Cover

SAMARTHYA

TECHNICAL TRAINING MANUAL (MGNREGA)

Ministry of Rural Development
Government of India

(March, 2015)

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CONTENT

ANNEXURES

सत्यमेव जयते

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Birender Singh

ग्रामीण विकास, पंचायती राज
और पेयजल एवं स्वच्छता मंत्री
भारत सरकार

Minister of Rural Development, Panchayati Raj
And Drinking Water & Sanitation
Government of India

MESSAGE

It gives me immense pleasure to know that the Mahatma Gandhi NREGA Division of the Ministry is imparting training on technical aspects to the technical personnel working at the grass roots level. Such an initiative will surely result in the creation of durable assets.

I expect that the States will create District Resource Teams and Block Resource Teams with the help of their State Resource Teams within a definite timeframe. 'Samarthya (MGNREGA)' will be useful for practitioners cutting across States.

I congratulate the MGNREGA team in the Ministry for having prepared this manual.

(Birender Singh)

सत्यमेव जयते

J.K. Mohapatra
Secretary (RD)

ग्रामीण विकास मंत्रालय
ग्रामीण विकास विभाग
भारत सरकार
Ministry of Rural Development
Deptt. of Rural Development
Government of India

MESSAGE

I am glad to learn that the Programme Division, MGNREGA is imparting technical training to the key personnel executing projects under this programme at the field level. A major focus area of the programme is to improve the quality and social utility of the assets created. This will be possible only with adequate capacity building of our technical personnel. They ought to know the do's and dont's pertaining to the execution of works.

'Samarthya' - the technical training manual - is the outcome of collective experience gained over almost a decade of the implementation of this flagship programme.

I do hope that the capacity building exercise with the help of this manual will contribute substantially towards enhancing the capacity and skill sets of our technical personnel in delivering 'Value for Money' under MGNREGA.

J.K Mohapatra

LIST OF FIGURES, IMAGES & TABLES

FIGURES

LIST OF FIGURES, IMAGES & TABLES

IMAGES

LIST OF FIGURES, IMAGES & TABLES

TABLES

ABBREVIATIONS

AKRSP (I)	Aga Khan Rural Support Programme (India)
AS	Administrative Sanction
ASA	Arid and Semi-arid
BIS	Bureau of Indian Standards
BMPTC	Building Materials & Technology Promotion Council
BNRGSK	Bharat Nirman Rajiv Gandhi Sewa Kendra
BOD/COD	Biochemical oxygen demand/Chemical oxygen demand
BPL	Below Poverty Line
BRGF	Backward Regions Grant Fund
C.A.	Catchment Area
CAD	Command Area Development
CCA	Culturable Command Area
CCT	Continuous Contour Trench
CDP	Catalytic Development Programme
CEO	Chief Executive Officer
CI	Contour Interval
CPT	Cattle Proof Trench
CSS	Centrally Sponsored Scheme
CWPC	Central Water Power Commission
DDO	District Development Officer
DLT	Drainage Line Treatment
DoLR	Department of Land Resources
DPC	District Programme Coordinator
EC	Emulsifiable Concentrate
FS	Financial Sanction
FSL	Full Supply Level
FYM	Farm Yard Manure
GRS	Gram Rozgar Sahayak
GS	Gabion Structure
Ha.	Hectare
HUDCO	Housing & Urban Development Corporation Ltd.
IA	Implementing Agency
IAY	Indira Awaas Yojana
ICAR	Indian Council of Agricultural Research
ID	Identification
IEC	Information Education and Communication
IHHL	Individual House Hold Latrine
IPC	Inter Personnel Communication
IPPE	Intensive Participatory Planning Exercise
IRC	Indian Road Congress
IWMP	Integrated Watershed Management Programme
JOC	Job Oriented Certification
LBC	Loose Boulders Check
LCC	Land Capability Classification
L-section	Longitudinal Section
M/B	Measurement Book
M/R	Muster Roll
MDWS	Ministry of Drinking Water & Sanitation
MFL	Maximum Flood level
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee act.

MIS	Management Information System
MOA	Ministry of Agriculture
MoE&F	Ministry of Environmental & Forest
MoWR	Ministry of Water Resources
MoY&S	Ministry of Youth Affairs & Sports
MSWM	Municipal Solid Waste Management
NBM	Nirmal Bharat Abhiyan
NGOs	Non-Government Organization
NRLM	National Rural livelihood Mission
NSL	Natural Surface Level
PCC	Plain Cement Concrete
PHC	Public Health Centre
PMGSY	Prime Minister Grameen Sadak Yojana
PO	Project Officer
PPC	Plant Protection Chemicals
PRA	Participatory Rural Appraisal
RCC	Reinforcement Cement Concrete
RES/ SoR	Rural Engineering Service/ Schedule of Rates
S.E./XEN	Superintending/ Executive Engineer
SA PPLPP	South Asia Poor Livestock Policy Programme
SBM	Swachh Bharat Mission
SCP	State Convergence Plan
SCT	Staggered Contour Trench
SHGs	Self Help Groups
SIRD	State Institute of Rural Development
SLWM	Solid and Liquid Waste Management
SoR	Schedule of Rates
SPCBs	State Pollution Control Boards
SQM	Square Meter
SSS	State Sponsored Scheme
TBL	Top Bund Level
TBL	Top Bank Level
TCB	Trench Cum Bund
TS	Technical Sanction
Va	Vent Area
VMC	Village Monitoring Committee
VWSCs	Village Water & Sanitation Committees
WBM	Water Bound Macadam
WHS	Water Harvesting Structure
WSHG	Women Self- Help Groups
ZP	Zila Parishad

CHAPTER 01

INTRODUCTION

CHAPTER 01

INTRODUCTION

1.1. MGNREGA – A BRIEF

1.1.1. The National Rural Employment Guarantee Act (Mahatma Gandhi NREGA) notified on September 7, 2005, aims at enhancing livelihood security of households in rural areas of the country by providing at least one hundred days of guaranteed wage employment in a financial year to every household whose adult members volunteer to do unskilled manual work. The Act covers all rural districts of the country.

1.1.2. As per the Para 3 of Schedule-I, MGNREGA, **The core objectives of the Schemes are:**

i) Providing not less than one hundred days of unskilled manual work as a guaranteed employment in a financial year to every household in rural areas as per demand, resulting in creation of productive assets of prescribed quality and durability;

ii) Strengthening the livelihood resources base of the poor;

iii) Proactively ensuring social inclusion and

iv) Strengthening Panchayat Raj institution.

1.2. LIST OF WORKS PERMITTED UNDER THE ACT:

At para 4. (1) of Schedule – I, Mahatma Gandhi NREGA, it is mentioned that, "The focus of the scheme shall be on the following works as categorised below"

I. Category A: Public works relating to natural resources management:

i) **Water conservation** and water harvesting structures to augment and improve groundwater like underground dykes, earthen dams, stop dams, check dams with special focus on recharging ground water including drinking water sources;

ii) **Watershed management** works such as contour trenches, terracing, contour bunds, boulder checks, gabion structures and spring shed development resulting in a comprehensive treatment of a watershed;

iii) Micro and minor irrigation works and creation, renovation and maintenance of irrigation canals and drains;

iv) Renovation of **traditional water bodies** including desilting of irrigation tanks and other water bodies;

v) **Afforestation**, tree plantation and horticulture in common and forest lands, road margins, canal bunds, tank foreshores and coastal belts duly providing right to usufruct to the households covered in Paragraph 5; and

vi) Land development works in common land.

II. Category B: Community assets or individual assets for vulnerable sections (only for households in paragraph 5):

i) **Improving productivity of lands** of households specified in Paragraph 5 through land development and by providing suitable infrastructure for irrigation including dug wells, farm ponds and other water harvesting structures;

ii) **Improving livelihoods** through horticulture, sericulture, plantation, and farm forestry;

iii) **Development of fallow or waste lands** of households defined in Paragraph 5 to bring it under cultivation;

iv) Unskilled wage component in **construction of houses** sanctioned under the Indira Awas Yojana or such other State or Central Government Scheme;

v) Creating infrastructure for **promotion of livestock** such as, poultry shelter, goat shelter, piggery shelter, cattle shelter and fodder troughs for cattle; and

vi) Creating infrastructure for **promotion of fisheries** such as, fish drying yards, storage facilities, and promotion of fisheries in seasonal water bodies on public land;

III. Category C: common infrastructure including for NRLM compliant self-help groups:

i) Works for promoting **agricultural productivity** by creating durable infrastructure required for bio-fertilizers and post-harvest facilities including pucca storage facilities for agricultural produce;

ii) Common work-sheds for livelihood activities of self-help groups.

IV. Category D: Rural infrastructure:

i) **Rural sanitation** related works, such as, individual household latrines, school toilet units, Anganwadi toilets either independently or in convergence with schemes of other Government Departments to achieve 'open defecation free' status. and solid and liquid waste management as per prescribed norms.

ii) Providing all-weather rural **road connectivity** to unconnected villages and to connect identified rural production centers to the existing pucca road network; and construction of pucca internal **roads** or **streets** including side drains and culverts within a village;

iii) Construction of **play fields;**

iv) Works for improving **disaster preparedness or restoration** of roads or restoration of other essential public infrastructure including flood control and protection works, providing drainage in water logged areas, deepening and repairing of flood channels, chaur renovation, construction of storm water drains for coastal protection;

v) Construction of **buildings** for Gram Panchayats, women self-help groups' federations, cyclone shelters, Anganwadi centers, village haats and crematoria at the village or block level.

vi) Construction of **Food Grain Storage Structures** for implementing the provisions of The National Food Security Act 2013 (20 of 2013);

vii) Production of building material required for construction works under the Act as a part of the estimate of such construction works.

viii) **Maintenance** of rural public assets created under the Act;

4. (2) The order of priority of works shall be determined by each Gram Panchayat in the meeting of the Gram Sabha keeping in view potential of the local area, its needs, local resources and in accordance with the provisions of Paragraph 9, provided that the District Programme Coordinator shall ensure that at least 60% of works to be taken up in a district in terms of cost shall be for creation of productive assets directly linked to agriculture and allied activities through development of land, water & trees.

4. (3) Works which are non-tangible, not measurable, repetitive such as, removing grass, pebbles, agricultural operations, shall not be taken up.

5. Works creating **individual assets** shall be prioritised on land or homestead owned by households belonging to the:

a) Scheduled Castes

b) Scheduled Tribes

c) nomadic tribes

d) de-notified tribes

e) other families below the poverty line

f) women-headed households

g) physically handicapped headed households

h) beneficiaries of land reforms

i) the beneficiaries under the Indira Awaas Yojana

j) beneficiaries under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (2 of 2007), and

k) after exhausting the eligible beneficiaries under the above categories, on lands of the small or marginal farmers as defined in the Agriculture Debt Waiver and Debt Relief Scheme, 2008 subject to the condition that such households shall have a job card with at least one member willing to work on the project undertaken on their land or homestead.

6. The State Government shall take concrete steps to achieve effective inter-departmental convergence till the last mile implementation level of the works under the Scheme with other Government Schemes/ programmes so as to improve the quality and productivity of assets, and bring in synergy to holistically address the multiple dimensions of poverty in a sustainable manner.

7. There shall be a systematic, participatory planning exercise at each tier of Panchayat, conducted between August to December month of every year, as per a detailed methodology laid down by the State Government. All works to be executed by the Gram Panchayats shall be identified and placed before the Gram Sabha and such works which are to be executed by the intermediate Panchayats or other implementing agencies shall be placed before the intermediate or District Panchayats, along with the expected outcomes.

9. (1) Adequate shelf of works shall be maintained by every Gram Panchayat to meet the expected demand for work in such a way that at least one labour intensive public work with at least one work which is suitable for Particularly Vulnerable Groups especially the aged and the disabled which shall be kept open at all times to provide work as per demand.

(2) The details of the said work(s) shall be prominently displayed through writings on the walls of the village.

10. While opening works in the public works category, it shall be ensured that the ongoing or incomplete works should be completed first.

11. Work shall be provided within fifteen days, from the date of registration of the demand for work or the date from which work has been demanded in case of advance applications, whichever is later.

12. (1) In case work could not be provided as per demand within the specified time limit, unemployment allowance shall be paid, as calculated automatically by the computer system or the Management Information System and as provided under the Act. The programme officer can reject the unemployment allowance only on grounds of force majeure.

(2) In cases where unemployment allowance is paid, or due to be paid, the Programme Officer shall inform the concerned District Programme Coordinator in writing the reasons for not providing employment to the applicants.

(3) The District Programme Coordinator shall, in his Annual Report to the State Council explain as to why employment could not provide in cases where payment of unemployment allowances is involved

13. Every work under the Scheme shall have a technical estimate duly sanctioned by an authority authorised by the State Government. While sanctioning the estimates, the following are required to be considered:

a) For all works involving construction, cost effective, labour intensive technologies and usage of local materials shall be employed as far as possible;

b) The Bill of quantities (used in the estimate) is stated in common terminology for easy understanding of all stakeholders;

c) Each work shall have a summary of the estimate, design and a technical note that indicate the expected outcomes from implementing the work.

14. The works finalised at the Gram Panchayat level and consolidated at the Block or District level shall be given Block-wise administrative or financial sanction by the competent authority within thirty days from the date of finalisation of the works at the Gram Panchayat level only after confirming that the shelf of works in any Gram Panchayat is not less than two times the labour budget approved for that Gram Panchayat.

16. Payment shall only be made based on the measurements taken at the worksite by the authorised personnel within three days of closure of the muster roll. The State Government shall ensure that adequate technical personnel are deployed to complete this work within the stipulated period. Suitable persons from the families of workers may be trained or skilled and deployed as barefoot engineers with appropriate delegation of technical powers and paid wages as skilled workers.

17. The State Government shall link the wages, without any gender bias, with the quantity of work done and it shall be paid according to the rural schedule of rates fixed after time and motion studies for different types of work and different seasons and revised periodically.

18. A separate Schedule of rates shall be finalised for women, the elderly, people with disabilities and people with debilitating ailments so to improve their participation through productive work.

19. (a) The schedule of rates of wages for various unskilled labourers shall be fixed up so that an adult person worked for eight hours which include an hour of rest will earn a wage which is equal to the stipulated wage rate;

(b) The working hours of an adult worker shall be flexible but shall not spread over more than twelve hours on any day.

20. For all works taken up by the Gram Panchayats, the cost of the material component including the wages of the skilled and semi-skilled workers shall not exceed forty per cent at the Gram Panchayat level. For works taken up by the implementing agencies other than Gram Panchayats, the overall material component including the wages of the skilled and semi-skilled workers shall not exceed forty percent at the **District level**.

21. The works executed shall be done without engaging any contractor. Implementing agencies under the Scheme shall execute the works in conformity with the processes specified under the Act and after complying with the mandatory proactive disclosures and social audit.

22. As far as practicable, works executed by the programme implementation agencies shall be performed by using manual labour and no labour displacing machines shall be used.

23. All material required for the works shall be procured by the Gram Panchayat or the implementing agency using a transparent tender process as specified by the State Government.

24. Out of the administrative costs allowed under the Scheme, at least one third (1/3rd) shall be utilised at the Gram Panchayat level to employ and pay the Gram Rozgar Sahayak ,other technical personnel as per the work done and for other administrative expenses.

1.3. IMPOTANT INSTRUCTIONS ISSUED ON MGNREGA WORKS FROM THE MINISTRY:

i) The Sub Para (1) of Paragraph 4 of Schedule 1, MGNREGA modified as on 21st July, 2014, lays down that "Provided that the District Programme Coordinator shall ensure that **at least 60% of the works to be taken up in a district in terms of cost shall be for creation of productive asset directly linked to agriculture and allied activities through development of land, water and trees".**

To clarify on MGNREGA works, directly linked to agriculture and allied activities through development of land, water and trees, the clarification vide Ministry letter No. J-11017/41/2012-MGNREGA (UN) (Pt-II), dated 17th September, 2014 has been issued that all works of category A, all works of category B &C, except one type of work in each category and work at Para (vi) of category D are directly linked to agriculture and allied activities through development of land, water and trees.

ii) **The Paragraph 22** of Schedule 1 MGNREGA lays down that **"As far as practicable, works executed by the programme implementation agencies shall be performed by using manual labour and no labour displacing machines shall be used".**

With this, there was confusion that machines cannot be used. In this regard, vide Ministry letter No. J-11011/09/2014-RE-I, dated 25th August, 2014 clarification & a suggestive list of such task and type of machines which can be used under MGNREGA have been issued.

iii) **Vide Notification dated 3rd January 2014,** Ministry of Rural Development, Government of India has expanded the scope of works listed in Schedule 1, Para 4 (i) of MGNREGA and included number of material intensive works such as construction of rural buildings, infrastructure for promotion of Livestock & agriculture productivity etc., whereas, as per Para 20 of Schedule I, of MGNREGA, the 60:40 ratio for wage and material costs is required to be maintained at GP level for all works to be taken up by GP and for works to be taken up by all other agencies it has to be maintained at the District level.

To increase labour component in construction of buildings & other infrastructures, production of building material required in execution of MGNREGA works, as one of the activities under MGNREGA has been included in schedule-1, MGNREGA at Para 4.(1) (iv) (vii). In pursuant to this, the guidelines for production of building material has been issued vide Ministry letter No. J-11017/26/2008-MGNREGA (UN) dated 13th January, 2014.

iv) Para 13. Of Schedule-1, MGNREGA, 2005 provides that each work proposed to be taken up under MGNREGA shall have a summary of the estimate, design and a technical note that indicate the expected outcomes from implementing the work. Therefore, in this regard Ministry has further issued instructions on outcome orientation in works under MGNREGA vide Ministry letter No. J-11011/02/2010-MGNREGA (Policy) (10093), dated 5th August, 2014.

v) Many other important instructions issued on MGNREGA works, time to time from the ministry have been referred in respective chapters of this manual.

1.4. THE STRATEGY:

To create productive assets of prescribed quality and durability to strengthen the livelihood resources, it is necessary that the engineers/ technical personnel implementing the programme are clear about the activities which are to be carried out under different type of works permitted under MGNREGA. Secondly, for quality and durability, the basic technical input required in selection of work site, surveying, designing, planning, layout, execution and maintenance of works etc. are well known to the engineers/ technical personnel implementing the programme. Therefore, in this manual all these aspects have been covered.

1.4.1. IN THIS MANUAL, FOLLOWING ASPECTS HAVE BEEN COVERED:

i) Activities which are to be carried out under different type of works permitted under MGNREGA for:

a) Development of rain fed areas on watershed approach,

b) Development of irrigated areas on command area approach and

c) Development of agriculture & rural infrastructure.

ii) The basic input required in selection of work site, surveying, designing, planning, layout, execution and maintenance of works

iii) Quality Control & Maintenance of works under MGNREGA

iv) How convergence of MGNREGS with other ongoing schemes in rain fed areas and command areas can be done for gap filling and value addition

The list of relevant Circulars on MGNREGA works issued by the Ministry and are effective have been annexed, at **Annexure-XXI.**

CHAPTER
02

WATERSHED DEVELOPMENT FOR RAIN FED AREAS UNDER MGNREGA





CHAPTER

02

There is a need for the adoption of watershed development approach for planning and implementation of MGNREGS in rain fed area to ensure larger and sustainable impact in the area. This will address the need for generating unskilled jobs, as well as, will create durable assets which will generate livelihood and will help in restoring ecological balance.

2.1. WHAT IS WATERSHED?

Watershed is a geo-hydrological unit of an area draining to a common outlet point. The undulating land area of any region forms several such units, each of which is called watershed.

The top of a watershed from where the slopes start is called the ridge, because it is the dividing line that partitions one watershed from another. In a watershed, the slopes falling from the ridge to the beginning of the plain/ arable, area called the ridge area. The channels which carry the rainwater in to the drains are called drainage lines. Gullies, streams and rivers are all drainage lines. The size of a watershed may vary from a few hectares to thousands of square kilometers.

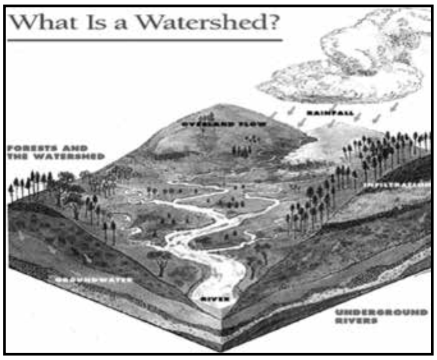


Figure 2-1: Water shed

Table 2-1 provides a system of classifying watersheds at different levels of aggregation.

Table 2-1: System of Classification of Watersheds in India

Category	Number	Size Ranges (‘ooo Ha.)
Regions	6	25,000-100,000
Basins	35	3,000-25,000
Catchments	112	1,000-3,000
Sub-Catchments	500	200-1,000
Watersheds	3,237	50-200
Sub-watersheds	12,000	10-50
Milli-watersheds	72,000	1-10
Micro-watersheds	400,000	0.5-1

(Source: Bali, 1979, p. 82)

2.2.WHY WATERSHED DEVELOPMENT?

2.2.1. Most of the works permitted under Mahatma Gandhi NREGA, at Para No. 4(1) of Schedule-1, MGNREGA are such that the rain fed area can be developed to bring the area under production and to increase the productivity through watershed management works.

2.2.2. It has been recommended by various technical Committees and established by implementation of different Watershed Management Programmes, that for integrated development of rain fed area and drought proofing; area treatment from ridge to valley on watershed approach is the only solution. This will lead to natural resource conservation, increasing the productivity of the land, bringing additional area under agriculture, employment generation and social upliftment of community living in the rural area. Therefore, to achieve the objective of the scheme and optimum utilization of MGNREGA funds in rain fed area, the projects are to be prepared on watershed approach with ridge to valley concept.

2.2.3. While planning for rain fed area, the sub/ micro watershed area covering a Gram Panchayat or a village can be a unit for planning. For planning of works the revenue map of the village should be superimposed on the G.T. Sheet or Watershed Atlas of the area by enlarging or reducing the scale of the maps to bring on similar scale for superimposition. Watershed should be delineated/ marked on this superimposed map. Thereafter planning of works on watershed approach with ridge to valley concept and water budgeting should be made. Once, the planning is completed the execution of works should start from ridge to valley.

2.2.4. Convergence of MGNREGS with other ongoing schemes in rain fed area:

i) As per Operational Guidelines of MGNREGA, an annual plan and a District Perspective Plan to facilitate advance planning and to provide a development perspective for the district is to be prepared. These plans in the district are to be coordinated by the District Programme Coordinator i.e. the Collector. The District Planning Committee, whose chairman is District Collector, has also to approve the perspective and annual action plan relating to Watershed projects in the district. Therefore, at the stage of preparing/ approving perspective and annual action plan relating to MGNREGS and IWMP, the District Collector should coordinate in such a way that with the convergence of ongoing schemes in the area a comprehensive project of village / watershed, incorporating/ integrating all the works/ activities required for the integrated development of the village on watershed approach is prepared.

   In this regard Ministry has recently issued Joint Convergence Guidelines MGNREGS & IWMP vide letter No. 11017/17/2008-NREGA (UN), dated 11th August, 2014, which is available on MGNREGA web site.

ii) For integrated development of rain fed area on watershed approach, it is necessary that the project/ perspective plan of a village is prepared with a Watershed approach integrating all the activities into a whole project. In this project, the works permitted under MGNREGA is planned / covered under MGNREGA and works not permitted under MGNREGA is covered under ongoing IWMP of DoLR (MoRD). Identify all the works/ activities to be covered under MGNREGS and under ongoing IWMP, separately with size of area/ work, estimated cost and the year in which proposed.

   Vide Ministry Circular No. 11017/17/2008-NREGA (UN), dated 11th August, 2014 guidelines have also been issued to take up watershed management works independently under MGNREGA, that: Watershed management works can be taken up independently under MGNREGA where there is no IWMP project sanctioned. These works shall be subject to the following guidelines:

a) Watershed management works can be taken up only after a comprehensive assessment of the entire watershed in the GP and shall address all issues of soil erosion, rainwater retention and afforestation.

b) Standalone works in the above category without a comprehensive watershed plan shall not be permitted.

c) In order to treat the entire watershed, the entire land shall be treated, without limiting to the lands of small/marginal farmers.

d) The comprehensive watershed plan shall be prepared in accordance with the concepts of ridge –to- valley treatment; and after proper verification of land utilization and capabilities through a participatory approach. It is recommended to use the satellite imagery for this planning work.

2.3. WATER BUDGETING AND PLANNING IN WATERSHED DEVELOPMENT:

Water budgeting is the process of assessing the volume of additional rain water to be harvested in the watershed area and to plan harvesting structures accordingly. It also involves calculating the volume of water required for human, livestock, agriculture and for maintaining the ecological balance sustainably.

i) THE POINTS TO BE CONSIDERED WHILE CALCULATING THE AMOUNT OF WATER TO BE HARVESTED ARE:

a) Calculation of total annual volume of runoff with respect to catchment area, rainfall, runoff co efficient (Qt)

b) Existing storage capacity of the area (B)

c) Water requirement by human life including agriculture purposes, livestock and to maintain ecology keeping 20 yrs. projection in mind (C)

d) Runoff available for harvesting (D) = (Qt)- (B)

e) Generally, maximum 75 % of balance available run-off (E)= 0.75x(D) is to be harvested and rest 25 % runoff water allowed to flow in the drainage line

f) Check whether (E) => (C), if not then make alternative plans like reducing water demand, mobilizing from neighboring water sufficient area etc.

Calculation of total annual volume of runoff in a watershed (surface water yield)

To calculate the annual volume of surface runoff water available in an area, we will need to multiply the annual rainfall with the area on which it falls and the coefficient of run off for that area.

Thus, $Q_t = C \times R \times A$ **.... (2.1)**

Where,
Q_t = annual volume or quantum of surface run-off (in cubic meters)

C = is the co-efficient of run-off (Please refer table given below)

R = is the annual rainfall (in meters) and,

A = is the area on which the rain falls (in square meters)

This is also known as the surface water yield of a watershed

Table 2-2: Coefficient for Estimating Run-off

Land Use & Slope	Sandy Loams	Clay/Silty Loams	Silty Clay
Cultivated Land			
0- 5%	0.30	0.50	0.60
5- 10%	0.40	0.60	0.70
10 - 30%	0.52	0.72	0.82
Pasture Land			
0- 5%	0.10	0.30	0.40
5- 10%	0.16	0.36	0.55
10 - 30%	0.22	0.42	0.60
Forest Land			
0- 5%	0.10	0.30	0.40
5- 10%	0.25	0.35	0.50
10 -30%	0.30	0.50	0.60

(Source: Dhruvnarayana, 1993)

Example: A typical exercise on water budgeting is at **Annexure-I.**

ii) WATERSHED DEVELOPMENT PLANNING:

Watershed development plan should be prepared with active participation of villagers through IPPE (Intensive Participatory Planning Exercise), so that their problems and priorities are addressed while addressing the issues of natural resources.

a) DIFFERENT COMPONENTS FOR WATERSHED PLANNING:

- **Size & selection of watershed:** Watershed boundaries are already defined naturally, but to make it a workable size around 500-1000 hectare area is preferred. One may refer to the watershed Atlas available with states.
- **Basic resource Survey:** Base line/bench mark surveys like climate, type of soils and its fertility status, rainfall pattern and runoff volume, present land use and problems, vegetation coverage and its quality. This will not only help us in planning but also in measuring the outcome of the programme.
- **Community Organization & People Institution:** Active participation of people is very crucial for planning & implementation of watershed development programme, so that it becomes community driven and community managed/owned. Government, NGOs and other stakeholders' roles are just to facilitate the process and to provide required resources like socio-technical and financial. The community must be aware about the concept of watershed and prepare their own watershed management plan through village level meetings, where representatives from SHGs, landless, ST & SC families, small and marginalized farmers participate.
- **Land Capability Classification:** Land capability classification (LCC) for management of land based ecological factors such as soil texture, soil depth, slope, water availability, erosion etc., are required for watershed development planning.
- **Preparation of Micro level Plan:** Micro level planning is prepared through the following steps:
  - Village wise social map, Resource map, present land use and problem maps are prepared through PRA exercise.
  - Different possible options/ solutions are discussed and finalized through village meetings. Through these processes, treatment plan is prepared for fallow/ non-arable & arable lands including drainage lines and infrastructural development. Emphasis should be given to rain water harvesting and massive plantation on community land/ along roads as well as private lands.
- **Convergence Approach:** The watershed development programme aims at holistic development of the area encompassing different types of activities. This requires convergence of resources and support from different departments to meet out financial, technical and other support services.
- **PRA as an important methodology of planning process:** Participatory Rural Appraisal (PRA) is the combination of different tools (Like Social mapping, Resource mapping, seasonal mapping, transact walk etc.) and techniques (focus group discussion etc.) which enables community to articulate and analyze their own situation, generating options and finalizing their plan based on their needs and priorities. This ensures identification of cost effective and appropriate interventions with greater ownership, sustainable use and management by the community.

  One may refer to IPPE manual issued from the Ministry for details of conducting PRA exercise in the villages.

2.4. WATERSHED INTERVENTIONS:

Watershed Interventions are defined and designed based on the situation, context and needs of the inhabitants. Different types of structural measures are designed based on different types of land. In a watershed the land can be divided into three broad areas based on their position i.e. ridge area, on farm mostly arable and drainage area like streams, nalla etc. Based on land slope, rainfall and present land use/ problems, different types of structural and vegetative measures are proposed which are as follows.

2.4.1. INTERVENTIONS IN NON-ARABLE/ RIDGE AREA:

Non-arable lands are those lands which are generally unsuitable for cultivation of agricultural crops. In the ridge area the problems are mostly high slope, soil erosion, rocky nature, shallow soil depth etc. Manmade activities like road construction and mining on steep hill slopes have rendered large areas denuded. Quite often, establishment of vegetation on these highly degraded lands is difficult due to high runoff/debris movement, lack of moisture and absence of fertile soils. Structural measures are, therefore, often needed before undertaking re-vegetation programme to stabilize the slopes and create conditions conducive for plant growth by arresting fertile soil and improving moisture regime.

Measures to be adopted based on situation and context of the area are:

2.4.1.1. DIVERSION DRAINS:

Excessive runoff water entering into an area from upstream / ridge area is often a cause of high soil erosion and land degradation of arable area. Diversion drains, made across the slope at the end of non-arable area or rolling topography can be used in such a situation to divert runoff water away in order to protect the downstream/ arable area and discharge it safely into a protected waterway.

i) SUITABILITY:

Diversion drains are suitable at places where runoff from the ridge area situated above is damaging or likely to damage the arable area lying on the downstream side.

ii) DESIGN:

a) Diversion drains should be aligned on non-erosive and non-silting grades.

b) The gradient of diversion drain should preferably be kept within 0.5 percent.

c) A narrow and deep drain does not get silted up as rapidly as a broad and shallow drain of the same cross-sectional area and is, therefore, self-maintaining.

Note: For designing diversion drain may refer to grassed waterway design at chapter no. 2.4.2.8

2.4.1.2. CONTOUR TRENCHING:

i) Contour trenching is a widely used practice for moisture conservation in plantations and grassland development. It is a practice of excavating trenches along a uniform level across the slope of the land. Bunds are formed along the trenches on the downstream side with soil taken out of them. The expected service life of a trench is about 3 to 4 years during which time the vegetation is supposed to perform/ take over the conservation function.

ii) Contour trenches break the velocity of runoff and store whole or a part of runoff. Trenches should be designed to store 60-70 pe rcent of runoff from 6hrs. Storm with 5 years return period in coarse textured soils. In fine textured soils about 50 percent of the runoff water may be stored. The intercepted runoff percolates through the soil slowly and is made available moisture to the plants planted towards down stream side. Contour trenches may be of two type’s namely continuous contour trenches and staggered contour trenches.

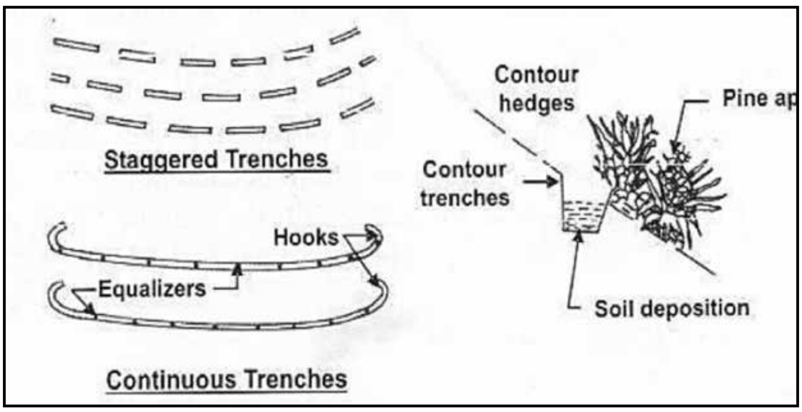


Figure 2-2: Contour and staggered trenches

a) Continuous Trenches: The trenches are called continuous when there is no break in length and can be 10 to 20 m long across the slope depending upon width of the area. Generally, trenches are dug with a cross-section varying from 30cm x 30cm to 45cm x 45cm with side slope 1:1 to 1.5:1.

b) Staggered Trenches: The staggered contour trenches are laid scattered with inter space between them. In staggered trenching, the trenches are located directly below one another in alternate rows and in a staggered fashion. Staggered trenches may be made to a length of 2-3 m and spacing between the rows may vary from 3m-5m.

iii) SUITABILITY:

a) Contour-trenches are normally constructed in the upper portion/ ridge area of the watershed for plantation of forestry/horticultural plants.

b) Continuous contour trenches are generally used in low-rainfall areas for moisture conservation.

c) In high rainfall areas, staggered contour trenches are generally adopted. There is a potential danger of overflow and breach in case of continuous trenches in such areas.

d) Fodder grass should be planted on the bund and horticultural/fuel fodder trees may be planted just downstream of the trench or in the trench itself in gravel soils.

e) On steep and irregular sloping lands, staggered trenches are more suitable.

f) The trenches can be suitably arranged under different field situations as shown in Fig 2-3 & 2-4.

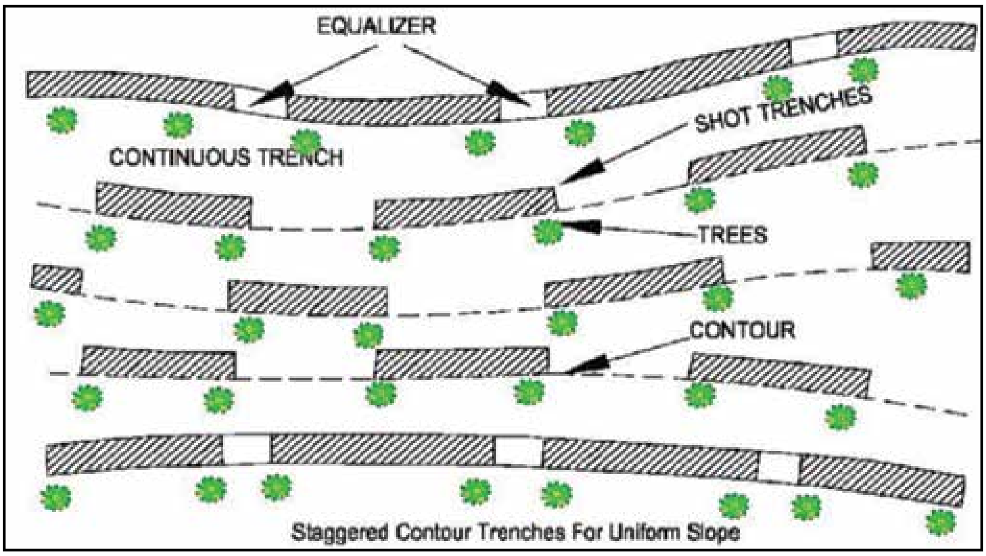


Figure 2-3: Staggered contour trenches on steep & irregular slope

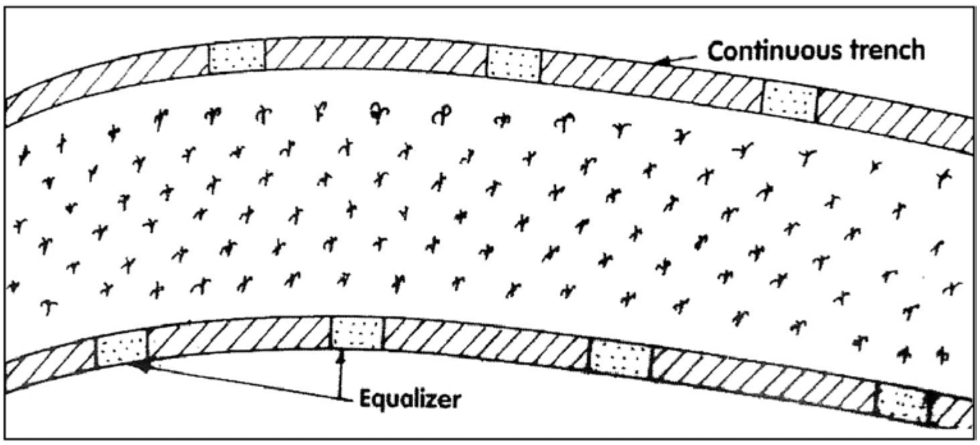


Figure 2-4: Continuous trenches for pasture development

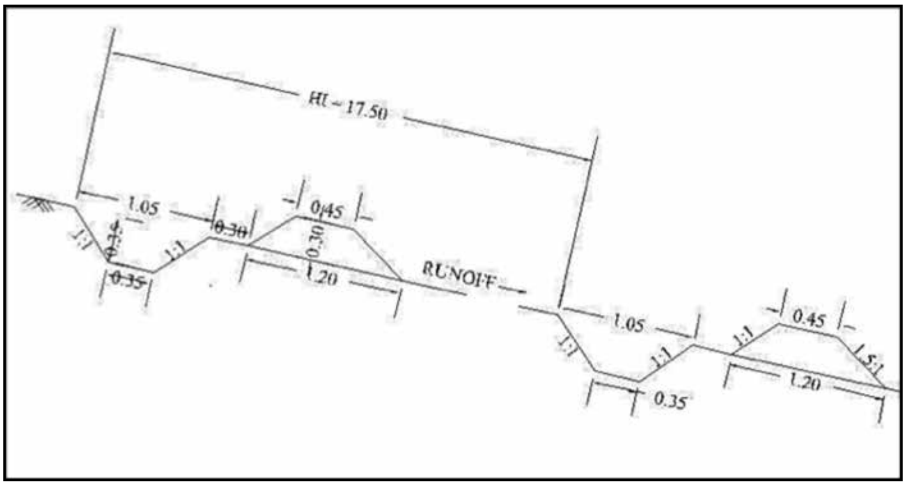


Figure 2-5: Definition sketch of a contour trench

Design

Calculation of runoff for the watershed having coarse soil, where 70% water will be stored:-

Q_t = C x Rx A **.... (2.2)**

where,
C = runoff coefficient,
R = 6hrs maximum rainfall of 5 years recurrance interval.
A = the area from which runoff is received in sqm.

As we required 70% of the runoff than Q_t= 70 x Q/100 Cum. = 0.7Q Cum.

The Total Length of the Trench in meters (L) = Q_t/ (A_t x f) in meters,

Where, A_t = Area of Trench in sqm and f = Nos. of refills of the trench.

There after we can calculate the Horizontal Spacing between the two successive contour trench
HI = A / L in m.

To decide the number of rows of contour trenches, we divide the longest length of the ridge area (Lr) by the HI
Nos of row of the trenches (N) = Lr / HI

Example: Design a continuous trench in an area of 50 ha. The runoff co-efficient of the area is 0.5. The 6hrs maximum rainfall of 5 years returned period is 80mm and 70% runoff is to be stored in the trench, the trench gets 2 refills in a day and the longest length of the ridge area is 5000m. On same parameters also design staggered contour trenches if distance between two trenches in a row is 3m.

Solution:

For continuous contour trench-

Find the Quantum of runoff by formula
Q_t= C x Rx A or Q = 0.5 x 0.08 x 50 x 10000 = 20000 cum.

As we have to design for 70% of total runoff so Q_1= 20000 x 0.7 = 14000Cum.

Find the Length of CCT (continuous contour trench):

Generally size of CCT is 0.245sqm.

Trapezoidal Section Top width= 1.05m., Bottom = 0.35m., Depth= 0.35m. side slop =1:1

= (1.05+0.35)/2 x 0.35

so A_t = 0.245sqm., It is given that trench get 2 refills in a day.

so the total length of CCT (L) = Q_1/A_t x f = 14000/0.245 x 2 = 28571 m.

Now the distance between successive rows (HI) = A/L = 500000/28571 = 17.50m. **.... (2.3)**

So the Number of row of CCT (N) = L_r/HI = 5000/ 17.50 =286 Nos

Runoff collection (Q_1)	**=**	**14000cum.**
Total Length of CCT	**=**	**28571m.**
Number of rows of CCT	**=**	**286**
HI of CCT	**=**	**17.50m.**

<u>For staggered contour trench-</u>

Q_1 = 14000 cum.

Volume of Trench = length x (Top+ Bottom width)/2 x height

= 5 x (1.05+ 0.35)/2 x 0.35 = 1.225 cum.

Refill 2 a day than volume = 1.225 x 2 = 2.45 cum.

Nos of trenches = Q_1 / Volume of each trench = 14000/2.45 =5714 trenches.

Total length of Contour trench (L)= 5714 x (5m.+ 3m.) = 45712m. . **.... (2.4)**

Distance between two row of trenches (HI) = A/L= 500000/45712 = 11m

Numbers of rows of trenches (N) = L_t/ HI = 5000/ 11 = 454

Runoff collection (Q_1)	**=**	**14000cum.**
Total Length of SCT	**=**	**45712m.**
Number of rows of SCT	**=**	**454**
HI of SCT	**=**	**11m.**

iv) DO'S AND DON'TS:

a) Do not make trenches on slopes higher than 25%. Instead adopt vegetative measures.

b) Do not plant inside the trench.

c) Do not make trenches on slopes less than 10%. Instead construct contour bunds.

d) Do not excavate trenches where there is already dense vegetation.

e) Do not excavate if roots of a tree are encountered Do not excavate trenches across large streams or drainage lines.

f) Do not start the lay-out of trenches from the shorter section. Always begin from the longest section within the largest area of uniform slope trend.

2.4.1.3. LOOSE BOULDERS BUNDING:

Loose Boulders Bunding (LBB) also known as dry stone walls can be constructed across the hill slopes at pre-determined spacing for developing land for cultivation, if stones are readily available in the locality. LBB can be constructed on contour or at minor gradient depending upon the need.

i) SUITABILITY:

a) LBBs are suitable at places where stones are locally available.

b) It helps in retaining soil and subsequent formation of a bench terrace as well as drainage of the excess water.

c) LBBs are widely adopted in the hilly areas of Tamil Nadu and Kerala.

ii) DESIGN:

The spacing of VI of contour stonewalls is not rigid and suitable spacing can be adopted as per site conditions/ suitability. The following formulae are used in southern region of India.

VI = S/10 + 2 (for the areas receiving rainfall up to 1500 mm per annum)

VI = S/10 +1.5(for areas receiving rainfall more than 1500mm per annum)

VI = S/8 + 4 (in Udhagamandalam, Tamil Nadu)

Length of Contour stone wall/ Ha. = 100 x S/V.I.

Where, S = Slope, percent, and VI = Vertical interval in mt.

Shallow foundation to a depth of about 30cm is adopted.

The most commonly adopted cross section for the contour stone wall is a trapezoidal section with 60cm top width and 80cm bottom width. The height above the ground level is about 50cm.

Table 2-3: Vertical interval in (m) and Length (m) of contour Stone Wall per ha. for different land slopes (per cent) & rainfall zones

% Slope	Rainfall less than 1500mm		Rainfall more than 1500mm		In Nilgiri Hills	
	VI=S/10 +2	Length	VI=S/10+1.5	Length	VI= S/8+4	Length
2	2.2	91	1.7	118	4.250	47
5	2.5	200	2.0	250	4.625	108
8	2.8	286	2.3	348	5.000	160
10	3.0	333	2.5	400	5.250	190
12	3.2	375	2.7	444	5.500	218
15	3.5	429	3.0	500	5.875	255
18	3.8	474	3.3	546	6.250	288
20	4.0	500	3.5	571	6.500	308
22	4.2	524	3.7	595	6.750	326
25	4.5	556	4.0	625	7.125	351
28	4.8	583	4.3	651	7.500	375
30	5.0	600	4.5	667	7.750	387

(Ref.; Participatory Integrated Watershed Management, a Field Manual, CSWCRTI, Dehradun-2006)

2.4.1.4. SPRING SHED DEVELOPMENT IN NORTH EAST:

In the North East mountainous region, the springs used to be full of water earlier even during the dry season, but now they have become seasonal. The spring discharge depends on rainfall. While most of the rainwater is lost as surface runoff, a part of it percolates into underground and gets stored in the fine pores and cracks of the rocks. The more percolation & natural recharge, leads to more availability of water in the spring. Dense vegetation reduces the speed of surface runoff thereby resulting in higher infiltration. It also helps in filtering the water and improving the water quality. Deforestation, hill cutting, landslides etc. drastically reduce the quantum of natural ground water recharge. This results in the springs drying up during the dry season.

DHARA VIKAS:

The objective of the Dhara Vikas initiative under MGNREGA in Sikkim is to increase the dry season spring discharge by enhancing the recharge of the springs during the monsoons. It is a climate change adaptation initiative that helps in enhancing rural water security.

i) Solution: Springs are fed by ground water. Ground water is the rain water that has percolated underground. To recharge a spring we need to increase the infiltration to ground water in its recharge area. This can be done by trapping the surface runoff during the monsoons and making it percolate inside the ground. Dugout trenches and ponds help to catch the surface runoff and increase the infiltration to supplement ground water.

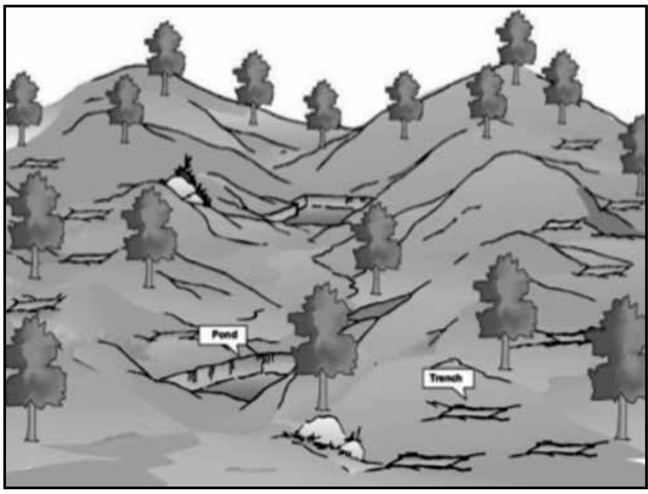


Figure 2-6: Model of spring shed development

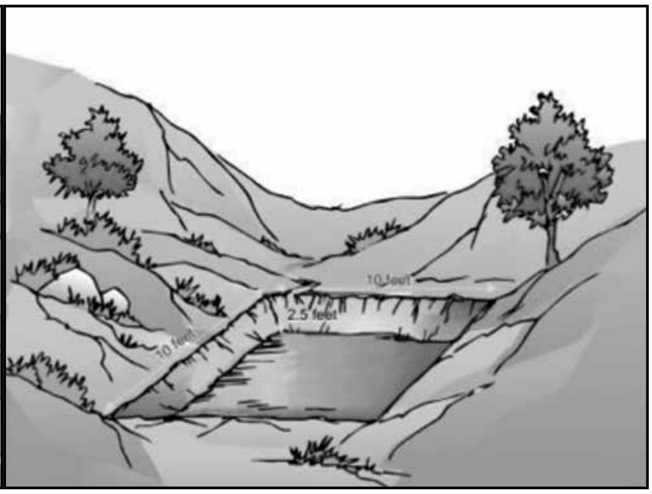


Figure 2-7: Dug out pond in depression

ii) Strategy for recharging springs: It is very important to identify the recharging area of different types of springs. Three types of springs are commonly found in the region and can be identified through proper geo- hydrological study of the area. These are as follows:

a) Depression springs: These springs occur where there is a sharp change in slope. The water table cuts the surface due to this sudden change in topography. The spring originates from the point where the water table cuts the surface. Recharge area for this type of spring will be just above the spring.

b) Fracture springs: Fracture springs originate along a fracture which cuts across an aquifer forming rock. The fracture acts as a channel for groundwater to move out of the aquifer forming a spring. A series of springs often emerge down slope along the fracture. Thumb rule for the identification of recharge area in fracture springs are:

- Along the fractures above the springs.
- Dip slope in the catchment area above the springs
- Escarpment slope of the rocks above the springs

c) Contact springs: A series of springs emerging at the contact of two different rock types are termed as contact springs. The rocks above the springs and below the springs will differ in nature. Rocks which are below the springs basically will be impermeable rock and above the springs will be permeable rocks. So the spring emerges from the contact point of these two rocks. Thumb rule for the identification of recharge area in contact springs is as follows:

- In the dip slope of the rocks above the springs or escarpment slope of the rocks above the springs.
- Along the fractures above the springs (if any)

2.4.1.5. VILLAGE POND:

While constructing or renovating pond, following principle are to be followed:

i) It should be on common land;

ii) Hydrologic design i.e. annual runoff available for storage & peak discharge should be worked out with respect to catchment area, topography and rainfall, as stated above at Para 2.3 under water budgeting. The size of village pond should be based on annual runoff available for storage.

iii) Pucca inlet and outlet should be constructed simultaneously with Hydraulic design to work out the size of inlet and outlet, as stated at para 2.4.2.9 under the head surplus arrangement/ waste weir.

iv) Advisory on construction of inlet with silt trap and outlet has been issued from the Ministry vide letter No. J-11017/40/2011-MGNREGA (UN), dated 23rd November, 2011, as follows:

a) **Inlet:** The inlet should be designed as chute spillway for conducting the runoff in to the pond in a controlled manner. The entry section can be designed as a rectangular broad crested weir. Since the velocity of runoff is accelerated along the side slope of the pond the width is contracted at 1m below the top level of the pond and continued at the same width thereafter.

b) **Outlet:** The outlet is constructed as rectangular or square channel. This outlet position will be little lower (15 -20 cm) than the elevation of the inlet to avoid back flow of water. The discharge capacity of outlet can be assumed to be half as that of the inlet capacity as peak rate of runoff.

c) **Silt trap:** A silt trap of suitable dimension should be created in the watercourse just near the entrance of the inlet to check the silt load entering the pond. The length of such silt trap can be slightly greater than the width of the water course and the depth may be about 0.6 to 0.75m.

d) **Cleaning silt trap:** The silt accumulated in the silt trap should be removed periodically and preferably as and when it gets filled up after a few runoff events.

