution of WUA
- Meeting register
- Water tariff collection book /coupon
- Bank Passbook
- Cash book

- In case of non- adherence to the norms and procedure, penal actions need be devised and incorporated by the WUA members themselves
- Maintenance of books of accounts and the office bearers are expected to present the accounts of WUA and Action Taken Report, if any, in all meetings
- Crop planning for entire command area, procurement of seed, fertilizers, pesticides, etc. collectively helps the farmer getting genuine inputs on fair cost
- Getting support for crop production practices and troubleshooting timely becomes essential requirements of WUA and the promoter shall provide it.
- A series of training and exposure visits be organized as listed below:
  - Awareness generation event – components, envisaged roles & responsibilities
  - Exposure visit to functional a WUA site – to see how the schemes is being managed by community, processes & systems, cropping, roles of framers
  - Operator's training
  - Group meeting conduction training –ATR, new decisions and compliances
  - Accounts keeping training
  - Crop planning, indent making, collective procurement
  - Crop production practices, handholding and trouble shooting
  - Maintenance mechanism, payments and responsibilities, etc.
- Such planned training and handholding support in adherence to WUA's evolved norms, maintenance of accounts and other book keeping, further fine tuning the procedures as per farmer's convenience, crop planning and production assistance and conflict resolution facilitates the strengthening of WUA for future sustainability.

8. Small Earth Dam

The small earthen dams are the most common storage structure across the drainage lines It is easy to construct and its sizes are usually governed by the availability of impounding area in the upstream. Based on the type of material used and method of construction, earth dam may be classified into Homogeneous Embankment Type or Zoned Embankment Type or Diaphragm / Core wall Type Embankments. Site condition plays a critical role for designing the structure for harvesting maximum volume of water.

Jharkhand's terrain offers great opportunity for the constructions of small earthen dam (Diaphragm or core wall type embankment type) in series as water harvesting structure in the stream at suitable sites. Such dam would harvest rain water and run off water in the reservoir and allows excess water to flow through spillway/diversion channels. The structure would facilitate promotion of irrigation through gravity.

8.1 Site[12] considerations :

i. Availability of a narrow gorge with a fan shaped valley in upstream, so that a small dam can store large volume of water,

ii. A Junction of two tributaries or depressions, with a fill of sufficiently low permeability with favorable geology[14],

iii. The catchment area adequate enough to fill the reservoir in about 2-3 heavy rains. The capacity should not be too small to be silted up with sediments very soon,

iv. Availability of natural site for spillway,

v. Higher elevation of impounding reservoir than that of the neighboring agriculture field so that irrigation may be provided with gravity flow,

vi. Adequate Cultivable Command Area on either / both side of dam,

vii. Access of local community to the site for easy supervision and maintenance purpose

viii. Submergence of forest land, cultivable area and displacement should be minimum and avoid interference of important communication structures like railway, NH and other important structure, etc.

[12] Suggestion from local community may provide additional and practical considerations for site

[14] Saline or alkaline soil, Peat or soils rich in organic matter, Heave clays subject to swelling, shrinking and cracking, Very light soils such as sand or loamy sand

Design **Considerations** :

i. Upstream face should be properly protected against wave action and downstream face against rain and other external actions of human and animal,

ii. The slopes should be stable in worst condition of loading i.e. sudden draw down or steady seepage during full reservoir level,

iii. The dam shall be drained out properly with the provision of sand filter and rock toe,

iv. The seepage line shall be well within the downstream face of the dam, so that no sloughing of the toe happens,

v. The borrow pits shall be in upstream to increase the reservoir capacity, the lowest level of reservoir / borrow pits shall not be lower than bottom level of core wall,

Incorporation of suggestions of local community would address many of the site and design considerations for small earth dam.

8.2 Design of small earth dam :

Locate the site having high, firm banks, flatter upstream which would be the reservoir and a space for the spillway along with adequate catchment and command area. The site identification may be done by GIS map[15] of Jharkhand Space application centre (JSAC) or with the help of survey of India topo-sheet map. After identification of site location by either process, a field visit to the site along with villagers would be essential to confirm the availability of

- o Firm banks,
- o Reservoir area,
- o Spillway site,
- o Adequate catchment and command area.

For design, peak discharge of the stream may be calculated from the following rational formula

By Dicken's formula

$Q_p = C A^{3/4}$

(Where Q_p = Peak discharge in cumec,

A = Catchment area in square km,

C[16] = a constant, depending on nature of catchment and intensity of rainfall)

[15] May be seen and located online at JSAC website

[16] Value of 'C' is taken 12 to 14 for calculation in Jharkhand. However, it's value increases for hilly catchment and higher intensity of rainfall and vice- versa.

Area Velocity Method: Mannings' formula may be used,

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

(Where V= velocity of flow in m/s,

R[17] = Hydraulic radius in meter,

S = Slope of the bed and

n = Rugosity coefficient[18])

Value of Manning's coefficient	
Condition of channel	Value of n
Very good	0.0225
Good	0.0250
In different	0.0275
Poor	0.0300

After getting V, cross sectional area of the stream may be obtained and the discharge may be calculated by multiplying V by A (cross sectional area) of the stream.

$Q = A \times V$

The discharge which is 1.5 times of minimum but not more than maximum by the above methods may be taken for further design and calculation.

Considering the volume of expected runoff from above calculation, reservoir capacity may be fixed and a survey would be required to fix the full reservoir level, accordingly Dam height, level of spillway i.e. FRL and height of core wall will be fixed. The dam height may be adequate to harvest 40 to 50% runoff in the stream, rest may be allowed to flow through spillway for downstream users.

Top Width of Embankment :

Top width shall be sufficient to keep the seepage line well within the dam, when reservoir is full. It should be adequate to withstand wave action and earthquake shocks. Additionally, the width shall incorporate the minimum roadway requirement of the local community.

Following formula may be considered for determining the Top Width (T):

- $T = 5/3 \sqrt{H}$ or
- $T = 0.4H + 1$ or
- $T = H/5 + 2$ (Up to 10 meter height of the dam)

Where H = Height of the dam from deepest level of river at dam site

Upstream and Downstream slopes :

Adequate upstream and downstream side slopes of the embankment must be provided to satisfy the stability requirements of reservoir filled with water. The top seepage line, that demarcates the saturated and unsaturated

Table: U/s and D/s	Slopes	(H:V)
Type of material	U/S slope	D/S Slope
Homogeneous well graded	2.5 : 1	2 : 1
Homogeneous course silt	3 : 1	2.5 : 1
Homogeneous silt clay		
H < 15 meter	2.5 : 1	2.5 : 1
H > 15 meter	3 : 1	2.5 : 1
Sand or Sand and clay with CORE wall	3 : 1	2.5 : 1

[17] R = A/P (where, P= perimeter of the stream, A = area of cross section of stream at weir section)

[18] The value of n may be taken as 0.03

zone, should pass through the base of the dam. The slope of this line can be taken as 4:1 for all practical purposes. The maximum side slopes recommended in case of small earth dams are given in the table. Considering the table, it may be proposed to adopt 3 : 1 and 2.5 : 1 slope of earthen dam in upstream and downstream respectively. The upstream slope can be protected against the erosive action of waves by 24" stone pitching /riprap over a gravel bed of 0.15 to 0.30 meter. Ripraps on entire upstream slope and turfing on downstream slopes shall be provided

Spillway :

The spillway is the structure to pass the surplus runoff or flood water after the reservoir is filled. It is located or constructed on either side of the embankment in such a way that the surplus water can be safely discharged over it. Spillway may be a natural side drain or excavated drainage channel or a piped spillway. For the designed peak runoff Q_p, the spillway dimensions are worked out by using the formula