2.4.2. INTERVENTIONS IN ON-FARM / ARABLE AREA:

In order to check the soil erosion and also conserve moistures for crop growth, Structural measures are adopted like Contour Bunds, Graded Bunds, Bench Terraces etc., basically these measures constitute a series of bunds across the slope to break the length of slope/ run to dissipate the energy of flowing water. The important principles to be kept in view while planning these bunds are:

i) Increasing the time of concentration of runoff and thereby allowing more time to be absorbed in the soil.

ii) Intercepting a long slope into several short ones so as to check erosive velocity of the runoff water and check soil erosion

iii) Protection against damage due to excess runoff by providing spillway for safe disposal of excess runoff

The selection and the suitability of engineering control measures to be adopted at different locations depend on soil type, soil depth, rainfall, land slope and crops to be raised. Structural measures like bunding, terracing etc. are adopted in arable lands on relative moderate to steep slopes.

2.4.2.1. BUNDING:

Bunding, adopted on mild sloping lands, may be defined as construction of small embankments or bunds across the slope of the land. Bunds decrease the length of slope and help in intercepting the runoff flowing down the slope, thereby conserving moisture and reducing soil erosion. Bunds may be of different types such as Contour Bund, side bunds, lateral bunds, supplementary bunds, Graded bunds etc.

Side Bunds: The bunds constructed at extreme corners of contour bund, running along the slope are called side bunds. They help in retaining specified depth of water in up stream side of the contour bund.

Lateral Bunds: Bunds constructed along the slope in between two side bunds in order to prevent flow of water along one side and to break the length of contour bund into convenient lengths are called lateral bunds.

Supplemental Bunds: Bunds constructed between two contour bunds so as to limit a horizontal spacing to a maximum value are called supplemental bunds.

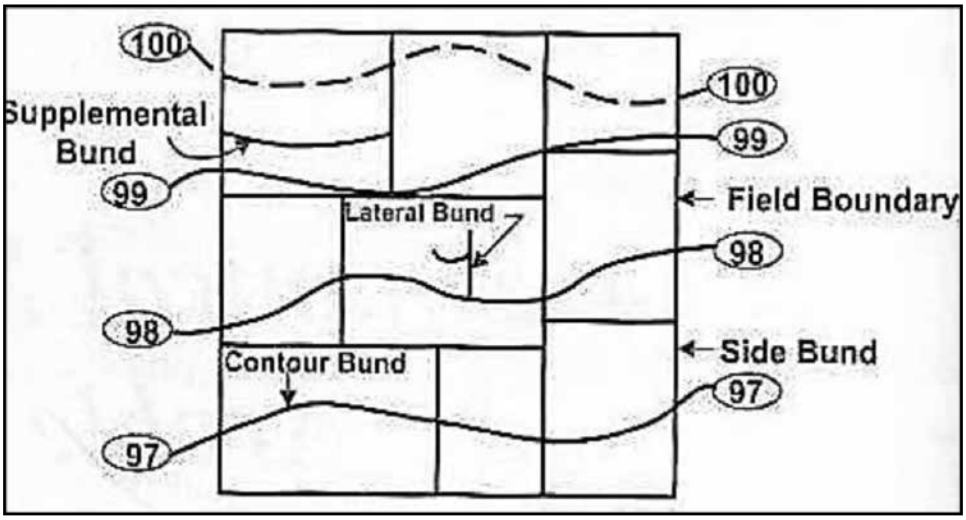


Figure 2-8: Location of different types of bunds

i) CONTOUR BUNDING:

The bunds are referred to as contour bunds when they are constructed on the points of equal elevation. Contour bunding is suitable for lands having slope up to 10 per cent, for areas with low rainfall (annual rainfall less than 800mm) and permeable soils. The practice of contour bunding is found to increase crop yield by about 15 to 20 per cent. However, because of small and scattered land holdings, farmers at places find it difficult to adopt bunds strictly on contours. Instead, field bunding, compartmental bunding near contour lines is commonly practiced under such conditions.

a) Planning and design of contour bund:

The design of a contour bund requires the estimation of:

- Spacing of bunds
- Cross section of bund
- Deviation freedom to go higher or lower than the contour bund elevation for better alignment on undulating lands.
- Waste weir

- **Spacing of bunds:** Spacing of bunds is usually expressed by vertical interval (VI) between the two consecutive bunds. The main criterion for spacing of bunds is to intercept the water before it attains the erosive velocity. The spacing of bunds depends on factors such as slope, soil, rainfall, cropping pattern and conservation practices etc.

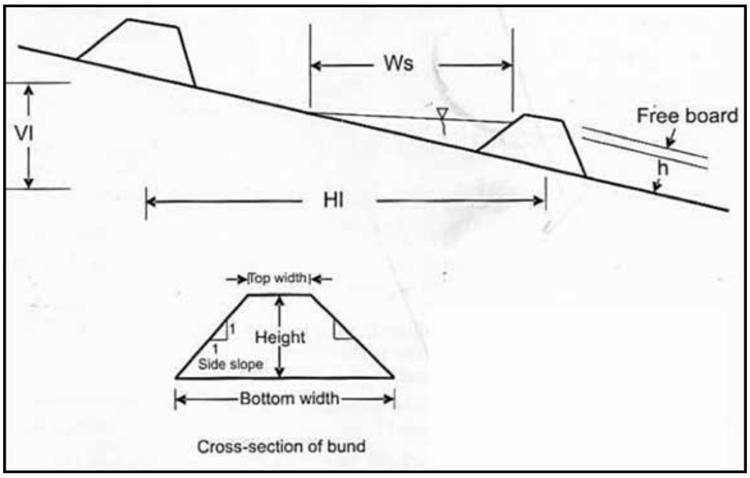


Figure 2-9: Contour bund and its design specification

Ramser's Formula: Ramser's formula for computing the spacing of bunds is as follows:

VI= 0.3(S/a +b) **.... (2.5)**

Where,
VI = Vertical interval between consecutive bunds (m)
S = Land slope (percent), and
a = Constants specific to a particular region.
b= 2 (Constants).

For soils with good infiltration rates, values of 'a' is taken as 3.

For soils of low infiltration rates the value of 'a 'is taken as 4.

Spacing of bund i.e. H.I. = 100x V.I./ S **.... (2.6)**

Length of bund per ha = 100 S/V.I. **.... (2.7)**

Calculation for Vertical Interval and Horizontal Interval with Length per Hac. of Bund.

(When the infiltration rate is good)						
% Slope	**V.I.= 0.3(S/a +2)**	**= in M.**	**Roundup in Meter**	**H.I.= 100xV.I./S**	**=In Meter**	**Length per Ha. = 100x S/V.I.**
1	0.3x(1/3 +2)	0.699	0.70	100x0.70/1	70.00	100x1/0.7=143 m.
2	0.3x(2/3 +2)	0.798	0.80	100x0.80/2	40.00	100x2/0.8=250 m.
3	0.3x(3/3 +2)	0.900	0.90	100x0.90/3	30.00	100x3/0.9=333 m.
4	0.3x(4/3 +2)	0.999	1.00	100x1.00/4	25.00	100x4/1.0=400 m.
5	0.3x(5/3 +2)	1.098	1.10	100x1.10/5	22.00	100x5/1.1=455 m.

6	0.3x(6/3 +2)	1.200	1.20	100x1.20/6	20.00	100x6/1.2=500 m.
7	0.3x(7/3 +2)	1.299	1.30	100x1.30/7	18.50	100x7/1.3=500 m.
8	0.3x(8/3 +2)	1.398	1.40	100x1.40/8	17.50	100x8/1.4=572 m.
9	0.3x(9/3 +2)	1.500	1.50	100x1.50/9	16.50	100x9/1.5=600 m.
10	0.3x(10/3 +2)	1.599	1.60	100x1.60/10	16.00	100x10/1.6=625 m.
(When the infiltration rate is Low but above 8mm/Hr.)						
1	0.3x(1/4 +2)	0.675	0.70	100x0.70/1	70.00	100x1/0.70=143 m.
2	0.3x(2/4 +2)	0.750	0.75	100x0.75/2	37.50	100x2/0.75=267 m.
3	0.3x(3/4 +2)	0.825	0.80	100x0.80/3	27.00	100x3/0.80=375 m.
4	0.3x(4/4 +2)	0.900	0.90	100x0.90/4	22.50	100x4/0.90=444 m.
5	0.3x(5/4 +2)	0.975	1.00	100x1.00/5	20.00	100x5/1.00=500 m.
6	0.3x(6/4 +2)	1.050	1.05	100x1.05/6	17.50	100x6/1.05=571 m.
7	0.3x(7/4 +2)	1.125	1.10	100x1.10/7	15.50	100x 7/1.10=636 m.
8	0.3x(8/4 +2)	1.200	1.20	100x1.20/8	15.00	100x 8/1.20=666 m.
9	0.3x(9/4 +2)	1.275	1.30	100x1.30/9	14.40	100x 9/1.30=692 m.
10	0.3x(10/4 +2)	1.350	1.35	100x1.35/10	13.50	100x10/1.35=740 m.

• **Cross-section:** A trapezoidal cross-section (shape) is usually adopted for the bund. The design of cross-section of the bund involves (i) height (ii) top width (iii) side slope and (iv) bottom width of the bund.

o Height: The height of the bund depends upon the slope of the land, type of soil and the rainfall expected in 24 hours period for 10 years frequency in a given area. Once the height is determined other dimensions of the bund viz: bottom width, top width and side slopes can be worked out depending upon the type of the soil.

Height of bund can be determined by the following methods:

- With 30 cm depth of impounding which is a usual practice in many states, and the 30 cm is provided as depth of flow over the crest of the waste weir and 20 cm is provided as free board. This makes the overall height of the bund as 80 cm, top width of 0.50 m and bottom width of 2.1 m, side slope as 1:1 and cross-section of 1.04 sqm.
- The design of bund for 30 cm depth of impounding is an arbitrary design. The height of bund to impound runoff from 24 hours rain storm can be calculated by the following formula:

  $$h = \sqrt{(Re \times VI / 50)} \qquad \textbf{.... (2.8)}$$

  Where,
  h = Height of Bund for 30cm impounding
  Re = 24 hour rainfall excess, cm and
  VI = Vertical interval, m
- To the theoretical height of bund so calculated 20% extra height or a minimum of 15 cm as free board (f.b) is added and another 15 to 20% extra height towards settlement due to consolidation.

o Top width: A minimum of 0.3 m to 0.6 m width is kept to facilitate plating of grasses on the top of the bund.

o Side slopes: Side slopes of the bund are dependent upon the angle of repose of the soil. Side slopes of bunds may vary from 1:1 (clayey soil) to 2:1 (sandy soil), (refer table 2.4 for side slope of different type of soils).

o Base width: Base width of the bund depends upon the hydraulic gradient of water in the soil. A general value of 4:1 assumed for the hydraulic gradient (refer table 2.10). The base should be sufficiently wide so that the seepage line not appears above the toe of the bund on the downstream side.

o Size of the bund: The size of the bund is expressed in terms of its cross-section (C/S) area. Contour bunds are usually of trapezoidal shape and the cross-sectional area of the bund is worked out by the following formula:

C/S area = (Top width + Bottom width)/2 x height of bund = (T+B)/2 x D

Where,
T = top width of bund m
B = Bottom width of bund m and
D = Height of bund, m

In general, the cross-section of bund depends on the soil type and rainfall and it varies widely between 0.50 to 1.0 sq. m in different regions. Recommended contour bund specifications for different soil depths are given in table below:

Table 2-4: Recommended cross-section of contour bund for different soil depths (including free board and settlement etc.)

Sl. No.	Soil type	Top width (m)	Bottom width (m)	Height (m)	Side slopes	Area of cross section (m2)
1	Very shallow soil (Full murrum or soil layer up to 7.5 cm)	0.45	1.95	0.75	1:1	0.9
2	Shallow soil (soil layer from 7.5cm to 23 cm).	0.45	2.55	0.83	1.25:1	1.21
3	Medium soils say sandy loam (soil layer from 23cm to 45 cm).	0.53	3.00	0.83	1.50:1	1.48
4	Medium to deep soils say sandy soil (45cm to 80cm).	0.60	4.20	0.90	2:1	2.22

(Ref.; Participatory Integrated Watershed Management, A Field Manual, CSWCRTI, Dehradun-2006)

o For Estimate Purpose we can calculate the E/W of Lateral/Side bunds as follow:

Length of side bund and lateral bund =100xd/2,

Where, d = the elevation difference between end point of side bund/ lateral bund and contour bund.

Cross section of side bund and lateral bund= 2/3rd of cross section of contour bund o Earth Work:

The quantity of earthwork required in bunding per hectare is given by:

Volume of earth work/ha (m^3/ha) = Cross section area of bund (m^2) x bunding intensity (m/ha).

o Area lost due to bunding:

This is obtained by multiplying the length of bunding per hectare by the bottom width (B) of the bund.

$$\text{Area lost (m2/ha)} = \frac{100S \times B}{VI} \qquad \textbf{.... (2.9)}$$

Where, B = Bottom width of bunding

• **Permissible deviations on alignment**

To avoid excessive curvature in the bunds which makes agricultural operations difficult the following deviations from strict contour are permitted:

- Not more than 15 cm deviation from strict contour while cutting across a narrow ridge;
- Not more than 30 cm deviation from strict contour in case of crossing a gully or depression;
- Deviation up to 1.50 m in respect of a sharp narrow depression not exceeding 5 m in width

b) Construction of contour bunds :

The following precautions may be taken while constructing a bund on the ground:

- The construction should start from ridge of the watershed and proceed downwards
- If the upper portion of the watershed is under a different land use and is not to be bunded, then diversion drains just at the top of the arable or rolling topography area to be provided to divert the runoff from causing overflow damages.
- Soil for construction of the bunds is taken from borrows pits of suitably chosen size and numbers. Borrow pit should not be continuous but interrupted with a gap of 0.6m.
- Borrow pits are located on the upstream side.
- Berm of 30 to 50cm in between borrow pit and foot of the bund should be maintained.
- Ramps are provided for the free passage of cattle, agricultural implements and bullock-carts.

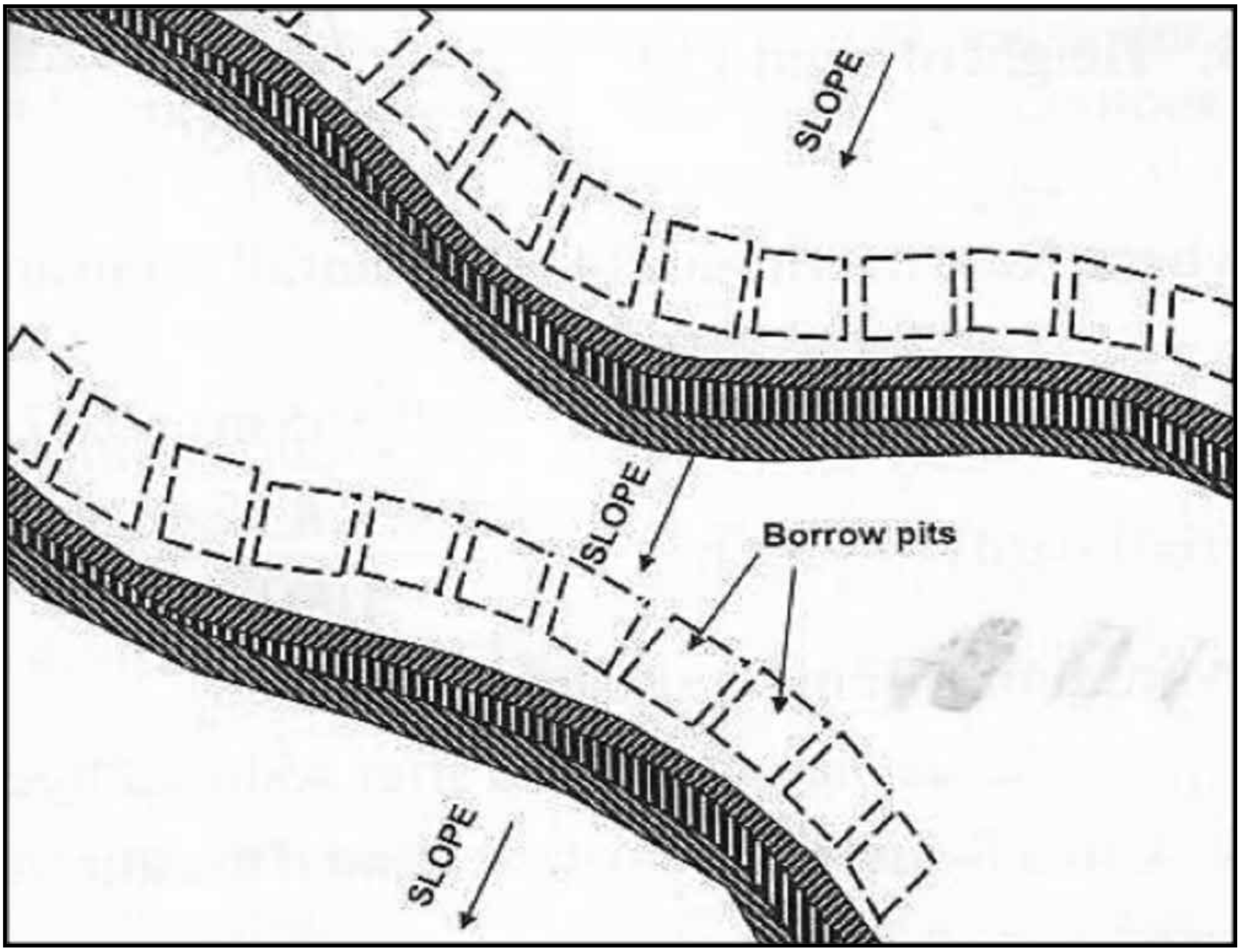


Figure 2-10: Construction of contour bunds showing borrow pits

c) Example:

A piece of land measuring 1350 meters along the slope and 250 meters across the slope has a uniform slope of 2%. The maximum 24 hour rainfall for 10 years recurrence interval is 200 mm. The soils are sandy loam in texture and having a good infiltration rate. Design the cross section of the main bund if the top width of the bund is 0.5m. The side bunds are to be taken up to the slope of 0.5 m above the main bund line. Find the earth work of bund.

Solution:

1. Vertical Interval (VI) = [S/3+2]0.3 = [2/3+2]0.3 =0.80m

2. Horizontal Interval (HI) = 100VI/S $= \frac{100 \times 0.80}{2}$ = 40m

   No. of bunds = 1350/40 = 34 Nos.

3. Height of bund (h) = $\sqrt{(Re \times VI/50)}$

   Where Re is maximum 24 hour rainfall in cm and VI is Vertical Interval in meters.

   $h = \sqrt{(20 \times 0.80/ 50)}$ = 0.565 m or 0.57 m

   Free board (15% of h) $= \frac{0.57 \times 15}{100}$ = 0.0855 or 0.10 m

   (Minimum 10 cm free board is provided)

   Actual height of bund after adding a free board = 0.57+0.10 = 0.67 m or 0.70m

4. X- Sectional area of the bund, given top width is 0.50 m, & side slope is 1.5:1 for sandy loam& Height of bund is 0.70m. Then base width of bund = 2x1.5x0.70 + 0.5= 2.60 m.

$$\text{X- Sectional area} = \frac{(2.60+0.50)}{2} \times 0.70 = 1.085 \text{ m}^2$$

Length of the bund (m/ha) = 100S /VI = 100x2/0.80 = 250m/ha

$$\text{Total length of the bund for the area to be bunded} = \frac{(250 \times 1350)}{100 \times 100} \times 250$$

= 8437.50 m

Volume of earth work for the main bund = length x cross sectional area

= 8437.50x1.085=9154.69 or

= 9155m^3

Number of side bunds = no. of bunds x 2 = 34x2 =68 no.

Length of side bund = 100 x d /2 = 100 x 0.50 /2 = 25m (d = 0.50m)

Cross sectional area of side bund is usually taken as 2/3rd of the main bund

= 1.085 x 2/3=0.7233 m^2

Volume of earth work for side bunds = 68x0.7233x25

= 1229.61m3 or 1230 m^3

Total volume of earth work for the main and side bunds

= 9155+1230 =10385 m^3

(Note: When length of contour bunds exceed 300 m lateral bund along the slope are provide and taken up to 0.30 to 0.50 m above the main contour bund for uniform spreading of rain water. Lateral bunds are similar to side bunds and are provided in between two side bunds. Cross sectional area of the lateral side bunds are usually taken as 2/3rd of the main bund.)

d) Contour Bunds: DOs and DONTs:

• DOs:

- Always provide a berm of 30 cm.
- Always provide a settlement allowance.
- Spillway for the safe disposal of runoff water must be provided, simultaneously.
- In impermeable soils increase the cross section area of bunds.

• DONTs:

- Do not start the lay-out of bunds from the shorter section. Always begin from the longest section within the largest area of uniform slope
- On high slopes do not make bunds closer than 30 m.
- On low slopes do not make bunds farther than 60 m. Do not make bunds on slopes higher than 10%. For higher slopes adopt vegetative measures or bench terracing as per the situation
- Do not construct bunds where there is already dense vegetation
- Do not excavate if roots of a tree are encountered
- Do not excavate soil continuously in permeable soils.
- In order to ensure safety and utility of the bund:

- o Increase the downstream slope of the bund
- o Decrease the distance between bunds
- o Provide an waste weir in the bunds

ii) GRADED BUNDING:

Graded bunds are laid along a predetermined longitudinal grade instead of along the contour for safe disposal of excess runoff.

a) Suitability:

Graded bunding is recommended in situations where the rain water is not readily absorbed either due to high rainfall or low intake rates of the soils. It is adopted in medium to high rainfall areas where annual rainfall exceeds 800 mm in low permeable soils and particularly in clayey soils (infiltration rate <8mm/hr.) even with lesser rainfall.

b) Planning and design of graded bunding:

The design of the graded bund involves the selection of the vertical interval and the provision of grades and suitable cross-section for the bund and channel. A typical bund and channel section is shown in Figure 2.12. By and large graded bunds of 0.3 to 0.50 m2 cross section are constructed.

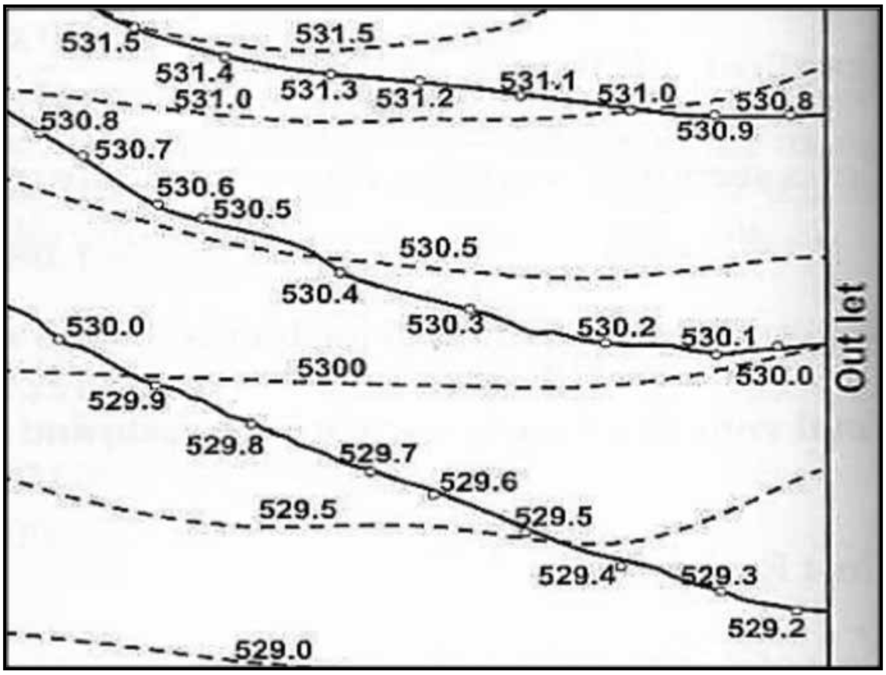


Figure 2-11: Planning of graded bunding on contour map

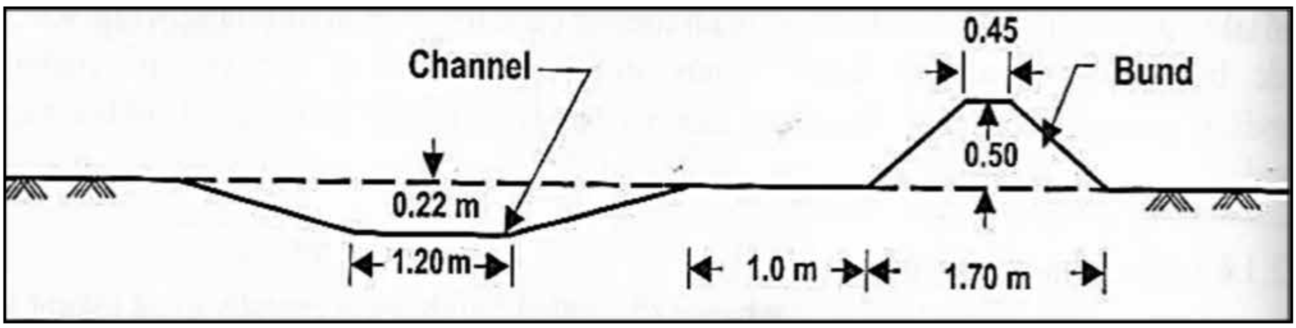


Figure 2-12: Details of graded bund

• **Vertical Interval:**

Graded bunds are spaced at the same vertical interval as that of contour bunds. The following vertical intervals have been arrived at by using an arbitrarily fixed formula.

VI = (S/6+2)*0.3 for the area where rain fall is > 800 mm.

Slope (%)	VI (m)= 0.3x(S/6 +2)	HI (m)= VI/S x100
1	0.3 x (1/6 + 2)= 0.6498 or 0.65m	0.65/1 x 100 = 65m
2	0.3 x (2/6 + 2)= 0.6999 or 0.70m	0.70/2 x 100 = 35m

VI = (S/4+2)*0.3 for the area where rainfall is <800 mm.

Slope (%)	VI (m)= 0.3x(S/4 +2)	HI (m)= VI/S x100
1	0.3 x (1/4 + 2)= 0.6750 or 0.70m	0.70/1 x 100 = 70m
2	0.3 x (2/4 + 2)= 0.7500 or 0.75m	0.75/2 x 100 = 37m

• **Grade:**

In general a grade of 0.20 to 0.40% is provided depending upon the soil type. In permeable soils the grade may vary from 0% at the upper end to 0.5% at the outer end. In case of impervious soils, it may start with 0.2% at the upper end and increase to 0.4% at the outlet.

• **Channel cross-section:**

- The main requirements of satisfactory channel cross-section are adequate channel capacity to discharge the flow and the channel side slopes flat enough to permit farming operations without causing damage to cross-section.
- Usually the channel depth of a settled terrace from bottom of terrace to the top of ridge should be at least 0.45 m. usually, a minimum cross-section of 1 sq. m is provided to the channel.
- The capacity of the channel of terraces depends on cross-section and velocity. The velocity should be non-erosive. The permissible velocity in different type of soil is as follows:-
  - o Bare Soil : 0.50 m/ sec,
  - o Sandy Soil : 0.30 m/sec.
  - o Clayey soil : 0.75 m/sec.
- The channel is designed for handling a peak discharge of 10 year frequency for the inter-bunded area using rational formula while manning's formula is used for deciding the cross-sectional area and flow velocity. The channel side slopes are kept as 5:1 or flatter to facilitate cultivation. Generally the shape and size of the channel remain same throughout the length while the gradient may be varied to take care of the increasing quantity of runoff as the length of bund increases.
- The availability of channel with good vegetation for disposing off the excess water from the graded bunds is essential.

For designing channel, formulas used are:

Rational formula, $Q = \frac{CIA}{360}$ **.... (2.10)**

Where,
Q = Design peak rate of runoff, m^3/s,
C = Runoff coefficient,
I = Intensity of rainfall, mm/hr for the duration equal to time of concentration (T_c) of watershed and design RI, and
A = Area of the watershed, ha.

Manning's formula for velocity of flow in channel

$$V = 1/n\ R^{2/3}\ S^{1/2} \qquad \textbf{.... (2.11)}$$

Where,
V = velocity of flow in the channel (m/sec),
R = hydraulic radius (m)'
S = hydraulic Slope (M/m) and
n = the manning's roughness coefficient.

c) Construction:

Starting from the ridge, the site of the first bund is located at desired/designed vertical interval aligned along the predetermined grade avoiding sharp bends through the permissible deviations mentioned under the contour bund. A channel of suitable width is marked leaving 1.2 m from the inner edge of the bund on the upstream side. Bund and channel are trapezoidal in shape with channel size depending on the size of the bund as the bund has to be formed from the soil excavated for making the channel. The waterways are to be protected with stone/vegetative checks and drops at suitable interval for providing stability. The channels and the channel grade need to be maintained once in 2 to 3 years for their effective functioning since cropping is done in the channel portion also.

d) Example:

Case study: Graded bunding in Manneguda watershed (A.P.)

Design the graded bund for the following parameters:

Maximum length of terrace, L = 340 m

Average slope of watershed S = 2%

Vertical interval, VI = 1.2 m as per the field situation

Solution:

Average width of terrace, W (HI)	=	VI/Sx100
	=	1.2/2x100 = 60 m
Inter – terrace area A	=	340x60 = 20400 m^2
		20400/10000 = 2.04 ha
Runoff coefficient C	=	0.25
Longitudinal gradient	=	0.4%
Length of run	=	340+60 = 400m
Fall	=	[0.4/100 x 340] + 1.2=1.36+1.20 =2.56m
Time of concentration (Tc)	=	15 Min. $Tc= 0.0195K^{0.77}$

where $K= \sqrt{L^3/H}$, L= Maximum length of flow of water (m),

H = Difference in elevation between the most remote point and the outlet (m)

Design intensity (I) for 10 years frequency and duration of 15 Min

(From the intensity – duration – frequency formula) = 96.40 mm/hr.

Peak discharge Q	=	CIA/360 = 0.25 x 96.40 x 2.04/360 = 0.137m3/sec
Top width	=	0.30m
Assumed height	=	0.60m
Side slopes	=	1:1
Bottom width	=	1.50m
Slope in channel	=	0.4%
Area of cross-section	=	$\frac{(1.5+0.3)}{2}$ x 0.60 = 0.54m^2

Assuming a water sheet flowing along bund with 0.15 m depth,

The flow area (A) becomes 0.57 m^2

The wetted perimeter for the section will be 7.57 m and hydraulic radius will be 0.075 m the longitudinal grade of bund is 0.4%

According to Manning's formula. $V = \frac{R^{2/3}S^{1/2}}{n}$

Where,
V = Velocity m/sec
R = Hydraulic radius, m
S = Slope, m/m
n = Manning's coefficient

$V = \frac{(0.075)^{2/3} \times (0.004)^{1/2}}{0.04} = 0.28$ m/sec

This velocity is within safe limits.

Discharge Q = AxV = 0.57 x 0.28 = 0.16 m3/sec

E/W Estimate:

Length of bund per hac. = 100 x S/VI = 100 x 2/1.20 = 167 m.

Where S = land slope % = 2%
VI = vertical Interval in m. = 1.2m (Given)

Cross Section of Bund = 0.54 Sq.m.

Volume of E/W per hac. = 167 x 0.54 = 90.18 Cum.

2.4.2.2. CONSERVATION DITCHING:

i) In black soils with their characteristic of low infiltration rates, excessive swelling and shrinkage properties, contour bunding suffers from two main drawbacks viz; lack of drainage for the crops in the water stagnated area on the upstream side of the bund and consequently, crop damage and frequent breaching of the bunds. On the other hand, graded bunds have the disadvantage that they drain out, though safely, the precious water out of the reach of a small farmer. As an alternative to contour bunding, and graded bunding, the possibility of using contour ditches has been explored. Conceptually contour ditching works on the principle that when suitably designed, it stores most of the runoff from a design rain storm and hence cuts off a vital portion of the runoff from causing erosion downstream of the ditch. In addition, the water stored in the ditch could also be utilized for life saving/supplemental water application during intervening drought periods. Thus, conservation ditching serves the dual purpose of a terrace and a storage structure at the individual field level.

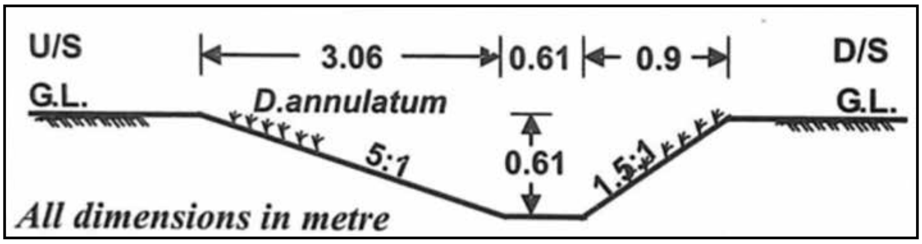


Figure 2-13: Cross section of a Conservation Ditch

ii) CONSTRUCTION:

In construction, the conservation ditch is essentially an inverted form of a contour bund (sunken into the ground) with flatter upstream side provided safety against scouring by the incoming runoff. Contour ditches, spaced at 75 m interval with dimensions of 30 m length, cross sectional area of 1.583m^2 (base width 0.61 m ; side slope upstream 5:1 downstream 1.5:1 and depth 0.61m) have been evaluated for storing 20% of a 10-year frequency and 24 hour rainfall. Along with the runoff, most of the eroded soil could also be stored in the ditches.

2.4.2.3. BENCH TERRACING:

Bench terracing has been a widely practiced measure to use the hill slopes for crop production on sustainable basis. It comprises, transforming original steep lands into a series of level or nearly level strips or steps running across the slope supported by risers. It has been a common practice to cultivate hill slopes over the ages. It breaks length of slope and reduces degree of slope as well thereby conserving moisture and soil for better crop production. Bench terraces are also necessary for proper irrigation water management.

i) SUITABILITY:

The slope limit for bench terracing in hilly areas is generally recommended not to exceed 33%. However, looking into the topographical and socio-economic conditions in the Himalayan region bench terracing is being practiced up to 50% land slope. Bench terraces may be:-

a) Table top for paddy cultivation

b) Inward sloping.

c) Outward sloping

The suitability of these types is governed by the factors like crops to be grown, rainfall, soil properties and management practices etc.

a) Table top bench terraces are suitable for areas receiving medium rainfall and having highly permeable and deep soils and it is the best practice for paddy cultivation.

b) Inward sloping bench terraces are more effective in high rainfall areas and for the crops like potato (which is susceptible to water logging). It helps in quick but safe disposal of runoff through a drain which is provided on inner side of the terrace these are widely used in different hilly regions of the country.

c) Outward sloping bench terraces are effective only in low rainfall areas with permeable soils of medium to shallow depth and generally from an intermediate step towards construction of table top or inward sloping terraces.

In the middle Himalayan region bench terraces are constructed on steep slopes beyond the recommended limit of 33% to the growing food requirements. A survey revealed that about 70% of the bench terraces were constructed between land slope of 50-70% with average outward and longitudinal slope of 10% and 8% respectively. This resulted in high soil and nutrient losses which need to be minimized by providing suitable earthen/ stone-cum-earthen shoulder bunds.

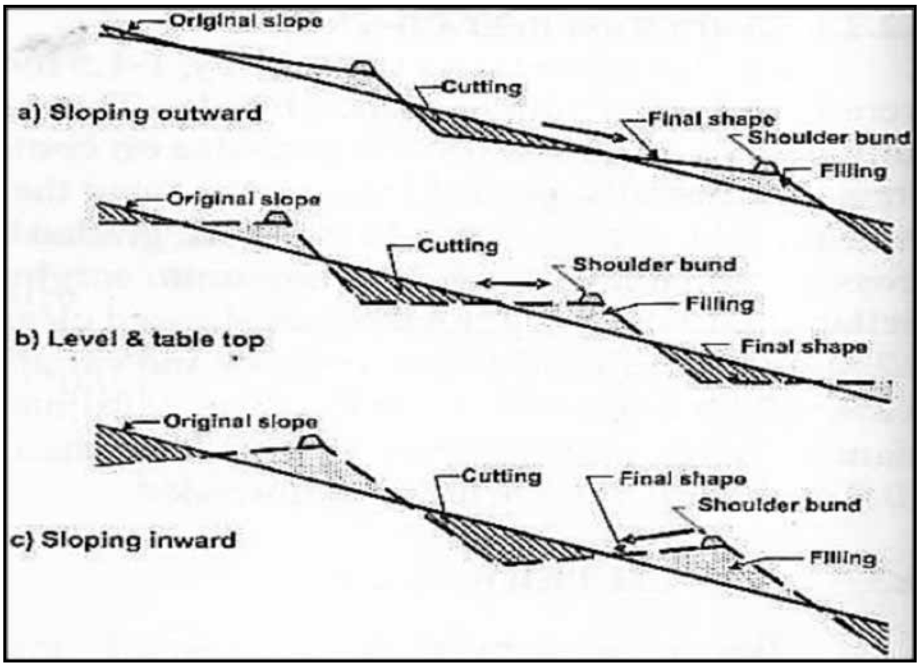


Figure 2-14: Some typical terrace systems

ii) SURVEY AND PLANNING OF BENCH TERRACES:

The area is surveyed and working plans prepared as per the procedure explained below:

a) Draw the contour map by selecting a suitable scale. The contour interval may be kept as 0.5 to 1.0m.

b) Determine the degree of land slope and its direction.

c) Find out the depth of soil by auguring or visualizing the profile in any vertical open cut.

d) Find out the proposed crops to be grown in the area.

e) Find the rainfall amount and its distribution.

f) Select and locate the position of outlets as per the existing topography making best use of natural depression lines.

iii) TERRACE DESIGN:

Condition of soil depth, slope, rainfall, farming practices etc. should be taken into account while designing the bench terraces. The design of bench terraces involves determination of the following parameters:

a) Terrace spacing
b) Terrace grade and length
c) Terrace cross- section

a) Terrace spacing: Terrace spacing is expressed in terms of the vertical interval (VI) i.e. the elevation difference between the two succeeding terraces. The VI can be computed as follows

Step 1. Find out the maximum depth of productive soil range (T) this a very important factor as lesser the cutting made the greater will be the depth of productive soil available for cultivation.

Step 2. Having the above consideration in view find out the maximum admissible cutting (d), for the desired land slope (S) and crop to be grown. This cutting at the same time should enable construction of terraces with convenient widths.

Step 3. Having fixed depth of cutting, the width of terrace (W) can be computed for a given slope (S) by the formula given below.

$$W = \frac{200d}{S} \qquad \textbf{.... (2.12)}$$

W= Width of terrace and d = Maximum admissible cutting

Where W and d are in meters and S in per cent

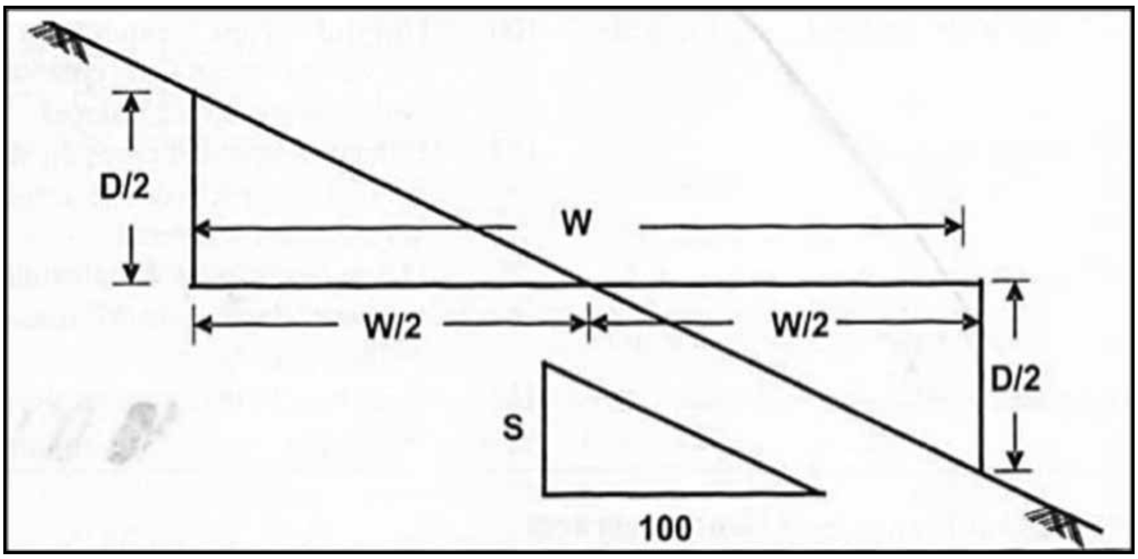


Figure 2-15: Cross-section of a bench terrace showing width and depth of cut

Step 4. Determine vertical interval (D) between the consecutive benches by the formula

VI = D = W x S / (100 – nS)   (where n is batter of the riser) **.... (2.13)**

Where,
VI = Vertical interval m
W = Net width of the bench m
S = Slope %   and
n= Batter of the riser

For a 1:1 batter in the riser:

VI= W x S/100 –S **.... (2.14)**

For a 0.5:1 batter in the riser:

VI =   2W x S / (200 – S) **.... (2.15)**

Also, see that VI = 2 (T- 0.15) **.... (2.16)**

Where T = productive soil depth m

(After cutting the soil, at least 15 cm of productive soil depth should be left)

b) Terrace grade and length

As a general rule a longitudinal grade of about 1 per cent is given for the drainage of excess water in the bench terraces. In case of inward sloping benches an inward grade of 2.5% is provided along with a toe drain. The length of terrace is generally limited to 100 m for operational efficiency preventing erosion and reducing cost. In level paddy benches a shoulder bund along the outer edge of bench terraces is provided for irrigation water management. The excess runoff from the bench terrace system should be safely carried through a grassed waterway/ natural vegetated gully.

c) Terrace cross-section:

The construction of bench terrace is such that the earth excavated from the upper half is deposited over the lower half slope. A minimum bench width of 3-5 m is necessary for farming   operations. The terrace riser should not be too high for its safety and may be limited to 1.5-2m. The depth of cut can be estimated roughly by dividing the height of riser by 2. For earthen risers a batter (slops) of 1:1 may be provided whereas stone riser may be constructed almost vertical (1:4-1:5batter). The earthen risers are protected with permanent vegetation.

iv) COMPUTATION OF EARTH WORK:

The earth work per ha is computed by using the formula

E (Earthwork per ha) $= \frac{100}{8}$ W x S   or = 12.5 W x S **.... (2.17)**

Where, W= Width of terrace (m): and
S = land slope (%)

Area available for cultivation (m^2)	=	100(100-n x S)	**.... (2.18)**
Area lost due to benching (m^2)	=	100 n. x S	**.... (2.19)**
Riser area to be sodded	=	$100 \times \sqrt{1+n^2}$	**.... (2.20)**
No. of terrace outlets/ha	=	L/2K	**.... (2.21)**

Where,
L = Total length of terrace/ha;
K = critical length of terrace, which is generally taken as 100 m; and
n = batter of the riser

Example:

In an area of one ha laying in a hilly region bench terracing has been proposed to bring the land under cultivation. The land has a general slope of 30%. The average depth of soil as observed by an auger is about 0.9m. the crops to be grown after bench terracing require at least soil depth of 0.25m. Risers are to be laid on 1:1 gradient and will be planted with local varieties of grasses. The critical length of terrace is approximately equal to 100 m. work out (i) Volume of Earth work in cum (ii) compute the number of outlets and the Quantum of earth excavation for the vertical drains; (iii) Length of grass plantation on the risers.

Solution:

(1) Terracing

The depth of cut
D = 0.7x0.9 = 0.63m
Still the depth of soil available = 0.27 m which is higher than 0.25 m as required.

Bench width (W) to be adopted is:-

$$W = \frac{200\,d}{S} = \frac{200 \times 0.63}{30} = 4.2\text{m or say } 4.25\text{m}$$

$$VI = \frac{W \times S}{100 - S} = \frac{4.25 \times 30}{100 - 30} \quad \text{for 1:1 batter in the riser}$$

$$= 1.82 \text{ m or say } 1.80\text{m}$$

H.I = W+VI = 4.25 +1.8 = 6.05 or say 6.0m

L = Length of Terrace/ha = 10000/HI

= 10000/6 = 1666 m

Cross-section of terrace (C) = (W X VI) /8 = (4.25 x 1.80)/8 = 0.956 m^2

(i) Volume of earth work/ha = L x C = 1666 x 0.956 = 1593m^3

Or Earthwork/ha = 12.5 W x S = 12.5x4.25 x30 = 1593 m^3

v) DISPOSAL DRAINS:

The critical length of terrace (K) = 100m

Number of outlets (assuming surplus water drained from both sides

a) L/2K = 1666/2x100 = 8 (approx.)

Approximate length of vertical drain/ha (outlet)

I = N x HI

Where

N = number of outlets/ha; and HI= horizontal interval in m.

Length of vertical drain/ha (I) = 8x6 = 48m

The cross section of disposal drain:

Bottom width = 0.3m, Top width = 1.05m, Height = 0.38m

Area of cross section of disposal drain = (0.3+1.05)/2 x 0.38 = 0.256sqm

The earthwork involved in vertical disposal drains

b) 48 x 0.256 = 12.30 cum

Sodding

Length of sodding /ha = Area/ HI = 10000/6 = 1667 m.