$Q_p = C L H^{3/2}$

$Q_p = 1.71 L H^{3/2}$

(Where, L = Length of the spillway in meter,

H = Head over crest over spillway in meter)

Free Board :

Free board is the vertical distance between the maximum reservoir level and top / crest of the dam. The minimum height of the freeboard shall be taken as 1.5 h_w

Where hw is the height of water waves in the reservoir generated due wind velocity.

h_w can be worked out as

$h_w = 0.032 \sqrt{(V \times F)} + 0.763 - 0.271 (F)^{1/4}$

(Where, V = Wind velocity in km/hr, F = fetch or straight length of water in the reservoir)

Table: Free board height (m)	
Dam height	Free board
Up to 4.5	1.2 to 1.5
4.5 to 7.5	1.5 to 1.8
7.5 to 15.0	1.85

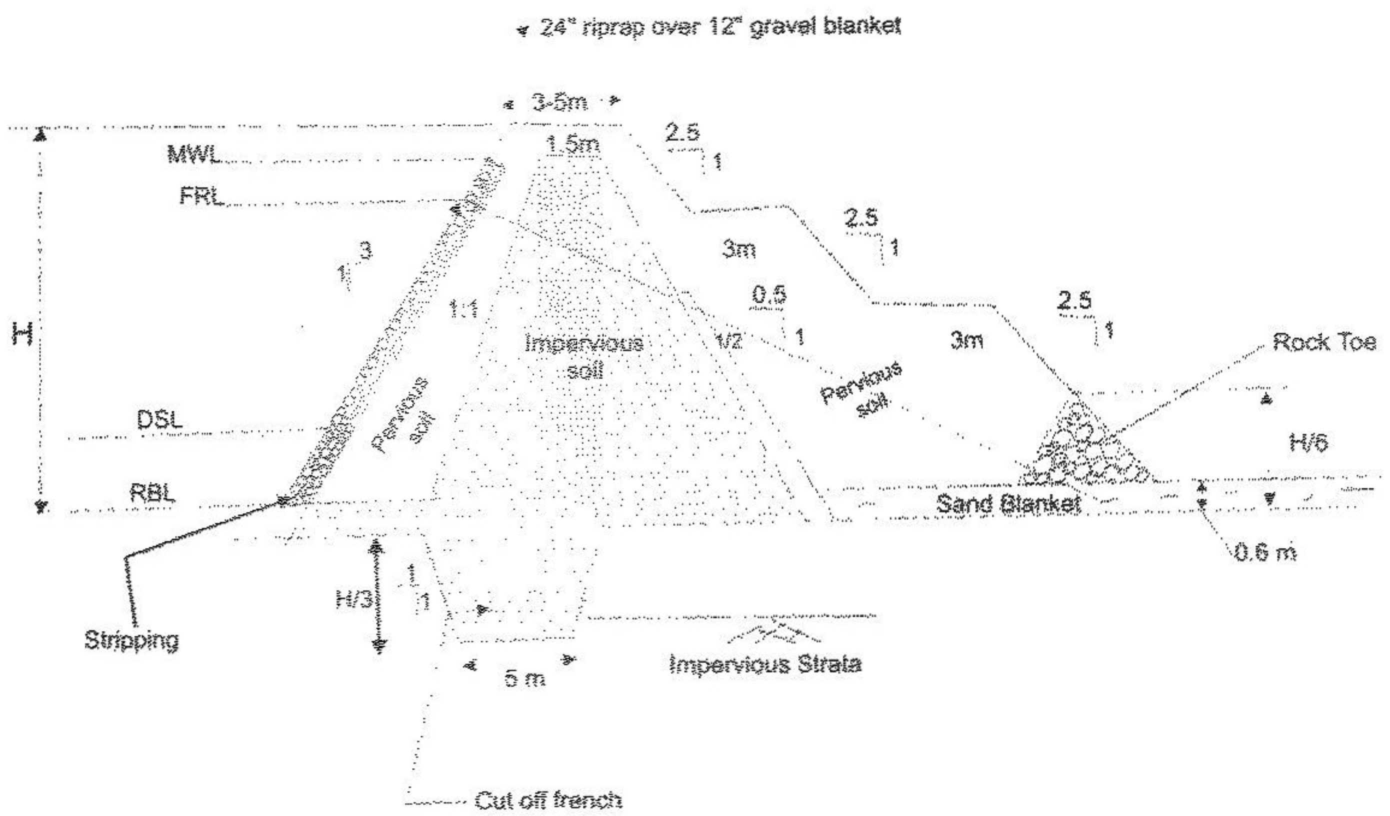
The free board of various height of earth dam may be adopted as per Strange's recommendation as given in the table. Most of the hydraulic failures of the earth dam occur due to inadequate free board. Additionally, settlement allowance @ 2% of the dam height plus 1 meter or as given in table which ever is more, may be provided.