Table 2-5: Width of bench terracing for various VI (m), slope (percent), and n (1 and 0.50)

Ground slope %	Vertical Interval (m)							
	0.6	**0.8**	**1.0**	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**
For Value of **' n' = 1.00**								
16	3.15	4.20	5.25	6.30	7.35	8.40	9.45	10.50
18	2.73	3.64	4.55	5.47	6.38	7.29	8.20	9.11
20	2.40	3.20	4.00	4.80	5.60	6.40	7.20	8.00
22	2.13	2.84	3.54	4.25	4.96	5.67	6.38	7.09
24	1.90	2.53	3.17	3.80	4.43	5.07	5.70	6.33
26	1.70	2.28	2.85	3.41	3.98	4.55	5.12	5.70
28	1.54	2.06	2.57	3.08	3.60	4.11	4.63	5.14
30	1.40	1.87	2.33	2.80	3.27	3.73	4.20	4.67
32	1.275	1.70	2.12	2.55	2.97	3.40	3.82	4.25
For Value of **' n' = 0.50**								
16	3.45	4.60	5.75	6.90	8.05	9.20	10.35	11.50
18	3.03	4.04	5.05	6.07	7.08	8.09	9.10	10.11
20	2.70	3.60	4.50	5.40	6.30	7.20	8.10	9.00
22	2.43	3.24	4.05	4.85	5.66	6.47	7.28	8.10
24	2.20	2.93	3.67	4.40	5.13	5.87	6.60	7.33
26	2.00	2.68	3.35	4.01	4.68	5.35	6.02	6.69
28	1.84	2.46	3.07	3.68	4.30	4.91	5.53	6.14
30	1.70	2.27	2.83	3.40	3.97	4.50	5.10	5.67
32	1.57	2.10	2.62	3.15	3.67	4.20	4.72	5.25

(Ref.; Participatory Integrated Watershed Management, a Field Manual, CSWCRTI, Dehradun-2006)

Table 2-6: Length of bench terraces per ha (m)

Ground slope %	Vertical Interval (m)							
	0.6	**0.8**	**1.0**	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**
16	2667	2000	1600	1333	1143	1000	889	800
18	3000	2250	1800	1500	1286	1125	1000	900
20	3333	2500	2000	1667	1429	1250	1111	1000
22	3667	2750	2200	1833	1571	1375	1222	1100
24	4000	3000	2400	2000	1714	1500	1333	1200
26	4333	3250	2600	2167	1857	1625	1444	1300
28	4667	3500	2800	2333	2000	1750	1556	1400
30	5000	3750	3000	2500	2143	1875	1667	1500
32	5333	4000	3200	2667	2286	2000	1778	1600

(Ref.; Participatory Integrated Watershed Management, a Field Manual, CSWCRTI, Dehradun-2006)

Table 2-7: Earth work (m^3) in B.T. per ha for various VI (m), Slopes (percent) and n (1 & 0.50)

Ground slope %	Vertical Interval (m)							
	0.6	**0.8**	**1.0**	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**
For Value of **' n' = 1.00**								
16	630	840	1050	1260	1470	1680	1890	2100
18	615	820	1025	1230	1435	1640	1845	2050
20	600	800	1000	1200	1400	1600	1800	2000
22	585	780	975	1160	1365	1560	1755	1950
24	570	760	950	1140	1330	1520	1710	1900
26	555	740	925	1110	1295	1480	1665	1850
28	540	720	900	1080	1260	1440	1620	1800
30	525	700	875	1050	1225	1400	1575	1750
32	510	680	850	1020	1190	1360	1530	1700
For Value of **' n' = 0.50**								
16	690	920	1150	1380	1610	1840	2070	2300
18	682	910	1137	1365	1192	1820	2047	2275
20	675	900	1125	1350	1575	1800	2025	2250
22	667	890	1112	1335	1557	1780	2002	2225
24	660	880	1100	1320	1540	1760	1980	2200
26	653	870	1087	1305	1522	1740	1957	2175
28	645	860	1075	1290	1505	1720	1935	2150
30	637	850	1062	1275	1487	1700	1912	2125
32	630	840	1050	1260	1470	1680	1890	2100

(Ref.; Participatory Integrated Watershed Management, a Field Manual, CSWCRTI, Dehradun-2006)

vi) LAYOUT AND CONSTRUCTION OF BENCH TERRACES

With reference to the contour lines the alignment of terraces as per designed vertical interval and width is staked out. The alignment may be done in such a way that minimum convenient width of terraces is always available for cultivation. All sharp and pointed curves should be conveniently smoothened out by deviating, if necessary, from the contour.

Construction of terraces should normally start from the first terrace on the top of the field however for preserving the top soil the terraces may be built from down slope up or top soil collected at one place before cutting the terrace and spread afterwards.

Steps to be followed are:

- First layout the top terrace.
- After staking the line on the ground, the line is adjusted to give smooth alignments, avoid depressions, sharp turns and field boundaries etc. the maximum permissible limit of deviation is 0.30m while crossing depressions.
- Excavate the earth from approximately upper half portion of the slope and push the excavated earth towards the lower portion of the slope until the desired level is obtained.
- Compact the fill portion of the terrace properly and check the levels.

- Construction of shoulder bund to the required size and trimming of side slopes to be done by manual labour.
- Protect the riser slope by sodding with suitable grass species
- Construct the disposal drain, if required.

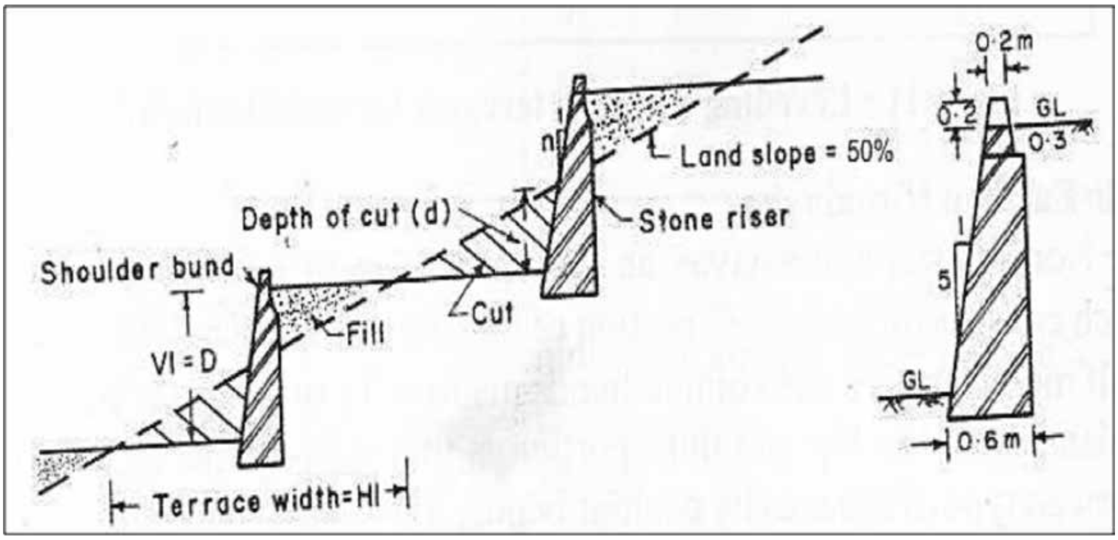


Figure 2-16: Terrace with stone risers

2.4.2.4. SOIL AND WATER CONSERVATION STRUCTURE (30X 40 MODELS) IN THE ARABLE LAND:

This is an alternative to contour bunding found suitable to high rainfall areas and easier for villagers to construct. This model was tried in District Purulia (West Bengal) and found very successfull.

Image 2-1: 30 X 40 model

Image 2-2: 30 X 40 model

i) WHAT IS THE 30 X 40 MODEL?

The 30 x 40 model is a method of in-situ soil and water conservation, which involves dividing uplands into small plots of 30 X 40 ft. (30 ft. along the slope and 40 ft. across the slope), digging pits at the lowest point in each plot, and bunding the plot using the soil dug out of the pits.

Design
Length of the plot = 40 ft., Width of the plot = 30 ft.
Pit

Length of the pit = 7 ft.,
Width of the pit = 7 ft.,
Depth of the pit = 3 ft.

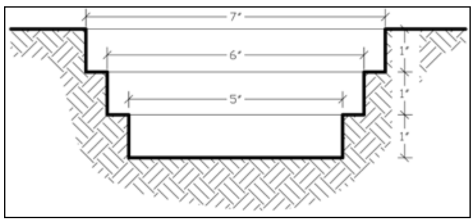


Figure 2-17: Cross Section of 30X40 model pit

ii) MODEL COST ESTIMATE OF 30 X 40 MODEL FOR ONE HECTARE LAND:

1Ha = 328X328 = 107584sft

Number of 30 ft. X 40 ft. plots = 1Ha/(30x40) = 107584/1200 = 90 (approx.)

Pit size in each plot = 7 ft. X 7 ft. (3 ft. deep)

Sl. No.	Items	Nos.	Length	Width (ft.)	Depth (ft.)	Quantity	Unit (in cum)	Rate per cum.	Amount in (Rs.)
	Earth work in cutting and making bund from the excavated soil (as per 10.1.6 of SoR)								
1	for 1st one feet depth	90	7	7	1	124.97	cum	108	13497
	for 2nd one feet depth	90	6	6	1	91.82	cum	108	9917
	for 3rd one depth	90	5	5	1	63.76	cum	108	6886
								Total	30,299
								Say	30,000

iii) HOW IT IS CONSTRUCTED?

a) Divide and mark the selected area into 30 X 40 ft., starting from the ridgeline, with the help of measuring tape, rope, and lime. The size of the plots may be altered up to + 10% to fit to the boundary and ownership.

b) Identify the lowest point in each plot.

c) Dig a 3 ft. deep pit that is 7 X 7 ft. at the top. The pit should have a sloping wall such that the bottom of the pit is 5 X 5ft.

d) Bund the plot with the excavated soil from the pit. The bund across the slope should be 1 ft. high with a top width of 1 ft. and bottom width of 2 ft.

e) Use the rest of the excavated earth to construct the field bund at the side, along the slope.

iv) WHEN IT IS CONSTRUCTED?

If the land is fallow, this work can be started in the month of August so that after the rain the soil becomes loose enough to be excavated. If the plot is under kharif crop, the work can be started in October or just after harvesting of the kharif crop. The work should be completed before the soil gets too hard in the summer months.

2.4.2.5. FARM PONDS IN THE CROP LANDS:

i) INTRODUCTION:

Farm pond (also traditionally known as Dabri is some parts of India and Hapa in West Bengal) is a structure constructed on a farmer's land to harvest rainwater, which would otherwise have flowed out of the farm. On flatter land in the village, streams are not very deep, nor do they have high embankments. Thus it becomes difficult to build water harvesting structures like earthen dams. In such flat lands, Farm Ponds are the most effective water harvesting Solution. The main objective of such structures is to provide protective irrigation to the kharif crop. In addition, in West Bengal, Assam, Chhattisgarh, Bihar, Jharkhand and Orissa, Farm ponds are being used to irrigate the rabi crops and also for fish Farming.

ii) SITE SELECTION AND DESIGNING:

Image 2-3: Farm Pond

a) Farm pond can be made on any and every crop field. It should be made in the farming area, so that protective irrigation can easily be given and the site should be relatively flat. Farm ponds should be constructed in a cluster basis, so that the overall soil moisture regime of the area will be enhanced and water will be available for longer period of time. The catchment area of the site should not be more than 2 ha. In case there is a well on the farm, the pond should be made upstream of it so that the well may benefit from recharge from the pond. The size of the pond needs to be calculated on the availability of runoff water and volume of water requirement.

b) If we want to provide 10 cm of protective irrigation to the crop over 1 hectare, we need 1000 cum of water. Volume of water required = Area to be irrigated x depth of irrigation = 1 hectare x 10 cm. = 10,000 sq.m. x 0.1m. = 1000 cum. Pond whose dimension is 25m x 20 m x 2.5 m will yield this amount of water. It will occupy 25m. x 20m. = 500 sq.m. in 1 hectare, i.e., 5% of the area to be irrigated (500/10,000 = 5%).

iii) WHY THIS IS SOMETIMES REFERRED TO AS THE 5% MODEL:

Generally the area of the pond varies 5 % to 10% area of command area as per the water requirement. Farm ponds should generally be made only where there are no appropriate sites for construction of other water harvesting structures such as earthen dams. This is because its storage of water is only in the excavated portion and not against an embankment as in an earthen dam.

iv) ESTIMATION FOR A FARM POND WHICH IS 5% OF PLOT SIZE:

Say plot area is 0.2 hectare. So area of the 5% model pond = (0.2 x 10,000)* 5 % = 100 Sq. mt. considering the size of the farm pond 14mx7.5mx3.6m

Typical Estimation of Farm Pond

ESTIMATION FOR FARM POND							
		Length (m)	**14**	**Breadth (m)**	**7.5**		
		Depth (m)	**3.66**	**Berm (m)**	**0.6**		
Sl. No.	**Description of Item**	**Length**	**Breadth**	**Depth**	**Quantity (cum)**	**Task/man-days (cum)**	**No. of man-days**
1	Mixed medium hard soil with soft moorum, kankar, pebbles, lead up to 24.4m & lift up to 1.5m (up to 0.6m depth from GL)	14	7.5	0.6	63.00	1.473	43.00
2	Mixed medium hard soil with soft moorum, kankar, pebbles, lead up to 24.4m & up to 1.5m(Next 0.6m depth)	12.8	6.3	0.6	48.38	1.473	33.00
3	Mixed medium hard soil with soft moorum, kankar, pebbles, lead up to 24.4m & lift beyond 1.5mt up to 2.4m (next 0.3m = 1.5m depth from GL)	11.6	5.1	0.3	17.75	1.473	12.00

Sl. No.	Description of Item	Length (m)	14	Breadth (m)	7.5		
		Depth (m)	3.66	Berm (m)	0.6		
		Length	Breadth	Depth	Quantity (cum)	Task/man-days (cum)	No. of man-days
	Hard soil/hard morrum, laterite or rocky soil; lead up to 24.4m, lift beyond 1.5m up to 2.4m (next .3m = 1.8m depth from GL)	11.6	5.1	0.3	17.75	1.077	16.00
4	Hard soil/hard morrum, laterite or rocky soil; lead up to 24.4m lift beyond 1.5m up to 2.4m (next .6m = 2.4m depth from GL)	10.4	3.9	0.6	24.34	1.077	23.00
5	Hard soil/hard morrum, laterite or rocky soil; lead up to 24m & beyond 2.4m up to 3m (next 0.6m= 3m depth from GL)	9.2	2.7	0.6	14.90	1.020	15.00
6	Hard Soil/Lateritic Soil, lead Up to 24.4m & lift beyond 3m up to 3.5m (next 0.45m = 3.45m depth from GL)	8	1.5	0.45	5.40	1.020	5.00
	Hard Soil/Lateritic Soil, lead Up to 80ft & lift beyond 11.5ft up to 4.57m (next 0.15m = 3.6m depth from GL)	8	1.5	0.15	1.80	0.992	2.00
	Total:			**3.6**	**193.32**		**149**

v) HOW IT IS CONSTRUCTED?:

a) Select an appropriate site on the basis of the considerations outlined above

b) Make the layout for the excavation of the farm pond at the chosen site

c) Leave a gap of about 2 to 3 m between the excavated portion and the mud piled up after excavation. This gap is known as a berm

d) If the mud excavated is fertile, spread it in the field.

e) A part of excavated earth should be used to strengthen the field bunds. Make a small 4” high bund around the pit to keep some standing water in the field.

Image 2-4: Farm pond

vi) WHAT ARE THE ADVANTAGES?

This model not only saves the crop in the plot but also increases percolation to augment water availability in the downstream. Additionally, this treatment increases the farmer’s access to water as there is a storage structure in each of his plots. So the farmer can exercise individual choice to best utilize it.

vii) PRECAUTIONS:

a) Proper calculation of water requirement and availability of runoff water to be done while designing the pond. The area of pond generally varies from 5% to 10% of command area.

b) Proper catchment area treatment should be done in the upstream of the farm pond to reduce the rate of siltation

c) For a given storage capacity, deeper ponds are better than shallower ones since they occupy less of the farmer's land and less prone to evaporation losses. Generally the depth varies from 2.5m to 3.75m

d) Proper inlet with the provision of silt trap should be made to ensure that maximum silt free runoff water is harvested

e) The outlet should be pitched properly with stones to avoid soil erosion when the water flows out of the outlet

f) Creation of such Farm ponds in cluster (6-8 no in 2Ha of farming patch) instead of one or two in isolation

g) Maintain adequate berm (1m- 2m) and slope of excavation (1-2%)

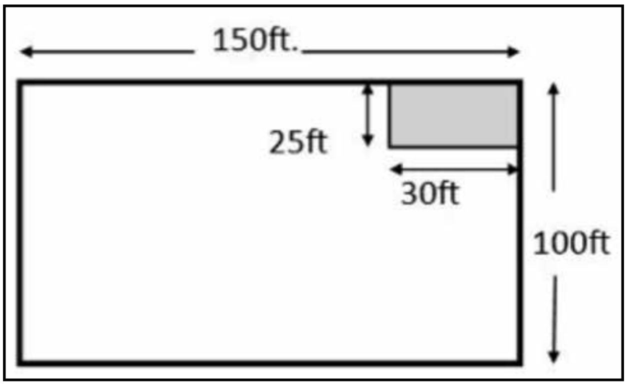


Figure 2-18: Location of Farm pond in a field

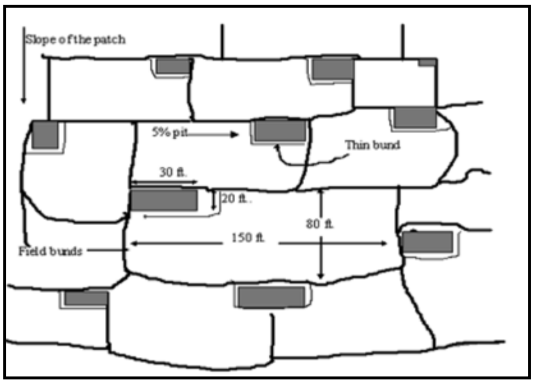


Figure 2-19: Location of Farm ponds in cluster of fields

2.4.2.6. TANKA:

i) It is covered underground tank locally called Tanka for storage of surface run off. It is the most common rainwater harvesting system in the Indian arid zone. It is very popular in arid and semi-arid (ASA) regions of India and almost every household, school and religious centers in the rural areas constructs Tanka for meeting the drinking water demands.

ii) The Tanka is constructed by digging a circular hole of around 4m diameter and around 6m deep with stone masonry walls, plastering the base and sides with 20 mm thick cement mortar. The top is covered with stone patties / RCC slab. The catchment of Tanka is made artificially by leveling the field and by constructing sedimentation tanks.

iii) Design of Tanka:

Consideration- 50 % of annual average rainfall would be available for harvesting and average annual rainfall in the area is 900mm.

Volume of runoff water available for collection

= Catchment Area x Annual Avg. Rainfall x 50 % as per Structural design

Catchment Area = $\pi/4 \times D^2$

= (3.14 x 8.3 x 8.3)/4 = 54.078 Sqm. D (Catchment Dia.) = 8.30 m,

Rainfall = 900 x 0.5/1000 = 0.45m,

Collection of runoff water= 54.078 x 0.45 =24.3351 cum. or 24335.1 ltr

Capacity of of Tanka (cum) = $\pi/4 \times D_t^2 \times$ Height,

Where, D_t (Inner diameter of Tanka) = 3m,

Ht. = 3.60

Capacity of Tanka = $\pi/4 \times 3 \times 3 \times 3.6$ cum = 25.434 cum= 25.434 x 1000= 25434 lit

Hence rainfall on catchment area can fill up the Tanka by runoff water

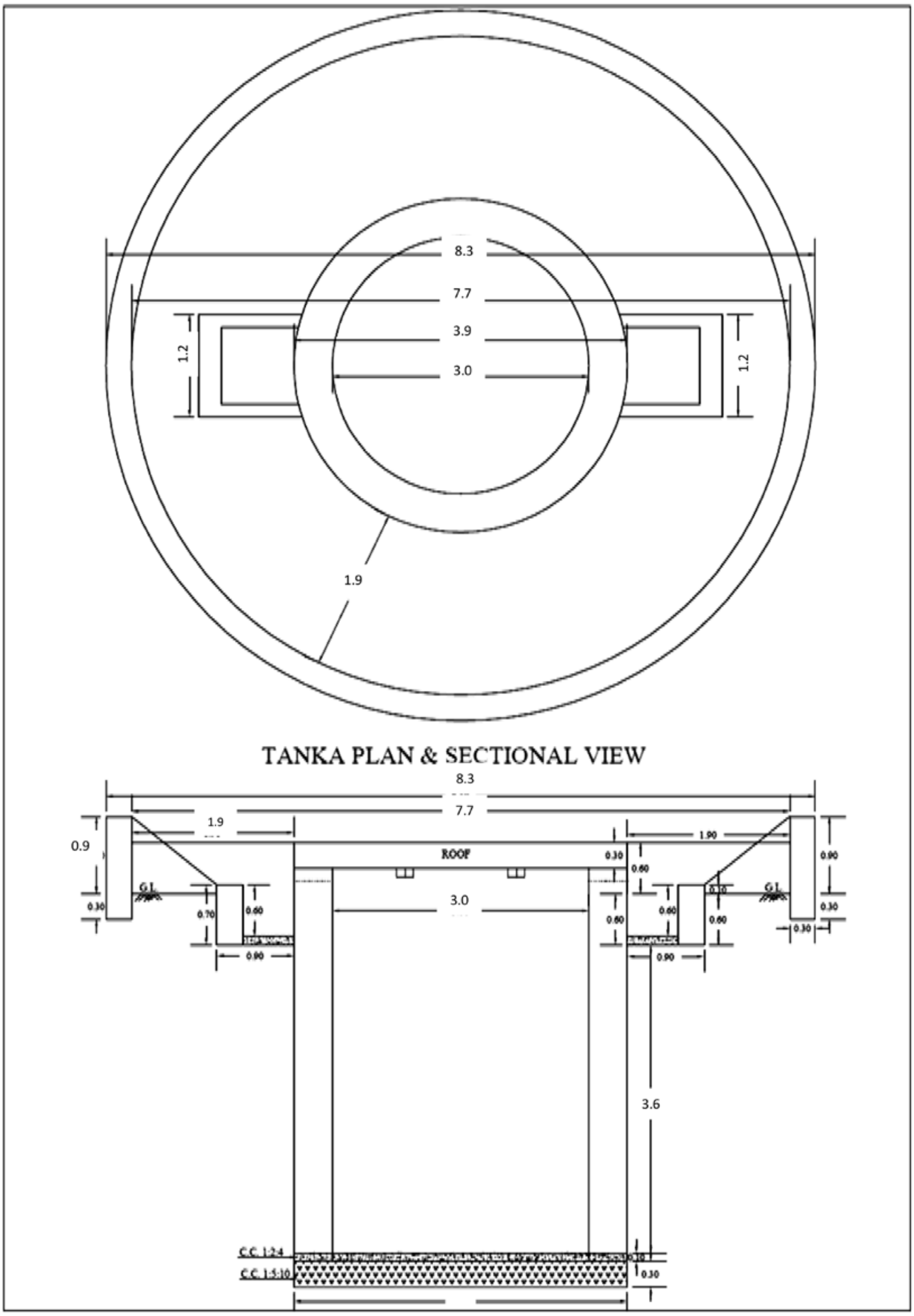


Figure 2-20: Plan and cross section of the Tanka

2.4.2.7. KHADIN:

Khadin is an innovative traditional system of growing crops on harvested and stored water by constructing an earthen bund across the gentle slope of the farm in the valley bottom. Khandins are generally practiced is areas receiving less than 100 mm average annual rainfall like Jaisalmer district in the extreme western desert tract of India, many large rocky areas, rugged hillocks and plateau form the runoff producing catchment for the adjoining flat valley bottoms which are main cultivable lands in the region. Water accumulated to a depth of 60 to 90cm, gradually seeps into the ground and recharges the adjoining wells. If the accumulated water persists longer, it is drained out through the sluice valve before sowing of the kharif/rabi crops. The soil of khadins is very fertile due to deposition of finer sediments over a period of times.

Ahars and Bundhies are similar to Khadins and are widely practiced in Bihar and Uttar Pradesh. The basic principle is to allow runoff water to collect behind an earthen bund usually 3 meters in height.

For design refer Earthen Dams at Para 2.4.3.5

2.4.2.8. GRASSED WATERWAY AND DIVERSIONS DRAINS:

i) INTRODUCTION:

Diversion drains are placed at the top of the arable area to intercept the water running from the above slope/ ridge area and divert it across the slope to a grassed waterway. Grassed waterways are used as outlets to safely convey runoff from field surface and sub- surface drainage systems and serve as emergency spillways for farm ponds or other structures. Grassed waterways therefore run down slope and safely dispose the surplus water into natural drainage courses. Though the functional aspects and alignments etc. are different for field channels diversions and grassed waterways their design principles are the same.

ii) SUITABILITY:

a) Diversion drains are provided across the slope on slight gradient. Their capacity is designed for a 10 year recurrence interval storm. Side slopes of 4:1 are provide.

b) Grassed waterways are located in natural depressions wherever possible but occasionally natural channels are reshaped to serve as outlets

c) It may be noted that while grassed waterways are provided along the prevailing slope diversion drains are provided across the slope on a slight gradient.

iii) DESIGN CRITERIA:

The design determines the shape, size and grade of the waterway. The design steps are as follows:

Step 1: Determine the watershed area draining into waterway from the map

Step 2: Estimate peak rate of runoff Q for a 10 years recurrence interval for the area using rational formula

$$Q = \frac{CIA}{360} \qquad \text{.... (2.22)}$$

Where

Q = peak discharge m^3 / sec, C = Runoff coefficient
I = Maximum rainfall intensity for designed recurrence interval and time of concentration in mm/hr.
and
A = Catchment area of grassed water/diversions drains in ha.

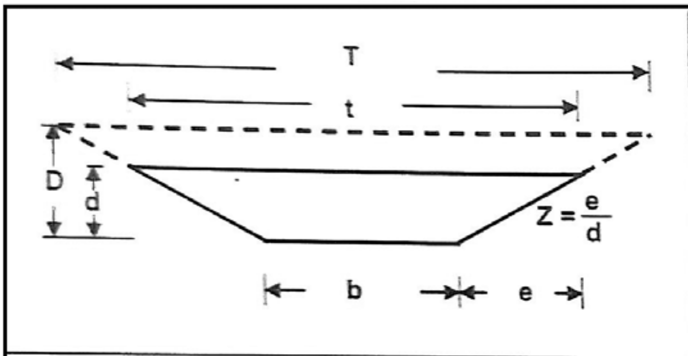
Step 3: Decide the permissible velocity for particular soil type using the following criteria

1.	Very light silty sand	-0.3m/sec
2.	Light loose sand	-0.5m/sec
3.	Coarse sand, sandy and sandy loam	- 0.75m/sec
4.	Silty loam	- 0.9m/sec
5.	Firm clay loam	- 1.0m/sec
6.	Stiff clay/ stiff gravel/ coarse gravel	- 1.5m/sec
7.	Shale, hard pan, soft rock etc.	- 1.8m/sec

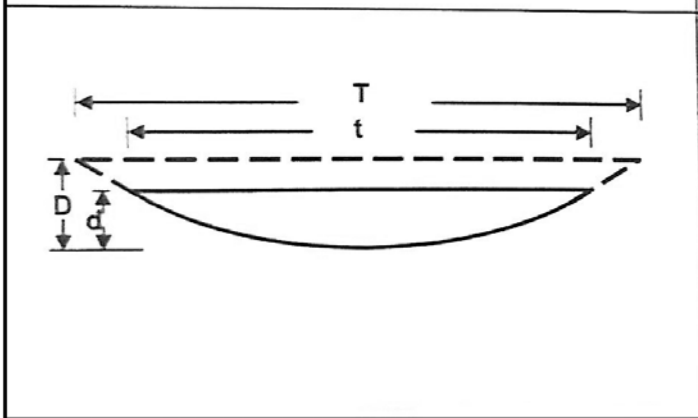
Step 4: Shape: Usually the shape of waterway may be trapezoidal or parabolic. The parabolic shape is structurally more stable hydro logically more efficient and easy to construct.

Step 5: Calculate the approximate cross section area of flow (A) by using the formula Q=AV.

Step 6: Work out the dimensions of the waterway (for proposed shape)by assuming either width or depth of the waterway and find out the other dimensions from the respective formula of cross sectional area equating the area (A) equal to the area obtained in step5, as mentioned in fig below.



Area	$bd+Zd^2$
Wetted perimeter	$b + 2d\sqrt{1+Z^2}$
Hydraulic radius	$\dfrac{bd+Zd^2}{b + 2d\sqrt{1+Z^2}}$
Top width	$t = b + 2dZ$ $T = b + 2DZ$



Area	$\frac{2}{3}td$
Wetted perimeter	$td + \dfrac{8d^2}{3t}$
Hydraulic radius	$\dfrac{t^2d}{1.5t^2+4d^2} \; \dfrac{2d}{3}$
Top width	$t = \dfrac{2a}{2d} \quad T = t\left[\dfrac{D}{d}\right]^{1/2}$

Figure 2-21 : Basic dimensions of common grassed waterway sections

Step 7: Compute velocity of flow in waterway by using Manning's formula

$V = 1/n\ R^{2/3}\ S^{1/2}$ **.... (2.23)**

Where, V is the velocity of flow in the channel (m/sec) R is hydraulic radius (m) S is hydraulic Slope (M/m) and n is the manning's roughness coefficient.

Step 8: Check whether computed velocity of flow is within permissible velocity as obtained in step 3. If yes, the design dimensions of waterway are correct. If not adjust channel dimensions to bring velocity of flow within the permissible limit.

Step 9: compute discharge through waterway Q= AV and check it with estimated discharge as obtained in step 2.

Step 10: Add a suitable free board of 20% as extra depth or minimum 15 cm to the design depth of waterway as obtained above to take care of any higher flood of greater recurrence interval (than the designed one).

iv) ESTIMATION:

Cost of constructing grassed waterway need the length of waterway and the cross-sectional area

Earthwork area (m^3)	=	length x cross-sectional area
1. Cost of earthwork	=	rate of earthwork x volume of earthwork
2. Cost of sod ding/seeding	=	wetted perimeter x length of waterway x cost/sqm.
3. Total cost	=	1+2

For detailed design may refer Para 3.3.2 of chapter 3 of this manual

v) CONSTRUCTION AND MAINTENANCE:

When waterways are located in natural depressions having little gully, these are converted into the required shape easily by smoothening the land. However, when proper natural depressions are not available, waterways of triangular or trapezoidal sections are artificially constructed preferably along the hedge rows or fence line to avoid inconvenience to farm operations. Before establishing grasses, the waterway are shaped to proper designed dimensions and aligned. It is advantageous to construct the grassed waterway at least one or two seasons ahead of channel terrace construction so that by the time the water is turned into it, the vegetation's gets established in the waterways. Depending upon the soil and climatic conditions, the mixtures of quick growing grasses for temporary control and hardy perennial grasses for permanent control are selected for establishment of vegetation in the waterway. The establishment of vegetation is done by seeding or planting techniques. Grass species of local variety may be used as perennial vegetation. For promoting the vegetation, manures and fertilizers are applied as per local recommendations to improve the fertility.

Maintenance of waterways is important for their proper functioning. Removal of weeds filing of the patches with grass and proper cutting of grass are common maintenance operations.

2.4.2.9. SURPLUSING ARRANGEMENTS / WASTE WEIR:

In order to protect the contour bunds from breaching and also for avoiding damage to the dry land crops due to water stagnation, outlet structures are constructed to drain away the excess water safely. These structures are usually constructed slightly above the lowest point in a holding, where due to the deviation of the contour bund to conform to field boundary, water stagnation occurs, which has to be drained out safely

i) MASONRY WASTE WEIR: Where the area that drains into a proposed waste- weir exceeds 3.5-4.0 ha construction of a masonry weir in the bund may be preferred.

a) Design of waste weir:

The minimum length of outlet required should be calculated by the formula used for a rectangular weir:-

$$Q = 1.711\ LH^{3/2} \qquad \textbf{... (2.24)}$$

Where, Q = Peak rate of runoff in cumec. expected from the catchment area of the bund itself and of the upper bund draining into the same (cumulative catchment) and

H = Depth of flow over weir taken normally between 0.3-0.7 m.

Q can be computed by using any one of the runoff estimation methods. Rational method is most commonly used. The most important parameter in estimating peak runoff rate is intensity of rainfall.

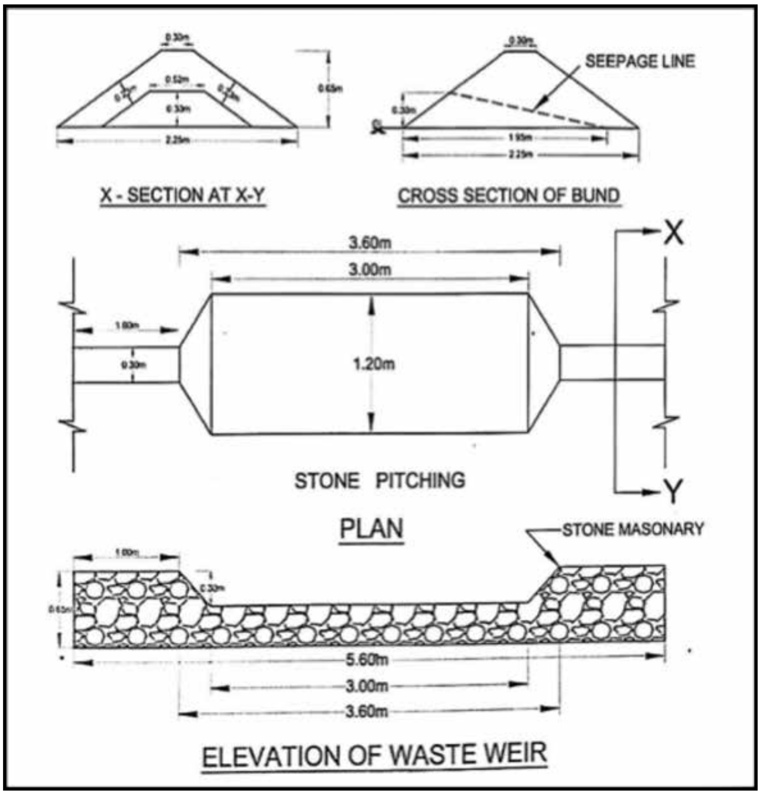


Figure 2-22: Drawing of Waste Weir

b) Example:-

Design a waste weir from the following data

Cumulative catchment area = 12 ha

HFL over the crest = 0.3m

Intensity of rainfall = 50 mm/hr.

Solution:

Assume a coefficient of runoff = 0.5

The peak rate of runoff

$$Q = CIA/360 = \frac{0.5x50x12}{360} = 0.83 \text{ cumec.}$$

The length of waste weir for a depth of flow of 0.3m (as given) is as under

$Q=1.711 \times L \times (h^{3/2})$

or,

$$L = \frac{Q}{1.711\times(h^{3/2})} = \frac{0.83}{1.711\times(0.3)^{3/2}} = 2.95 \text{ m. say } 3.00 \text{ m.}$$

ii) PIPE OUTLET:

A pipe outlet comprises a pipe discharging surplus water, the design consists of a hume pipe of required diameter with one well on the upstream side A 15 cm diameter pipe is suitable for 4 ha catchment, 22.5 cm pipe up to 6 ha and 30 cm pipe can work up to 10 ha. A well consists of 0.45 m and 30 cm outlets. The well top is kept 0.30 m above the contour level.

iii) RAMP- CUM WASTE WEIRS:

When, there is no approach track for the farmer fields, Ramp-cum waste weirs are constructed. These are of a temporary nature. A ramp-cum waste weir consists simply of an earthen bund pitched with stone Kharanja with its top 22.5 cm above the contour level and having a slope of (H:V) 5:1 like a ramp both on the upstream and on the downstream side. The sides are also covered by stone Kharanja they will be situated at the side of bund.

2.4.3. INTERVENTIONS IN DRAINAGE LINE:

i) INTRODUCTION:

Drainage lines are essential features of a watershed which carry runoff and sediment flow. They may have different forms such as drainage channels, gullies, natural/artificial waterways, streams, rivers or torrents. Network of these drainage lines, quite often suffers from degradation due to uncontrolled runoff and may go on extending and render adjoining lands degraded. The adjoining lands along the drainage lines are generally heavily cultivated due to better moisture regime and higher nutrient status. Drainage line treatment (DLT), therefore, assumes a special significance in the integrated watershed treatment plan. Some of the DLT objectives are as follows:

ii) OBJECTIVES:

a) Check soil erosion in the channel bed and adjoining lands
b) Improve moisture for biomass production
c) Protect banks/side slopes from undercutting or scouring
d) Recharge ground water
e) Store water wherever feasible and needed
f) Flow guidance, bank protection and/or land reclamation in the downstream torrents.

iii) DEPENDING UPON THEIR LOCATION AND OBJECTIVES, THE MEASURES FOR DRAINAGE LINE TREATMENT MAY BE MAINLY GROUPED AS:

a) upper & middle drainage line measures
b) middle & lower drainage line / water harvesting measures
c) Torrent and stream bank erosion control measures

iv) SURVEY AND PLANNING:

A detailed drainage line survey is needed for the planning and design of drainage line treatment measures. It is carried out in order to prepare longitudinal section (L-Section), plan and cross-section (at every 30 mt.). From the L-Section, channel gradient (or bed slope) and points of sudden drop (or fall) can be located to plan the location of treatment measures and their types. Plan of a drainage line depicts its configuration. Cross-section will provide width of the drainage line and its depth for planning and designing treatment measures.

From the L-Section, drainage line can be divided into the (a) upper, (b) middle, and (c) lower reaches depending upon the slope ranges or variations. This helps in planning different types of drainage line treatment measures.

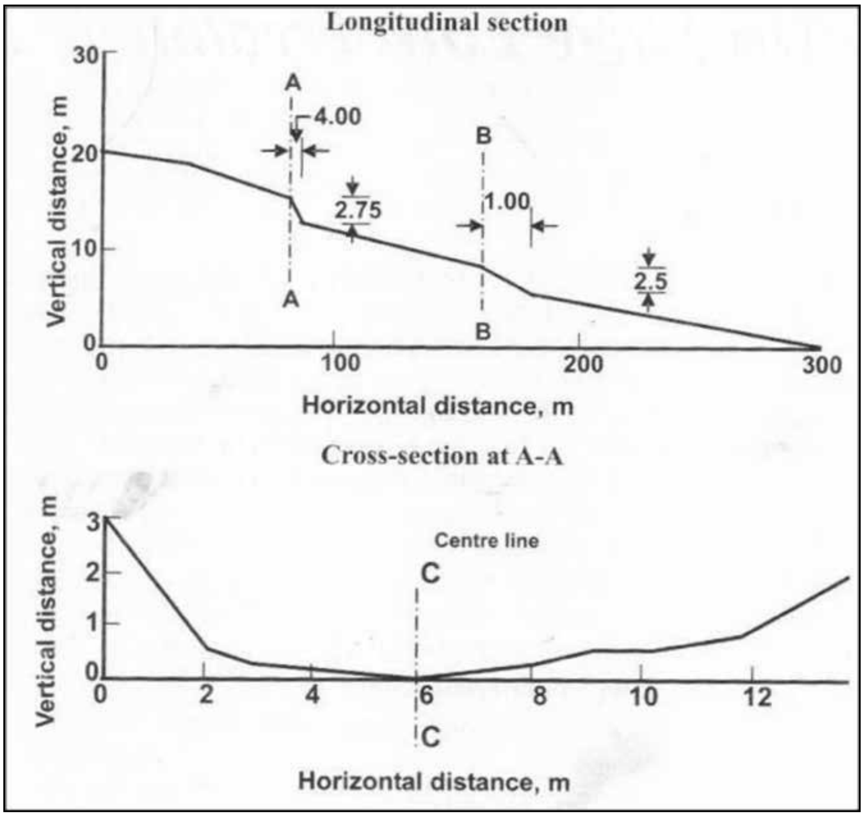


Figure 2-23: Longitudinal section and cross section of a typical drainage line/gully.

A) UPPER & MIDDLE DRAINAGE LINE MEASURES:

If the channel gradient is such that the flow velocities attain erosive velocity, it needs to be reduced so as to bring the runoff velocities within permissible limits. Series of check dams can be used to transform the longitudinal gradient from a steep slope to a succession of flat steps with low drops. These checks help in storing water and silt on their upstream. Suitable type of check dams can be selected depending upon the size of drainage line, its slope, catchment area, land use, peak runoff, availability of local material and severity of the problem.

2.4.3.1. LOOSE BOULDERS CHECK (LBC):

i) SPACING OF LBC

By the L-Section of the Gully or Nallah the LBC in series should be placed in such a way that the top of the downstream check dam should be at level with the bottom of the one upstream of it (as shown in the figure 2-24). The horizontal distance between the check dams can be exactly determined. For Estimation purpose we can calculate the numbers of LBC as given below:

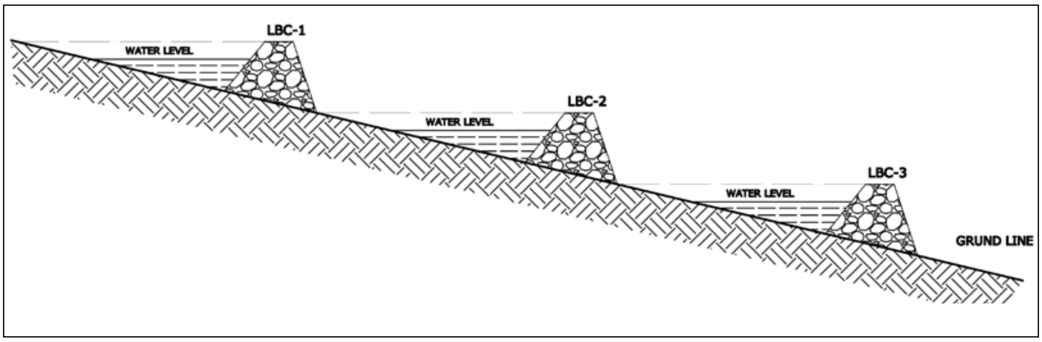


Figure 2-24: Location of LBCs

Example, in the micro-watershed, if there is a stream 1500m long, with a slope of 10%, then how many 1m high loose boulder checks can be made?

Solution

Basically we have to divide up the length of the stream into portions that will be occupied by units of loose boulder checks and the water stored behind them.

We know that: Slope S = 10%, Length of the Stream L = 1, 500 m, Height of the Boulder Check VI = 1 m. How far will the water stored behind the boulder check go?

HI = V I/Slope x 100 = 1/10 x 100 = 10 m

Also, the base of the boulder check itself will occupy 5m. Therefore the effective width of a boulder check, w = 10 m + 5 m = 15 m

Number of Boulder Checks = Length of stream, L / Effective Width of 1 Boulder Check

= 1, 500/15= 100 boulder checks

Similarly, loose boulder checks can be planned for every micro-watershed. After a comprehensive survey in the field with surveying equipment, we can arrive at the actual number of loose boulder checks required as compared to the number we had estimated. By measuring the width of the stream during this survey, we should categorize the different sizes of boulder checks required, which will enable us to know how many 8m long, or 10m long or 13m long boulder checks there will be.

ii) DESIGN:

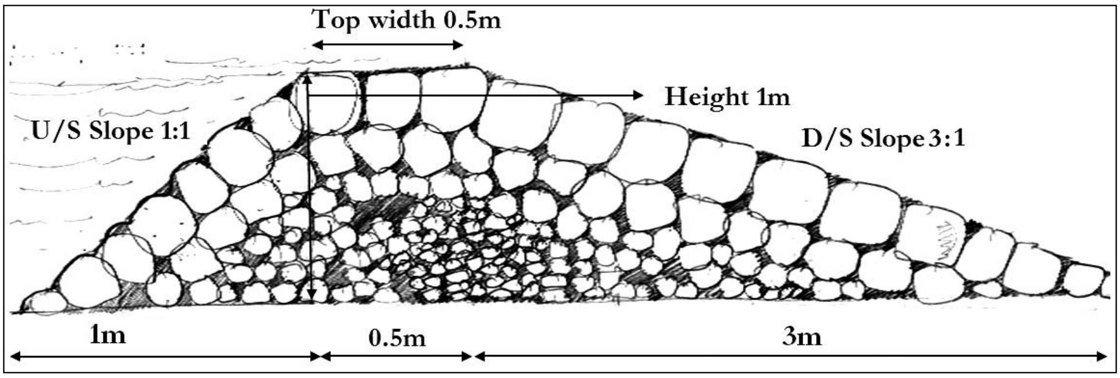


Figure 2-25: In the construction of a boulder check, bigger boulders are placed outside smaller ones inside. On the outside, the biggest boulders are placed on the downstream side.

a) Cross section of a boulder check:

Through years of experience in watershed development, the maximum height generally accepted for loose boulder checks is 1m. The design height of 1m means that the top of the check in the middle of the stream is 1m above ground level. The top width of the boulder check is usually as 0.4m. As the material used in the check has a high angle of repose, the upstream slope of the check should be fixed at 1:1 in general, to be varied only in exceptional cases where the structure has to handle very high volume of runoff of high velocity. The downstream slope of the boulder check can vary from 2:1 to 4:1 depending on the volume and velocity of runoff. The higher the volume and velocity of runoff, the flatter the slope. Since the boulder check is composed of highly porous material it is not expected to hold water for a long period.

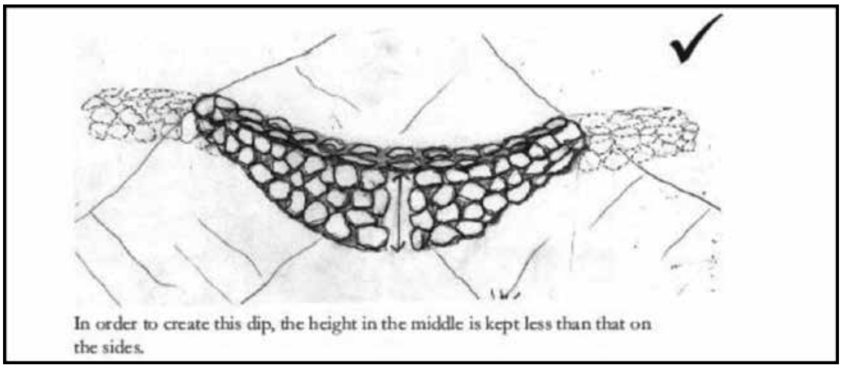


Figure 2-26: Boulder Check with dip

b) Boulder Check with dip:

- It is advisable to direct the maximum overflows through the middle of the structure
- If no dip is given in a boulder check in the middle, and its sides are not embedded in the embankments, water will tend to cut through the embankments on either side, thus eroding them
- With a dip in the middle and sides embedded on either embankment, water flows over the dip safely without endangering the bund

c) Downstream Slope:

Unlike in earthen structures, the downstream slope of the structure is not made to handle seepage problems. The downstream slope is given for two reasons:

- to absorb the impact of water which enters the structure at a high velocity; and
- to drain out water from the structure and make it trickle through at a non-scouring velocity.

d) The height of the boulder:

Check on either side should not exceed the height of the embankment or 1.5m whichever is lower. The check should be embedded 0.5m into both the embankments. This is to prevent erosion of the embankment where the check joins it. If the bed of the drainage line has only boulders, the boulder check can be constructed without any foundation digging. If there is mud or sand in the bed, this must be excavated up to a maximum depth of 0.25m to secure an adequate foundation for the boulder check.

iii) CONSTRUCTION:

a) Draw a line running through the center of the proposed site for the boulder check till it reaches the points on either side which are 1.5m above the bed of the stream. Naturally, if the embankments are less than 1.5m high, this line will only reach till the top of the embankment. From this central line, mark 25cm on the upstream and downstream sides and draw parallel lines from embankment to embankment. These lines mark the boundaries of the crest. Suppose the required slope is 1:1 upstream and 3:1 downstream. From the center of the upstream crest line, mark a point at a distance of 1.25m, along the perpendicular to this line. From the center of the downstream crest line, mark a point at a distance of 3.25m, again along the perpendicular to this line. These points mark the upstream and downstream ends of the boulder check respectively. Draw lines connecting each of these points to the end of the crest lines on both sides. The trench in a boulder check is not usually dug in the bed of the stream. But if there is sand or mud at the base of the check, a foundation should be dug to a depth of 0.25m. Generally, digging the trench is only required for embedding the check into the embankment. Along the center line after it enters the embankments, dig a trench which is half a meter wide and half a meter deep. The trench must extend half a meter beyond the point where the crest of the check meets the embankment on both sides. Now the filling begins. The check should be raised in horizontal layers. The largest of the boulders must be placed on the outer sides especially on the downstream face.

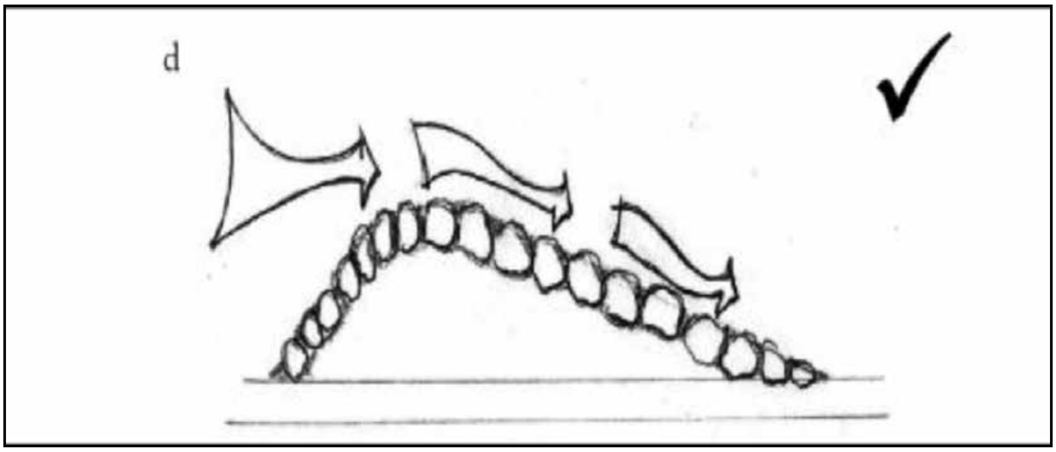


Figure 2-27: The largest boulders must be kept on the outer side as shown in the fig. above. Otherwise, smaller boulders will be displaced by the force of water and the boulder check will break

b) The trenches cut into the embankments on either side of the check and must also be filled up with boulders. As successive layers are laid out, care must be taken that the downstream and upstream slopes are maintained as per design. When one reaches the crest of the check one must ensure that the top layer slopes down away from the embankments dipping towards the center of the check, thus providing a channel for the safe exit of excess runoff.

iv) MATERIAL:

a) The larger boulders must be placed on the downstream face of the check. The outermost edge of the downstream side must be dug up to a depth of 0.25m and the largest boulders available must be placed at the lower most edge of the check on the downstream and anchored to the ground.

b) Smaller stones can be used to fill up the interiors of the check.

c) The use of boulders with a diameter of less than 15cm (or weight less than 1 kg) must be avoided.

d) The use of angular stones gives greater stability to the check than the use of rounded boulders.

e) Shale, limestone, mudstone or any loosely cemented rock must not be used, because they disintegrate when in touch with water.

v) ESTIMATION OF LBC:

For estimation of LBC average height of center and side of structure at different places of cross section of LBC should be worked out to arrive at the quantity of LBC.

vi) DOs AND DONTs:

DOs:

- Locate the check only where the height of the stream embankment is greater than or equal to the sum of the peak depth of flow in the drainage line and design height of the structure.
- The top of the check should be lowest in the middle of the stream and highest at either embankment.
- The height of the check in the middle of the stream should be 1m above ground level.
- Upstream slope of the check should be 1:1 while the downstream slope can vary from 2:1 to 4:1.
- The bed of the stream at the base of the check should be cleared of mud/sand up to 0.25m depth.
- The top of the check should extend into either embankment by cutting a trench and filling it with boulders.
- Larger boulders should be placed on the outer portion of the check.
- The use of angular boulders should be preferred.

DONTs:

- No checks where the bed slope is above 20%
- No checks should be constructed where boulders are not adequately available within a radius of 50m.
- Do not use boulders dug up or picked up from the neighborhood, such use would increase soil erosion in the area from where the boulders are picked up.
- Do not use boulders of diameter less than 0.15 m at any point which comes into contact with flowing water.

2.4.3.2. GABION STRUCTURE:

Gabion structures are of stone and wire dams constructed across drainage lines with a catchment area of 50-500 ha. They are also constructed to reinforce highly erodable stream embankments.

Image 2-5: Gabion structure

i) OBJECTIVES:

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

a) Reduction in soil erosion;

b) Trapping silt, which reduces the rate of siltation in water harvesting structures in the lower reaches of the watershed.

c) Increasing recharge of groundwater and

d) 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 more fully as they get many more refills.

e) Because of wire mesh, the biomass & debris flowing with the runoff water of first rain of rainy season is arrested in the wire mess & chock the water passing through the stones, resulting storage of water in the upstream side of the gabion.

ii) LOCATION:

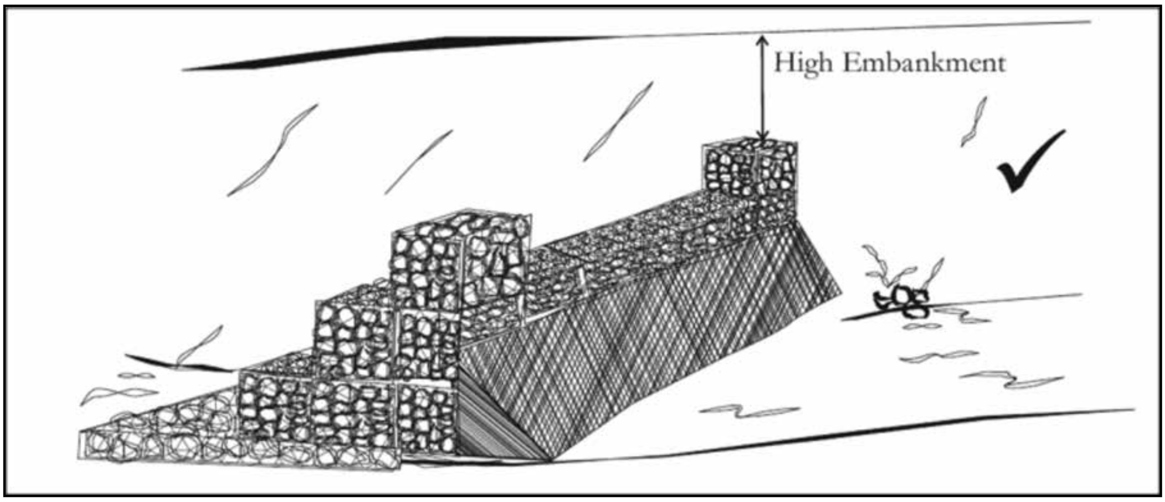


Figure 2-28: Gabion structures should be made where the embankments of the drainage line are high as shown above

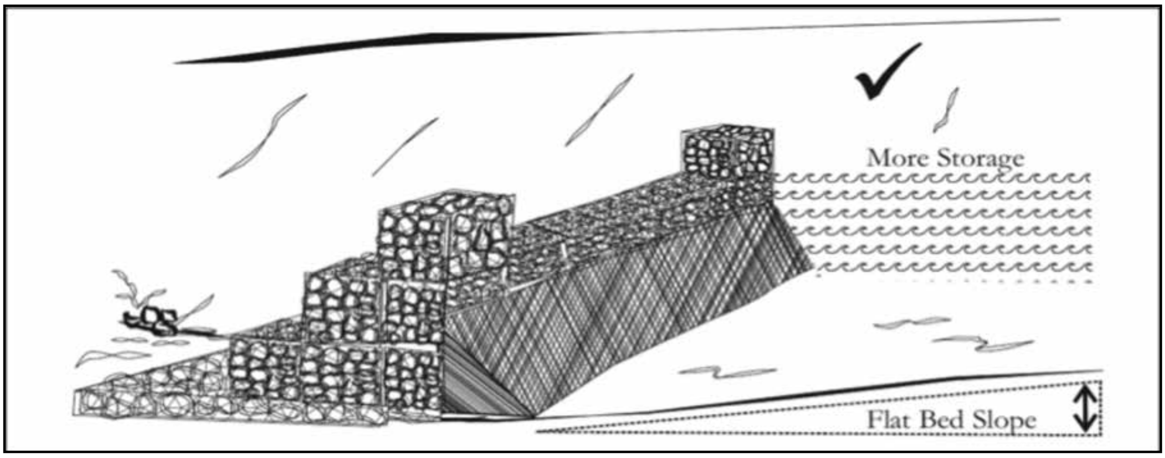


Figure 2-29: Gabion structures should be made where the bed slope is flatter

a) The minimum independent catchment area for a gabion structure is 5 ha. For a catchment area smaller than this even a loose boulder check may suffice.

b) The precise location of a gabion structure depends on the following factors:

- Stability of the embankments is the primary consideration. The less stable and more erodable the material on the embankments, the weaker the structure is likely to be. In such a situation, making the structure stronger would render it too expensive.
- The height of side embankments from the bed of the stream must be at least equal to the sum of the depth of peak flow in the stream and the designed height of the structure. For example, if the height of the embankments is 6m and the depth of peak flow is 4 meters, then the height of the gabion must not exceed 2 meters. Otherwise water will jump over the sides. Hence, observation of the peak flows is imperative before a gabion structure is planned.
- 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.
- The bed of the upstream of the structure should not be completely impermeable, so that there is temporary storage followed by groundwater recharge.

iii) DESIGN:

There are two ways of reinforcing a loose boulder structure with wire mesh:

a) To make the structure as per the dimensions of the design and wrap it with wire mesh on all sides.

b) To cage the boulders in rectangular boxes. The structure would be made up of several such boxes tied together. In such a structure the wire mesh not only provides a covering shell, it also gives horizontal and vertical reinforcements within the structure.

c) The second method is far superior to the first in terms of strength although more wire mesh is used than in the first method. In this chapter, we concentrate on the second method.

iv) DIFFERENT PARTS OF THE GABION:

The rectangular, box type gabion structure has the following sections

a) Foundation: The foundation should be dug up to a depth of 0.6 m across the bed of the drainage line for the entire length and width of the Headwall of the structure. Where the stream bed has a thick layer of sand or silt the foundation will have to be dug deeper till a more stable layer is encountered.

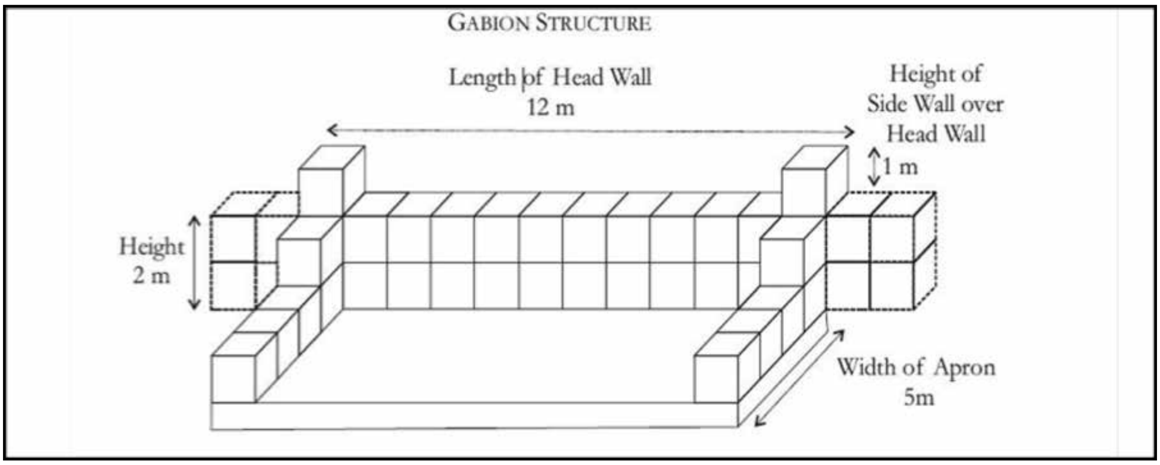


Figure 2-30: Gabion Structure

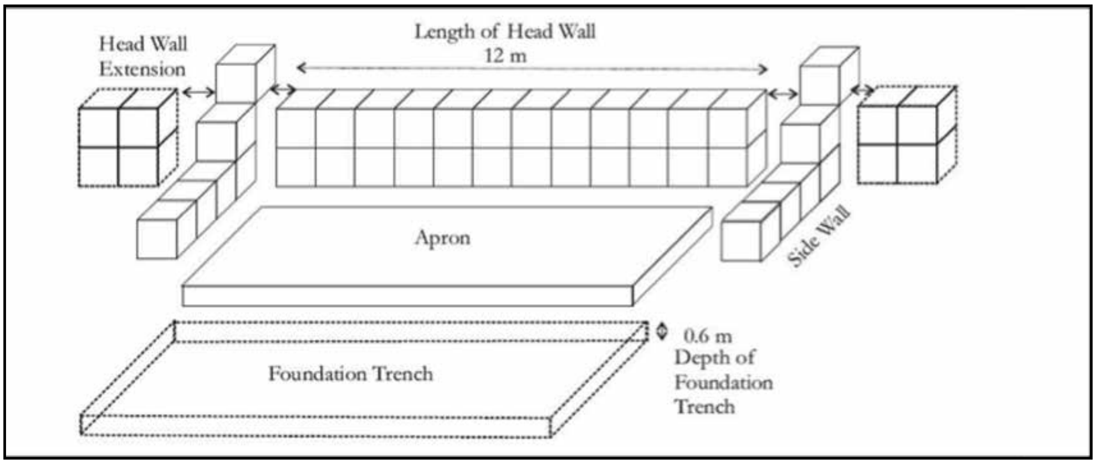


Figure 2-31: Different parts of the gabion

b) Headwall: The headwall is built across the width of the stream from embankment to embankment. In most cases the top of the structure across the entire stream can be level. The entire length of the headwall serves as a spillway for the stream. Where it is required that most of the flows be directed towards the center of the stream, that part of the headwall is lowered. For a height of up to 2m, the width of the headwall can be restricted to 1m. For heights beyond 2m, it is advisable to design it as a step-like structure, where the downstream face is constructed as a series of steps. For every 2m fall, a step should be provided of 1m width.

c) Sidewalls: Sidewalls are built to protect the embankments downstream from erosion by the stream spilling over the Headwall. On either end of the headwall, where the natural embankments begin, a block of the Sidewall is laid. The height of the sidewall above the top of the headwall is determined by the depth of peak flow in the stream. From here the Sidewall descends in a series of steps along the embankments to the bed of the stream.

d) Headwall Extension or Wing Walls: The headwall is extended into both the embankments in order to anchor the structure and secure it against sagging on account of the pressure of water. From the same height as the top of the sidewall, the headwall extends into the embankments.

e) Apron: During peak discharge, the stream spills over the headwall and falls on the stream bed with considerable force that can causes severe erosion. Hence, some way has to be found to neutralize the force of falling water. For this we dig the stream-bed to a depth of 0.6m. for a distance of 3 to 6m from the Headwall downstream of the structure. This trench is filled with boulders and enclosed in a wire mesh. This is called an apron. The length of the apron depends upon the radius of the arc made by the water spilling over the headwall, which is in turn determined by the depth of peak flow in the nala. Therefore, the higher the depth of flow, the longer the apron should be.

v) MATERIAL:

a) Wire Mesh: Good quality galvanized wire of gauge 12-14 (chain link) 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.

b) Binding Wire: The wire used for tying the wire mesh sections must be of the same strength as the wire used in the wire mesh. It could either be of the same gauge or of a thinner gauge plied and twisted together.

c) Boulders: The minimum size of the boulders is dictated by the gap size in the wire mesh. The boulders should be hard and should not deteriorate under water. Angular boulders are to be preferred to round boulders. Arrange smaller sized boulders in such a way that they fill the gap left by larger sized boulders. Besides rendering the structure less permeable, this minimizes the damage to the structure on account of settling and sagging.

d) **There are two types of pressures operating on a gabion structure:** static pressure of standing water; and the pressure of moving water. If small boulders are used in the structure, they could get shifted and dislocated on account of these pressures and the structure would tend to sag. The same problem will occur if the wire mesh is not drawn tight over the boulders.

vi) ESTIMATION OF GABION STRUCTURE:

Find the cost of a Gabion Structure (GS) with the following parameters:
Length = 12 m (see figure above)
Height of head wall = 2.0m
Depth of foundation at all points = 0.6m
Length of headwall extension = 2m
Height of sidewalls over headwall = 1m
Width of apron = 5m.

Step 1 : Excavation:

1. Excavation for apron and main wall foundation in hard soil

= Length x Width x Depth

= 12 x (5 + 1) x 0.60

= 43.2 cum

2. Excavation for head wall extension in hard soil

= 2 x Length x Width x Depth

= 2 x 2 x 2 x 2 = 16 cum

3. Boulder filling for apron and main wall foundation

= Length x Width x Depth

= 12 x (5 + 1) x 0.6

= 43.2 cum

Step 2 : Area of wire mesh

1. Area of wire mesh on apron and main wall foundation

= Length x Width = 12 x (5 + 1) = 72 sqm.

2. Area of wire mesh for keying of apron

= Length x Width = (12 + 12 + 5 + 1 + 5 + 1) x 1 = 36 sqm.

3. Total area of wire mesh apron: = 72 + 36 = 108 sqm

Step 3 Gabion Boxes:

As we know the gabion is made with GI wire mesh cubical boxes of 1.0 m. filled

with the boulders. For making one cubical box of 1 cum capacity:

Quantity of boulder required = 1.00 cum

Quantity of wire mesh required = 5.00 sqm...................... (As out of the six faces of cube two Faces will remain common for joining the two boxes)

For estimating the quantity of GS, we have to count the number of boxes in each part of the structure:

- Total boxes for main wall = Number of boxes in the main wall c/s x Length of GS = 2 x 12 = 24 boxes
- Total boxes for both sidewalls = Number of boxes in the side wall c/s x 2 = 6 x 2 = 12 boxes

- Total boxes for both side head wall extensions = No. of boxes in the head wall extensions x 2 = 4 x 2 = 8 boxes
- Total boxes for main wall + sidewall + extension wall = 24 + 12 + 8 = 44 Boxes
- Total quantity of wire mesh required for main wall + sidewall + extension wall =

No. of boxes x 5 = 44 x 5 = 220 sqm

- Volume of Reverse Filter = 1/2 x 1 x 2 x 12 = 12 cum

Step 4 Total Cost

Cost Sheet for Gabion Structure

No.	Particulars of work	A/U	Quantity	Rate	Amount
1.	Earthwork in hard soil for apron and main wall foundation	Cum	43.20	23.20	1,002.20
2.	Earthwork in hard soil for head wall extension	Cum	16.00	23.20	371.20
3.	Boulder filling for apron and main wall foundation	Cum	43.20	39.30	1,697.80
4.	Wire mesh for apron	Sqm	108.00	60.00	6,480.00
5.	Boulder filling for head wall, side wall and head wall extension	Cum	44.00	39.30	1,729.20
6.	Wire mesh for head wall, side wall and head wall extension	Sqm	220.00	60.00	13,200.00
7.	Reverse filter on upstream side	Cum	12.00	136.00	1,632.00
	Total cost of Gabion Structure	Rs.			26,112.40

(Note: Rates of items will vary from state to state. Calculation of wire mesh becomes more complicated as the Gabion Structure's length and height go up. Since the headwall is made in the form of steps, many more boxes will have common faces and hence the average number of faces per box, depending on the length and height of the structure, could go down to 4.)

vii) CONSTRUCTION:

a) First of all boulders must be collected on the location site. For the Headwall, a 1m wide and 0.6m deep trench should be dug across the stream bed from embankment to embankment. Foundation of similar depth should also be dug for the area demarcated for the apron and the sidewalls. For the headwall extension the embankments are cut to the appropriate depth.

b) Before the foundation trench is filled, lengths of wire mesh are placed vertically at three places:

   - The upstream edge of the foundation;
   - Where the headwall ends and the apron begins; and
   - Against the downstream edge of the apron.

c) At all three places the wire mesh runs along the entire length of the structure. Everywhere, 0.15m of the wire mesh is folded along the bed of the trench so that the mesh can be embedded under the boulders. After that the trench is filled with boulders up to ground level. Then, the wire mesh is laid over the entire surface and tied to the mesh which has been embedded under the boulders. The headwall as well as the sidewalls should be constructed as boxes of 1 to 2m length and 1m height.

d) First the four vertical faces of these boxes are erected with wire mesh which is tied to the wire mesh in the section below as well as the section alongside. Then the boxes are filled with boulders and covered at the top with wire mesh. This wire mesh is tied to each of the vertical faces on all four sides. Such boxes are filled up in succession till the structure is complete.

e) To increase impermeability of the structure, a reverse filter should be constructed on its upstream face. This device is made by placing layers of small boulders, gravel, sand and mud against the structure.

However, the order of placement of these materials is exactly the opposite of the arrangement in a normal filter. The boulders are placed closest to the structure, with gravel, sand and mud being placed successively away from it. The reason for the reverse order is that we want the finest material to come into contact with water first. Following the normal filter scheme would have allowed water to pass unchecked through the boulders and coarser material on the outer surface. One can even try to place used cement or fertilizer bags filled with fine sand against the structure in several layers.

viii) DOs AND DON'Ts:

DON'Ts:

a) Do not build a gabion structure where the embankment is highly erodable or is of insufficient height.

b) Do not build a gabion structure at a point on the stream, below which the stream drops sharply.

DOs:

a) Locate the gabion structure where the nala width is relatively low.

b) Locate the structure where the bed-slope of the nala upstream of the structure is low.

c) Care must be taken that the boulders are placed compactly against each other so that they do not slide or move under the impact of water.

d) Smaller boulders must be placed in the interior part of these boxes while the larger ones must be placed on the outside.

e) Even the smallest boulder should be bigger than the gap in the wire mesh.

f) The wire mesh must be stretched taut so that there is no bulging or sagging.

g) The wire used for tying the wire mesh sections must be of the same strength as the wire used in the wire mesh. It could either be of the same gauge or of a thinner gauge plied and twisted together.

h) For height above 2m, the Headwall must be made as a series of steps sloping on the downstream side to impart stability to the structure.

2.4.3.3. EARTHEN GULLY PLUGS:

An earthen gully plug, constructed of local soil across the gully at a suitable site, can also be used for gully stabilization.

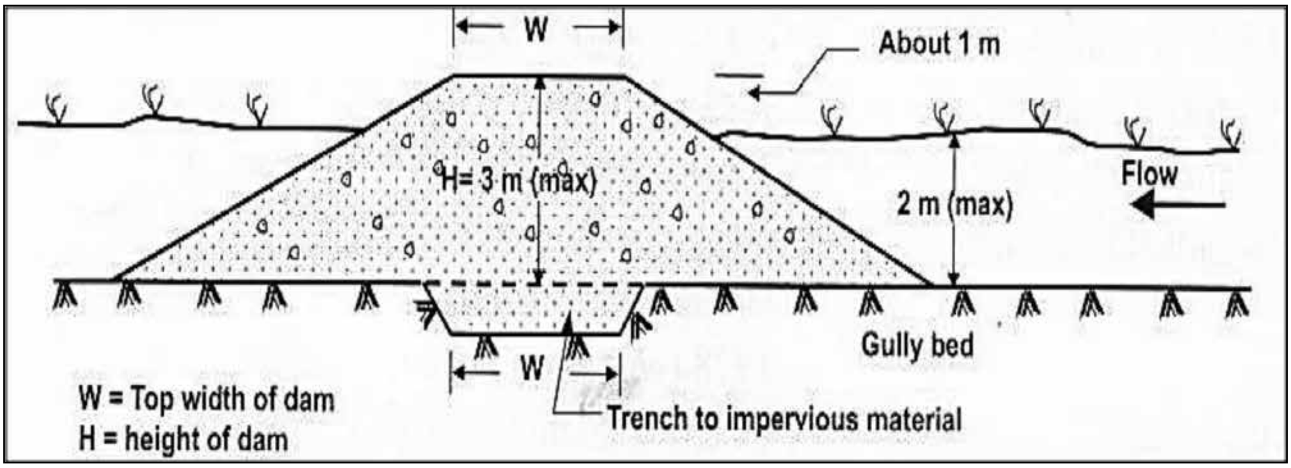


Figure 2-32: Cross-section of an earthen gully plug

i) SUITABILITY:

a) In the upper catchment areas where there is scope for water storage.
b) Suitable soil for the embankment is available.
c) The depth of gully is less than 2 m.
d) Gully bed slope is less than 10%
e) The site is having facility for side spillway

ii) DESIGN SPECIFICATIONS:

Top width	:	0.6 m
Side slopes on u/s and d/s side	:	2 H: 1 V
Maximum height	:	3.0 m
Minimum height	:	1.0 m
Stone–pitching	:	Upstream side up to FSL (full supply level of water)

iii) CONSTRUCTION:

After clearance the site, the bed of the gully is excavated up to about 0.3 m uniform depth. Foundation trench is filled with compacted earth and earthen embankment is constructed by using local soil. Side spillway is also provided. Pitching of local stones on the upstream side of the bund is provided up to the full supply level whereas grass planting is done on downstream side and top portion.

B) MIDDLE & LOWER REACH DRAINAGE LINE MEASURES:

i) INTRODUCTION:

Permanent soil conservation structures such as drop spillway, drop inlet, chute spillways & earthen dams are used in watershed development for gully stabilization and as water harvesting structures.

ii) SUITABILITY:

Their use becomes necessary when runoff from the catchments is too large to be handled with vegetative measures/temporary structures or where high degree of safety is warranted against the loss of life and property. However, it should be ensured that the benefits from such structures are justifiable over the cost of construction.

Drop spillways are used for gully stabilization or as water storage structures where the drop is low. Drop inlet structures are used at appropriate locations in the gully for storage of water/ sediment. Chute spillways are used at higher gully heads to convey the water safely to the gully bed.

iii) DESIGN CRITERIA:

The hydraulic structures consist of three major components i.e. the inlet, conduit and outlet. Water enters the structure through the inlet, is conveyed through the conduit and leaves through the outlet which is responsible for the energy dissipation to prevent erosion.

Permanent structures in soil conservation are normally designed for a recurrence interval (RI) of frequency of 10-50 years which means that they are supposed to discharge the maximum runoff expected during the design frequency or recurrence interval (RI) safely. The structure should be strong enough to withstand the forces exerted by water/earth. A structure should, therefore, be designed with the following considerations:

a) Hydrologic design: It involves computation of the peak discharge at the point of watershed where the structure is to be constructed. Generally, Rational method is employed for this purpose.

b) Hydraulic design: It involves calculation of the dimensions of the spillway which is able to carry the above peak discharge safely.

c) Structural design: It involves calculation of the dimensions of each component of the structure which ensures its safety against water/earth forces, the structure is likely to withstand.

2.4.3.4. DROP SPILLWAY:

Drop spillway is a weir structure. Flow passes through the weir opening, drops to an approximately level apron or stilling basin and then passes into the downstream channel. The different components (fig. 2.34) of the drop spillway are : (1) head wall and head wall extension, (2) side walls, (3) wing walls, (4) apron, and (5)

Longitudinal and transverse sills.

i) FUNCTIONAL USES:

a) Gully and ravine stabilization
b) Erosion control structures for stabilization of landslides and mined areas
c) Protection of fields, roads and hutments etc. from gullies
d) Grade control for stabilizing channels and waterways
e) Reservoir spillway where the total drop is relatively low
f) Control of irrigation water
g) Rain water harvesting

ii) ADAPTABILITY:

The drop spillway is an efficient structure for controlling low heads, normally up to 3 meters.

iii) DESIGN OF DROP SPILLWAY:

a) Hydrologic design: The peak rate of runoff expected during the designed recurrence interval (RI) from the watershed can be computed using Rational formula as given below:

$$Q = \frac{CIA}{360} \qquad \textbf{.... (2.25)}$$

Where,
Q = Design peak rate of runoff, m^3/s,
C = Runoff coefficient,
I = Intensity of rainfall, mm/hr for the duration equal to time of concentration (Tc) of watershed and design RI, and
A = Area of the watershed, ha.

b) Hydraulic design: The discharge through a broad crested rectangular spillway is governed by the following formula:

$$Q = 1.711\ LH^{3/2} \qquad \textbf{.... (2.26)}$$

Taking into account the free board (f.b.) to be provided for the wave action, the above formula is modified as:

$$Q = \frac{1.711\ Lh^{3/2}}{(1.1 + 0.01\ F)} \qquad \textbf{.... (2. 27)}$$

Where,
Q = Maximum discharge capacity of weir (including f.b.), m^3/s,
L = Crest length of weir, m,
H = Depth of flow over weir crest, m
h = Height of weir (including f.b.), m, and
F = Net drop from top of transverse sill to crest, m.

The peak discharge (Q) in Eq. 2.27 can be taken as the one calculated from Eq. 2.25. The net fall, F, is known from the survey of the site where the structure is to be located. Still Eq. 2.27 consists of two unknown variables L and h, hence the equation cannot be solved as such and requires hit and trial solution. To start with, one of the unknown values of L or h can be assumed based on nala/ gully cross section and computations are done as follows:

- Assume a suitable value of h such that $h/F<0.5$ (as h/F ratio increases, the tendency to scour increases, this ratio should in no case exceed 0.75).
- Put this assumed value of ‘h’ in Eq. 2.27 and compute of ‘L’.
- Check if $L/h > 2$. If not, assume another lower value of ‘h’ and compute corresponding value of L as in step 2, till this condition is satisfied.
- See that the computed value of ‘L’ is appropriate with respect to width of the gully.

c) Structural design: After L, h and F have been decided by the hydraulic requirements, the dimensions of the components of the structure can be computed from the following empirical relations (Fig. 2.32):

E = Minimum length of head wall extension, m
= (3h + 0.6) or (1.5 F) whichever is greater **.... (2.28)**

L_B = Length of apron, m
= F (2.28 h/F + 0.52) **.... (2.29)**

S = Height of end sill, m = h/3 **.... (2.30)**

J = Height of wing wall and side wall at junction, m
= (2h) or [F + h + s - (L_B + 0.10)/ 2] **.... (2.31)**

M = 2 (F + 1.33 h-j) **.... (2.32)**

K = (L_B + 0.01) – M **.... (2.33)**

S_h = Height of Longitudinal sill = h/4 **.... (2.34)**

S_t = Height of transverse sill = h/3 **.... (2.35)**

d) Foundation design: Cutoff and toe walls are constructed below the ground level in foundation. Cutoff wall is constructed below the head wall to prevent seepage below the structure. Whereas, toe wall is extended below the front of apron to prevent undercutting. Scour formulae are adopted for the design of cutoff and toe walls as below:

Normal scour depth (NSD) = 0.473 $(Q/f)^{1/3}$ **.... (2.36)**

Where, f = silt factor (1 to 1.2)

Maximum scour depth (MSD) = 1.5 x NSD **.... (2.37)**

The height of the cut-off and toe walls may be taken equal to MSD in Eq. 2.37.

e) Apron thickness: Thickness of the apron in plain concrete may be kept from 20 to 30 cm for over fall height (F) varying from 0.5 to 3.0 m. For masonry and gabion constructions, the same may be increased by 1.5 and 2 times, respectively.

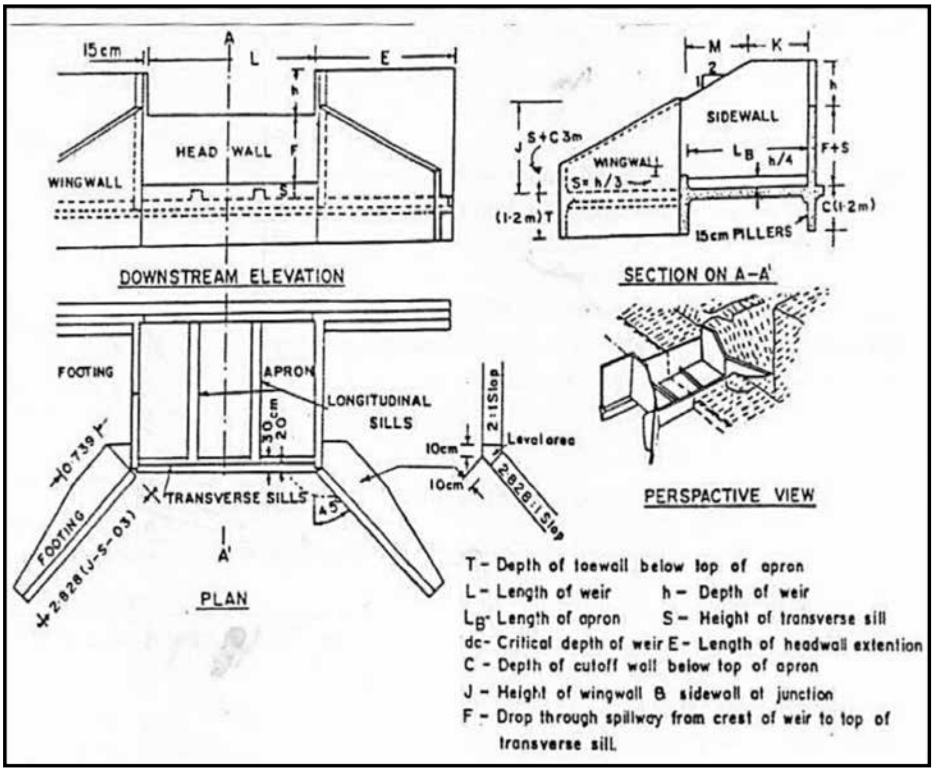


Figure 2-33: Nomenclature and symbols of drop spillway

f) Wall thickness: Top widths and minimum base widths of headwall, side wall, wing wall and headwall extension for different wall heights for different constructions can be determined using the formulae presented in Table.2.8

Table 2-8: Formulae for determination of base widths of different walls of a drop spillway in different constructions

Type of construction	Minimum top Width (m)	Walls	
		Head Wall	Side Wall
Plain concrete	0.25	0.67 (F-0.4) + 0.25	0.55 (F-0.45) + 0.25
Masonry	0.45 (head wall)	0.67 (F-0.67) + 0.45	0.55 (F-0.55) + 0.30
	0.30 (other walls)		
Gabion	0.75	0.67 (F-1.12) + 0.75	0.55 (F-1.40) + 0.75
F = height of wall from top of the crest to the bottom of apron.			

Table 2-9: Thickness of walls (m) of a drop spillway constructed in stone or brick masonry

Description	Head wall	Side wall
Minimum top width, m	**0.45**	**0.30**
Wall height (m)	**Recommended base widths**	
0.5	0.45	0.30
1.0	0.67	0.55
2.0	1.33	0.10
2.5	1.67	1.37
3.0	2.00	1.65

Example:

Design a drop spillway to be constructed in a gully having width of 5 m and the outlet of a watershed having an area of 58 ha. The net drop is 2.0 m. Take the rainfall intensity for duration equal to time of concentration of the watershed and design return period of 25 years as 120 mm/hr. The coefficient of runoff for the watershed is 0.3.

Solution:

1. Hydrologic design

The design peak runoff rate (m3/s) for the watershed from Rational formula is given as (Eq. 2.25):

$$Q = CIA/360 \qquad \textbf{... (2.25)}$$

$$= (0.3 \times 120 \times 58)/360 = 5.8\text{cum/s}$$

2. Hydraulic design

The maximum discharge capacity of the rectangular weir is given by (Eq. 2.27):

$$Q = \frac{1.711\ Lh^{3/2}}{(1.1 + 0.01\ F)} \qquad \textbf{... (2.27)}$$

$$5.8 = \frac{1.711\ Lh^{3/2}}{(1.1 + 0.01 \times 2)} \qquad (F = 2.0\text{ m})$$

Therefore, $Lh^{3/2} = \frac{5.8 \times 1.12}{1.711} = 3.796$

To find suitable values of 'L' and 'h'

i) Assume L = 4.0 m (since width of gully is 5.0 m)

ii) Putting the above value

$h^{3/2}$ = 3.796/4.0 = 0.949

h = (0.949)2/3 = 0.965 or say 1.0 m

iii) Test: L/h = 4.0/1.0 = 4.0 > 2 (O.K.), h/F = 1.0/2.0 = 0.5 < 0.5 (O.K.)

Hence, the designed hydraulic dimensions of the spillway are:

Crest length (L) = 4.0 m

Weir depth (h) = 1.0 m

3. Structural design

The dimensions of the components of the structure (Fig. 2.35) are determined as below (using Eqs. 2.28 -2.37):

(i) Minimum head wall extension,

E = (3h + 0.6) or 1.5F, whichever is greater

E = 3 x 1 + 0.6 = 3.6 m or 1.5 x 2.0 = 3.0 m

Hence, E = 3.6 m

(ii) Length of apron or basin, L_B = F (2.28 h/F + 0.52)

$= 2 (2.28 \times \frac{1}{2} + 0.52) = 3.32$ m

(iii) Height of end sill, S = h/3 = 1/3 = 0.33 m

(iv) Height of wing wall and side wall at junction

J = 2h or [F + h + s – (LB + 0.10)/2]

= 2 x 1 or [2 + 1 + 0.33 – (3.32 + 0.10)/2]

= 2.0 or 1.62

Adopt J = 2.0 m

(v) M = 2 (F + 1.33 h-j) = 2 (2 + 1.33 x 1-2) = 2.66 m

(vi) K = (LB + 0.1) – M

= (3.32 + 0.1) – 2.66 = 0.76 m

(vii) Depth of foundation

Normal scour depth (NSD) = $0.473 (Q/f)^{1/3}$

$= 0.473 \times (5.8/1.2)^{1/3} = 0.80$

(taking f = 1.2)

Maximum scour depth (MSD) = 1.5 x NSD

= 1.5 x 0.80 = 1.2 m

Therefore, depth of foundation = 1.2 m

Apron thickness: For an over fall of 2.0 m, the apron thickness in concrete construction is 0.30 m. If the structure is constructed in masonry or gabion, the same may be increased by 1.5 and 2.0 times, respectively.

Wall thickness: The thickness of different walls of the structure (masonry construction) is given below:

Description	Thickness of walls (m)	
	Top width	Bottom width
Head wall	0.45	1.33
Side wall	0.30	1.10
Wing wall and head wall extension	0.30	0.80

2.4.3.5. EARTHEN DAMS:

i) OBJECTIVES:

Earthen dams can be of 2 major types depending on their primary objective:

a) Irrigation Dam: Such dams can be constructed to meet two different kinds of Demands of:

- Storing water during the rainy season to be used for irrigation in the Post-monsoon period.
- Providing protective irrigation during dry spells within the rainy season. Most parts of India typically receive rainfall between June and September, very intensively within a few hours and a few days. The number of rainy days does not average more than 40-50. Therefore we may need structure for providing protective irrigation for kharif season.

b) Percolation Dam: Percolation dams are constructed for recharging groundwater. Such structures are usually made on the upper part of the catchment area. Water stored here percolates to wells and tube wells located in the lower part of the catchment. Such dams can also be made in the immediate upstream portion of wells and tube wells. Depending on the capacity of the dam and duration of water storage, the dam can have secondary benefits (such as pisciculture) that are vital for the livelihood security of marginal farmers and landless labourers.

ii) LOCATION:

Deciding how to locate an earthen dam requires balancing many considerations and arriving at the best possible solution.

a) Balance between Catchment Area and Storage Capacity: The first is to create the best possible match between the storage capacity of the dam and its catchment area.

b) Side banks of the Drainage Line: We must also try to ensure that where the dam is located the drainage line should have well-defined embankments so that we can anchor the dam into them.

c) Slope of the Drainage Line: Ideally, upstream of this site, the drainage line should be relatively flat (bed slope not more than 5%). This helps maximize storage capacity.

d) Upstream Width of the Drainage Line: As we move upstream of the dam site, it would be good if the width of the drainage line increases, so as to contain maximum storage within its banks.

e) Geology: In an irrigation dam, the water spread area and the natural embankments should be impermeable. In a percolation structure, the natural embankments should be impermeable but the water spread area should comprise relatively more permeable material.

f) Availability of Materials: Even with all other factors favoring a site, we may be compelled to abandon it if the requisite materials (earth, boulders, water etc.) are not easily available. This could make costs of transporting material prohibitively high.

g) Waste weir: It is very important to be able to find a proper location for the surplus weir at the dam site. We know that if water flows over the top of an earthen dam it will break. Hence, the surplus weir is required to channelize excess runoff safely out of the structure.

iii) DESIGN:

It is neither desirable nor possible to capture the entire surface water run-off within the watershed. In any case, no single earthen dam can do this. A thumb rule we have devised to make an earthen dam cost-effective is that it should aim to capture no more than 40% to 70%[1] of the season's total surface water run-off.

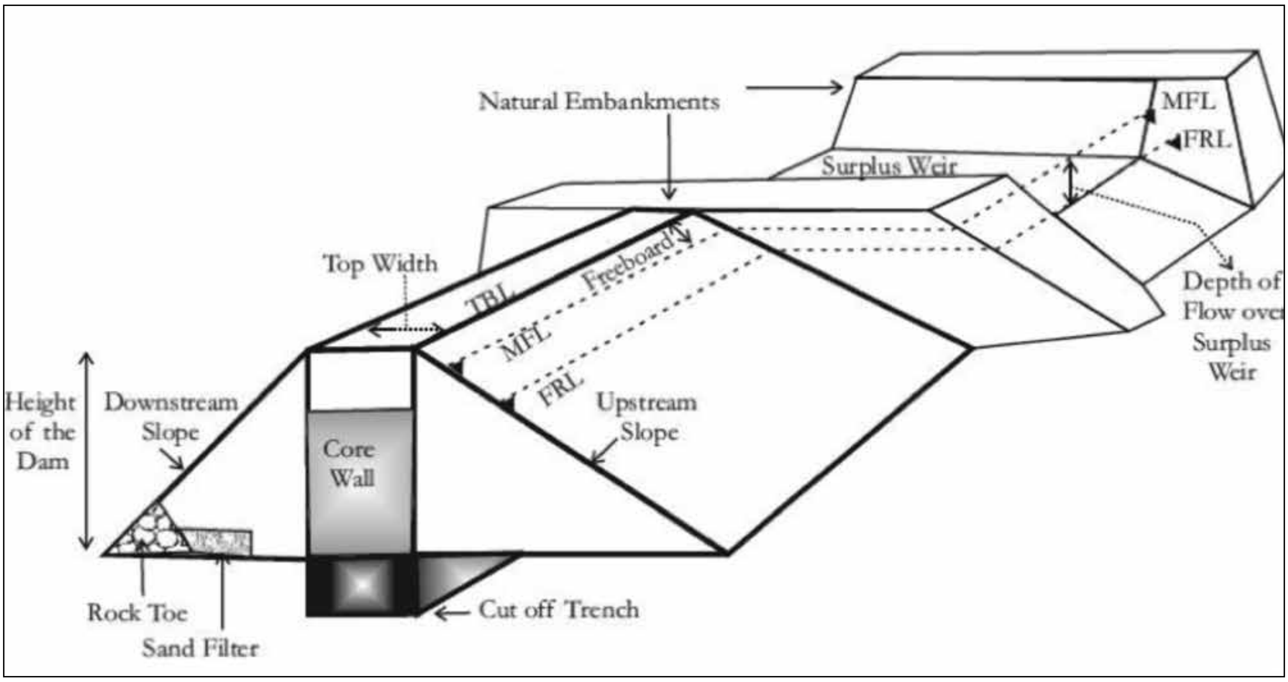


Figure 2-34: The design of an earthen dam and its main parts

a) Full Reservoir Level (FRL):

The FRL indicates the maximum level up to which water will rise when the structure is full. The FRL is determined bearing in mind the total runoff in relation to the effective storage potential of the site, which in turn depends on the shape of the side embankments, the upstream bed slope and geology of the drainage line and its width. The precise method of determining the storage potential of the site is provided in the Appendix to this chapter. Once we know the storage potential, how high we keep the FRL is determined by specific conditions at the site, such as height of the embankments, upstream bed slope, width of the drainage line and maximum permissible submergence. The submergence permissible in any such structure would depend upon the nature of the catchment: in particular, whether it is inhabited, forested or whether it includes fertile agricultural land. The permission of those whose lands may be getting submerged would also need to be obtained prior to fixing the FRL. They should be actively involved in the planning and design of such structures from beginning to end. In case they suffer a loss due to the structure, they must be adequately compensated, possibly through sharing the benefits from the structure with them.

b) The Maximum Flood Level (MFL):

The MFL is the maximum level up to which water is allowed to rise in a structure after an intense spell of rain. This provision takes care of extraordinarily high floods, which might damage the structure because it takes time for flood water to move out of the surplus weir. This may happen especially when there are temporary obstructions in the surplus weir due to accumulation of fallen tree trunks, leaves etc. This is particularly important after the first rains.

c) The Freeboard:

Over and above the MFL, we provide an extra height to the dam, which is called the freeboard. Freeboard is the difference in height between the top of the bund and the maximum level up to which floodwater rises in a dam. Normally, the freeboard should be at least double the difference between FRL and MFL. It has been found through years of experience that for earthen structures with height less than 5m, a freeboard of 1m would be adequate.

[1] We know that rain in most parts of India falls in spells within a 4-month monsoon period. An examination of data on intensity of rainfall from all over the country suggests that any one spell is unlikely to yield more than 40% of the season's total run-off. Our small dams should not, therefore, be designed to capture more than this. As Tideman says "In engineering design it is uneconomical to design structures to cope with extreme events. A designer takes a calculated risk and designs a structure that will accommodate the largest rain storm that can be expected during a particular time interval" (Tideman, 1996).

d) Top bund level (TBL):

MFL + freeboard = TBL. The TBL refers to the top level of the dam. If water flows over the top of the bund in an earthen dam, the dam will break. Hence, unlike in masonry or boulder structures, the excess water cannot be directed over the top of an earthen structure. Therefore, the TBL in all earthen structures has to be kept higher than the FRL/MFL.

e) Top Width:

Top width of dams varies with the height and purpose of the dam. For earthen dams in the range of 3 to 6 meters height, top width is kept in the range of 1 to 2 meters. If the top is to serve as a road, the top width will need to be more than 2m. The top width may be determined by the empirical formula,

W = 0.4 x h + 1 where, W = top width of bund

h = maximum height of bund

f) Hydraulic Gradient:

Saturation Gradient; Percolation Gradient: Line of saturation or Seepage and percolation line are all synonymous terms. It is a line inside an embankment marking the boundary between wet earth and damp or dry earth.

In the case of earthen embankments which hold up a depth of water against one face, the bank becomes gradually saturated by percolation up to certain level constituting a gradient or an inclined line falling from the point where the water touches the embankments on the upstream side. This inclined line is called the Hydraulic Gradient or Seepage Line for that soil and below which the embankment portion is saturated. This is due to the pressure of water, and the more the soil is porous the less is the resistance to percolation, and the flatter the hydraulic gradient.

The plane of the surface of percolation is called the plane of saturation or percolation and if this cuts the outer face of the bank, visible flow will appear along and below the line of intersection. The hydraulic grade line must fall within the toe of the bank and be covered by at least 100 cm of soil and which should be much more in the case of Core walls of puddle-clay etc. reduce the seepage line and prevent the flow lines from cutting the downstream face of the embankment. Sometimes filler materials are placed on the downstream toe to provide free drainage, which will force the seepage line down. Filter materials can be placed in several layers, each layer coarser than the last.

Table 2-10: The hydraulic grade line in different types of soils:

S. No.	Soil Type	hydraulic grade/seepage line
1.	Good clay	3:1
2.	Good compacted soil	4:1
3.	Average soil (sandy loam)	5:1
4.	Bad soil	6:1
5.	Fine silt	6:1
6.	Fine sand	8:1
7.	Coarse sand	10:1

(Source: Indian Practical Civil Engineers Hand book, by P.N. Khanna)

g) Upstream and Downstream Slopes of the Dam:

The upstream slope of the dam is subject to erosion by the sloughing action of waves and by receding water. The downstream slope of the bund is subject to erosion by intense rainfall and the scouring action of flowing water. In order to protect the dam from such erosive action, the slopes of the dams must be very carefully determined. The precise upstream and downstream slopes of the bund depend on the angle of repose and erodability of the materials used in the outermost face. However, it is necessary to provide a lower slope on the upstream side than the downstream side to counter the sloughing action. Through experience it has been found that for a stable earthen structure, the upstream slope should range from 2.5:1 to 4:1. The downstream slope should range from 2:1 to 3:1.

h) Settlement Allowance:

The soil used on an earthen dam is usually compacted to a certain degree. Even the, this artificial compaction can never match the state of natural compaction in which the materials are found on earth's surface. Hence, a certain allowance has to be made for natural process of compaction due to the weight of the dam, movement of its materials towards their natural angle of repose, the increased moisture caused by water storage and the direct impact of rainfall. This allowance to be provided for this settlement depends on the type of fill material and the method of compaction used. Thus, the earthen dam must be made convex shaped with the middle portion being higher than the sides.

i) Waste weir:

Water in excess of the FRL is drained out by the waste weir. The base of the waste weir is at the FRL. Spells of rain can vary greatly in intensity. There may be a sudden storm and dangerous amounts of water may have to be dealt with. A safety valve is required that lets some of the runoff go as soon as the dam is filled up to the designed FRL.