Rock Toe and Toe filter :

The rock toe consists of stones of size usually varying from 15 cm to 20 cm. The toe filter generally consists of three layers of fine sand, coarse sand and gravel. The height of the toe is generally kept between 15 to 20% (Generally H/5 to H/6) of height of the dam on graded filter. Horizontal sand blanket of depth 0.6 meter is provided at D/s foundation level for proper seepage of water which is entering into the dam. The top of the rock toe must be sufficiently higher than the tail water depth, so as to prevent the wave action of the tail water.

When the height of dam is more than 6 meters, suitable catch water / berm is provided on the d/s face of the dam. Generally, it is provided at 4-5 meter height interval of the dam.

A typical section of an small earthen dam may be as following:



Typical Section of a small Earth dam

8.3 Safety against failure of small earth dams

An earth dam usually fails due to sliding of large soil mass along a curved surface or due to piping action. The failure of earth dam can be grouped in followings:

- o Hydraulic failure
- o Seepage failure
- o Structural failure

Hydraulic failure: The hydraulic failure occurs by overtopping of the dam, erosion of upstream face, erosion of downstream face by gully formation and erosion of downstream toe. The overtopping is due to under estimation of discharge or insufficient capacity of spillway. Sufficient provision of free board provides additional safety against overtopping. Erosion of upstream and downstream slopes may be addressed by provision of adequate slopes of upstream and downstream faces, riprap in upstream slope, grass turfing at downstream slope and inverted filter at the toe of the downstream face.

Seepage failure: Controlled seepage or limited uniform seepage is inevitable in earth dams and ordinarily does not produce any harm to the dam. However uncontrolled or concentrated seepage through the body of dam or through the foundations may lead to piping or sloughing and subsequent failure of the dam. This may be avoided by provision of adequate cut off in the foundation, provision of core wall in the body of the dam, thoroughly and properly compacting the soils during construction.

Structural failure: The structural failure of the dam is caused by the foundation or slope slide of embankment. The foundation slides occurs due to weak foundation i.e. dam built on fine silt or soft clay or loose sand. In this type of failure, the top embankment gets cracked and subsides, the lower slopes moves outward forming large mud waves near the heel and gets collapsed. The upstream slope failure is generally caused by sudden draw down of the reservoir. These may be prevented as briefed in hydraulic failure section.

Notes

A. Any new or innovative water harvesting structure / practice may be encouraged to be taken up as pilot in the field. After getting success in the field, the model /pilot may be scaled up with proper implementation arrangement in place.

B. All Boulder Check dam, Small Earth Dam and Lift Irrigation Schemes having budget less than Rs. 10 lakh may be implemented directly by the water user association (WUA) under the Technical and Managerial support of an experienced Non Governmental Organization (NGO). These NGO may be empanelled through open EoI and their cost may be met as per the provision made in Common Guideline 2008 for Integrated Watershed Management Project (IWMP) issued by DoLR, GoI. A detailed procedure may be developed for engaging NGO in the implementation of MI projects.