The dimensions of the surplus weir are determined by taking into consideration the peak runoff from the catchment. The surplus weir must have the capacity to drain out safely the peak runoff when the water is at FRL of the dam. Peak runoff from a watershed is estimated as per the Rational Formula:

Peak Runoff $Q = C \times I \times A / 360$ **.... (2.38)**

Where,
Q = peak runoff in cubic meters per second
C = coefficient of runoff
I = intensity of rainfall in millimeters per hour
A = catchment area of the structure in hectares

The discharge capacity of the surplus weir has to be equal to the peak run-off. The surplus weir is given by the Crested Weir formula:

$Q = 1.711 \times L \times H^{3/2}$ **.... (2.39)**

where,
L = Length of the Weir (m)
H = Depth of flow through the weir (the height to which we would allow water to rise inside a surplus weir) (m)

iv) CONSTRUCTION STEP BY STEP:

a) Trial Pits:

At three or four places in the proposed dam site, experimental pits of 1m. x 1m. should be dug. Fill water in these pits to get an idea of the percolation rate of the proposed site. The site should be abandoned if the percolation rate is too high. Trial pits also help us determine the depth of the cut-off trench along the base of the dam. A third purpose of the trial pit is to assess the strength of the strata underlying the dam.

b) Site Clearance:

Remove all vegetation at the proposed site. Scrape the location to 10 -20cm depth. All tree roots as well as sand; stones etc., at the site should be removed. "Toothing" should be provided at the proposed site by making the base of the dam uneven. This helps better grip of the structure on the ground.

c) Layout:

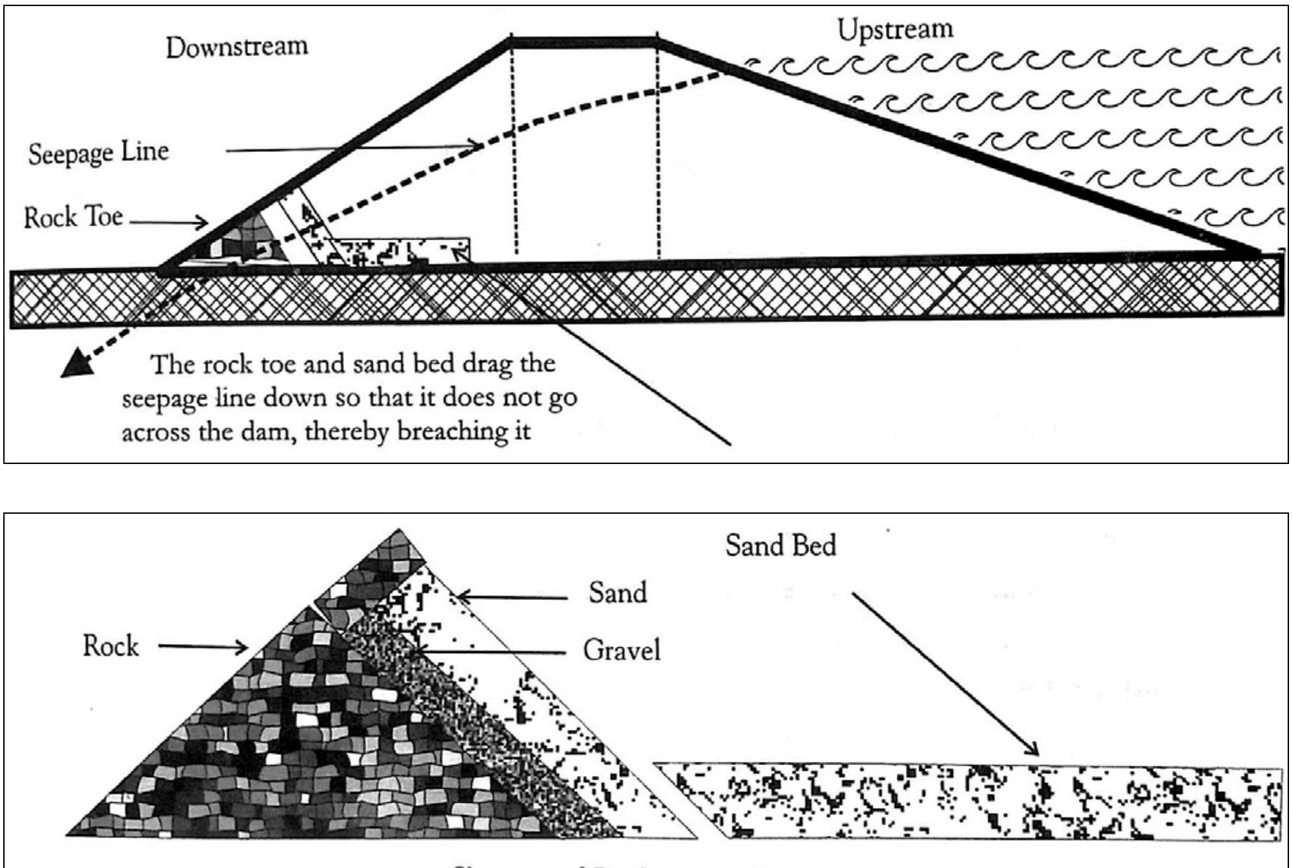
Draw a line along the center of the proposed bund from embankment to embankment (center line). Determine the FRL and TBL of the structure. At 4 meter intervals on the center line, use the dumpy level to mark a series of points where the dam will be raised to TBL. Settlement allowance must be added to this height at each point. On the basis of the slope parameters decided, indicate distances on the upstream and downstream side at each point and draw lines through these points. Care must be taken to provide the required top width exactly in the middle of the bund. For instance, if the maximum dam height is 5m, top width 2m and upstream and downstream slopes 2.5:1 and 2:1 respectively, the upstream edge of the dam must be marked at (5x2.5)+1=13.5m distance and the downstream edge at (5x2)+1=11m distance.

[2] Only where the stream bed is made of impervious material, a cut-off trench may not be necessary

d) Cut-off Trench:

We need to prevent the water from leakage and seepage we have stored in an earthen dam. For this we dig a cut-off trench and fill it with puddled clay the purpose of the cut-off trench is not to provide a foundation but to control excessive seepage below the dam wall.

Dig a 1m wide trench of required depth along the center line of the proposed dam. In earthen dams, the depth of the cut-off trench is usually fixed as 25% of the TBL or till impervious strata is reached, whichever comes earlier. After excavation, the base of the cut-off trench should be rammed thoroughly by watering. Fill the trench with 30-35 cm thick layers of puddled clay. Each layer should be properly watered and rammed into the layer below. Ramming inside the trench is usually done by labourers walking on the puddled clay.



Close-up of Rock Toe and Sand Bed

Figure 2-35: The seepage line and rock toe - Horizontal Sand Filter/Rock Toe Drain

Even in a relatively impervious structure, some amount of water stored in a reservoir percolates from the upstream side to the downstream through the body of the dam, thus forming a seepage line. If this line emerges above the base of the dam, it would slowly cut into the downstream side and gradually erode it. This would pose a serious threat to the stability of the structure. In order to drag the seepage line downwards so that the water is drained within the base of the dam, 30 to 50 cm thick sand layers are placed inside the dam, at the base of the downstream portion, forming a horizontal sand filter. On the outermost side of the downstream portion, boulders are placed to drag the seepage line down, which forms the rock toe drain. The rock toe is usually constructed in the design of a reverse filter with each subsequent layer increasingly coarser than the previous layer. The filter material must be more pervious than the bund material so that the seeping water can be rapidly removed.

e) Embankment and Core wall:

Depending on the construction materials used, earthen dams can be classified into three types:

- **Dams of Homogeneous Material:** In places with an impervious foundation where availability of clay is virtually nil, dams can be made from relatively more pervious material by increasing the cross-section area of the dam. Watering and ramming should be carefully done in such dams. The cross section of this type of dam should be made broader by providing lower slopes on the upstream and downstream, as well as by increasing the top width.

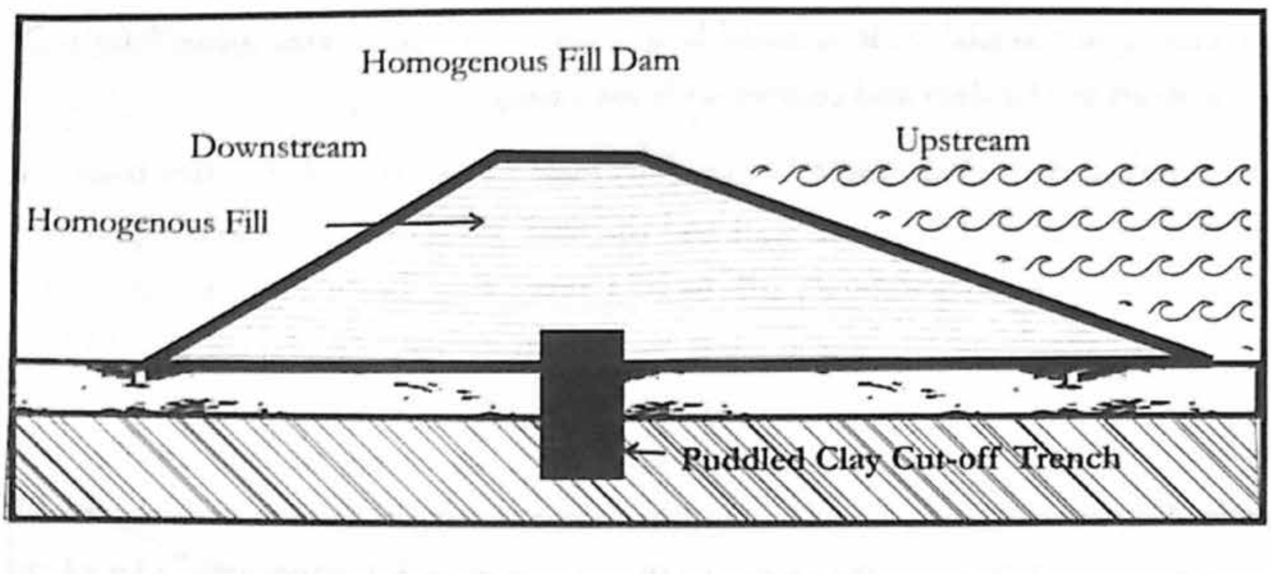
- **Core Wall Type Dam:**

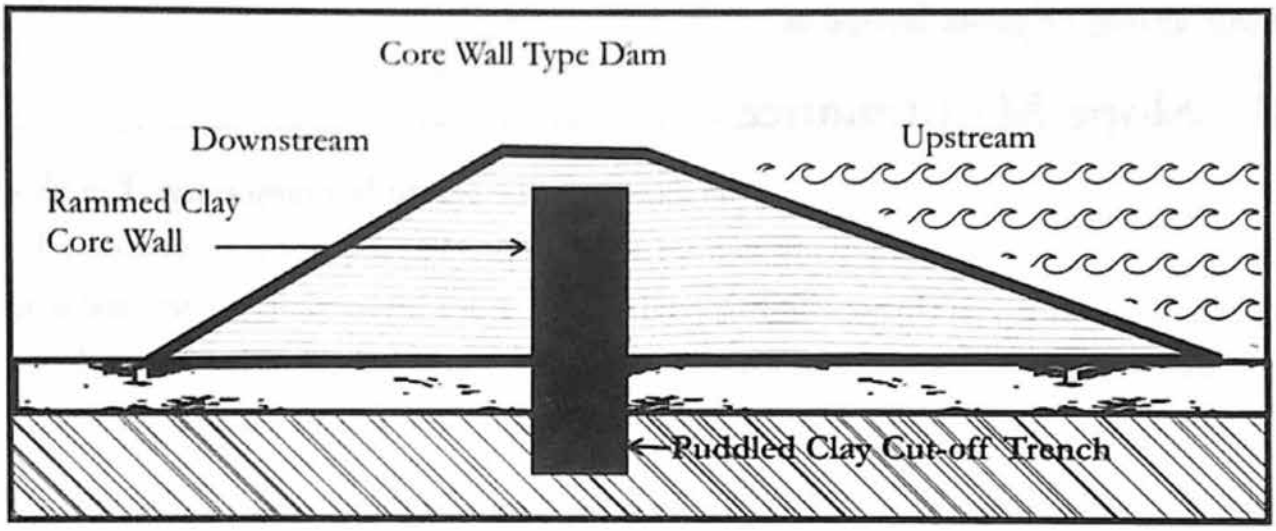
  Where both pervious and impervious materials are available, the dam wall can be partitioned between these according to their relative abundance. Where the availability of impervious clayey soil is limited, we can choose to economies on clay by watering and kneading by human labour (puddling). In the core wall type dam, there is a narrow, impermeable, puddled clay barrier, extending from side to side. The clay is soaked, kneaded and rammed to make a thin impermeable wall. This forms the core wall of the dam. The cut-off trench is filled with puddled clay till ground level is reached. This is a labour intensive method but it maximizes impermeability of clay. To support and protect this, the outer flanks of the dam are made of rammed coarser soils, which are arranged by grade. The finest particles are placed inside, graduating to the coarsest material on the outer face of the dam. The final shelter is provided by stone pitching, which involves placing a layer of boulders on the upstream face of the dam.

- **Hearting and Casing Type Dam:**

  Where clay is available easily and in large quantities, it is possible to construct the heart of the dam with wetted and rammed clay, and provide a casing of coarser soils to protect it. Here, a thicker wall of clay is raised by laying, wetting and ramming (see Figure 2-36). The inner clay wall will also have side slopes, unlike the core wall, which is vertical. After the cut-off trench has been filled, the dam wall is raised in horizontal layers. Even in situations where pure clay is not available, it is possible to make an earthen dam using finer soils for the heart of the dam and coarser soils for casing.

  In all three types of dams, care must be taken to raise all sections of the dam together. In a core wall type, the puddle core wall and the shell must be simultaneously raised. Core wall needs to be on structred only till the FRL is reached. In the hearting and casing type, both the hearting and the casing must be done together. The layers should be 6 to 8 inches on either side which are laid, wetted and rammed. While laying, it should be kept in mind that the finer soils should be laid inside, i.e., closer to the clay core, the coarser soils should graduate outwards. As layer after layer gets compacted, the width of the casing is reduced to create the slopes of the upstream and downstream sides of the dam till the desired height is arrived at.





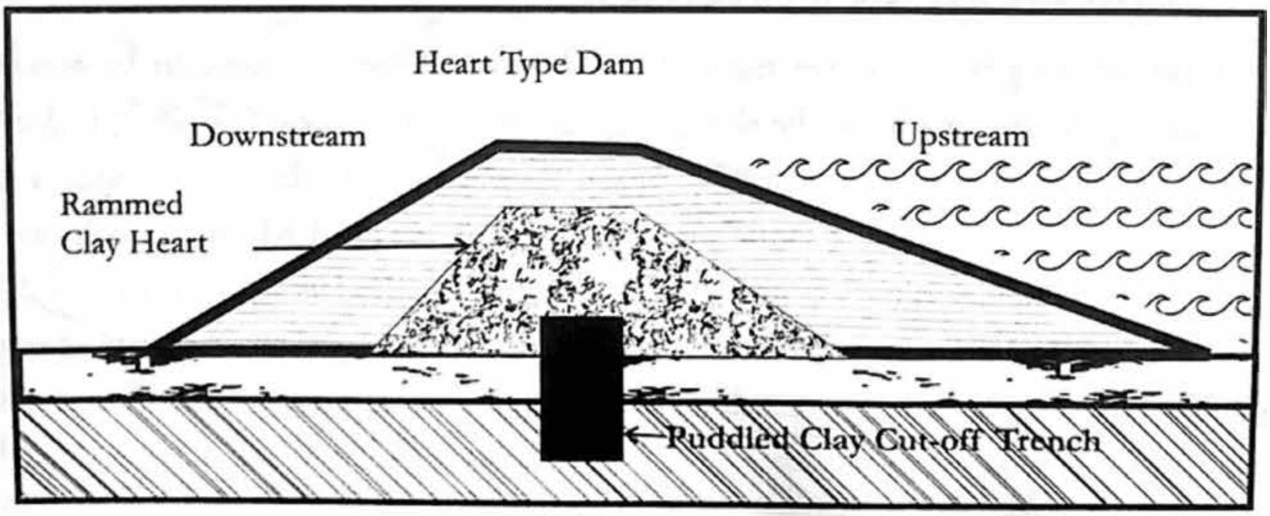


Figure 2-36: Three types of Dams

f) Slope Maintenance:

Upstream and downstream slopes of the dam must be carefully maintained. For this, it is advisable that side slopes are made as a series of steps. These steps are necessary for the laborers to walk up to throw the material. Even more importantly, they allow us to make mid-term corrections in case the slopes go a little off the mark. Towards the end of the construction, the steps should be broken and a continuous slope provided.

g) Stone Pitching and Grass Turfing for Embankment Protection:

As mentioned already, the outer faces of the dam are subject to erosion by water. To protect the upstream face from the sloughing action of waves, stone pitching is done by using boulders of size 15-30 cm width. Use stones which are flat on one side and angular on the other. The area of stone pitching depends on the FRL of the dam and its upstream slope. Where boulders are not easily available, the freeboard zone on the upstream face and all of the downstream face can be protected by planting grass (grass turfing). The grass roots form a protective web that binds the soil together. The grass blades also cushion the force of raindrops making them less erosive. Grass turfing should be done before the monsoon begins on the down streamside of the dam.

h) Surplus Waste Weir:

After the construction of the main dam is over, surplus weir must be constructed[3] the site for surplus weir should be chosen in such a way that it minimizes excavation. As far as possible, the surplus weir should be connected to some natural drainage channel flowing nearby so that the excess runoff does not cause further erosion.

[3] In extraordinary circumstances where the monsoon is rapidly approaching and completing the dam before it appears difficult, we may also make the surplus weir first, in order to protect the work already done on the dam

The following points also should be kept in mind while constructing surplus weirs:

- In some cases, it may be difficult to provide a surplus weir on the side of the dam due to adverse topography or geology. In such cases, a stone or cement masonry weir must be provided in the main body of the dam itself.
- All types of surplus weirs should have adequate protection of their sides and bed through stone pitching or stone/cement masonry.
- The surplus weir should not be very steep or have sharp curves. High slopes and sharp curves would both increase the danger of soil erosion.

v) ESTIMATION OF RESERVOIR CAPACITY:

To estimate the storage capacity of a dam, it is necessary to conduct a detailed contour survey of the proposed dam site. Multiplying the average of the area at two successive contours with the contour interval (CI) gives us the volume of water stored between two successive contour lines (see figure 2.36).

Effective storage capacity = Storage Capacity +Volume of water percolating from it during a season.

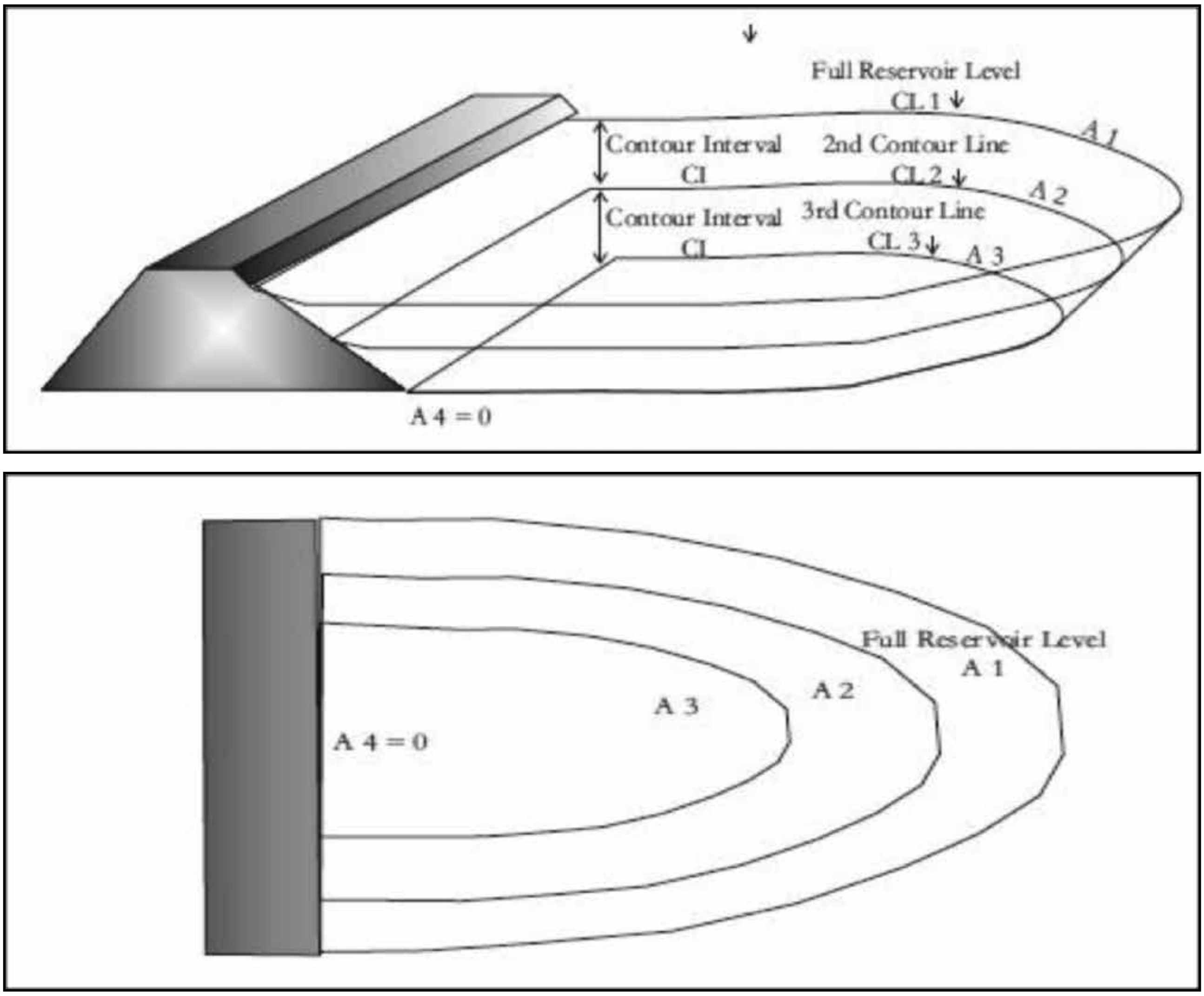


Figure 2-37: Estimation of reservoir capacity

vi) ESTIMATION OF AN EARTHEN DAM:

The cost of an Earthen Dam 20 meters in length and a maximum height of 5 meters. The upstream and downstream slopes are 1:3 and 1:2 respectively. Top width of the dam is 2.5 meters; depth and width of the cutoff trench are 2.5m and 1m respectively. Freeboard = 1m. Height of the dam at different points along the dam is given below:

Point	A	B	C	D	E
Height	0	2	5	3	0
Distance	0	5m	5m	5m	5m

Solution

Step 1 Volume of Cutoff Trench = Length x Width x Depth

= 20 x 1 x 2.5 = 50 cum

Step 2 Volume of Embankment

Volume of embankment is calculated by multiplying the cross section area with length. Cross section area at each point on the structure is calculated by the following formula for a trapezium:

Area of Cross Section = 1/2 x (S x H^2) + (TW x H) where, S = S_1 + S_2, (sum of upstream and downstream slopes), H = Height of the structure at any point, TW = Top width of structure = 2.5m

S_1 = 3 and S_2 = 2

Using the above formula, we calculate the area of cross section at each point. Multiplying the average cross section area between two points with the distance between the two points, we get the volume of the section.

Estimation of volume of embankment

Station (1)	Chainage (2)	Height (3)	Cross Section Area (4)	Average Cross section (5)	Length of Section (6)	Quantity (7 = 5x6)
A	0	0	0	-	-	-
B	5.0	2.0	15.0	7.5	5.0	37.5
C	10.0	5.0	75.0	45.0	5.0	225.0
D	15.0	3.0	30.0	52.5	5.0	262.5
E	20.0	0	0	15.0	5.0	75.0
Total volume of embankment						600.0 cum

Volume of Core wall

Cross section area of core wall = Width of core wall x Height of core wall

Height of core wall = Height of bund - Free board

Width of core wall = 1.00m

Free board = 1.00m

Cross section area of core wall = Width x (H - Freeboard) = 1.00 x (H - 1) = (H - 1) m

Estimation of volume of Corewall

Station (1)	Chainage (2)	Height (3)	Cross Section Area (4)	Average Cross section (5)	Length of Section (6)	Quantity (7 = 5x6)
A	0	0	0	-	-	-
B	5.00	2.00	1.00	0.50	5.00	2.50
C	10.00	5.00	4.00	2.50	5.00	12.50
D	15.00	3.00	2.00	3.00	5.00	15.00
E	20.00	0	0	1.00	5.00	5.00
Total volume of corewall						35.00 Cum

Volume of Rock toe

Cross section area of the Rock Toe = $(1 + S_2^2)/S_2$ X $(H^2/32)$

We know that $S_2 = 2$

Cross section area = $(1 + 2^2)/2 \times (H^2/32) = 5/2 \times (H^2/32) = 5/64 \times H^2$

Estimation of volume of Rock Toe

Station (1)	Chainage (2)	Height (3)	Cross Section Area (4)	Average Cross section (5)	Length of Section (6)	Quantity (7 = 5x6)
A	0	0	0	-	-	-
B	5.00	2.00	0.31	0.15	5.00	0.75
C	10.00	5.00	1.95	1.13	5.00	5.65
D	15.00	3.00	0.70	1.33	5.00	6.65
E	20.00	0	0	0.35	5.00	1.75
Total volume of rock toe						14.80 cum

Volume of casing/outer cover

Total volume of dam - (Volume of core wall + Volume of rock toe)

= 600 - (35 + 14.80) = 550.20 cum

Excavation for waste weir

The exit is rectangular in shape

Volume of excavation for waste weir = Length x Width x Height = 10m x 4m x 1.5m = 60 cum

Total Cost

	Particulars of work	Unit	Volume/ Area	Rate/Unit (Rs.)	Amount (Rs.)
1	Excavation for Cutoff Trench in Hard Soil	Cum	50.00	23.20	1,160.00
2	Filling Cutoff Trench with Puddled Clay	Cum	50.00	104.00	5,220.00
3	Construction of Casing in Hard Soil	Cum	550.20	28.30	15,571.00
4	Construction of Clay Corewall	Cum	35.00	104.00	3,640.00
5	Construction of Rock Toe Filter	Cum	14.80	124.65	1,845.00
6	Excavation for Exit Weir	Cum	60.00	30.70	1,842.00
	Total Cost of Dam Construction				29,278.00

fOther Rainwater Harvesting Techniques being followed in different parts of India by adopting similar technique as earthen dam.

vii) DOs AND DONTs:

DOs:

- The effective storage capacity of the dam should not be either too large or too small in relation to runoff.
- At the dam site, the drainage line must have well-defined embankments into which the dam can be anchored.
- The upstream slope of the dam should be lower than the downstream slope
- The surplus weir must be properly designed to drain out the peak runoff safely when the water is at FRL.
- Adequate settlement allowance must be provided for in earthen dams.
- Rock toe must be provided to drag the seepage line downwards.
- The bed of the drainage line upstream the dam site should not have a high slope.

DONTs:

- Do not use highly erodible material like clay on the outer faces.
- Do not raise the core wall over the FRL of the dam.
- The surplus weir should not be very steep or have sharp curves.

2.4.3.6. NADI:

Nadis are small excavated or embankment type village ponds for harvesting meagre precipitation to mitigate the security of drinking water in desert regions like kutchh, Nagpur, Barmer, Jodhpur and Jaisalmer. Nadies normally provide water for periods from two months to year after rain, depending upon the catchment and rainfall characteristics. A nadi should be located at the lowest elevation to have the benefit of natural drainage and minimum excavation of earth.

2.4.3.7. BANDHARA:

Bandhara is the Marathi term for weir with vents as these are practiced in Maharashtra State. The vents have removable shutters held in groves in piers. The vents are kept open during floods to carry away heavy silt. The Bandharas catch the base flow of streams and utilize it to provide irrigation to crops (mainly sugarcane). In many cases, the water is pumped out of the Bandharas and conveyed to higher elevations.

C) TORRENT AND STREAM BANK EROSION CONTROL MEASURES:

Hill torrents and stream cause extensive damage to adjoining lands, life and property as a result of the frequent changes in their course and associated flash flows during monsoon. Spurs, retards and retaining walls etc. are used at such downstream reaches for training the torrent flow.

2.4.3.8. SPURS:

Spurs are the commonly used structures for torrent and stream training. These structures are constructed transverse to river flow extending from one of the banks at an angle to the flow (Fig-2.37) According to the function served, spurs may be of three types (i) attracting type (pointing downstream at an angle of 30- 45°), (ii) deflecting type (at 90°) and (iii) repelling type (pointing upstream, 5-20° normal to flow)

i) SUITABILITY:

The functions of a spur system may be one or a combination of the following:

a) Protection of river banks (including land, road, buildings and other structures along them)

b) Reclamation of land along torrent beds, in excess of that required for the flow discharge.

c) Diversion of current in a desired direction.

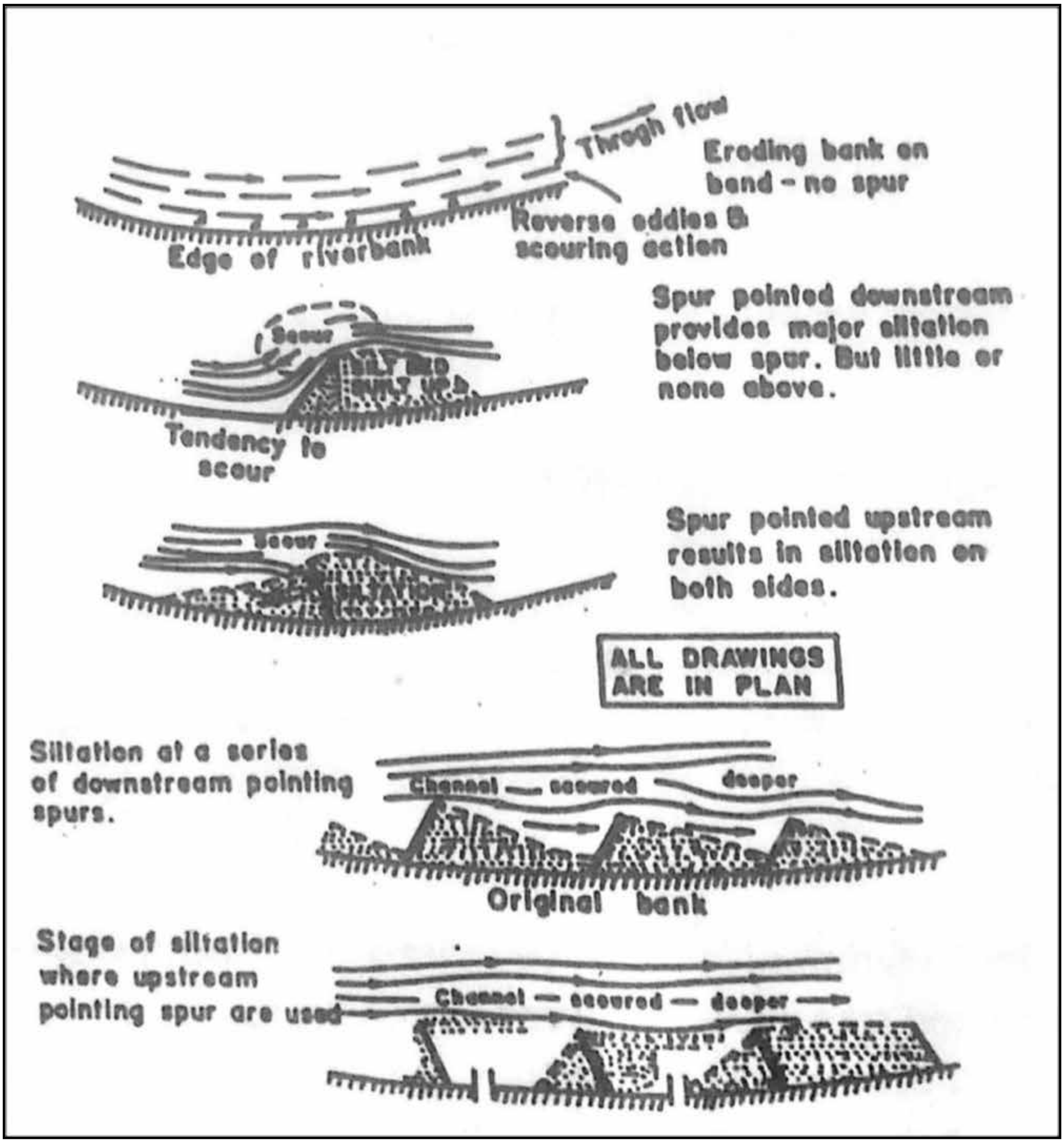


Figure 2-38: The principle of spurs

ii) DESIGN CRITERIA OF SPURS:

Construction of spurs for river training is quite expensive. Hence they are to be judiciously planned and executed optimally at the most crucial reaches along a river course. Some of the important factors that determine the design parameters of spurs are:

a) River characteristics: Factors like river geometry (width, flow depth, bank heights) flow velocity, flow pattern, bed slope, sediment-debris boulder movement, river meandering and curvature etc. are important parameters that may determine the design specifications of structures.

b) Spur geometry: The length of spur, its alignment to flow shape and permeability are important design considerations.

c) Spur Length: Construction of spur causes constriction of river flow which should be limited so as not to affect the river regime adversely. This is represented by a 'blockage ratio' b/B, where b is the projected length of spur and B is the river width. The blockage ratio should not exceed 0.3 i.e. the projected length of the spur should not exceed 1/3rd of the width of river.

d) Alignment of spur: The spur alignment is defined by the angle the spur makes with the flow direction as measured from the downstream. As the angle of the inclination of the spur along the flow direction increases, its sedimentation capacity increases but stability decreases due to greater scour. Attracting (downstream pointing) spurs with an angle of 30° – 45° are normally used for flow diversion whereas short and closely spaced right angled deflecting spurs are recommended for quick sedimentation along banks.

e) Shape of spur: In oblique faced spurs, such as with trapezoidal cross section the scour depth is lesser because of energy dissipation of incoming flow on the sloping wall. Simple rounding of corners and edges of spurs reduce the scour considerably. The upstream nose of the spur is only affected by scour.

f) Permeability of spur: Permeable spurs such as gabion and vegetative spurs are more efficient, less expensive and can be made by locally available material. Their stability is better than the solid ones due to lesser scour around them.

g) Spacing of spur: A spur protects only a certain length of the bank. It is usual, therefore to use spurs in series, spaced so as to give a continuous effect. The recommended optimum spacing of spurs is 3-4 times the projected spur length. A larger spacing can be adopted for convex bank and a smaller one for concave bank i.e. 2 to 2.5 times the length of spurs.

h) Vegetative reinforcement of spurs: In the vicinity of the spur and particularly at its nose, suitable shrubs and grasses may be planted to prevent scour. Arundo donax (Narkul or Nada), Vitex negundo, Ipomoea carnea (Besharam) etc. have been found useful for vegetative reinforcement of the structures.

2.4.3.9. RETAINING/ TOE WALLS:

Gabion retaining/ toe walls are constructed along the vulnerable torrents banks to prevent bank cutting and erosion. They may be used singly or in combination with spurs. Generally the height of wall is restricted to 3m. The top width is kept 1m and base width can be taken 2/3rd of the height of the wall.

i) SLOPE AND STREAM BANK PROTECTION MEASURES:

These measures directly cover the stream bank/slope to protect it from erosion. Commonly used measures for stabilization and protection of slopes/ banks are as below:

2.4.3.10. REVETMENTS:

Revetments are used where the protection by plantation is not possible and valuable properties extend right up to the edge of the stream bank. They are provided to cover the slope of the stream bank, preferably after easing out the slopes. The side slopes for these measures should not be steeper than 1.5:1 or flatter. Both vegetative (brush mat revetment) and/or mechanical measures (rock riprap) are used in this method to cover the stream banks depending upon the site conditions. Gabion revetments, about 0.5 m thick laid on 1.5:1 or flatter slope can also be used.

CHAPTER 03

COMMAND AREA DEVELOPMENT FOR IRRIGATED AREAS UNDER MGNREGA

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3.1. WHAT IS COMMAND AREA DEVELOPMENT (CAD)

3.1.1. INTRODUCTION

After Independence the Government of India launched a countrywide programme of multipurpose river valley projects to make use of unharnessed water resources in the country. The purpose of the scheme was to generate hydroelectric power and to supply water for irrigation. The culturable area which can be irrigated by a particular command may be defined as the culturable command area (CCA). The total area covering home state area, roads, houses, barren land, and uplands coming under that command area adjacent to the CCA is known as Gross Command Area (GCA). In rural development the construction and maintenance of CAD works can be given top priority because the area on one side will provide employment to the needy rural masses and on the other hand it will provide better irrigation and drainage facilities which will improve the socio economic conditions of the farmers and generate livelihood.

3.1.2. THE OBJECTIVES

The main objectives of the CAD programmes are summarized as under:

The efficient utilization of water imply

i) Minimization of water losses through lining of canals, increasing canal capacity, installation of control structures, improved techniques for more efficient water use and field applications, etc.

ii) The maximization production of grains from water use through on farm development works, the construction of an improved and wider road network, improved agriculture techniques brought by adaptive research and agriculture extension etc.

iii) The equitable distribution of water throughout the command area and greater control over canal system as a whole.

3.1.3. LINKAGES WITH MGNREGA

The works permitted under MGNREGA at Para No.4 (I) (iii), (VI) & II (i) are such that the command area can be developed to bring the command area under better production and increase the livelihood generation.

If the irrigation & drainage development in command areas is given priority, the productivity of land will increase. Under MGNREGA the demand for employment may be met by irrigation and drainage works in irrigated command area.

3.1.4. CONVERGENCE OF MGNREGS WITH OTHER ONGOING SCHEMES IN COMMAND AREA

3.1.4.1. There is a gap between the irrigation potential created and that utilized. Many of the irrigation projects in the country have also been under operation below their designed potential due to inadequate maintenance, which is one of the important factors for reduced irrigation efficiency at project level. This has resulted in the problem of low efficiency of water use and low productivity. Increasing trend of water logging, salinity and alkalinity is offsetting the advantages of irrigation projects by rendering the affected areas unproductive or under-productive. The process of reclamation is lagged behind by an additional area becoming water logged and saline/alkaline. Therefore, for integrated development of command area, the convergence of MGNREGS with schemes of Ministry of Water Resources (MoWR) and schemes of MOA for gap filling and value addition should be made. Convergence between MGNREGA and Programmes of MoWR is mutually beneficial.

3.1.4.2. There are several programmes of MoWR being implemented in the country with works similar or complementary to MGNREGA works. In this regard Ministry has issued Joint Convergence guidelines for MGNREGS & Scheme of MoWR vide letter dated 18th Feb 2009.

3.1.4.3. For integrated development of irrigated area, it is necessary that the project of a village is prepared on Command Area Development approach, integrating all the activities required with a project. In this project, the activities permitted and to be covered under MGNREGS and those to be covered under schemes of MoWR may be clearly indicated in terms of the size of area / work, estimated cost, so as to ensure that all the required works / activities have been proposed and there is no duplicity.

3.2. WHY COMMAND AREA DEVELOPMENT

3.2.1. INTRODUCTION

The Command Area Development (CAD) Programme was Initiated In 1974 with the objective to bridge a gap between irrigation potential created and utilized. Therefore there is an immense need for successful micro level infrastructure development and efficient farm water management to enhance agriculture production and productivity and to improve socio-economic condition of farmers. The most important aspect of these works are to save the most valuable irrigation water and to improve irrigation efficiency of the system. Our ultimate aim is to increase optimum crop production per unit of water and per unit of area.

3.2.2. COMPONENTS OF CAD WORKS

3.2.2.1. MAIN IRRIGATION SYSTEM

Construction and maintenance of canal system

i) Main Canal

ii) Branch Canal

iii) Distributaries

iv) Minors

v) Hydraulic Irrigation Structures

vi) Watercourses

vii) Culverts, turnouts, tail escapes, etc.

3.2.2.2. MAIN SURFACE DRAINAGE SYSTEM

In most of the commands the surface drainage system have been constructed

It covers – the following types of drains:

i) Field drains

ii) Seepage drains

iii) Carrier drains / Intermediate / Collector

iv) Sub main drains

v) Main drains

vi) Hydraulic structures

3.2.2.3. SUB SURFACE DRAINAGE SYSTEM

In this system perforated PVC pipes along with filter are laid in the sub surface as lateral drains, their collector subsurface drains are constructed. Then the outfall of the collector subsurface drain is given in the surface main drains of the surface drainage system.

3.2.2.4. LAND LEVELLING & GRADING

Levelling is also an important item of work for efficient irrigation which can benefit the rural farmers. Therefore it should be done on priority under MGNREGA.

3.3.COMMAND AREA INTERVENTIONS

Following works can be done under MGNREGA. There may be repair as well as new construction:

i) Construction of Minors

ii) Construction of watercourses

iii) Construction of field drains and seepage drains

iv) Construction of farm roads on the both sides of field drains, etc.

v) Construction of Hydraulic structures such as falls, culverts, tail escapes, inlet to drains turnouts etc.

vi) Construction of earthen watercourses on ridge lines

vii) Construction of pucca watercourses

viii) Construction of drains on the field boundaries

ix) Construction of field drains on the micro valley lines

x) Construction of Collector drains

xi) Land levelling and land shaping

3.3.1. WATER CONVEYANCE SYSTEM

The Water Conveyance System in any command area mainly comprises a reservoir, where the water is stored for irrigation in a dam. Thereafter, water goes to the field of a farmer through Main canal, Branch canal, Distributary canal, Minor and Watercourse.

3.3.1.1. CONSTRUCTION & MAINTENANCE OF WATERCOURSES:

Design criteria: In command area generally watercourses should be designed for 1 cusec. Capacity i.e. 28.31 LPs but may vary between 20 LPs to 40 LPs capacity depending on the area to be irrigated & topography. Similarly bed slope in the watercourse should generally be 1:1000 but may vary from 1:500 to 1:2500 depending upon the natural topography, soil type & availability of working head in the canal etc. Since canal water is being diverted from the reservoir, there is no likelihood of silting in the watercourse in view of meager discharge in watercourse but no eroding velocity should be allowed. The maximum allowable velocities in channels for different soil textures is given in table 3-10.

Non silting & non eroding velocity (Vo) may be worked out by:

$Vo = 0.3092\ y^{0.5}$

Where y is the depth of flow in meter.

In case of flatter slopes more than 1:3000, lining will have to be provided in the watercourses.

Cross-Section

A typical cross section of watercourse is given below-

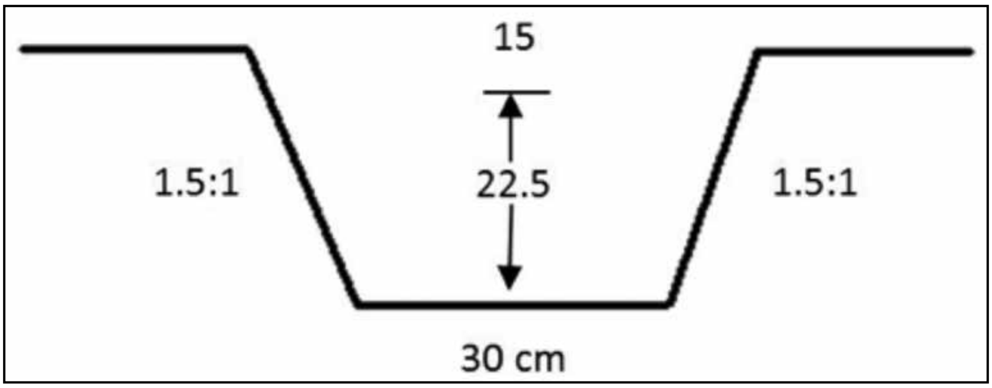


Figure 3-1: Typical cross section of watercourse

Bottom width of watercourse	=	30.0 cm
Full supply Depth (F.S.D.)	=	22.5 cm
Free board	=	15.0 cm
Total depth of watercourse	=	37.5 cm
Side slope	=	1.5: 1
Top width of the bank of watercourse	=	30 cm.
Total bed width of the levee	=	56.25 + 30.0 + 56.25 + 30.0 + 56.25 + 30 + 56.25 = 315.00 cm
Bottom width of levee of watercourse	=	315 cm
Top width of levee of watercourse	=	225 cm

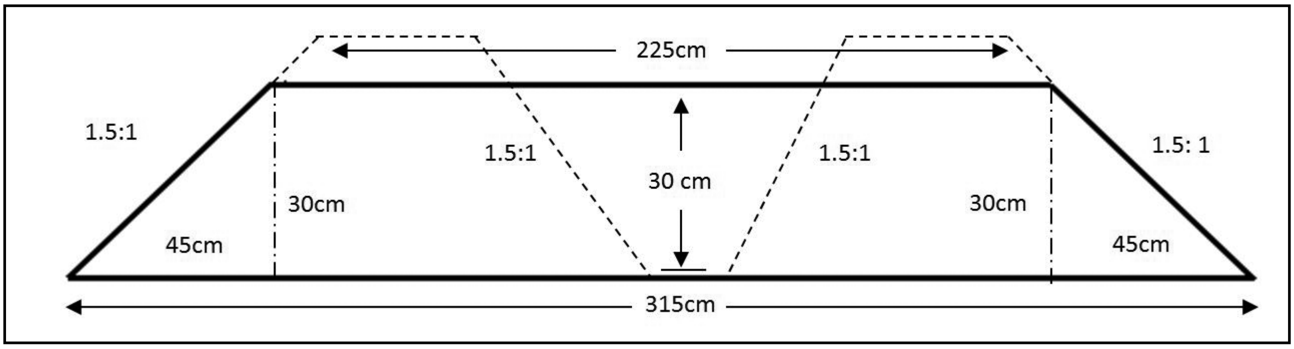


Figure 3-2: Typical Cross-section of earthen levee of watercourse.

In case of maintenance of watercourse if it is destroyed or silted up more than 60-70% then the complete levee should be constructed & then proper section as per design should be cut, as per designed L-section & X-section of the watercourse.

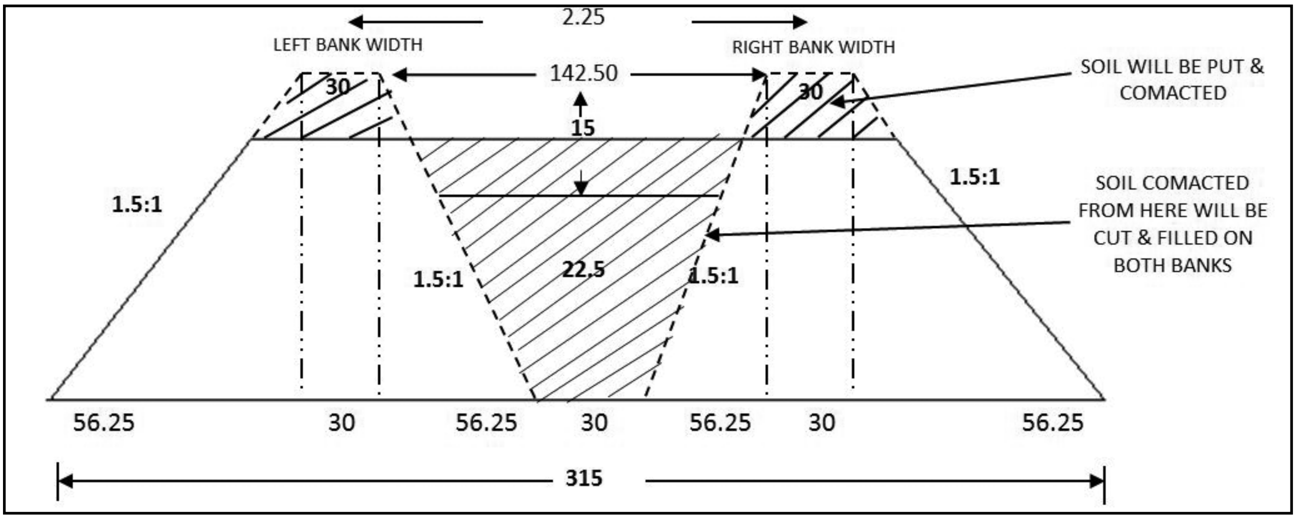


Figure 3-3: Typical Cross Section of Earthen Watercourse before section cutting

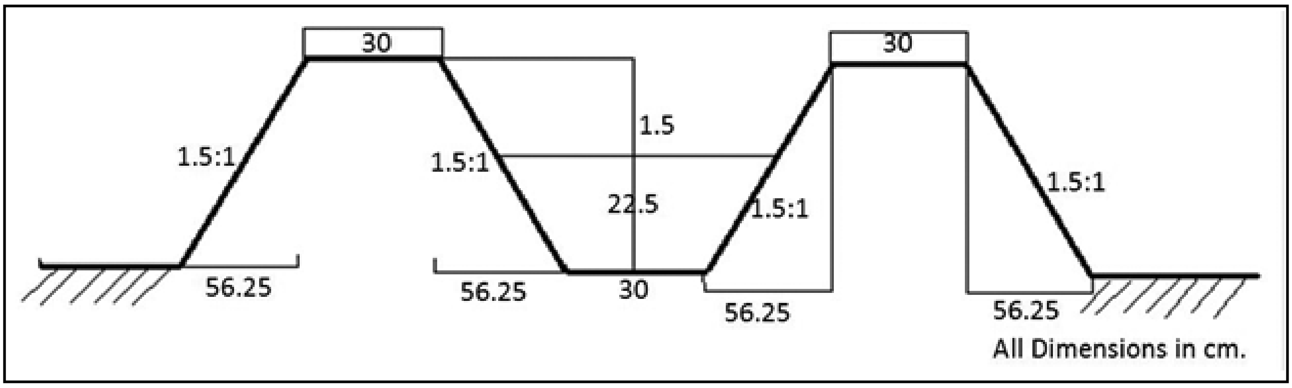


Figure 3-4: Typical Cross Section of Earthen Watercourse after section cutting

For convenience Table (Annexure-II) is given showing velocity & discharges at different depths & slopes for watercourse at a given bed width (0.3 cm.), side slope (1.5: 1), and roughness coefficient (0.03).

Table 3-1: Detailed Cost Estimate for Construction of 1000 m watercourse levee by shifting soil manually from reverse grade, higher patches etc.

S. No.	Item	Length	Width	Height	Quantity	Rate	Amount
1	Dag belling 7.5 to 10 cm deep (in center line & both the sides of levee)	3000m					
2	Scraping of grasses & shrubs	1000					
3	Earth work for embankment in dry or moist soil including laying in layers of 15 cm breaking of clods, dressing to required profile with manual compaction to attain a minimum of 85% of proctor density with initial lead of 30m & lift of 1.5m in hard soil	1000					

S. No.	Item	Length	Width	Height	Quantity	Rate	Amount
	excluding watering & compaction charges.						
	Total						
	Add 3% contingencies						
	Grand Total						
	Cost per meter						

Table 3-2: Detailed Cost Estimate of section cutting & dressing of a watercourse

L – 1000 meter

S. No.	Item	L	Top Width	Bed Width	Quantity	Rate	Amount
1	Dag belling 7.5 to 10 cm deep (in center line & both the sides of levee)	1000x3					
2	Excavation in loose soil silt pebbles & river boulders etc. dry or moist including dressing & disposal of excavated material with in initial lead of 30m & lift of 1.5 m & putting it in required banks of the watercourse & well compaction	1000					
3	Dressing of uneven embankments in required profile	1000					
	Total						
	Add 3% contingencies						
	Grand Total						
	Cost per meter						
	Total cost of watercourse is (Cost of levee & cost of section cutting)						
	Total length of watercourse						.
	Cost per meter of watercourse						

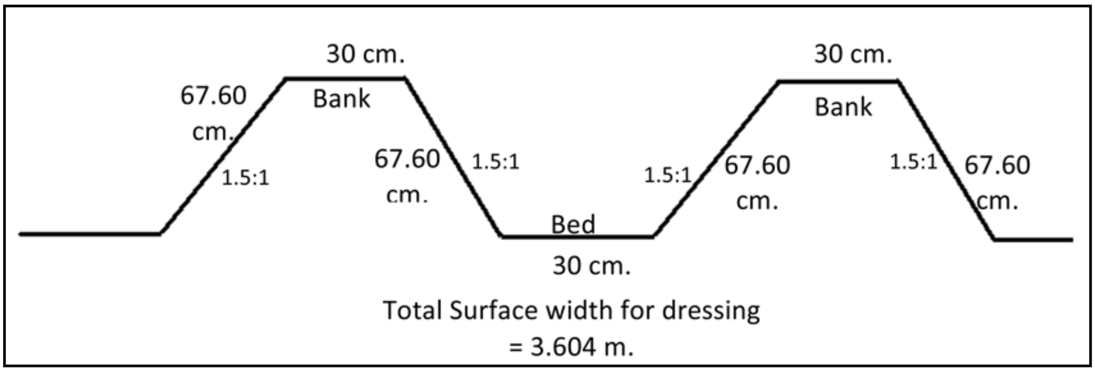


Figure 3-5: Typical Cross Section of Earthen watercourse showing details of dressing surface

3.3.1.2. CONSTRUCTION OF PUCCA / LINED WATERCOURSE:

Wherever required the Pucca/Lined Watercourse can also be constructed under MGNREGA. The design discharge will be 1 cusec only. Following types of lining is mostly provided in rural areas in India.

i) P.C.C. Watercourse

ii) Stone masonry watercourse

iii) Brick masonry watercourse

Typical drawings and estimates have been given here for ready reference, however if required lining by R.C.C. or pre-cast slabs or precast sections or semicircular R.C.C. pipe watercourses can also be constructed. In such a case the pre-cast fabrication should also be done by the MGNREGA labour / mason to provide rural employment. For production of building material detailed guidelines have been issued vide Ministry letter No.J-11017/26/2008-MGNREGA(UN) dated 13th Jan, 2014, which can be followed for this purpose also.

These drawings and estimates are suggestive. These can be changed keeping in view local conditions. The figures given in this chapter are not to scale.

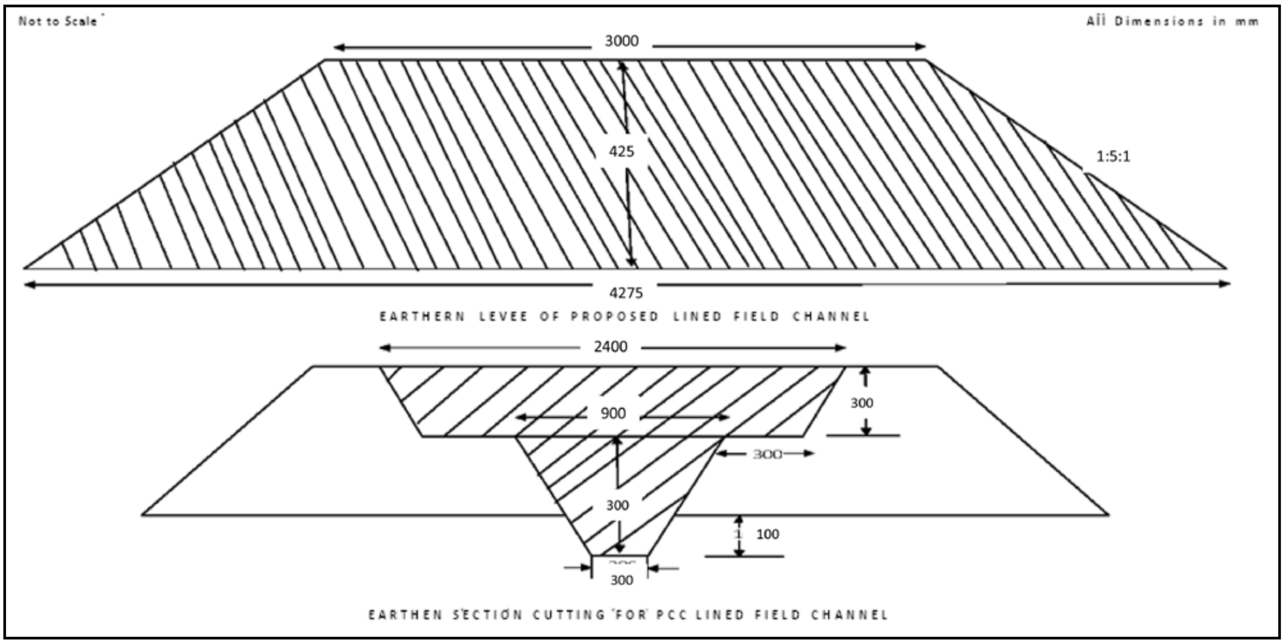


Figure 3-6: Cross Section of Earthen Levee and Section Cutting

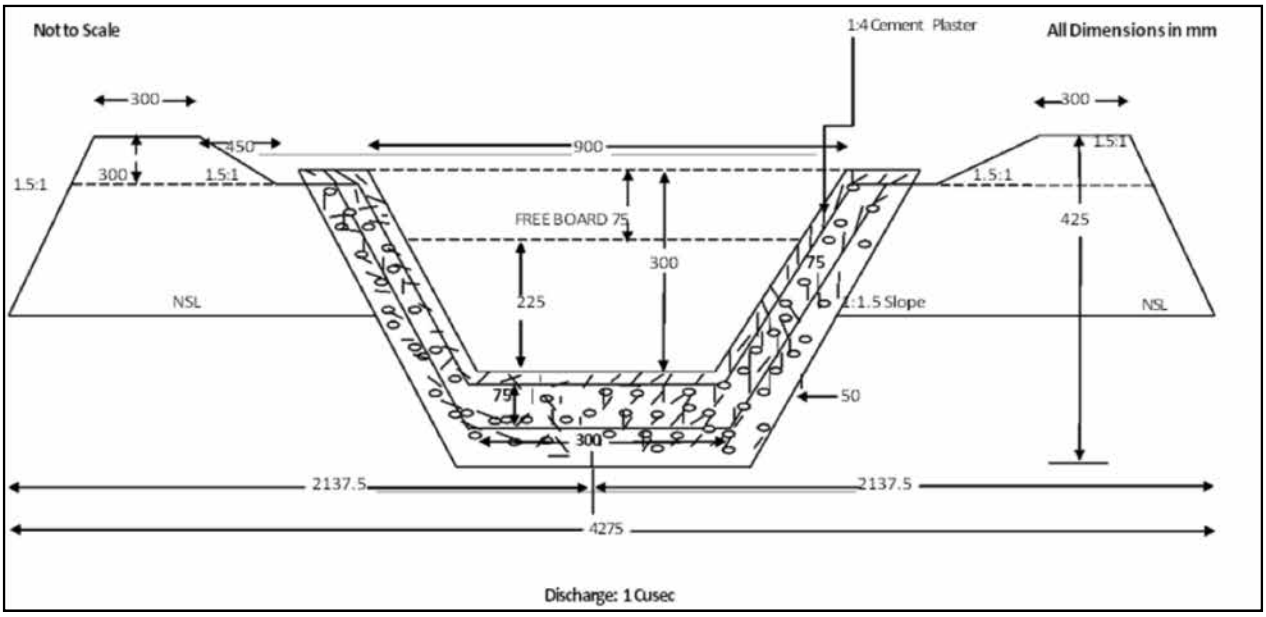


Figure 3-7: Cross Section of Watercourse – Cement Concrete

Table 3-3: Detailed Cost Estimate of Lined Watercourse – Cement Concrete (Discharge = 1Cusec)

S. No.	Name of Item	Length	Width	Height/ Depth	Quantity	Rate (Rs./unit)	Unit	Amount (Rs.)
1	Dag belling 7.5 to 10 cm deep	1.00					Rmt	
2	Cutting & clearance of jungle, bushes, shrubs Ankara/Ipomoea, Julie flora typha etc. on canals and bunds in dry/moist/slushy conditions including disposal	1.00					sqm	
3	Earth work in excavation including loading, unloading, disposal and dressing of excavated earth within initial lead of 100m and lift up to 1.5 m in dry or moist soil including dressing of excavated area With cost of dewatering wherever required, and all applicable taxes and levies etc. Complete in all respect	1.00					cum	
4	Earth work in excavation including loading, unloading, disposal and dressing of excavated earth within initial lead of 100m and lift up to 1.5m in dry or moist including dressing of excavated area with cost of dewatering wherever required, and all applicable taxes and levies etc. Complete in all respect.	1.00					cum	

S. No.	Name of Item	Length	Width	Height/ Depth	Quantity	Rate (Rs./unit)	Unit	Amount (Rs.)
5	Supplying and laying sand in required profile including all lead & lifts.	1.00					cum	
6	Cement concrete(1:3:6) well mixed and laid in position complete including all leads of all construction materials including curing and finishing having well graded crusher broken stone aggregate of maximum size up to 20 mm	1.00					cum	
7	Wire Mesh	1.00					Rmt	
8	Plaster in cement sand mortar 1:4 including racking of joints, smooth finishing & curing etc. Complete including all leads of construction materials; of thickness: 12mm							
	Inner	1.00						
	Outer	1.00						
	Total						sqm	
							Total	
							Add Contingency 3 %	
							Grand Total	

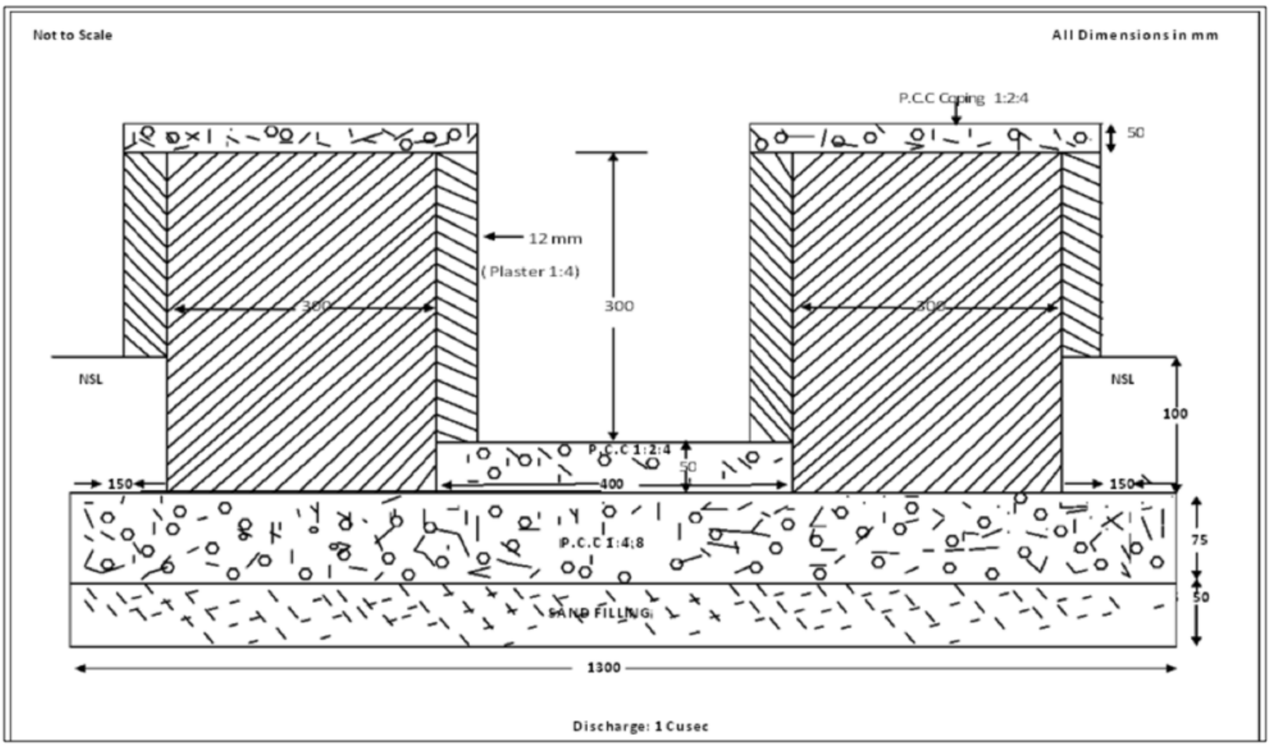


Figure 3-8: Cross Section of Watercourse – Stone Masonry

Table 3-4: Detailed Cost Estimate of Lined Watercourse with Stone Masonry (Discharge = 1Cusec)

S. No.	Name of Item	Length	Width	Height/ Depth	Quantity	Rate (Rs./unit)	Unit	Amount (Rs.)
1	Dag belling 7.5 to 10 cm deep	1.00					Rmt	
2	Cutting & clearance of jungle, bushes, shrubs Ankra/Ipomoea, Julie flora typha etc. on canals and bunds in dry/moist/slushy conditions.	1.00					sqm	
3	Earth work in excavation including loading, unloading, disposal and dressing of excavated earth within initial lead of 100m and lift up to 1.5 m in dry or moist soil including dressing of excavated area with cost of dewatering wherever required, and all applicable taxes and levies etc. Complete in all respect	1.00					cum	
4	Supplying and laying sand in required profile Including all leads & lifts.	1.00					cum	
5	Cement concrete (1:4:8) M-7.5 well mixed and laid in position complete including all leads of all materials including curing and finishing having well graded Crusher broken stone aggregate of maximum size up to: 20mm.	1.00					cum	
6	Random rubble stone masonry (using R.R. stones where 75% stones to be not less than 15 cm in size in any direction and weighing not less than 23 Kg.) for super structure including curing all leads of construction materials, & all taxes and with initial lift / de-lift of 5m from ground level etc. complete in cement sand mortar 1:6	1.00					cum	
7	Cement concrete (1:2:4) well mixed and laid in position complete including all leads of all construction materials including curing and finishing having well graded crusher broken stone aggregate of maximum size up to: 20mm.	1.00					cum	

S. No.	Name of Item	Length	Width	Height/ Depth	Quantity	Rate (Rs./unit)	Unit	Amount (Rs.)
8	Plaster in cement sand mortar 1:4 including racking of joints, smooth finishing & curing etc. complete including all leads of construction materials; of thickness: 25mm.							
	Inner	1.00						
	Outer	1.00						
	Total						sqm	
9	Providing and laying cement concrete coping in (1:2:4) with maximum size of crusher broken aggregate up to 20mm, including shuttering etc. with all leads of material complete in all respect in thickness of : 50mm.	1.00						
10	Re-handling of excavated material including loading Unloading and dressing within initial lead of 100m and lift 1.5m. With cost of dewatering wherever required and all applicable taxes and leveies etc. complete in all respect	Quantity as per Item No. 3					cum	
							Total	
							Contingency Charges 3%	
							Grand Total	

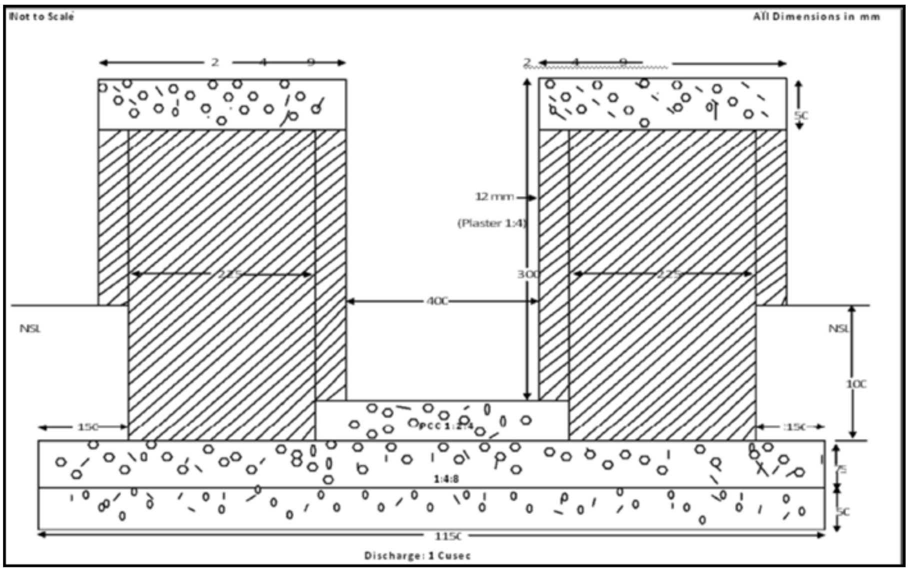


Figure 3-9: Cross Section of Watercourse - Brick:

Table3-5: Detailed Cost Estimate of Brick Lined Watercourse - Brick (Discharge = 1Cusec)

S. No.	Name of Item	Length	Width	Height/ Depth	Quantity	Rate (Rs./unit)	Unit	Amount (Rs.)
1	Dag belling 7.5 to 10 cm deep	1.00					Rmt	
2	Cutting & clearance of jungle, bushes, shrubs Ankra/Ipomoea, Julie flora typha etc. on canals and bunds in dry/ moist/ slushy conditions disposal.	1.00					Sqm	
3	Earth work in excavation including loading, unloading, disposal and dressing of excavated earth within initial lead of 100m and lift up to 1.5 m in dry or moist soil including dressing of excavated area with cost of dewatering wherever required, and all applicable taxes and levies etc. Complete in all respect	1.00					Cum	
4	Supplying and laying sand in required profile Including lead & lifts.	1.00					Cum	
5	Cement concrete (1:4:8) M-7.5 well mixed and laid in position complete including all leads of all materials including curing and finishing having well graded Crusher broken stone aggregate of maximum size up to: 20mm.	1.00					Cum	
6	Brick Masonry	1.00					Cum	
7	Cement concrete (1:2:4) well mixed and laid in position complete including all leads of all construction materials including curing and finishing having well graded crusher broken stone aggregate of maximum size up to: 20mm.	1.00					Cum	
8	Plaster in cement sand mortar 1:4 including racking of joints, smooth finishing & curing etc. complete including all leads of construction materials; of thickness: 12mm.							
	Inner	1.00						
	Outer	1.00						
	Total						Sqm	

S. No.	Name of Item	Length	Width	Height/ Depth	Quantity	Rate (Rs./unit)	Unit	Amount (Rs.)
9	Providing and laying cement concrete coping in (1:2:4) with maximum size of crusher broken aggregate up to 20mm, including shuttering etc. with all leads of material complete in all respect in thickness of : 50mm.	1.00					Sqm	
10	Re-handling of excavated material including loading Unloading and dressing within initial lead of 100m and lift 1.5m. With cost of dewatering wherever required and all applicable taxes and leveies etc. complete in all respect.	Quantity as per Item No. 3					Cum	
							Total	
							Contingency Charges 3%	
							Grand Total	

3.3.2 SURFACE DRAINAGE SYSTEM

3.3.2.1 INTRODUCTION

The surface drainage is equally important and essential to remove excess water from soil so as to allow good root zone aeration for better and higher crop production. On farm field drains collect excess water from individual holdings & disposes the excess water to the river or nallas through the collector & main drains.

3.3.2.2. WHY DRAINAGE SYSTEM

i) In rural areas whenever there is more rainfall and the removal of surface water is up to 40 hrs. or more, the crop production suffers adversely. In various villages the inundation of water for a longer period also adversely affects the lives of livelihoods and therefore in such areas the surface drains are to be excavated. In most of the command areas the surface drainage system has been executed and there main drains and carrier drains fall in to natural rivers or bigger nallas. If these drains are silted then the desilting up to the designed cross-section may be done through MGNREGA workers. However, there may be need of construction of new drains which can also be done under MGNREGA. These drains are constructed in the natural valleys or depressions.

ii) The main drains usually form the back bone of a farm drainage system. The main advantages of the drainage system:

   a) Low initial cost
   b) Rapid removal of surface water
   c) Provides road network from the individual farm holding to the main road because along the drains the roads are constructed with the excavated soil.
   d) Easy to construct.
   e) Capacity to carry large volume of water.

iii) The drainage system of a particular irrigated command area starts from the donstream side ie; river:

   a) River
   b) Main drain

c) Sub main drain
d) Carrier / collector drain / intermediate drain
e) Field drain
f) Seepage drain

A typical layout plan of a drainage system is given below:

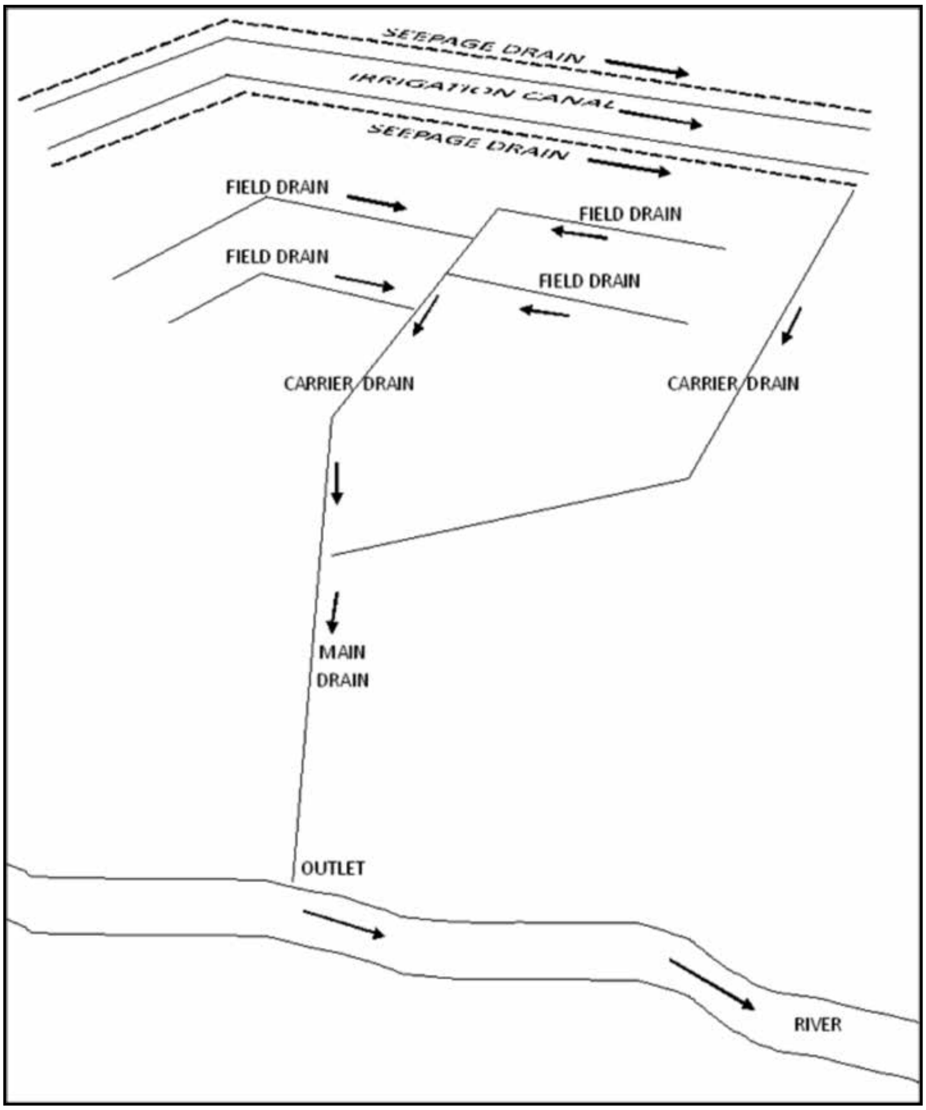


Figure 3-10: A typical layout plan of a drainage system

3.3.2.3. DESIGN CRITERIA:

i) The first step in surface drainage system design is to calculate the catchment area and the peak run off of rain water that might occur. The volume of water that must be removed by surface drainage channel is dependent upon a number of variable conditions. The most important of these variables are:

a) Intensity of rainfall
b) Soil characteristics of catchment
c) Size and topography of the catchment area
d) Vegetative cover and land use in the catchment
e) Cropping pattern showing the tolerance of crops regarding flooding in the area to be protected.

ii) The following commonly design conditions are assumed as per technical paper No.7 of Department of Agriculture, Ministry of Agriculture, GoI for smaller catchments. In Chambal Command, Kota, Rajasthan for calculating the runoff, the Rational Method is used.

The calculation of run off can be made by Rational Method with following assumtions:

a) 24 hours maximum rainfall of 5 years frequency and intensity.

b) Average rainfall of the district being representative for the catchment area (120-140 mm as average 24 maximum rainfall)

c) The crops for which surface drainage is to be provided are either ordinary crops or kharif paddy or combination of both.

d) Drainage removal time of 40 hrs. for ordinary crops 45% area & 72 hrs. kharif paddy & sugarcane crops 24% area & fallow land 31% area.

iii) As per CWPC recommendation the empirically designed discharge of 0.55 lps per ha. Is too low. The rational method gives design runoff rate of 2.35 lps per ha. But for economic reasons it may be reduced to 1.1. lps per ha. However the design of structures should be based upon 2.35 lps/ha. These design rates are used to define the capacity of the drainage system strictly with respect to erosion and over topping concerns.

Table 3-6: Drainage Discharge for Agriculture Drains

Drainage Areas (ha.)	Drainage discharge for small catchments in cum/sec.			
	5 years 24 hours maximum rainfall			
	140mm		120mm	
	HSG-C	HSG-D	HSG-C	HSG-D
25	0.080	0.103	0.057	0.075
30	0.097	0.124	0.068	0.091
35	0.113	0.145	0.083	0.105
40	0.125	0.161	0.093	0.115
45	0.146	0.182	0.104	0.135
50	0.162	0.207	0.119	0.151
55	0.178	0.228	0.130	0.166
60	0.190	0.240	0.140	0.176
65	0.207	0.261	0.155	0.186
70	0.218	0.285	0.166	0.202

(Source: Design manual of Chambal Command Area Development, Kota, Rajasthan, April, 1998)

Note:

HSG-C: Hydrologic Soil Group-C – indicates the soil having slow infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textured. These soils have a slow rate of water transmission.

HSG-D: Hydrologic Soil Group-D – soils having very slow infiltration rates with high swelling potentials. Soils with a permanent high water table, soil with a clay pan, clay layer at or near the surface and shallow soils cover nearly impervious material.

For the estimation of peak flow rate in India for other commands mainly Rational Method is used. Rational Method is used to predict flows from small urban and rural catchments up to 500 ha. but it can work up to 1300 ha. However the rainfall intensity used should be uniform over the entire watershed.

The peak runoff rate occurs when the entire catchment is contributing runoff. All the water bodies in the catchment should be filled in and soil becomes complete saturated, under that condition entire catchment is contributing the runoff.

In rural areas under MGNREGA generally the development unit is a village or few villages only therefore, only this method can be considered for the calculation of peak runoff. This method is expressed as

$$Q = 0.0028\, C\, i\, A$$

Where

Q = peak runoff rate, cum/sec.

C = runoff coefficient (as given in table below)

i = intensity of rainfall, in mm/hr, for the design period and for a duration equal to the time of concentration of the catchment area.

A = catchment area, in hectare

Table 3-7 Runoff Coefficient (C)

Topography and vegetation	Open Sandy Loam	Clay and Silt Loam	Tight Clay
Woodland			
Flat (0-5% slope)	0.10	0.30	0.40
Rolling (5-10% slope)	0.25	0.35	0.50
Hilly (10-30% slope)	0.30	0.50	0.60
Pasture			
Flat (0-5% slope)	0.10	0.30	0.40
Rolling (5-10% slope)	0.16	0.36	0.55
Hilly (10-30% slope)	0.22	0.42	0.66
Cultivated			
Flat (0-5% slope)	0.30	0.50	0.60
Rolling (5-10% slope)	0.40	0.60	0.70
Hilly (10-30% slope)	0.52	0.72	0.82
Urban Areas	30% of Area impervious	50% of Area impervious	70% of Area impervious
Flat (0-5% slope)	0.40	0.55	0.65
Rolling (5-10% slope)	0.50	0.65	0.80

(Source: Participatory Integrated Watershed Management – A field manual by VN Sharda, et al, 2006)

For watersheds with more than one type of topography or vegetation the following equation may be used to provide runoff coefficient with weighted average.

$$C = \frac{\sum C_1 A_1 + C_2 A_2 + \ldots\ldots}{\sum A_1 + A_2 + \ldots\ldots}$$

C = Runoff coefficient with weighted average.

C_1 = runoff coefficient for area A1

C_2 = runoff coefficient for area A2

C_3 = runoff coefficient for area A3

A_1 = catchment area in ha.

A_2 = catchment area in ha.

A_3 = catchment area in ha.

TYPICAL WATERSHED

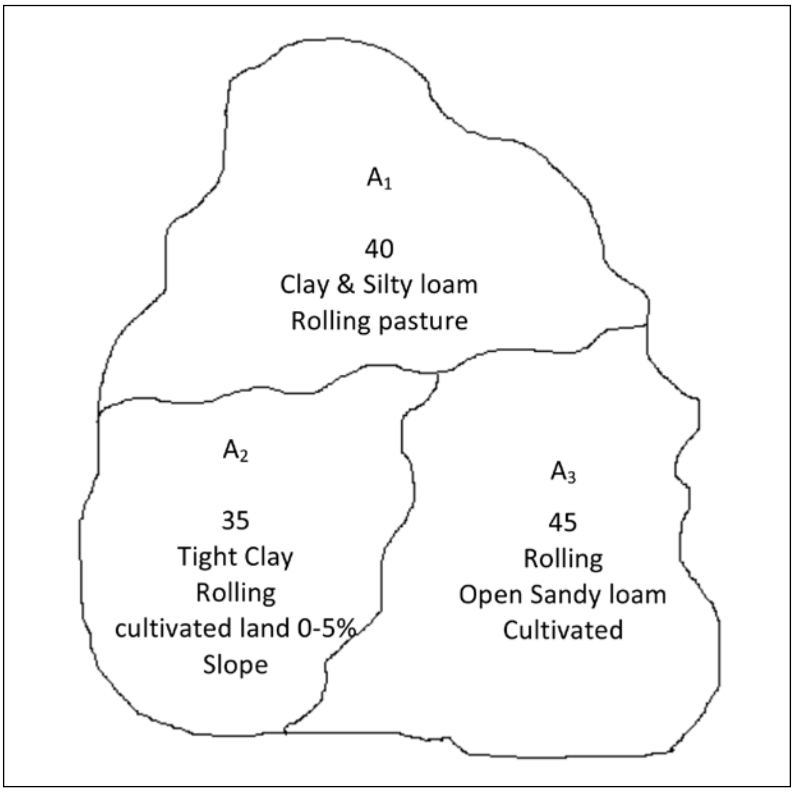


Table showing runoff coefficient as per Table 3-7

S.No.	Area	Type of Soil	Topography	Vegetation	Runoff coefficient
1	A_1 = 40 ha.	Clay & silty loam	Rolling	Pasture	$C_1 = 0.36$
2	A_2 = 35 ha.	Tight Clay	Flat (0 – 0.5% Slope)	Cultivated	$C_2 = 0.60$
3	A_3 = 45 ha.	Open sandy loam	Rolling	Cultivated	$C_3 = 0.40$

$$C = \frac{A_1 C_1 + A_2 C_2 + A_3 C_3}{A_1 + A_2 + A_3}$$

$$= \frac{40 \times 0.36 + 35 \times 0.60 + 45 \times 0.4}{+ 35 + 45} = \frac{14.4 + 21.0 + 18.0}{40+35+45} = \frac{53.4}{120}$$

$C = 0.449$

Rainfall intensity is obtained using the storm duration and a selected rainfall frequency. The storm duration for this method is equal to the time of concentration (Tc). Time of concentration (Tc) of a watershed is the time required for water to flow from the most remote point of the area to the outlet, once the soil has become saturated and minor depressions filled up. Tc can be estimated from Table 3.8 or from the following equation:

$Tc = 0.0195 \, L^{0.77} \, S^{-0.385}$

Where

L = maximum length of flow (m)
S = grade of drainage area (m/m)
Tc = time of concentration (min)

Table 3-8: Time of Concentration for Small Drainage Areas, Tc (Minutes)

Maximum length ofv(m)	Gradient of Drainage Area (percent)					
	0.05	**0.1**	**0.5**	**1.0**	**2.0**	**5.0**
100	13	10	5	4	2	2
200	21	16	9	7	5	4
300	29	23	12	9	7	5
400	37	28	15	12	9	6
500	44	33	18	14	11	7
1000	74	57	31	23	18	13
1500	102	78	42	32	25	17
2000	127	97	52	40	31	22
2500	150	115	62	47	36	26
5000	256	196	106	81	62	44

(Source: Field Manual on Watershed Management, ICAR, Hyderabad, 1990)

From the estimated storm duration (Tc) and a selected rainfall frequency, the design rainfall intensity (i) is obtained. Agricultural drainage systems are normally designed for a rainfall frequency of 5 to 10 years return period. In MGNREGA, 10 years recurrence interval may be considered.

Table 3-9: Peak discharge (cumec) from catchments of 10 to 100 ha for different intensity (I, mm/hr) and runoff coefficient values (using rational formula)

Area (ha)	I = 40		I = 60		I = 80		I = 120		I = 140		I = 160		I = 180	
	C = 0.4	C = 0.6	C = 0.4	C = 0.6	C = 0.4	C = 0.6	C = 0.4	C = 0.6	C = 0.4	C = 0.6	C = 0.4	C = 0.6	C = 0.4	C = 0.6
10	0.44	0.67	0.67	1.00	0.89	1.33	1.33	2.00	1.56	2.33	1.78	2.67	2.00	3.00
20	0.89	1.33	1.33	2.00	1.78	2.67	2.67	4.00	3.11	4.67	3.56	5.33	4.00	6.00
30	1.33	2.00	2.00	3.00	2.67	4.00	4.00	6.00	4.67	7.00	5.33	8.00	6.00	9.00
40	1.78	2.67	2.67	4.00	3.56	5.33	5.33	8.00	6.22	9.33	7.11	10.67	8.00	12.00
50	2.22	3.33	3.33	5.00	4.44	6.67	6.67	10.00	7.78	11.67	8.89	13.33	10.00	15.00
60	2.67	4.00	4.00	6.00	5.33	8.00	8.00	12.00	9.33	14.00	10.67	16.00	12.00	18.00
70	3.11	4.67	4.67	7.00	6.22	9.33	9.33	14.00	10.89	16.33	12.44	18.67	14.00	21.00
80	3.56	5.33	5.33	8.00	7.11	10.67	10.67	16.00	12.44	18.67	14.22	21.33	16.00	24.00
90	4.00	6.00	6.00	9.00	8.00	12.00	12.00	18.00	14.00	21.00	16.00	24.00	18.00	27.00
100	4.44	6.67	6.67	10.00	8.89	13.33	13.33	20.00	15.56	23.33	17.78	26.67	20.00	30.00

(Source: Field Manual on Watershed Management, ICAR, Hyderabad, 1990)

Table 3-10: Maximum allowable velocities in channels for different soil textures

Soil texture	Maximum allowable velocity (m/sec)
Very light silty sand	0.30
Light loose sand	0.50
Coarse sand	0.75
Sandy and sandy loam	0.75
Silty loam	0.90
Firm clay loam	1.00
Stiff clay or stiff gravelly soil	1.50
Coarse gravel	1.50
Shale, hardpan, soft rock etc.	1.80
Hard cemented conglomerates	2.50

(Source: IMTP, 1986)

Slightly higher velocities are allowed if water contains colloidal silt.
If the land slopes are steeper to create scouring velocity, the same has to be reduced by a gentle slope of the drain through provision of suitable drops / falls in the channels.

- **Side slopes**

The side slopes of the drains in general are recommended as given below:

Firm soil	1.0 : 1 (horizontal : vertical)
Loam soil	1.5: 1
Sandy soil	2.5: 1

- **Roughness Coefficient**

Values of roughness coefficient 'n' in the Manning equation for earthen channels can be selected from Table-3-11.

Table 3-11: Values of 'n' for earthen channels

S. No.	Type of Channels	n-values		
		Min.	Design.	Max.
1	Earth bottom, rubble sides drainage ditches, large, no vegetation	0.028	0.032	0.035
2	(a)0.8m, hydraulic radius	0.040		0.045
	(b)0.8 – 1.2m, hydraulic radius	0.035		0.040
	(c)1.2-1.5m, hydraulic radius	0.030		0.035
	(d)1.5m , hydraulic radius	0.025		0.030
3	Small drainage ditches	0.035	0.040	0.040
4	Stony bed, weeds on bank	0.025	0.035	0.040
5	Straight and uniform	0.017	0.0225	0.025
6	Winding and sluggish	0.0225	0.025	0.030

(Source – Schwab et al, 1981)

These values increases with poor maintenance of drain and weeds growth. In newly dug channels, the value of 'n' is lower and velocities higher than design values.

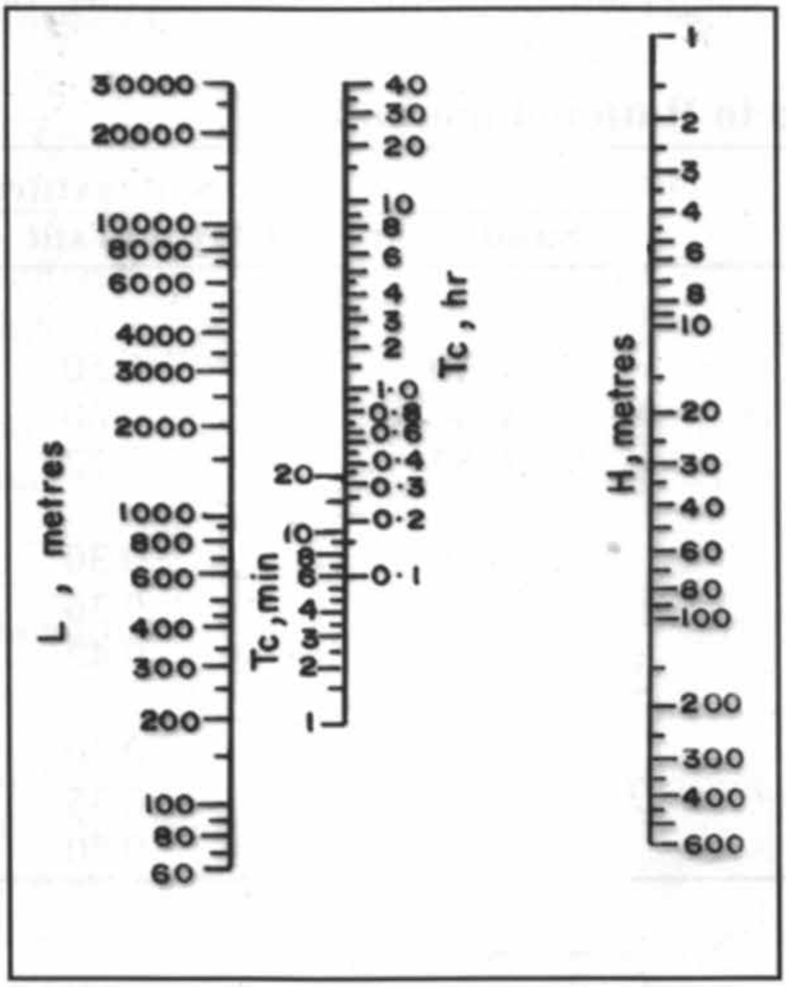
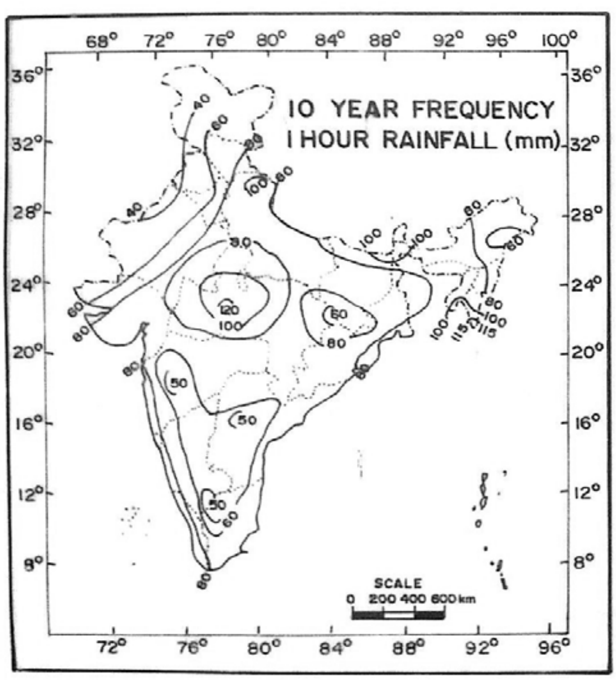
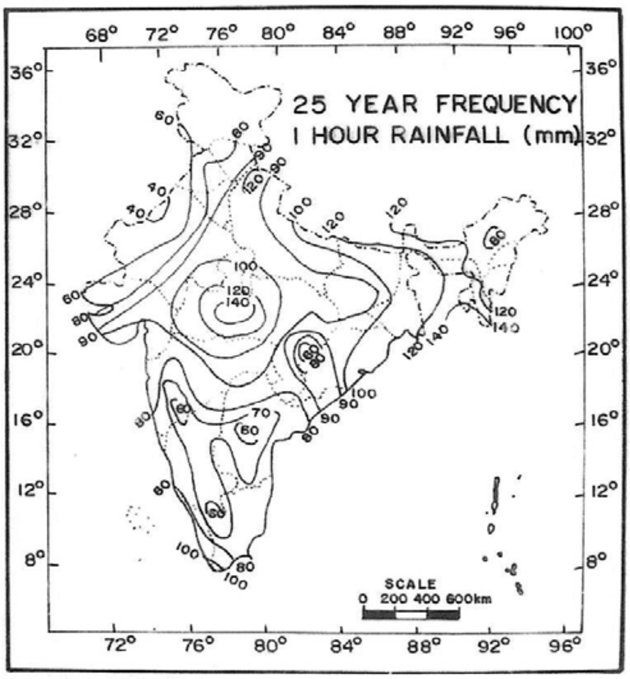


Figure 3-11: Nomograph for estimating time of concentration

(Source: Participatory Integrated Watershed Management – A field manual by VN Sharda, et al, 2006)





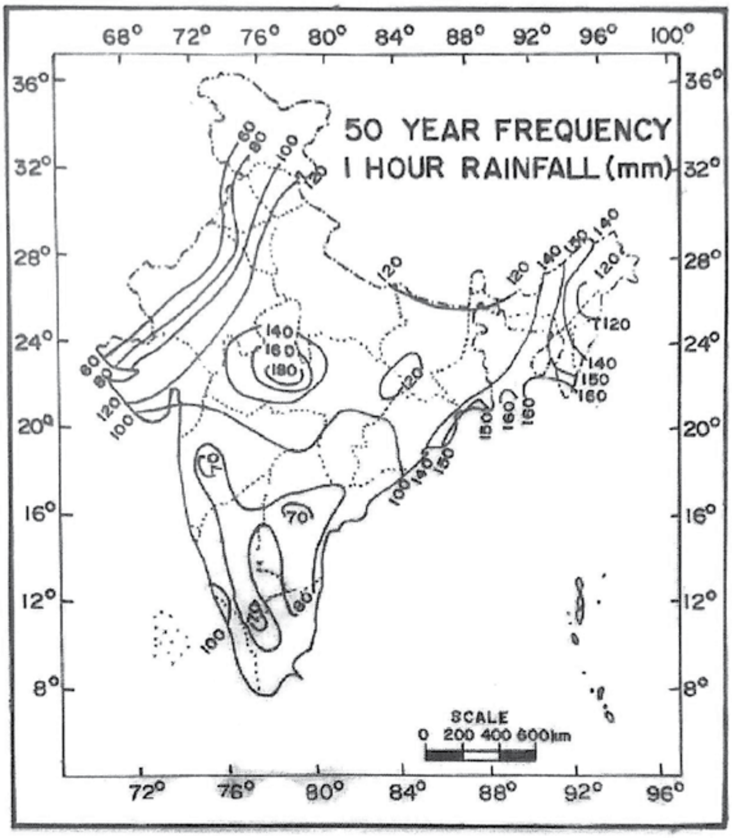


Figure 3-12: One hour rainfall intensity for different frequencies in India

(Source: Participatory Integrated Watershed Management – A field manual by VN Sharda, et al, 2006)

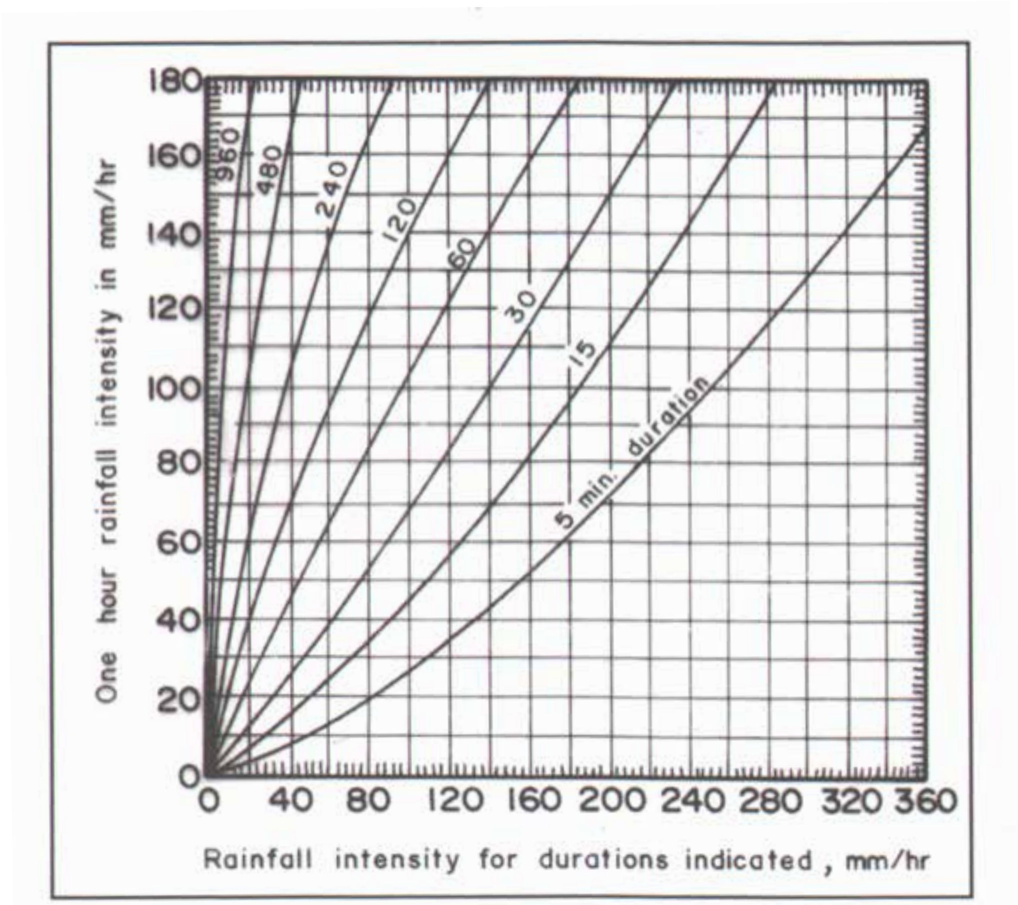


Figure 3-13: Relation of one hour rainfall intensity with intensities at other durations

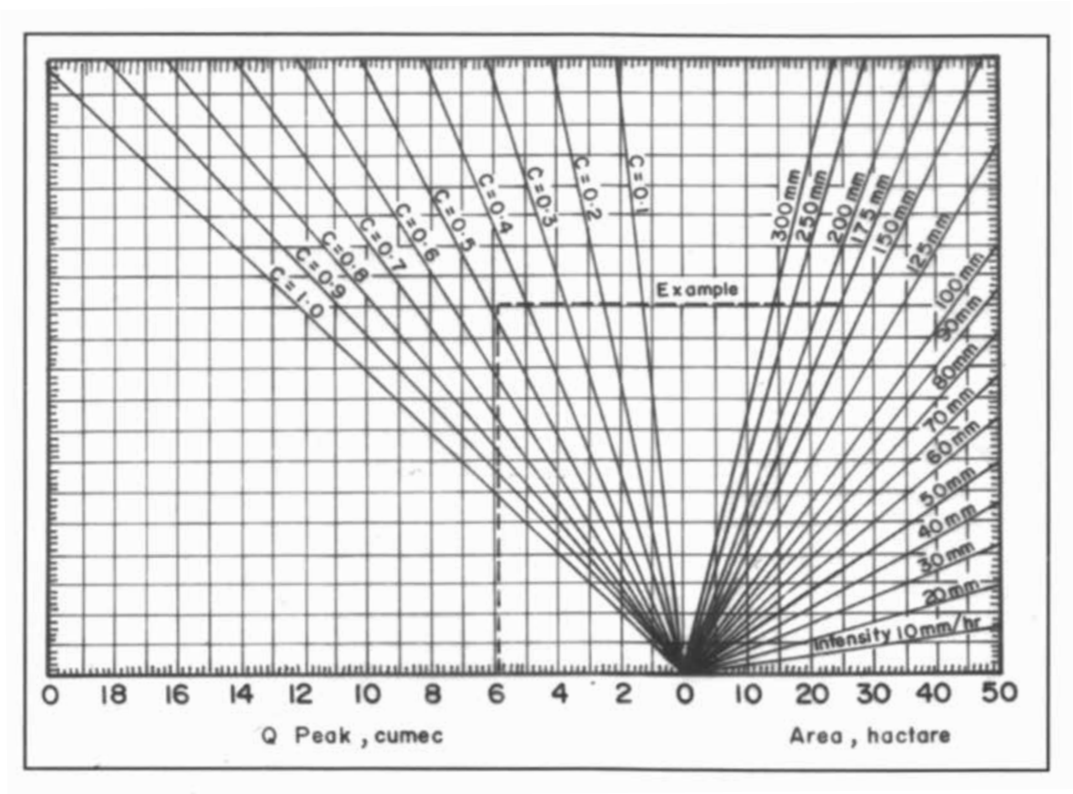


Figure 3-14: Chart for estimation of Q peak by Rational Method

(Source: Participatory Integrated Watershed Management – A field manual by VN Sharda, et al, 2006)

Example:

Estimate the peak rate of runoff expected to occur once in 25 years from 50 ha watershed located at 76E longitude and 25N latitude with sandy loam soil. The land use comprises of 20 ha of agricultural land, 15 ha of grassland and 15 ha of forest land. The difference in elevation between the highest and outlet points is 20m and maximum length of run is 1200 m. The average land slope is 3%.