C. The contents of manual are subjected to be improved / modified as per the suggestion of field and design Engineers at an interval and as decided by the department.

Annexure – I

Frictional losses[19] in flow of water through PVC pipes

Pipe dia (in mm)	90mm	110mm	125mm	140mm	160mm	180mm	200mm	225mm	250mm
Discharge (in LPS) ↓	← Friction losses in m/km →								
1	0.42	0.16	0.09	0.05	0.03		0.01	0.01	0
2	1.45	0.56	0.3	0.18	0.09		0.03	0.02	0.01
3	2.97	1.14	0.62	0.36	0.19		0.07	0.04	0.02
4	4.94	1.9	1.03	0.6	0.32		0.11	0.06	0.04
5	7.34	2.82	1.53	0.89	0.47		0.16	0.09	0.06
6	10.15	3.89	2.12	1.23	0.65	0.31	0.22	0.13	0.08
7	13.34	5.12	2.78	1.62	0.86	0.42	0.29	0.17	0.1
8	16.9	6.48	3.52	2.05	1.08	0.55	0.37	0.21	0.13
9	20.82	7.99	4.34	2.53	1.34	0.76	0.46	0.26	0.16
10	25.1	9.63	5.23	3.05	1.61	0.96	0.56	0.32	0.19
11	29.72	11.4	6.2	3.61	1.91	1.04	0.66	0.37	0.23
12	34.68	13.31	7.23	4.21	2.23	1.34	0.77	0.44	0.26
13	39.95	15.81	8.33	4.85	2.56	1.46	0.88	0.5	0.3
14	45.52	17.49	9.5	5.53	2.92	1.69	1.01	0.57	0.33
15	51.51	19.76	10.74	6.25	3.31	1.94	1.14	0.65	0.39
16	57.75	22.15	12.04	7.01	3.71	2.2	1.28	0.73	0.44
17	64	24.68	13.41	7.8	4.13		1.42	0.82	0.49
18	70.19	27.32	14.84	8.64	4.52		1.52	0.9	0.54
19	78.82	30.65	16.33	9.51	5.03		1.73	0.99	0.6
20	85.76	32.92	17.88	10.41	5.5		1.9	1.03	0.65
21	91.56	35.89	19.5	11.36	6		2.07	1.18	0.71
22	101.5	38.98	21.17	12.33	6.52		2.25	1.28	0.77
23	109.9	42.17	22.91	13.34	7.03	4.74	2.43	1.39	0.84
24	112.5	45.48	24.71	14.38	7.6	4.51	2.62	1.49	0.92
25	127.4	48.89	26.55	15.46	8.18	4.9	2.82	1.61	0.97
26	136.5	52.41	28.47	16.58	8.76	5.01	3.02	1.72	1.04
27	146	56.04	30.44	17.72	9.37	5.63	3.23	1.86	1.11
28	155	59.77	32.47	18.91	10	6.01	3.45	1.9	1.19
29	165.7	63.61	34.5	20.12	10.64	6.4	3.67	2.09	1.26
30	176.6	67.55	36.71	21.37	11.3	7.3	3.89	2.22	1.34