Solution:

Step-1: Calculation of average value of 'C' (as per Table No.3.6)

$$C = \frac{20 \times 0.3 + 15 \times 0.1 + 15 \times 0.1}{50} = 0.18$$

Step-2: Time of concentration from Fig.3.6 for vertical fall (H) of 20m and maximum length run / flow (L) 1200m is 22 minutes (Tc).

Step-3: For longitude of 76E and latitude of 25N, 1 hour rainfall intensity for 25 years frequency is 120 mm/hr (Fig.3.7).

Step-4: From Fig.3.8, rainfall intensity for duration equal to time of concentration (0.4 hr) is 190 mm/hr.

Step-5: Refer Fig.3.9 for watershed area of 50 ha, rainfall intensity of 190 mm/hr and runoff coefficient of 0.18, the peak rate of runoff Q works out to be 4.75 cumec.

In the command area we can also calculate the run off by Strange's table.

Table 3-12 Estimated runoff and yield per ha from catchment areas – Strange's table

Total monsoon rainfall (mm)	Good catchment		Average catchment		Bad catchment	
	% of runoff to rainfall	Yield of runoff from catchment per ha (cum)	% of runoff to rainfall	Yield of runoff from catchment per ha (cum)	% of runoff to rainfall	Yield of runoff from catchment per ha (cum)
25.00	0.10	0.25	0.10	0.25	0.05	0.13
50.00	0.20	1.00	0.15	0.75	0.10	0.50
75.00	0.40	3.00	0.30	2.25	0.20	1.50
100.00	0.70	7.00	0.50	5.00	0.30	3.00
125.00	1.00	12.50	0.70	8.75	0.50	6.25
150.00	1.50	22.50	1.10	16.50	0.70	10.50
175.00	2.10	36.75	1.50	26.25	1.00	17.50
200.00	2.80	56.00	2.10	42.00	1.40	28.00
225.00	3.50	78.75	2.60	53.50	1.70	38.25
250.00	4.30	107.75	3.20	80.00	2.10	52.50
275.00	5.20	143.00	3.90	107.25	2.60	71.50
9300.00	6.20	136.00	4.60	138.00	3.10	93.00
325.00	7.20	234.00	5.40	175.50	3.60	117.00
350.00	8.30	290.00	6.20	217.00	4.10	143.50
375.00	9.40	325.50	7.00	262.50	4.70	176.25
400.00	10.50	420.00	7.80	312.00	5.20	208.00
425.00	11.60	493.00	8.70	369.75	5.80	232.00
450.00	12.80	576.00	9.60	432.00	6.40	288.00
475.00	13.90	660.25	10.40	494.00	6.90	327.75
500.00	16.00	800.00	11.25	562.50	7.50	377.00
525.00	16.10	845.25	12.00	630.00	8.00	420.00
550.00	17.30	951.50	12.90	709.50	8.60	473.00
575.00	18.40	1058.00	13.80	793.50	9.20	529.00
600.00	19.50	1170.00	14.60	878.00	9.70	582.00
625.00	20.60	1287.50	15.40	962.50	10.30	643.75
650.00	21.80	1417.00	16.30	1059.50	10.90	708.50
675.00	22.90	1545.75	17.10	1154.25	11.40	769.50
700.00	24.00	1618.00	18.00	1260.00	12.00	840.00
725.00	25.10	1819.75	18.80	1363.00	12.50	906.25
750.00	26.30	1972.50	19.70	1477.50	13.10	982.50
775.00	27.40	2123.50	20.50	1580.00	13.70	1061.75
800.00	28.50	2218.50	21.30	1704.00	14.20	1136.00
825.00	29.60	2442.00	22.20	1831.50	14.80	1221.00
850.00	30.80	2618.00	23.10	1963.50	15.40	1309.00
875.00	31.90	2791.25	23.90	2090.25	15.90	1391.00
900.00	33.00	2917.00	24.70	2223.00	16.70	1485.00
925.00	34.10	3154.25	25.50	2358.75	17.00	1572.00
975.00	36.40	3549.00	27.30	2661.75	18.20	1774.00

Total monsoon rainfall (mm)	Good catchment		Average catchment		Bad catchment	
	% of runoff to rainfall	Yield of runoff from catchment per ha (cum)	% of runoff to rainfall	Yield of runoff from catchment per ha (cum)	% of runoff to rainfall	Yield of runoff from catchment per ha (cum)
1000.00	37.50	3750.00	28.10	2810.00	18.70	1870.00
1125.00	43.10	4348.00	32.30	3633.75	21.50	2418.00
1250.00	48.00	6100.00	36.60	4575.00	24.40	3050.00
1375.00	54.40	7480.00	40.80	5610.00	27.70	3740.00
1500.00	60.00	9000.00	45.00	6750.00	30.00	4500.00

(Source: Participatory Integrated Watershed Management – A field manual by VN Sharda, et al, 2006)

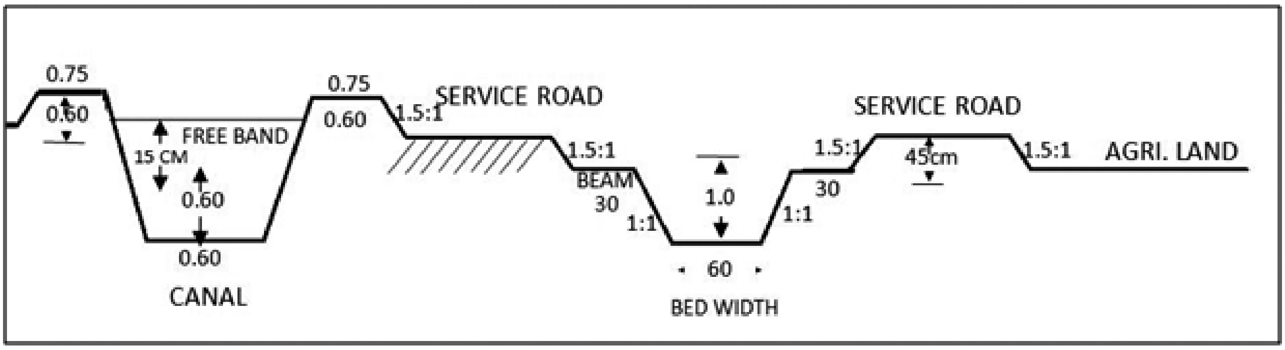


Figure 3-15: Typical cross section of the seepage drain, also showing canal Cross-Section

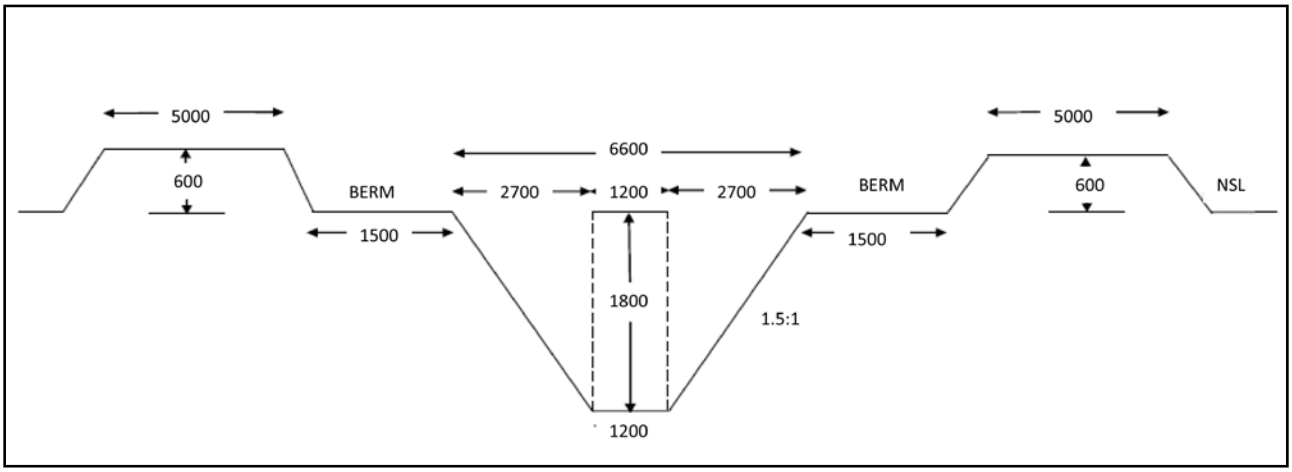
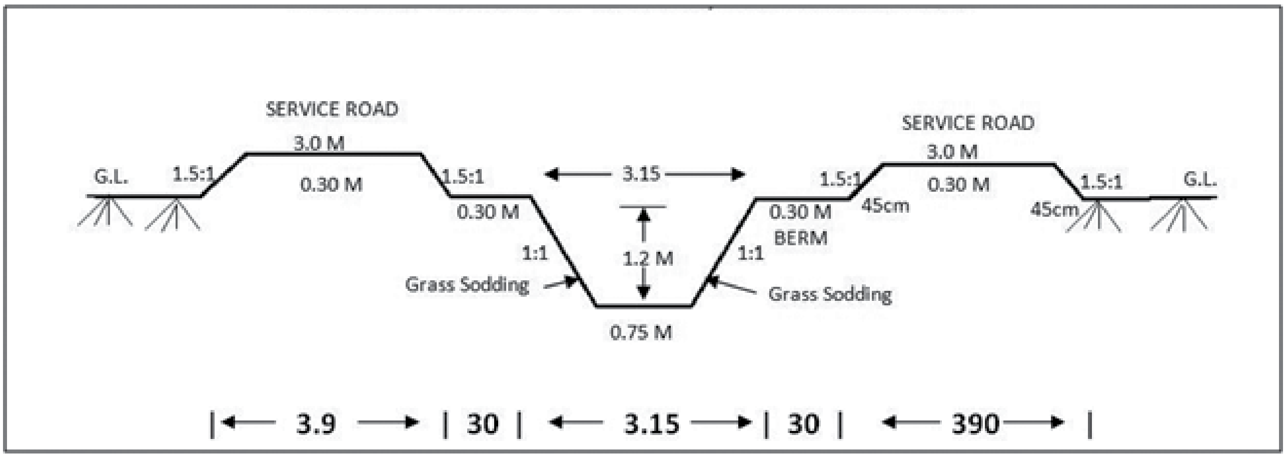


Figure 3-16: Cross Section of Main and Carrier drain

Table 3-13: Detailed Cost Estimate of Construction of Carrier/ Collector/ Intermediate Drain

S. No.	Item	Length (meter)	Width (meter)	Height (meter)	Quantity	Rate	Amount
1	Layout / Dag belling 7.5 to 10 cm deep (in center line & both the sides of levee)	1000 m x 3			3000 m		
2	Clearance of bushes shrubs and trees up to 7.5 cm girth (ordinary jungle) including scrapping of grasses & disposal as directed	1000	11.15		11150 sqm		
3	Excavation in wet soil dry or moist including dressing & disposal of excavated material within initial lead of 30 m & lift 1.5 mt.	1000	$\left[\frac{3.15+.75}{2}\right]$ = 1.95	1.2	2340 cum.		
4	Grass sodding on both sides of drains at 20 x 20 m grid	1000	$\sqrt{(1.2)^2+(1.2)^2}$ = 3.394	-	3394 sqm		
	Total						
	Add 3% contingencies charges						
	Grand Total						
	Cost per meter						

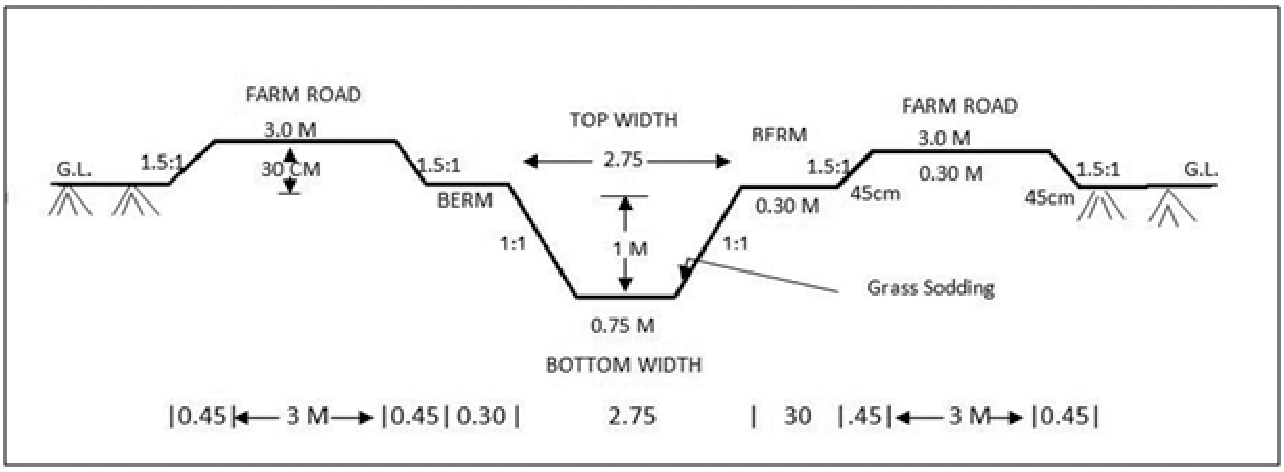


3-17: Typical Cross-Section of Carrier / Collector drain

3.3.2.4. COST ESTIMATES

Table 3-14: Detailed Cost Estimate of Construction of Field Drain (1000 m)

S. No.	Item	Length (meter)	Width (meter)	Height (meter)	Quantity	Rate	Amount
1	Layout / Dag belling 7.5 to 10 cm deep (in center line & both the sides of levee)	1000 m x 3			3000 m		
2	Clearance of bushes shrubs and trees up to 7.5 cm girth (ordinary jungle) including scrapping of grasses & disposal as directed	1000	11.15		11150 sqm		
3	Excavation in wet soil dry or moist including dressing & disposal of excavated material within initial lead of 30 m & lift 1.5 mt.	1000	$\left(\frac{2.75+0.75}{2}\right.$ = 1.75 m.$\left.\right)$	1.0 m.	1750 cum.		
4	Grass sodding on both sides of drains at 20 x 20 m grid	1000	$\sqrt{(1)^2+(1.2)^2}$ = 2.82 m.	-	2820 sqm		
	Total						
	Add 3% contingencies charges						
	Grand Total						
	Cost per meter						



3-18: Typical Cross-section of field drain having both sides farm roads

The calculation of velocity and discharge of a drain having bed width of 0.6m, slide slope (1.1) and roughness coefficient (0.04) can also be done by the **Annexure-III.**

3.3.3. LAND LEVELLING & LAND SHAPING

3.3.3.1. INTRODUCTION:

Land levelling or grading is the process of preparing or modifying (i.e. reshaping) the land surface to a planned grade to provide a suitable field surface for controlling flow of water, check soil erosion, provide better surface drainage flow, moisture and ensure uniform application and distribution of water.

3.3.3.2. LINKAGES WITH MGNREGA:

In MGNREGA the work of land levelling and land shaping in the field of individual farmers under land development can be done. The main objective of land shaping and land levelling is to get the well graded shaped smooth surface to help the irrigator to achieve uniform application of water throughout the field. It provides better and optimum crop production. Uniform grading ensures uniform and efficient application of irrigation water and also removal of excess water if any without erosion. It conserves water and increases the production per unit of water. About 20% water is saved in field application.

3.3.3.3. HOW TO DO THE LAND LEVELLING / GRADING:

i) First of all the work is to be done in a particular field. If the field is big, then it has to be divided into boarders of width of about 20-30 m to minimize the earth works. It should be done along with adjusted contours and slanting for minimisation of earth work.

ii) Fix a temporary bench mark, located on a nearby pucca structure. Do the topographical survey by dividing the field by grids of 5 x 5, 15 x 15, 20 x 20 m grids, depending upon the surface relief of the area & precision required in levelling.

iii) Fix wooden stakes usually of size 1 cm x 4 cm x 50 cm – 1 m at the grid points. Each grid point is at the center of the grid square and represents nearly equal area.

iv) After all points have been staked, determine the ground elevation using a dumpy level at each stake and record on the grid map.

v) After having the elevation of every grid point with respect to the bench mark considered for this purpose draw contour lines at a suitable contour interval as given below:

S. No	Slope percentage required	Contour interval
1	0 – 1	5 to 15 cm
2	1 – 2	15 to 30 cm
3	2 – 5	30 to 60 cm
4	5 – 10	60 to 150 cm

vi) Land levelling design is usually done using plane method. In this method the average elevation of the field is determined and this elevation is assigned to the centroid of the area.

vii) With the help of the contour map the land is divided into fields / boarder strips that can be graded and irrigated individually to the best advantage.

3.3.3.4. PROFILE METHOD OF LAND LEVELLING

i) In the profile of the boarder strip the average cut is 0.30 m and the width of the boarder is 30m and length is 55m then the volume of EW will be 495 cubic meter.

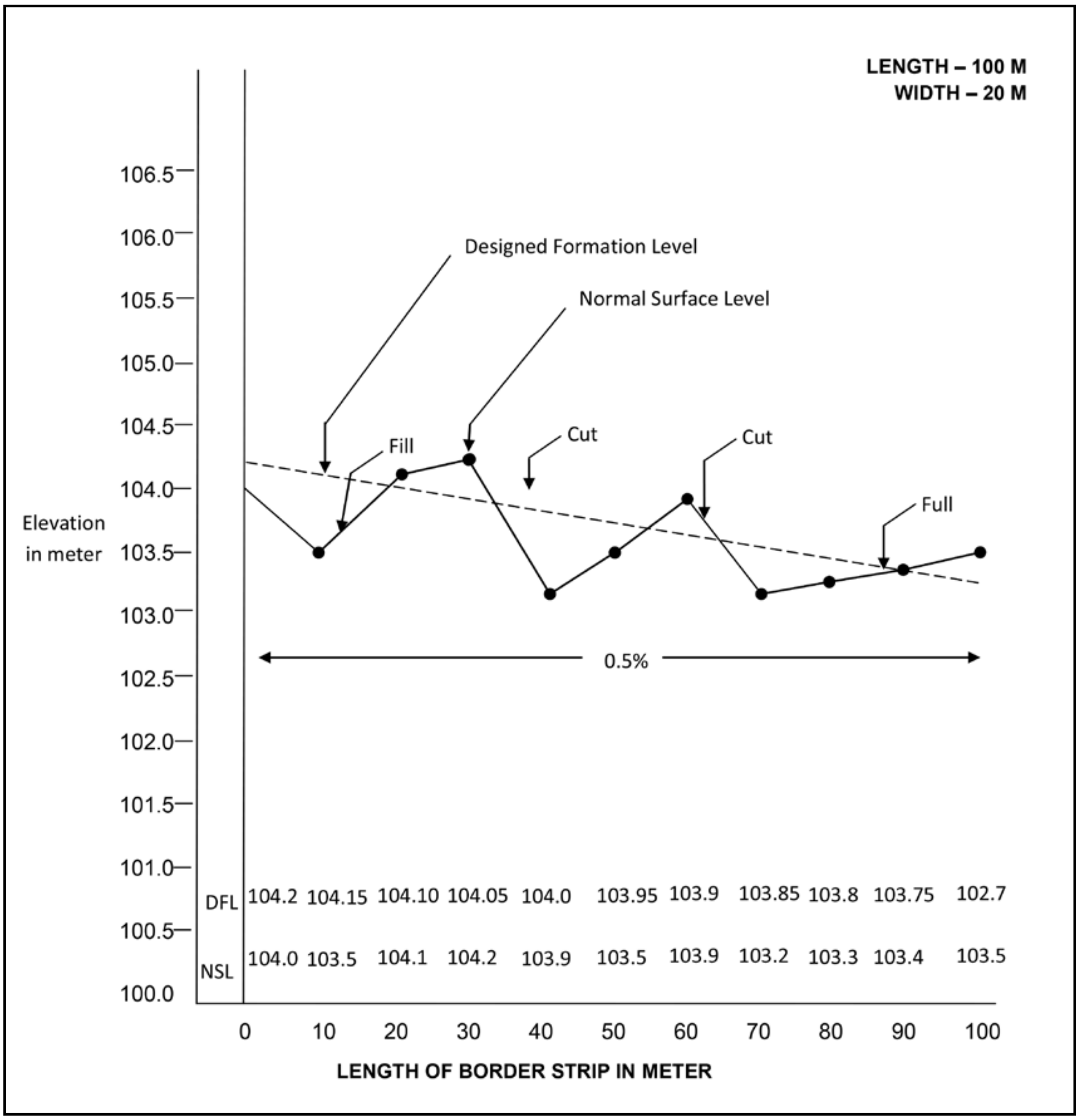


Figure 3-19: L-Section of design border strip laid along adjusted contour

ii) Profile method is practical and easier.
iii) There are so many variables in getting the land levelling done by labour which cannot be accurately measured; therefore the experience says that the cost of land levelling cannot be calculated on the basis of Cut & Fill. It is suggested that SoR for land levelling for the area should be worked out by the competent authority after conducting a time motion Study for land levelling with cut-fill / profile method.

3.3.4. CONSTRUCTION OF IRRIGATION & DRAINAGE STRUCTURE

The following hydraulic structures may be constructed / repaired if needed under MGNREGA because they are essential for better water management, to save water and avoid leakages, etc. Here the typical drawings have been provided prevailing in command areas in India. If required the estimates, technical report can be prepared by the technical staff as per the site and got approved from the competent authority.

i) Outlet from watercourse or turnouts
ii) Pipe type outlet from watercourse
iii) Three way division box
iv) Falls on lined watercourse
v) Tail escape
vi) Inlet to drain
vii) Typical drawing of field drain crossing (pipe type) i.e. culvert

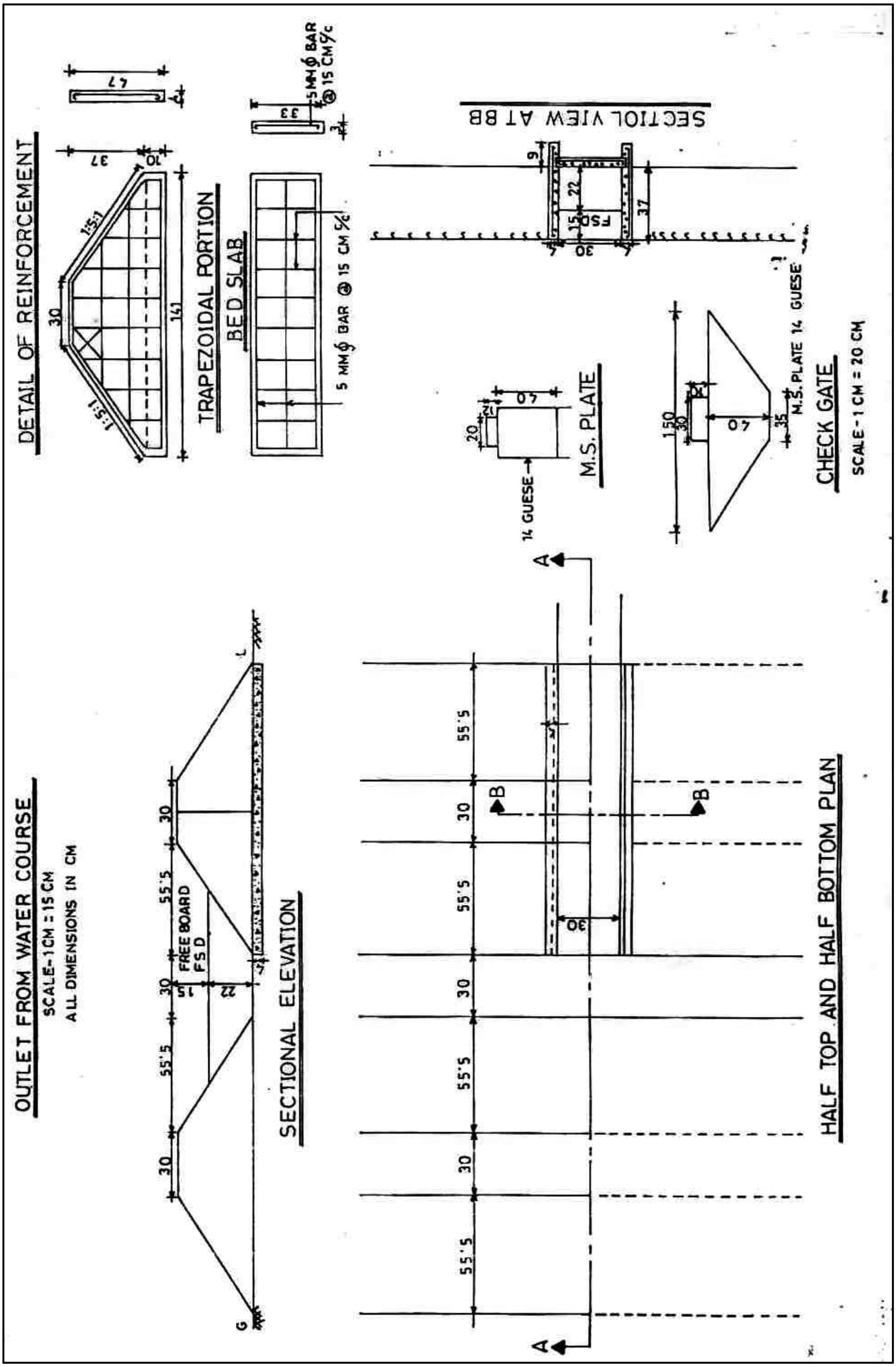


Figure 3-20: Outlet from watercourse or turnouts

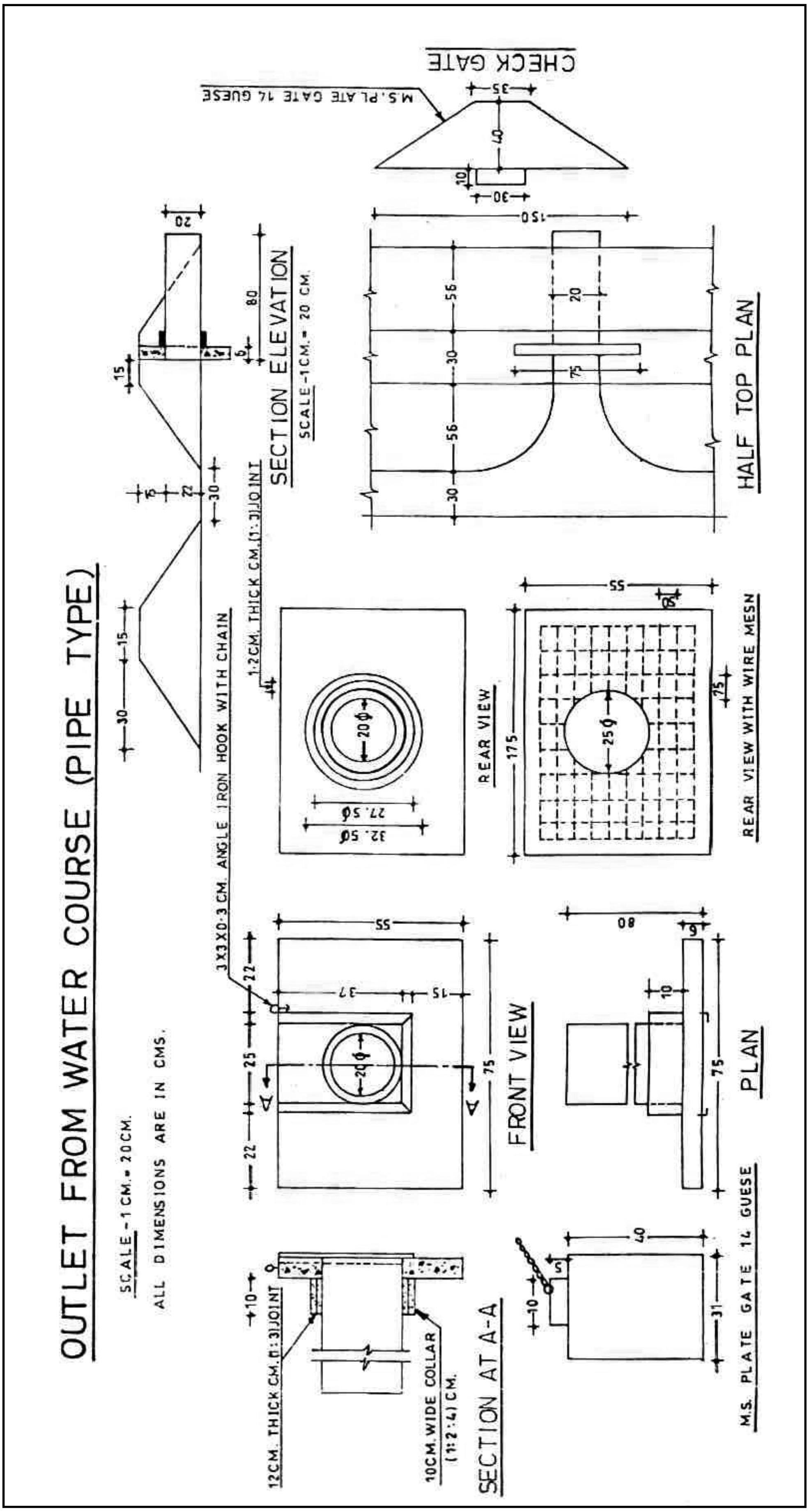


Figure 3-21: Pipe type outlet from watercourse

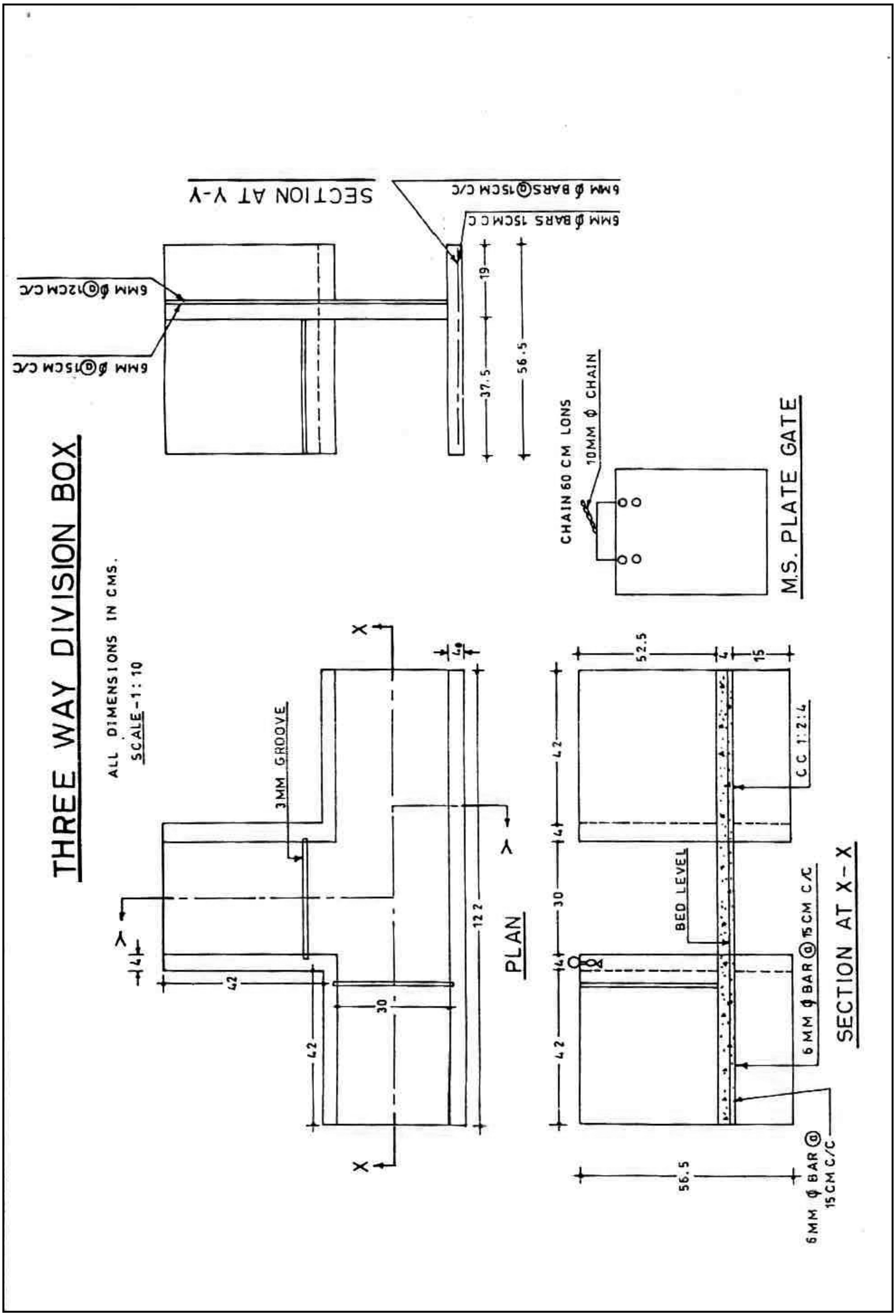


Figure 3-22: Three way division box

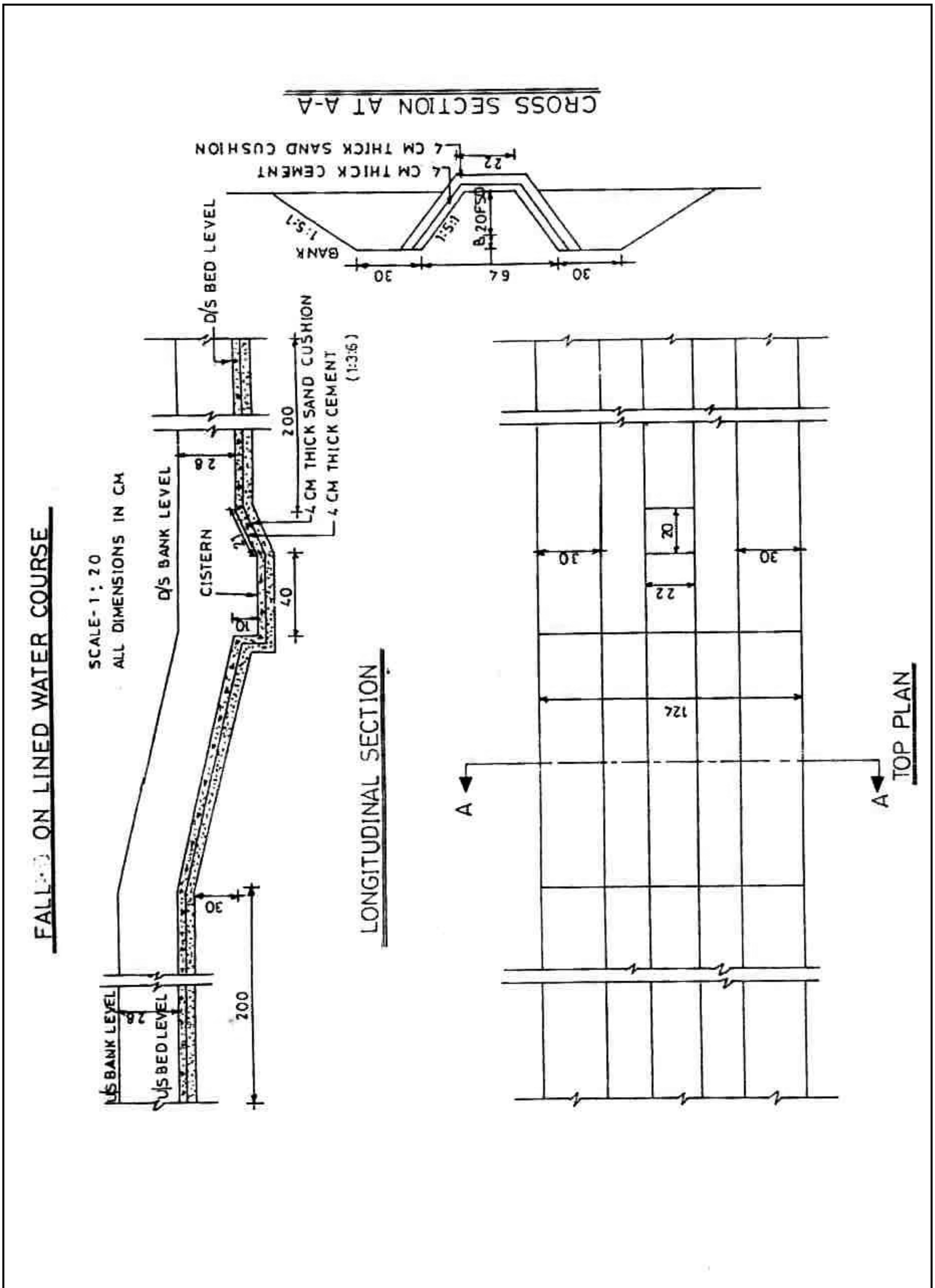


Figure 3-23: Falls on lined watercourse

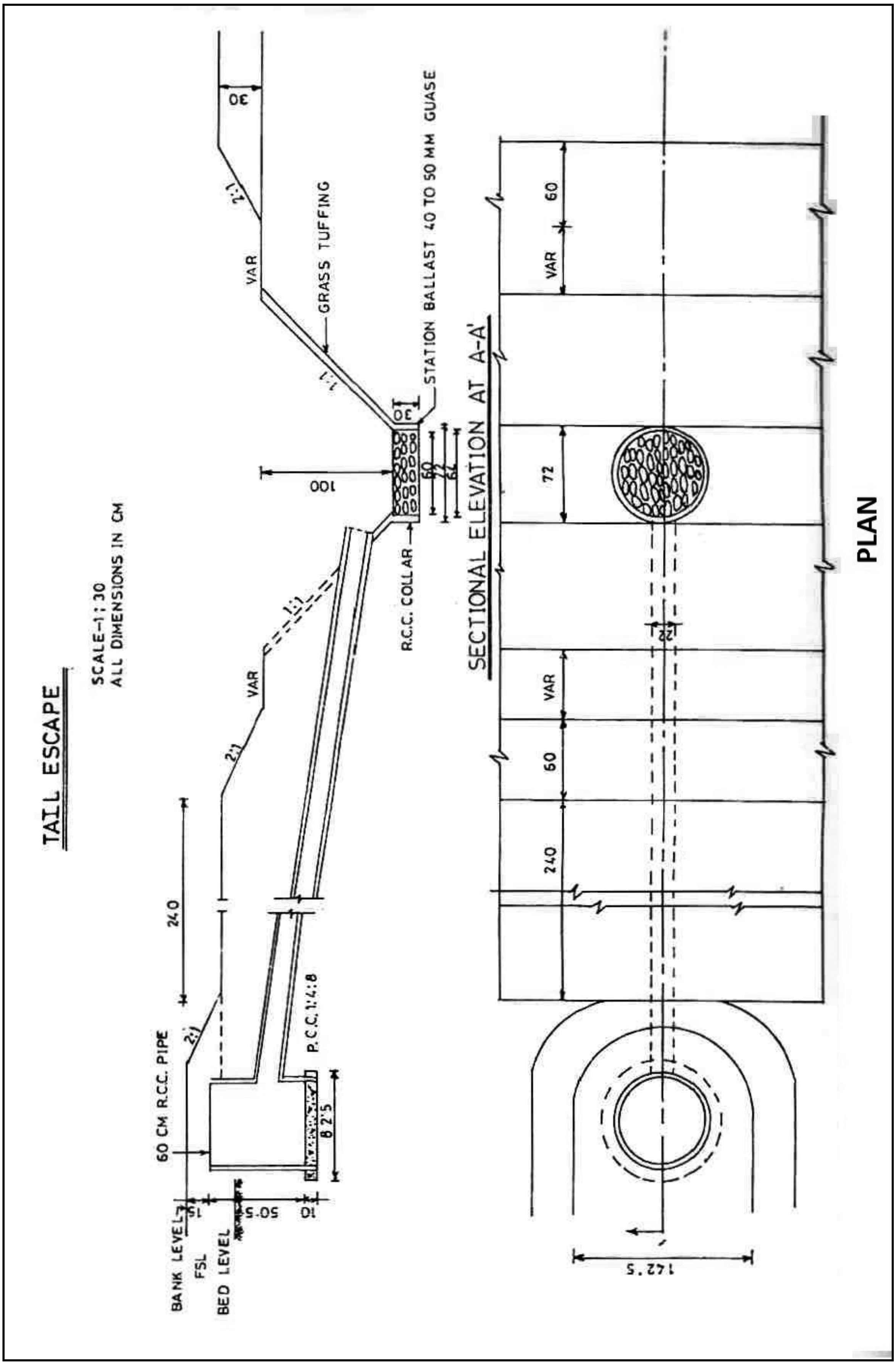


Figure 3-24: Tail escape

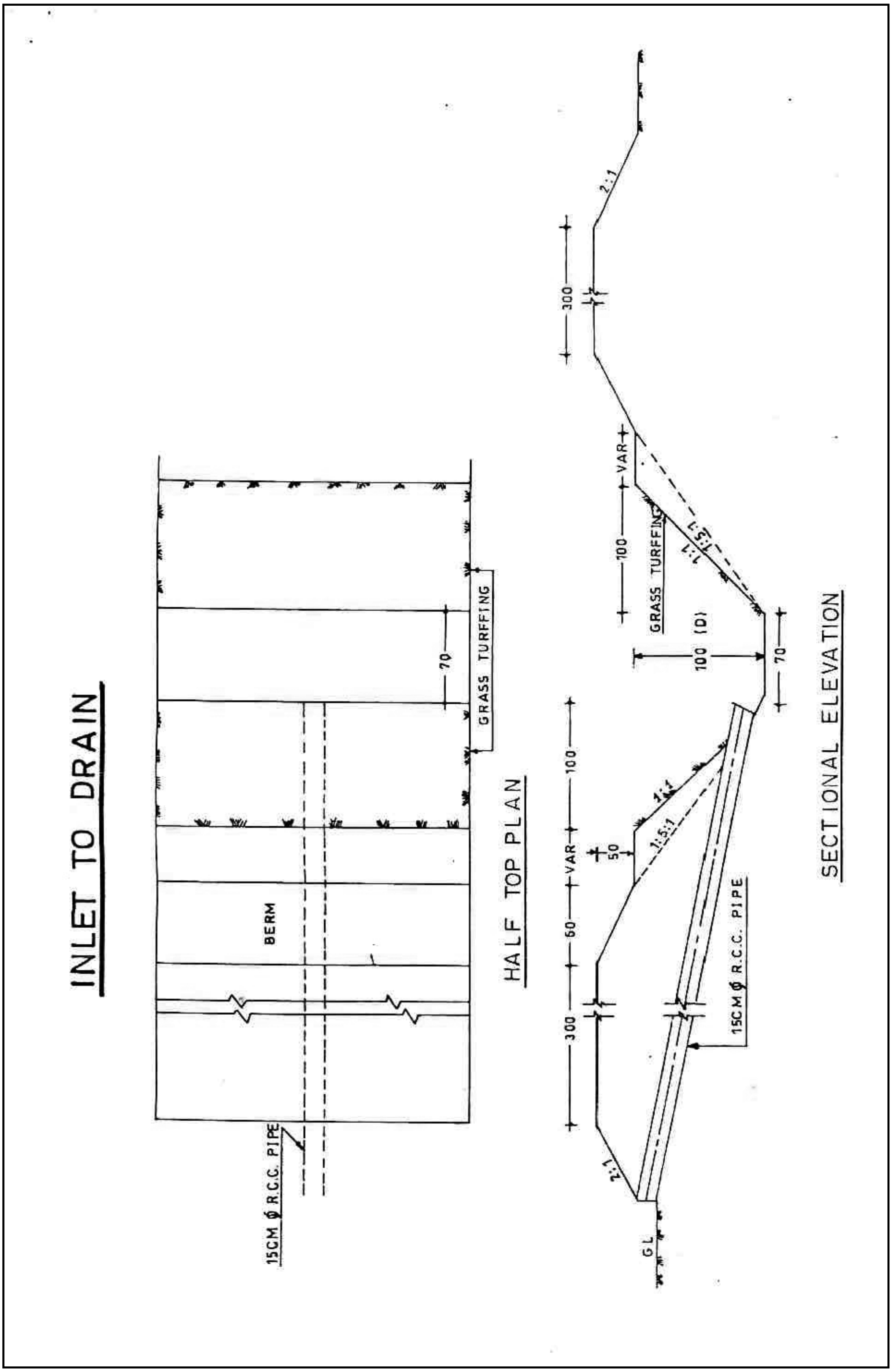


Figure 3-25: Inlet to drain

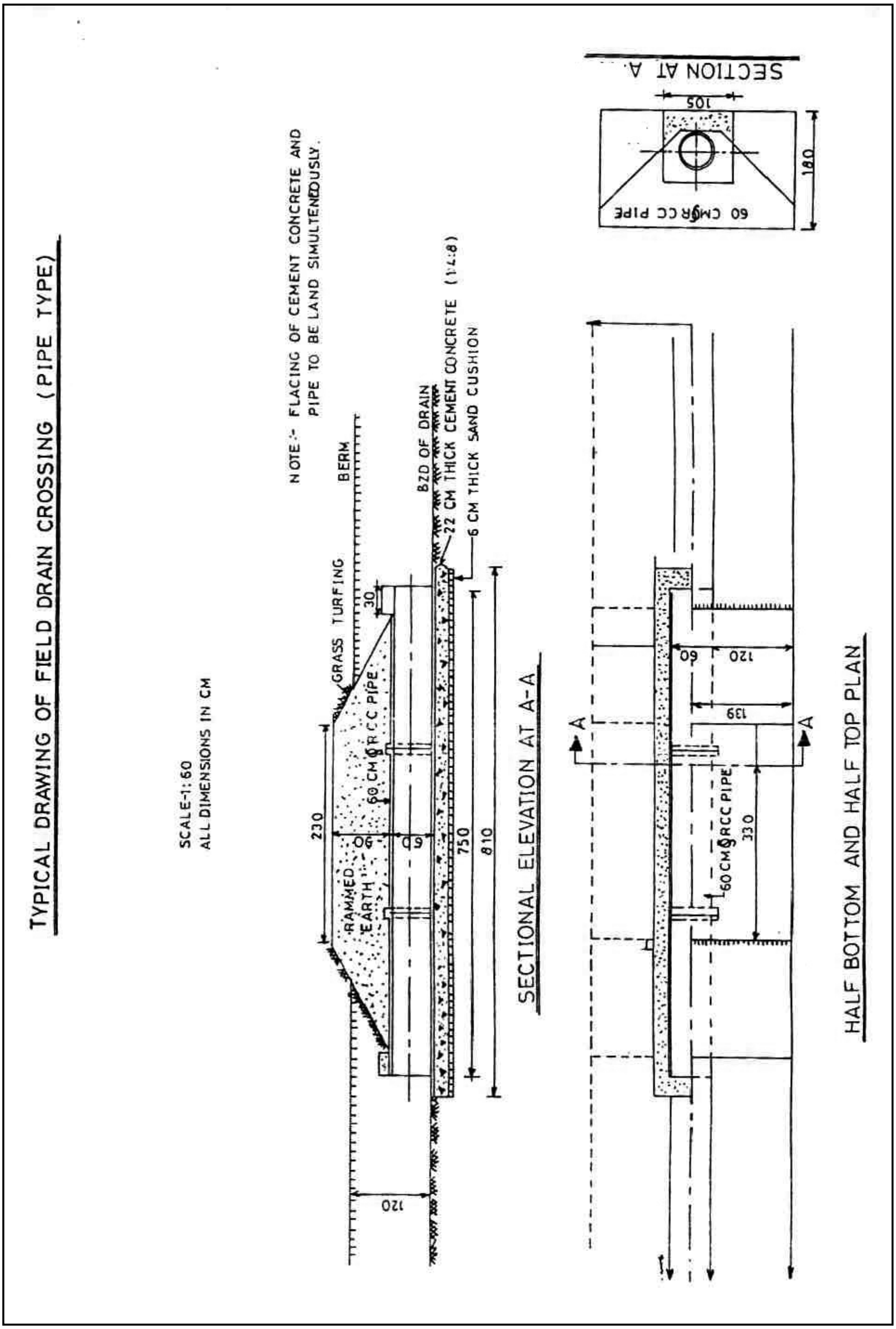


Figure 3-26: Typical drawing of field drain crossing (pipe type) i.e. culvert

3.3.5. ENGINEERING SURVEY

Before starting the work of watercourse either new construction or de-silting and repair of the watercourse, the designed L-Section and Cross-Section is required. The existing L-Section and cross section of the watercourse is to be taken essentially at site at every 30 m. length. The designed L-section and cross section is already available that should be taken from the records and difference of both should be executed. The survey should be done by the same Junior Engineer who will prepare the estimate and will get the execution done. So that he is well aware about the field condition and his approach will be practical. However, the labour from the MGNREGA can be used for survey.