[19] Recommended permissible losses in PVC pipe flow: 0.5 % of pipe length

Annexure – II A

Performance Of NW+ Type Engine Coupled Set at Rated RPM Capacity LPS

Type of the pump	Size in mm	IMP dia (mm)	Head (m) and Discharge EnLps: 8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	ENGINE: HP	RPM
NW2+	80/65	223					22	20	19	17.8	16	14	10.8								5	1500
NW3+	65/50	243											14	12.9	11.8	10.5	8.8				5	1500
NW4+	100/100	197	30.8	29.1	27	24.2	20.6														5	1500
NW4+	65/50	207										16.2	15.6	14.6	13.5	12.2	10.2				5.75	1800
NW4+	100/100	167	30.3	28.6	26.5	23		12.5													5.75	1800
NW2+	80/65	223					22	20	19.5	17.8	16		10.8								6	1500
NW4+	100/100	260	32	30.2	28.2	25.7	22.7														6	1500
NW3+	65/50	259											15.2	14.4	13.5	12.5	11.3	9.6	5.6		7	1500
NW4+	100/100	205	34.5	32.8	31.2	29.2	27	20	19												7	1500
NW1+	65/50	221													17.1	16.2	15.3	14.2	12.9	11.2	7	1800
NW2+	80/65	203							23.2	22.2	21	19.6	18.2	16.6	14.6	11					7	1800
NW3+	65/50	230														16.7	16.1	15.4	14.5	13.6	7	1800
NW4+	100/100	184	35.6	34.5	33.2	31.6	29.8	27	21.7	20.7											7	1800
NW1+	65/50	223													17.8	16.8	16	14.8	13.7	12.2	8	1800
NW2+	80/65	212								24.8	23.9	22.8	21.6	20.4	19	17.4	15.5	12.4			8	1800
NW3+	65/50	235															17.2	16.4	15.5	15	8	1800
NW4+	100/100	188	37	36	34.7	33.3	31.6	29.7	27.2	24.4	20										8	1800
NW2+	80/65	196									25.4	24.4	23.4	22.2	21	19.7	18.1	16.2	13.2		8.7	2000
NW3+	65/50	216																17.4	16.3	16	8.7	2000
NW4+	100/100	173	38	37	36	34.6	33	31.4	29.3	26.8	23.6	18.5									8.7	2000

Annexure – II B

(SINGLE PHASE) APPROXIMATE PERFORMANCE AT 210 VOLTS, 50 HZ SUPPLY

Pump Type	2 Pole Motor Rating (HP/Kw)	Suction (mm)	Delivery (mm)	Discharge Rate In Litre/Second — Total Head In Meters: 6	8	10	12	14	16	18	20	22	24	26	28
KDS-116++	1/0.75	50	40	5.3	5.0	4.9	4.2	3.6	3.0	2.0		–	–	–	–
KDS-128+	1/0.75	50	40	–	–	–	1.95	1.9	1.8	1.7	1.6	1.4	1.1	0.75	0.4
KDS-1.514++	1.5/1.1	50	50	9.5	8.5	7.2	5.7	3.5	–	–	–	–	–	–	–
KDS-1.522+	1.5/1.1	50	40	–	6.3	5.9	5.5	5.0	4.5	3.9	3.1	1.7	–		–
KDS-1.525+	1.5/1.1	50	40	2.6	2.55	2.55	2.5	2.4	2.3	2.2	2.1	2.0	1.8	1.6	1.3
KDS-216++	2/1.5	65	50	–	11.0	10.0	8.8	7.2	4.0	–	–	–	–	–	–

Annexure – II C

(THREE PHASE) APPROXIMATE PERFORMANCE AT RATED VOLTS, 50 HZ SUPPLY

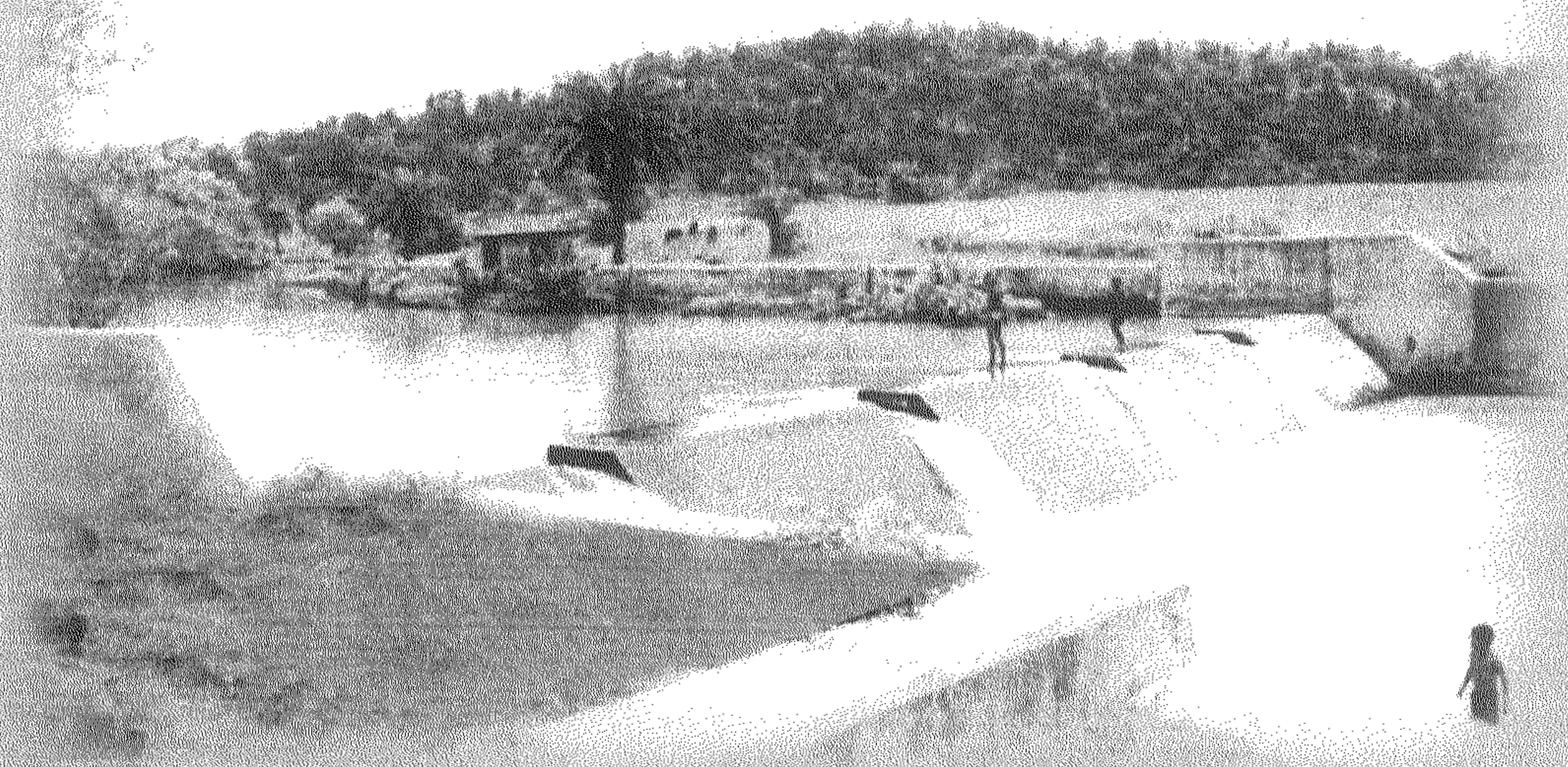
Pump Type	2 Pole Motor Rating (HP/Kw)	Suction (mm)	Delivery (mm)	Discharge Rate In Litre /Second — Total Head In Meters																	
				6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36		
KDS-225++	2/1.5	50	40	_	5.3	5.1	5.0	4.8	4.5	4.2	3.9	3.5	3.0	2.2	_	_	_	_	_		
KDS-314+	3/2.2	80	80	19.0	18.0	16.2	13.9	10.4	_	_	_	_	_	_	_	_	_	_	_		
KDS-318++	3/2.2	80	65	_	13.4	12.6	11.7	10.7	9.2	7.5	_	_	_	_	_	_	_	_	_		
KDS-325++	3/2.2	65	50	_	_	9.2	8.9	8.4	7.8	7.5	7.0	6.4	5.8	4.9	_	_	_	_	_		
KDS-335++	3/2.2	50	40	_	_	_	_	4.9	4.8	4.7	4.5	4.4	4.2	4.0	3.8	3.5	3.2	2.7	2.0		
KDS-515+	5/3.7	100	100	32.8	31.0	28.0	24.2	19.0	12.9	_	_	_	_	_	_	_	_	_	_		
KDS-520+	5/3.7	80	80	24.0	23.0	22.0	20.8	19.5	17.9	16.0	14.0	11.0	_	_	_	_	_	_	_		
KDS-527++	5/3.7	80	65	_	_	_	_	_	14.3	13.5	12.5	11.6	10.3	8.7	6.4	_	_	_	_		
KDS-822++	7.5/5.5	100	100	_	_	_	27.3	25.6	24.0	22.2	20.1	17.6	14.5	_	_	_	_	_	_		
KDS-830++	7.5/5.5	80	65	_	_	_	_	_	19.0	18.2	17.3	16.4	15.4	14.2	13.0	11.1	_	_	_		
KDS-1030++	10/7.5	100	100	_	_	_	_	31.0	29.8	28.5	27.0	25.0	23.5	21.0	18.0	13.5	_	_	_		
				18	20	24	28	30	32	36	40	44	48	52	54	56	60	64	68	72	76
KDS-538+	5/3.7	65	50	_	8.5	8.3	7.8	7.6	7.2	5.8	_	_	_	_	_	_	_	_	_	_	_
KDS-550++	5/3.7	50	40	_	_	_	_	_	_	4.1	3.7	3.3	2.7	2.0	_	_	_	_	_	_	_
KDS-844++	7.5/5.5	65	65	_	_	10.7	10.3	10.0	9.6	8.4	7.1	4.7	_	_	_	_	_	_	_	_	_
KDS-852++	7.5/7.5	65	50	_	_	_	_	_	8.6	8.1	7.5	6.8	5.9	4.5	_	_	_	_	_	_	_
KDS-1040+	10/7.5	80	65	21.6	20.9	19.5	17.9	16.9	15.7	13.4	9.6	_	_	_	_	_	_	_	_	_	_
KDS-1050++	10/7.5	65	65	_	_	12.9	12.5	12.3	12.0	11.4	10.6	9.7	8.0	6.0	_	_	_	_	_	_	_
KDS-1065++	10/7.5	65	50	_	_	_	_	_	_	_	7.8	7.4	7.0	6.5	6.0	5.8	5.1	4.3	_	_	_
KDS-1331+	12.5/9.3	100	100	33.5	32.0	29.2	23.8	20.0	_	_	_	_	_	_	_	_	_	_	_	_	_
KDS-1348+	12.5/9.3	80	65	_	19.6	19.0	18.2	17.8	17.3	15.8	14.1	11.9	7.0	_	_	_	_	_	_	_	_
KDS-1537+	15\11	100	100	36.8	35.9	33.0	30.0	28.0	25.0	17.5	_	_	_	_	_	_	_	_	_	_	_
KDS-1555+	15\11	80	65	_	_	_	_	19.4	19.2	18.5	17.5	16.0	14.5	12.2	10.5	_	_	_	_	_	_
KDS-1575+	15\11	65	50	_	_	_	_	_	_	_	_	_	_	8.1	7.9	7.7	7.4	6.9	6.4	5.8	4.9
KDS-2050+	20/14.7	100	80	33.8	33.2	32.0	30.5	29.7	28.8	27.2	25.0	23.0	19.4	14.0	_	_	_	_	_	_	_

10. References :

a) From Subsistence Agriculture to Irrigated Farming by Tilak D Gupta

b) Irrigation Engineering and hydraulic structures by S. K. Garg

c) Integrated Natural Resource Management, Foundation Course materials, PRADAN



For any further information contact :

Chief Engineer (Monitoring)
Water Resources Department, Govt. of Jharkhand
Nepal house, Doranda, Ranchi - 834002
Tel: 0651- 2491158, Fax : 0651 - 2491158
Email: cemont-wrd-jhr@nic.in