3.3.5.1. PREPARATION OF L-SECTION & CROSS-SECTION OF WATERCOURSE:

i) Mark the position of watercourses on field at every 30 meter.

ii) Take level of field on both the sides of alignment of the watercourse i.e. Normal Surface Level.

iii) Show off taking position, required value of FSL in watercourse, designed and available FSL in canal as well as working head at off taking point.

iv) FSL line be drawn, in such a way that minimum 10 cm. head of water is available

   a) Grade should not be changed from steeper to flatter. If it is necessary, then a fall should be proposed before changing the grade. The grade can be changed from flatter to steeper by providing a grade change structure.

   b) Slope should never be provided steeper than 1:300. In case ground is very steep, fall structures should be proposed.

   c) After a fall structure, we can go in cutting up to 1 to 2 chain distance. If a field starts just after fall structure then its outlet should be fixed at upstream of fall structure or at the time of execution position of fall structure may be changed according to field condition.

v) Draw cross section of watercourse, at a particular chainage on sheet at suitable scale. A typical L-section has been shown in Fig. (3.27).

3.3.5.2. PREPARATION OF L-SECTION & CROSS-SECTION OF FIELD DRAIN:

i) Mark the points at every 30m interval on drain line in the field. Take levels of every point and draw the Normal Surface Level.

ii) Draw the proposed bed level line keeping in mind that difference of NSL and bed level should not be more than 1.5m, and less than 0.6m. On an average, difference should be 1.1 to 1.2m so that sufficient quantity of soil is available for construction of service road along both sides of field drain.

iii) No fall structure should be proposed, as far as possible.

iv) The bed line should be drawn in such a way that out fall is available at out fall point. Maximum it can be flushed with the bed of carrier drain at outfall point but if there is main drain at outfall point then a minimum of 30 cm. difference should be kept between bed level of the main drain and field drain at junction point. Mark the out fall level in the L-Section itself.

v) If outfall is not available then a note of same should be given for deepening of carrier / main / sub main drain and it should be executed compulsorily before rains.

vi) Bed slope of drain should normally be the same as ground slope. However it should not be flatter than 1:1500 and steeper than 1:500 as far as possible.

vii) Get the L-section approved by higher authorities.

viii) A typical L-section & Cross-Section of a drain has been shown in fig 3.28.

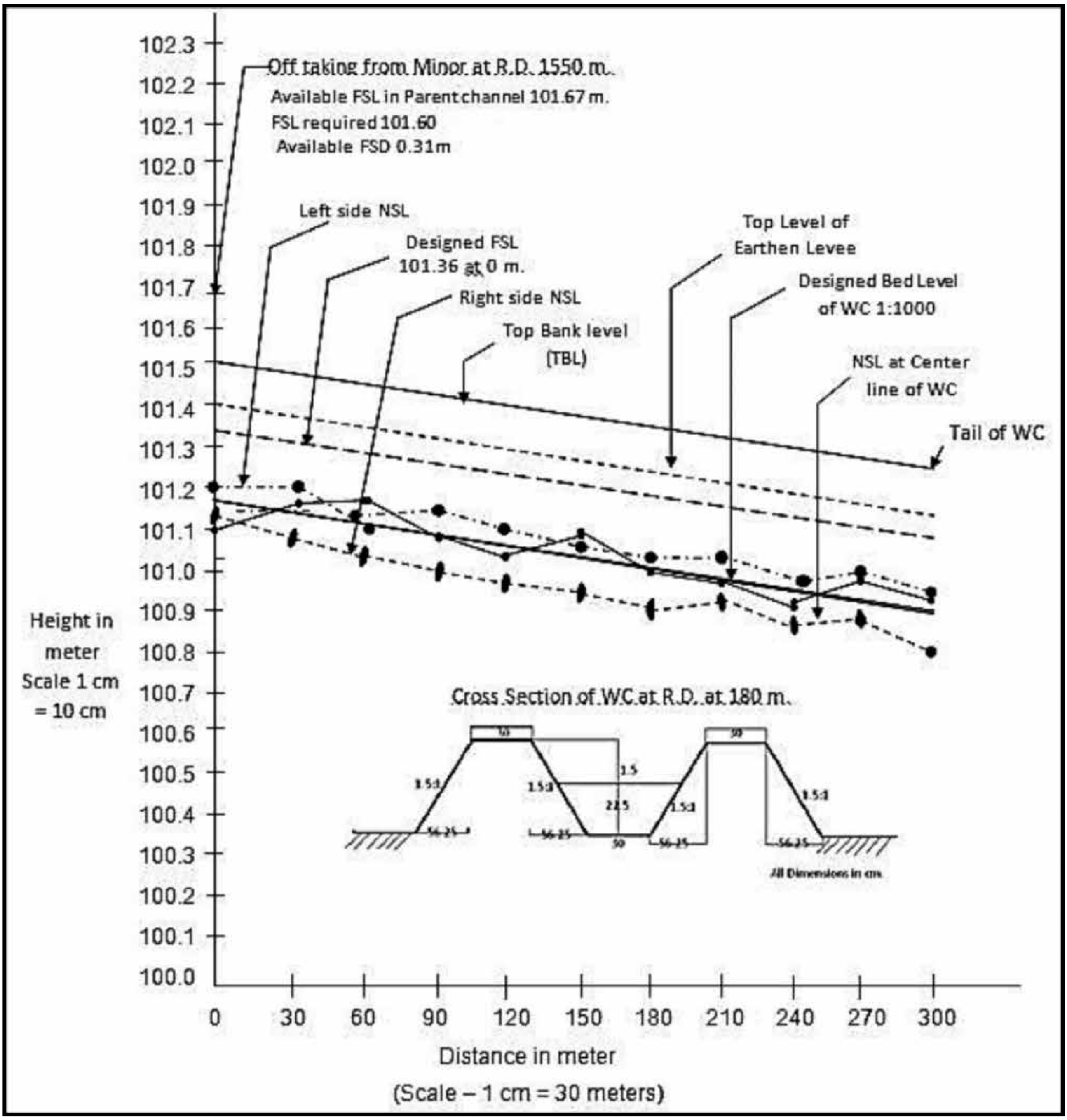


Figure 3-27: Designed L-Section & Cross-Section of Watercourse

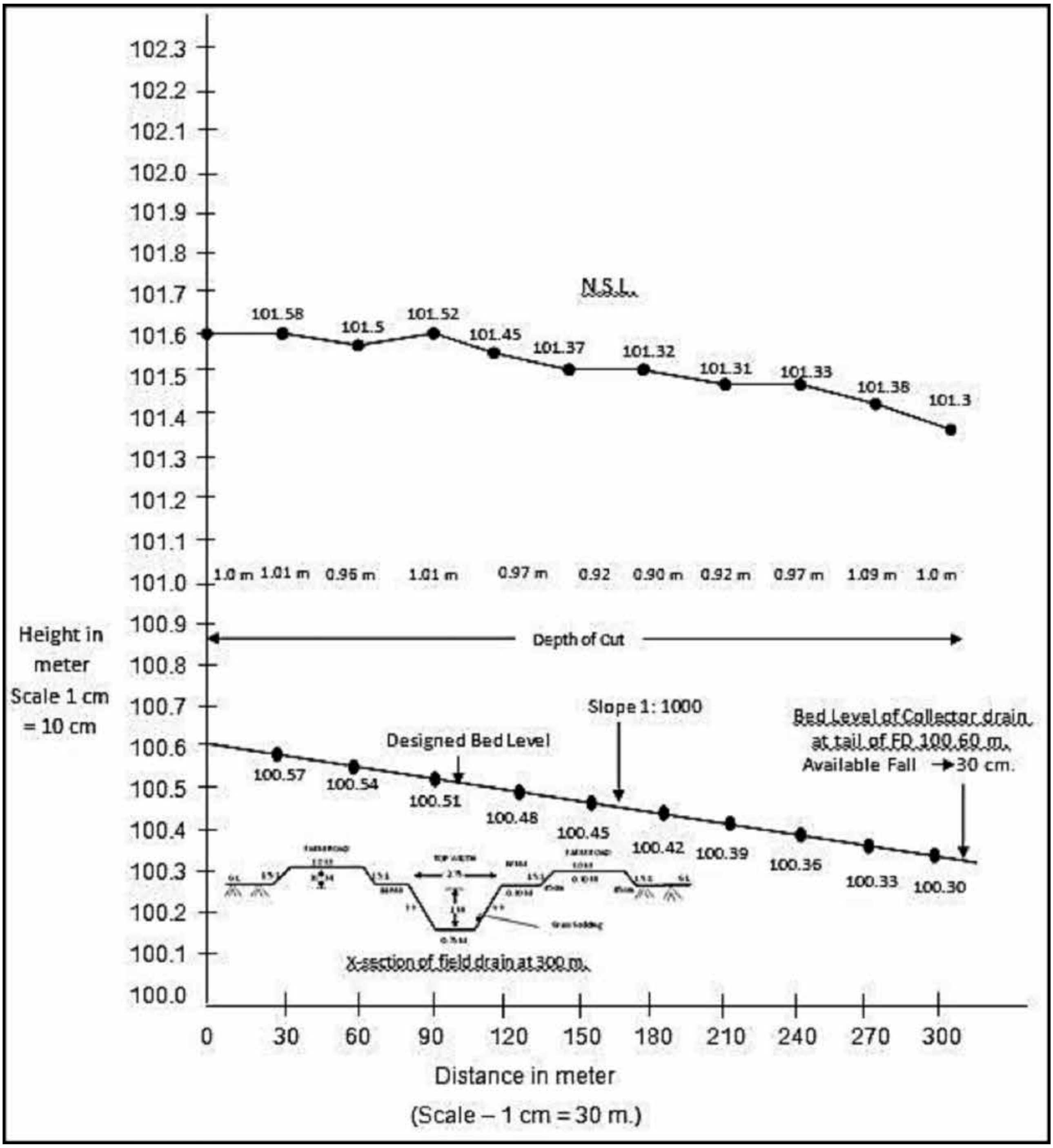


Figure 3-28: Designed L-Section and Cross-Section of Field Drain

3.3.6. EXECUTION OF WORKS

3.3.6.1. PREPARATORY WORKS

i) Check instruments like dumpy level, theodolite, total station, staff and arrows and get them set/repaired.

ii) Visit area, do PRA and accordingly finalise the plan and decide the works

iii) Take help of field technical man / mistry in marking the watercourse and drain alignment in the field.

iv) Shift GTS bench mark to the permanent structures in the area.

3.3.6.2. STEPS TO BE TAKEN FOR THE EXECUTION OF WATERCOURSE

i) Give alignment in the field with the help of survey instrument.

ii) Do dag belling, mark the center line and both bottom width lines of the watercourse.

iii) Scrape top 10 cm. soil from the watercourse alignment for proper bondage / removal of organic material.

iv) Mark the height up to which levee is to be constructed on cut stone pillars / arrows which have been installed to mark the alignment of watercourse.

v) Construct well compacted levee in 15 cm. layer by labour from the soil taken from the higher patches.

vi) Take special care at the outlet point of the watercourse i.e. off taking from the parent canal / minor. Earth in sufficient should be there to avoid seepage / leakage at the outlet point in future.

vii) Construct levee in 15 cm. layers and then do compaction by labour using sheep foot rollers.

viii) Get the section cutting properly and then mark the bed level and bank level and field level by labour along with dressing.

ix) Check it with designed L-section and submit one copy to the S.E. /XEN.

x) The farm outlets / turn outs should be provided to each individual farmer.

xi) Get the watercourse connected properly to canal outlet. Must check the levels of outlet pipe and ensure its correct installation.

xii) Run water into watercourse right up to its tail and irrigate the tail end field too.

xiii) Identify vulnerable reach for lining purpose, prepare estimates there off and get the lining done also.

xiv) If the work of repair of existing watercourse is to be done then do only those steps which are required. In that case the difference between designed and existing watercourse will be measured.

3.3.6.3. STEPS TO BE TAKEN FOR THE EXECUTION OF DRAINS

i) Arrange jungle clearance and typha cutting if needed on the alignment of drains.

ii) Carry out dag belling / layout.

iii) Arrange / supervise the excavation of drains to the given specifications, particularly for side bulging, berm clearance and road formation.

iv) Check bed levels and must ensure their confirmation to the designed levels.

v) Construct drain crossing, if any.

vi) Ensure the outfalls, if not available then do the desilting of outfall drain first.

vii) Start the drainage work execution from the tail.

3.3.6.4. STEPS TO BE TAKEN FOR LAND LEVELLING

i) Draw profile on graph sheet, mark formation level and do cut & fill accordingly by labour.

ii) The total area to be leveled should first be divided in small blocks or boarders so as to minimize the earth work.

iii) Mark the cut and fill point in the field as per the designed gird map.

iv) Do cut and fill properly

v) Take working levels and ensure proper level of the farm as per design

vi) Fill up the soil little bit extra (about 15 cm higher) on the filling points to take care of compaction or settlement at the time of rains / irrigation.

vii) Do the work in the presence of farmer and take care of his suggestions if any.

3.4. DOS & DON'TS

- Before starting construction of watercourse levee at least 10 cm. depth throughout its width and length should be scraped.
- The level of the surface should be undulated to provide better bonding of the levee with the ground.
- After the excavation of proper section of the watercourse the bed level as per designed L-Section and bank level should be checked properly and should be achieved.
- Some provision for the settlement beyond the TBL (Top Bank Level) should also be taken in any type of earthen embankment.
- We should ensure at least 10-20 cm. working head of water on every field, so as to provide easy & quick irrigation by gravity.
- The layout should be given on proper micro ridge so that the watercourse can irrigate both sides of the fields.

- For construction of the watercourse the work should be started from the head of the watercourse.
- The watercourse should not be constructed in 100% filling as far as possible. If done so ensure proper compaction or lining of that reach.
- The earth used for the construction should not be saline, alkaline, pebble or concrete mixed to avoid seepage. If so the lining of that reach be done after one year of irrigation if seepage is there.
- Turn outs (field inlets) should be provided at a proper naka point on every field to facilitate the proper irrigation to the individual farm.
- If the junction of minor / distributary from where water will be taken in the watercourse should be properly designed so that the water in proper quantity is available and there is no leakage.
- There should be proper gate so that whenever water supply is not needed the watercourse is closed properly.
- For the drain we should ensure that the outfall level is available. Otherwise get the outfall level first cleared then only do the excavation of desired drain.
- The work of drain should be started from the tail.
- After the excavation of the drain, bed levels should be marked on the working L-Section and ensure the designed bed level.
- Proper berm as per the designed Cross-Section of the drain should be ensured to avoid back filling of the loose soil in the drain.
- Grass sodding on the sides of the drain up to the level of the designed Full Supply Depth (FSD) should be done.
- The proper dressing of the watercourse should be ensured.
- If existing watercourse is 60% to 70% damaged and require repair then it is better to go for new construction at a proper ridge.
- The turnout should be given on proper point of watercourse. If there is a fall in the watercourse then at least 30m-60m of the watercourse will be in cutting in such case take the outlet before the fall in the watercourse.
- After new construction the testing of watercourse should be done properly. Even the tail end fields should be provided proper irrigation to ensure the design and quality of watercourse.
- During the construction of watercourse and drains and land levelling, the cultivators should be taken in confidence and should be consulted in design, alignment and construction. Their suggestions are valuable and should be given due consideration. The user society should be constituted so that they fallow participatory irrigation management 'Barabandi' etc.
- These R.D. works should be made peoples movement as Mahatma Gandhi's freedom movement.
- The section of the drain may be made higher than the designed to provide earth for the roads on the sides of the drain because that is also an essential item of development. In rural areas there are no roads up to the field and the poor farmers face lot of difficulty in reaching to their fields. It affects the production adversely. The poor farmers are on the mercy of the bigger land lords because there is no proper access up to the field of the poor farmer. These roads may be made fair weather roads under MGNREGA.
- The lining should be done by the local material only to minimize the cost.
- The lining of watercourse, earthen watercourse, and drains are the work of beneficiaries. Before starting the construction it should be ensured that they take guarantee of not damaging these works. Because experience says that the farmers take away the building material such as bricks, stones to their homes, fill the drains, damages the watercourse by cutting at so many points and then not repairing.
- The land levelling should be done in such a way that minimum earth work is involved and lead is also not much. To do the same the complete field may be divided in small benches, boarder strips or so.
- The filling portion should be filled at least 15 cm. higher than the designed level for settlement.
- The working profile should be prepared and the survey instrument should be used properly.
- These are micro engineering field works and cannot be done without the help of precision survey instruments like dumpy level / total station etc. Therefore the survey instruments should be properly maintained. It is seen that the survey instruments are mostly not used in the field.

CHAPTER
04

AFFORESTATION, TREE PLANTATION & HORTICULTURE





CHAPTER 04

AFFORESTATION, TREE PLANTATION & HORTICULTURE

4.1. INTRODUCTION:

4.1.1. One of the main objectives of Mahatma Gandhi National Rural Employment Guaranteed Scheme (MGNREGS) is to strengthen natural resource management through works that address causes of chronic poverty (like drought), so as to encourage sustainable development. Accordingly, emphasis has been laid to generate green / vegetative cover on marginal lands, degraded lands and waste lands to improve the natural resource base at grass-roots level.

4.1.2. Tree planting is carried out basically for aesthetic value and shade but they do create several other benefits. Raising of tree plantations is the need of the hour in the context of climate change which leads to adverse impact on the on-set of monsoon, distribution of rainfall, etc. Tree cover has a vital role for maintaining the earth's ecological balance. Green cover is an integral component of the biosphere, essential for the stabilization of the climate change, management of the land and water. Depletion of forest cover, biodiversity and other natural resource, are leading to poverty and disturbance in hydrological cycle, which in turn affects the cropping pattern and cropping intensity. Depleted natural resource base are to be restored through effective conservation and harvesting of rainwater to rejuvenate forest cover, waterbodies and ground water table.

4.1.3. The importance of tree cover is listed below:

i) Timely on set of monsoons by attracting clouds,

ii) Converts wastelands into productive lands

iii) Restricts soil erosion and water run-off velocity,

iv) Recharges ground water

v) Ameliorate NTFPs and leads to alternative livelihoods,

vi) Improve bio-diversity

vii) Leads to change in micro and macro climate.

viii) Reduces pollution (Air, sound and water)

ix) It helps in carbon sequestration and carbon credits

4.1.4. As per schedule 1, of MGNREGA, the works under Category – A includes public works related to natural resource management especially listed in item (v) such as afforestation, tree plantation, and horticulture in common and forest lands, road margins, canal bunds, tank foreshores and coastal belts duly providing right to usufruct to the households covered in Para 5, of schedule-1, MGNREGA); Item (vi) includes Land development works in common lands.

4.1.5. Works under Category – B emphasizes on Individual assets or community assets for vulnerable sections (only for households in para 5)

In Item (i) for improving productivity of lands through land development and by providing suitable infrastructure for irrigation including dug wells, farm ponds and other water harvesting structures;

Item (ii) for improving livelihoods through horticulture, sericulture, plantation, and farm forestry.

Item (iii) for Development of fallow/ waste lands to bring it under cultivation.

4.2. PLANNING ACTIVITIES:

4.2.1. As per the MGNREGA operational guidelines 2013, the Gram Panchayat Annual Plan for the next financial year gets approved by the Gram Sabha on 15 August of the current year. The planning process to be adopted for the conduct of afforestation, tree plantation and horticulture activities, in a Village or Gram Panchayat, should be participatory in nature involving all concerned stake holders. MoRD has issued a manual on Intensive Participatory Planning Exercise (IPPE) which can be referred for better planning. In the planning process, preference should be given to identify the land use plan prevailing in the given locality. The base line data available with Village Level Officer (Patwari) on land use pattern of the Village/Gram Panchayat needs to be triangulated through participatory planning exercises to identify land for tree planting.

4.2.2. LANDS WHICH ARE IDENTIFIED FOR RAISING TREES ARE:

i) Waste lands,

ii) Barren lands,

iii) Salt affected lands,

iv) Problematic lands (degraded, marginalised, waterlogged, coastal sandy soils, lateritic soils, etc.),

v) Tank foreshore,

vi) Road/Canal/Railway track side

vii) Field boundaries

viii) Institutional lands such as school, Anganwadi, panchayat / government premises, temple land, burial grounds, etc

ix) Common lands

x) Forest lands

4.2.3. After identification of suitable land, the livelihood pattern and needs of the people (especially the vulnerable households) dwelling in the area concerned, must be identified for drawing up a suitable plan for tree plantation like fuelwood, fodder, timber, fruit yielding etc.

4.2.4. The Paragraph 5 households (of schedule I), are eligible to enjoy the usufruct rights arising from afforestation, tree plantation and horticulture carried out in common/forest lands. The action plan issued by MoRD on roadside tree plantation defines the process for allotment of trees to the para 5 households and also states, that by engaging these households in the maintenance activities, will not only provide them with additional employment round the year, but will also enhance their livelihood opportunities, thereby creating durable assets. Further the allotment of trees must be socially justified i.e. preference among the needy households for each priority order (To know the descending priority order of the para 5 households, mentioned in Schedule I, under MGNREGA, please do refer para 1.2 of this manual.) while descending, should be given to the poorest of the poor especially landless and other households to avail the usufruct rights.

4.2.5. From the above exercise, for a Village/Gram Panchayat, the identified land, alongwith the number of beneficiaries identified (to whom the trees will be allotted) can be drawn up for various types of plantation as shown in Annexure- IV, through a group of resource persons from the concerned Village/Gram Panchayat and technical resource persons from concerned line Departments at the Gram Panchayat/Block level. It is suggested that the identification of location specific species, must be with the guidance of local wisdom and technical support from the concerned line departments. To achieve this, the concerned line department to prepare the list of forest/horticulture plant species, region-wise as suitable to the type of plantation and as per agro-climatic condition (the list of plants species needs to be prepared before the start of the participatory planning exercise in the village/GP). The prepared list of plants species will become an informed choice for the identified beneficiaries of para 5 of schedule 1, who will in turn make his/her choice when asked by the planning team for the selection of species for the conduct of plantation activity and for estimating the number of plants required to be raised in the nursery or to be procured from outside nursery. (It is advised that each State/UT prepare the list of forest/horticulture plant species, suitable to the type of plantation and as per the agro-climatic condition, as shown in Annexure-V. The list of plants species if needed may be revised annually.

4.2.6. As tree planting is a time bound activity, it should be taken up in a mission mode. It is therefore necessary to prepare the month-wise schedule of activities for raising nursery (as shown in table 4.1) and the month-wise schedule of activities for the conduct of tree plantation along with responsible stakeholders for each financial year covering the entire maintenance period as shown in annexure VI, by the concerned line departments.

Table 4-1: Indicative Month wise schedule of activities for preparation of nursery under MGNREGA

Month	Schedule of Activities for raising of nursery
Aug	Selection of SHGs or other groups/committees/beneficiaries, by the Gram Sabha, for taking up nursery works. Training to the beneficiary group/Officials by concerned line department
Sept	Selection of Nursery site considering essential parameters. Preparation of drainage system at nursery, Making nursery sheds with thatch and bamboo, Purchase of nursery tools, FYM, Insecticides, Collecting good soil, fencing, cleaning of site & preparation of mother beds, Collection, Treatment, and sowing of seeds, and watering regularly
Oct	Filling up poly bags with FYM (dust & screened) good soil (1:3), Weeding, maintenance and watering regularly
Nov	Pricking out seedling from Mother bed and planting in poly bags, Weeding/cleaning beds, maintenance, watering & shade
Dec	Weeding/cleaning beds, maintenance, watering & shade
Jan	Weeding, maintenance, watering & shade
Feb	Shifting polybags, Weeding, maintenance, watering & shade
March	Weeding, maintenance, watering regularly
Apr	Shifting polybags, pruning roots coming out from polybags, Weeding, maintenance, watering & shade
May	Weeding, maintenance, watering regularly
Jun	Shifting polybags, pruning roots coming out from polybags, Transportation of poly bags with plants to plantation sites, Weeding/cleaning beds, maintenance, watering regularly
July	Transportation of poly bags with plants to plantation sites, Weeding/cleaning beds, maintenance, watering regularly
Aug	Transportation of poly bags with plants to plantation sites, Weeding/cleaning beds, maintenance, watering regularly

4.2.7. It is advised to the States/UTs to prepare a small booklet in vernacular language, by compiling information gathered on Annexure number IV, V, VI, VII, VIII, IX, X and Table 4.1, 4.2, 4.3. with other necessary information, as per local specific agro climatic condition. Also a small booklet with information in vernacular language, not more than 10 pages to be prepared for – Recommended package of practices for the tree species selected by the identified beneficiary and kept with him/her, so that the month wise notified task of activities for weeding, manuring, watering etc can be accomplished in a scientific and systematic manner. The two booklets can be prepared by a group of resource persons and technical resource persons from concerned line departments/ RD Department, coordinated by State Nodal Officers nominated for Afforestation/Horticulture for each State/ UT. Also these booklets to be made available to all concerned Engineers/technical staff at Gram Panchayat and Block level before the start of nursery and tree plantation activity.

4.2.8. Monitoring: Monitoring of the on-going works need to be undertaken by the Gram Rozgar Sahayak (GRS) and Village Monitoring Committee (VMC) set-up at Gram panchayat level. VMC need to monitor 100 per cent of works.

Monitoring	1. Field Assistant – Once in 7 days 2. Technical Assistant – once in 15 days 3. Asst. Programme Officer – once in a month 4. Addl. Programme Director - once in three months 5. Project Director/District Programme Coordinator – as and when situation demands

4.3. TYPES OF PLANTATION:

Raising of tree species varies with the purpose and type of plantation. Broadly two types – Linear and Block Plantation

4.3.1 LINEAR PLANTATION: Trees are planted in a line or in linear strips. Linear plantation include Bund Plantation, trees planted along the sidesof Roads, Canals , Railway tracks etc.

4.3.1.1 BUND PLANTATION:

Under Bund Plantation, tree species including fruit bearing, timber yielding, fodder (green manure yielding), fibre, oil yielding, are planted on the bunds. Interspacing between the pits depends on the type of species to be planted. Intra spacing of bunds depends on the nature of slope.

Image 4-1: Bund plantation

Criteria for selection of species for bund planting:

i) Tree which grow straight and have less canopy to avoid smothering effect

ii) It should be farmer friendly, economical and multipurpose tree species

iii) It should not compete with the main agriculture crop for nutrient and water

iv) It should not be an alternative host for pest and diseases

v) It should be drought resistant tree and act as wind break

Benefits: Strong live fences, fruit, timber, fuelwood, fodder, etc.

4.3.1.2 AVENUE PLANTATION:

Under Avenue Plantation trees are planted along the road sides, to provide shade, beautification of the landscape, prevention of soil erosion, prevention of dust and noise pollution and enhancement of livelihood.

4.3.1.2.1 ROAD SIDE TREE PLANTATION:

It will not only create productive assets but will also check the deterioration of roads. For the conduct of roadside tree plantation please do refer “Action Plan on Roadside Tree Plantation, under MGNREGA” issued by MoRD, dated 31st July 2014, No. J-11017/17/2008 –NREGA (UN) (Part-II). While planning for roadside tree plantation certain restrictions imposed by engineering, traffic and meant for safety requirement should be followed, which are-

i) Trees should be planted minimum 0.5 meter beyond the toe of the roadway and as close to the edge of the Right-of-Way as possible so that they are not a safety hazard or affect the required sight distance.

ii) Considerations of sight distance and safety be primary.

iii) Trees should be planted clear of roadside drains other drainage structures so that their root system does not interfere with efficient working of the drainage facilities.

Image 4-2: Avenue plantation

For further details please do refer “Guidelines on Tree Plantation along rural roads IRC:SP:103-2014” published by Indian Roads Congress, 2014, for conducting roadside tree plantation on rural roads, And “Guideline on Landscaping and Tree Plantation IRC:SP:21-2009 published by Indian Roads Congress, 2009 for conducting roadside tree plantation on State and National Highways.

Region wise list of tree species based on agro-climatic conditions recommended by Indian Roads Congress (IRC) for different States is provided in **Annexure VII**. A model estimate for road side tree plantation has been provided in **Annexure VIII**.

4.3.1.3. CANAL SIDE PLANTATION:

Planting of tree species on canal sides’ help in reducing the sliding of shoulders of the bunds. It also reduces water evaporation losses due to shading of trees.

4.3.1.4. PLANTING TREES ALONG RAILWAY TRACKS:

Planting trees along Railway tracks helps in checking soil erosion. Waterlogging can be checked by planting Eucalyptus species.

4.3.2. INSTITUTIONAL PLANTATION:

It includes planting trees in the premises of public Institutions/places, such as Public Health Centre (PHC), Schools, Anganwadi centres, Gram Panchayat building, Temple, other Government buildings, burial ground etc. These plantations are expected to provide shade, aesthetic value and are carried out as per the nature of the Institute, e.g. in the premises of School buildings planting fruit bearing tree species of their choice which can supplement nutrition to school students, planting Drum Stick in Anganwadi’s, similarly planting different flowering plants in hospital premises will give relaxation to the patients.

Table 4-2: Indicative list of species as per their economic value

S.No.	Category	Name of Plant
1	Timber	Aam, Ailanthus, Akhrot, Angu, Anwala, Bahera, Bamboo, Banj, Chamkharik, Chir, Deodar, Eucalyptus, Fir, Haldu, Harar, Jamun, Kafal, Khair, Maple, Neem, Poplar, Ringal, Sain, Sal, Salix, Semul, Shisham, Siris, Spruce, Surai, Tejpat and Tun etc.
2	Fuel-wood	Acacia, Banj, Haldu, Eucalyptus, Jamun, Kwiral, Kharsu, Moru, Sain, and Shisham etc.
3	Fodder	Babul (Acacia nilotica),Subabul, Bakil, Bans, Bhimal, Banj, Dhauri, Kharsu, Kharik, Kwiral, Maple, Moru,Neem, Phalyat, Robinia, Shahtoot, Siris and Timla etc.
4	Fruits	Aam, Akhrot, Amrood, Anwla, Bahera, Ber, Harar, Imli, Jamun, Kafal, Malta,Mehal, Nimbu, Shahtoot and Timla etc.
5	Fiber	Kapok (Ceiba pentandra), cotton tree (Bombax ceiba) etc.
6	Oil Yielding	Karanja, Simarouba, Mahua, Cheura, Kokum, Olive, Neem, Jatropha, Jajoba, Tung, Wild Aprikot etc.
7	Rejuvenation of depleting water sources	Akhrot, Banj, Deodar, Maple, Phalyat, Ringal, Siris and Utis etc.

(Source: Forest Works Manual and Schedule of Rates for Forestry related works in Uttarakhand, under MGNREGA, Ministry of Rural Development (MoRD), Govt. of India)

It is advised that each State/UT should list out category wise tree species, as per the agro-climatic condition, as shown in Table 4.2

4.3.3. FARM FORESTRY:

Farm forestry, promote commercial tree growing by farmers on their own land. The National Commission on Agriculture (NCA), as per the report of social forestry, the concept of farm forestry has been restricted to raising rows of trees on bunds or boundaries of fields and individual trees in the private agricultural land itself. Forest Survey of India,under "Trees Outside Forests for rural areas 2002", has categorized Farm Forestry as Trees along field bunds and in small patches of up to 0.1 ha.

4.3.4. BLOCK PLANTATION:

The major plantation method adopted by Forest Department is block plantations, wherein single/multiple species are planted in a large or given area. This type of plantation method is adopted in forest land and common lands to preserve the bio-diversity and enrich energy plantations. The common lands can be planted with diverse fruit yielding tree species, and the usufruct rights can be allotted to groups/individuals following MGNREGA processes.

4.3.5. HORTICULTURE PLANTATION:

Image 4-3: Horticulture plantation

Raising different kinds of fruit yielding tree species, on common and individual beneficiaries land is important because, they mainly: i). Provide nutrition ii). Improve economy, and iii). Improve the environment. MGNREGS has encouraged convergence with horticulture/agriculture departments in order to bring in fallow, barren, uncultivated land under production system. Dry-land horticulture is gaining importance in modern agriculture. Under dry land horticulture system trees such as Ber, Custard apple, Guava, Chikku (sapota), Cashewnut, Mango, Pomegranate, etc., are promoted. The scheme extend the financial support for five years, to ensure 100 per cent survival rate. In individual farmers land, under favourable conditions, tissue culture plants may be promoted to reduce the gestation period and to reap higher yield. Drip irrigation should be promoted. State should provide the beneficiaries a handbook (in vernacular language not exceeding 10 pages) providing information with regard to recommended package of practices for selected species along with schedule of activities to be under taken. A typical estimate for Block Plantation in convergence with other Centrally/State sponsored schemes, or without convergence, on Individual beneficiary/common land is given in **Annexure-IX.**

4.4. RAISING OF NURSERY:

A nursery can be defined as the site or place where quality seedlings are produced. The success of plantations depends primarily on the quality of seedlings. Based on the duration, Nurseries are mainly of two types viz., i) Permanent and ii) Temporary. In a continuing Plantation programme that is likely to go on for more than five years, it is desirable to have at least a few permanent nurseries with proper infrastructure. However, in case of plantation programme with execution period of five years or less, temporary or semi-permanent nurseries can be established in which the cost can be reduced by dispensing with some of the infrastructure elements such as construction of permanent structures for green houses, store and other nursery sheds, fencing with angle iron posts and irrigation facilities. A model estimate for raising Nursery under MGNREGS is provided in **Annexure-X.** The establishment of a nursery and raising of quality seedlings is a technical process. It has been described systematically in the following steps:

4.4.1. SELECTION OF NURSERY SITE:

It is one of the most important aspects for the establishment of a proper and quality nursery. One has to consider not only the physical aspects for the selection of the site but also the end use of the seedlings. Following points may be kept in mind while selecting a site for the nursery.

4.4.1.1. LOCATION:

The site should be centrally located with easy access for transportation of seedlings. It should be close to the area where seedlings are to be utilized. Sites used earlier for agriculture may be avoided.

4.4.1.2. WATER:

Enough water should be available especially during the dry season. A natural source of water, located at a higher elevation, if tapped by gravity will be cheaper. If no natural source of water is available, ground water may be used with drip/sprinkler irrigation system. Use of Solar operated water pumps should be promoted. It is estimated that the water requirement for a semi-arid area is minimum 2,000 litre per day during summer, for every 1,00,000 seedlings. Requirement of water will be somewhat less for moist or cold areas.

4.4.1.3. TOPOGRAPHY AND DRAINAGE:

The area should be almost flat with good drainage. This can be managed by providing gentle slope (5 degrees) and channels should be dug to drain out excess water from the nursery. In the hills Northern aspect (aspect is the direction in which a slope faces) is desirable up to 1,200 m elevation and beyond it, Western or South Western aspect is best for moist areas and Northern for dry areas. Nursery site should not be selected close to the edge of a high forest or in the middle of the grassland. Frost pool areas should be avoided.

4.4.1.4. SOIL:

The ideal nursery should have sandy loam to loamy texture. Sandy soils may be given preference over heavy soils. Soil should have pH 5.5 to 7.5, moderate fertility, with a minimum of 2.5% organic matter. The higher the organic matter content of the nursery soil, the better it is. High organic matter content ensures good retention of nutrients and water and may improve the working properties of the soil. The depth of soil should not be less than 25 cm. It is not always possible to get good soil everywhere. Under such circumstances, one has to get extra soil, sand as well as farm yard manure from outside; therefore, location of nursery should be close to such areas.

4.4.2. LAYOUT OF NURSERY:

4.4.2.1. SIZE AND SHAPE

As far as possible the nursery should be of a rectangular shape; so that it can be divided into smaller nursery beds of rectangular shape, leaving space for roads, inspection paths, dumping of manure and space for people working in the nursery to rest during rain or intervals.

The requirement of the total area for the nursery can be calculated by adding together the area required for mother beds, polybags, entire plant/root shoot cuttings and beds required for rooted cuttings. Another 40% area may be added for making the path. Area will also increase if seedlings are kept in the nursery for more than one year, especially for raising tall plants. Area required for sheds, water tank, storage of seed, manure etc. should also be kept in mind.

Polybags of size 18 x 5.5 cm need 1 m2 for keeping 772 bags and slightly larger bags 18 x 7.5 cm need 1 m2 for keeping 400 polybags. Accordingly 1,00,000 polybags will require 250 m2 area plus 40% for paths. Thus for raising 1,00,000 polybag seedlings, an area of 350 m2 may be sufficient.

4.4.3. ESTABLISHMENT OF NURSERY:

4.4.3.1. SITE PREPARATION:

The site should be cleared properly by removing all stumps, roots, lops and tops. Stones collected from the site may be used for metalling the main nursery road. Thorough ploughing or hoeing to a depth of 30 cm should be done, especially in places where plants are to be raised in the nursery beds. The soil should be levelled to form an even slope or, if a site is flat, should be slightly domed. As far as possible, removing of top soil must be avoided. Drainage channel should be dug as early as possible to avoid soil erosion. Drains should be dug on both sides of the paths and connected to main drain. In plains, drain should be adequately sloped and steps should be used in hills to check the flow of water. For design and planning of drainage system refer para 3.3.2 of chapter 3 of this manual.

4.4.3.2. TYPES AND SIZE OF BEDS:

Beds are prepared to germinate seeds, keep polybags and transplant pricked out seedlings. In the plains, beds of 10 x 1 m size and in the hills beds of 2 x 1 m are generally prepared. However, size can be changed depending on the availability of the area. Width of beds should not be more than 1.2 m otherwise weeding/ watering of seedlings; especially in the middle part of the bed shall be a problem. The beds should be oriented in East-West direction in the plains and should follow contours in the hills. In areas where lifting may be restricted due to frozen ground, orienting beds in a North-South direction will facilitate early thawing by the morning sun, and thereby lifting. Following types of beds are prepared in the nursery.

i) SUNKEN BEDS:

Sunken beds are made in dry season or in arid areas. The objective of sunken bed is to allow outside water to the bed area. These beds are always 15 cm deeper than normal ground level.

ii) RAISED BEDS:

These types of beds are generally made in high rainfall areas. The beds are raised 15 cm above the ground to prevent waterlogging or increase drainage and promote warming of seedbed. Beds are given side supports of bamboos, twigs, bricks or other locally available materials.

iii) LEVEL BEDS:

Level beds are made in normal rainfall areas. Surface dressing should be given so as to maintain proper drainage in the bed. If the soil is heavy such drainage are made necessary.

4.4.4. PREPARATION OF SEEDBEDS:

The plot where seedbeds are to be prepared must be ploughed and levelled and sloped (1 to 3%), depending upon the texture of soil (less slope for sandy soils). It should be ascertained that the soil in the seedbed is light. If necessary, sand and soil (1:1) may be mixed so that the seedlings can break through when germinate, and this will also be helpful when plants are lifted for pricking out. The seed beds should not be over filled in with soil, so as to avoid the washing away of top soil and seed. The surface of the seedbed should be made firm by sprinkling water and then using a wooden plank.

4.4.5. PROCUREMENT OF QUALITY INPUTS:

The procurement process should not deviate from the process specified in the Operational guidelines – 2013. It is necessary to consider the points mentioned below while procuring the polybags, necessary equipment’s, quality seeds, fertilizers, pesticides etc. required for raising nursery and plantations.

i) Specifications in terms of quality, type, quantity etc should be spelt out

ii) Avoid unwarranted, superfluous and non-essential elements

iii) Offers should be invited following a fair, transparent and reasonable procedure

iv) Implementing agency (IA) should be satisfied with the selected offer

v) IA should satisfy itself with the price offered is reasonable and consistent with the quality required.

vi) At each stage of procurement, the concerned implementing agency must be placed on record.

vii) State should encourage “e-procurement” system provided in MGNREGASoft

viii) Procurement details should be displayed on notice boards &information board of panchayats and posted on MIS.

4.4.6. SEED PROCUREMENT:

For proper germination and to obtain a healthy plant, good quality seeds need to be procured. The concerned line departments should be consulted while procuring quality seeds for nursery raising. Some of the basic information provided by concerned line department (as specified in Table-4.3), on selected seeds, must be communicated to the individual/SHG/agency who are going to undertake nursery raising.

Table 4-3: Seed weight, collection time, viability and pre-sowing treatment of selected species

Local Name	Seed Collection Time	Number of seeds/kg	Seed Viability (days)	Duration of Germination (days)	Germination %	Recommended Pre-sowing treatment

It is better to have a nursery journal or register with proper information maintained in the nursery.

4.4.7. SEED TREATMENT (PRE-SOWING):

Seeds contain tiny, fragile plants that live under the hard seed shell. They need water to germinate. Some seeds have such a hard shell that water cannot easily enter the seed to help it sprout. Pre-sowing treatment of seeds facilitate germination, therefore, all plants will be of the same size and will be ready for out planting at the same time. Following methods can be used for the treatment of different seeds to enhance their germination.

4.4.7.1. BOILING WATER TREATMENT:

This method is generally used for the species which have a very hard coat e.g. Acacia and Prosopis. Water is boiled in a pan and seeds are kept in the water only for 1 to 2 minutes. After 2 minutes, pour off the water and replace it with the cold water. Let the seed soaked in cold water for 2 to 3 days or until the seed swells. Seeds are sown immediately after the treatment.

4.4.7.2. HOT WATER TREATMENT:

This method is generally used for the species which have a hard shell e.g. Albizia, Cassia,Callindra, Leucaena, Sesbania, Samanea, etc. Sufficient quantity of water is boiled in a container. Once it is boiled, water is taken off the fire and allowed to cool for about 10 minutes. After that, the seeds are poured into the container and kept as such for 2 days or until most of the seeds have swelled. The water of the container can be changed everyday and seeds are sown immediately after the treatment.

4.4.7.3. COLD WATER TREATMENT:

Some seeds need lots of water to facilitate germination. Others may have chemicals inside the seed which must be removed before the seed can germinate. Examples are Citrus, Gliricidia, Neem and Pinus. Seeds are kept in sufficient water for 1 to 2 days. Water can be changed after every 12 hours and seeds that float on the top must be discarded. Plant all swollen seeds immediately.

4.4.7.4. WET AND DRY METHOD:

This method is generally used for teak seeds. Seeds are soaked in the cold water for one day. Next day, they are spread in the sun to dry for at least 1 day. When dry, they are again soaked for overnight. The process is repeated for about 20 to 30 days after that seeds are sown in a germination bed.

4.4.7.5. CRACKED SHELL TREATMENT:

The method of seed treatment is generally used for the seeds which are contained within a nut. When the shell is cracked, water enters the seed and they germinate immediately. The nuts are kept on a solid surface and hit with a piece of wood or a small hammer. One has to be careful not to hit too hard to crush the seed inside. Once the seed is cracked, sow it immediately.

4.4.8. SEED TREATMENT (PRE-SPROUTING):

This method is used for the seeds which have a very short viability e.g. Neem. Seeds are spread between the pages of newspaper. Wet the paper and put them in the shade. Seeds start germinating and must be transplanted immediately when the roots emerge.

4.4.9. SEED SOWING:

Sowing can be done either by broadcasting/scattering, or in lines along the width of the bed. Broadcasting method is used for minute seeds such as Eucalyptus. These are generally mixed with equal amount of fine sand to facilitate uniform seed distribution. Better germination can be obtained if such seeds are sown in small wooden boxes or other containers, which can be kept under controlled environment, so as to protect seeds from excessive heat, rains etc. The small and medium sized seeds are sown in lines or drills 5 to 10 cm apart, the seed is covered with sand or sieved soil and gently firmed.

Sowing depth is crucial for the production of a uniform bed of seedling. Best germination is obtained in the case of small and medium sized seed, when they are sown as deep (0.3 to 0.6 cm) as necessary to cover them. The general rule is that the upper surface of the seed should be at a depth equal to the diameter of the seed.

Seed density and spacing also play an important role in germination. Too dense sowing may result in damping off disease. Mulching by covering the seedbed with dry grass or paddy straw is helpful, as it helps retain moisture, reduces weeds and improves germination. Seed beds sown with minute seeds should be well shaded. After germination, the shade should be removed gradually in stages and the mulch should also be removed. It has been found that different species have different germination potential. For example, seeds of ‘Siris’, ‘Mango’ etc give 90-100 per cent germination whereas in case of ‘Pipal’, germination is only 1-5 per cent. Sometimes instead of seeds the whole fruit can be sown to obtain better results i.e. ‘Timla’ (Ficus auriculata), ‘Pipal’(Ficus religiosa), ‘Bedu’(Ficus palmata) and ‘Banyan’(Ficus benghalensis), etc.

4.4.9.1. DIRECT SOWING OF SEEDS IN POLYTHENE BAGS:

Sometimes seeds are directly sown in the polythene bags viz. seeds of Gulmohar. In such cases the bags should be completely filled with dry soil and left standing for few days, so that the soil settles. The bags should be watered well the day before sowing. Two seeds should be sown per bag and then covered with sand or with a mixture of sand and soil. Heavy soil should not be used for covering, as the germinating seeds may not be able to break through this hard covering. Seeds directly sown into bags normally attain more growth compared to pricked out seedlings and become ready for planting much earlier. After germination, only one healthy seedling per bag should be retained and the other be pricked out into vacant bags.

4.4.10. VEGETATIVE PROPAGATION OF PLANTS:

4.4.10.1. CUTTINGS:

Seedlings are generally raised from seeds but, in some cases where seed is difficult to get or germination is poor due to small size of seed or infertility, plants are raised by vegetative methods. Cuttings of sections of roots, stems, branches or twigs, which are taken from suitable mother trees. A light, loose rooting medium should be used for this purpose. The soil should be dug 30 cm deep and sand and compost mixed with it. Cuttings of 5–10 mm diameter and 15–20 cm length should be obtained from young vigorous trees. The leaves should be stripped off the cuttings to reduce the transpiration. It is better to keep such cuttings for rooting into small poly houses to maintain humidity and temperature. Some of the common species which are raised through cuttings are Chullu, Mehal, Mulberry, Poplar, Siris, Subabul. The planting period of these species are between February to march while the planting period for Cheura and Timla are between July to August.

Some species such as Shisham, Arjun, Kanji, Jamun, Aam, Neem and Imli grow slow. These species should be grown in beds and should be taken out for planting as ball plants.

4.4.10.2. GRAFTING:

Grafting is a method of asexual plant propagation widely used in agriculture and horticulture where the tissues of one plant are encouraged to fuse with those of another. It is most commonly used for the propagation of trees grown commercially. In most cases, one plant is selected for its roots, and this is called the rootstock. The other plant is selected for its stems, leaves, flowers, or fruits and is called the scion. The scion contains the desired genes to be multiplied in future production by the compound stock and scion combined plant.

Scion: Scion is the part of mother plant used in budding and grafting to develop the fruit tree. It is an upper portion of the composite plant which forms the fruit bearing part of the tree.

Rootstock: It is the part of the original tree on which the scion is worked upon to produce the desirable tree. The scion and rootstock from separate mother plants are considered for budding purpose.

In a nursery, technical hands are needed for the preparation of grafted seedling which also takes time. In the absence of technical hands the Grafted seedlings can also be procured from nearby Horticulture Department nurseries and other Government recognized nurseries.

There is an opportunity under MGNREGS, to identify the rural youth with Job Oriented Certification “JOC” in Forestry or Horticulture or sustainable rural development. These identified youths can be trained at State level as Master trainers on Composting methods, Nursery management, and propagation methods like grafting. Services of such rural youth can be utilized for building capacities of SHG’s and rural youth at Block level to work as para professionals in their respective Gram Panchayats.

4.4.10.3. BUDDING:

It is the vegetative method of plant propagation and can be defined as an art or technique of inserting a single matured bud taken from a desired tree in the rootstock, in such a way that the union takes place, bud sprouts and the combination continues to grow. When scion part is small piece of bark containing single bud, the operation is called as budding.

Methods of Budding:

1. T-Budding
2. Chip Budding

4.4.10.4. LAYERING:

Layering is a method of vegetative propagation by which a good stem is induced to produce roots while it is still attached to the parent plant. In this manner a new plant usually can be developed in a relatively short time and with less trouble than other methods of propagation. It can be used successfully on many fruit yielding trees.

Types of layering:

a) Air Layering,
b) Tip Layering,
c) Trench Layering,
d) Mound Layering,
e) Serpentine Compound Layering.

4.4.10.5. SPECIALIZED STEMS AND ROOTS:

Bulbs, corms, tubers, tuberous roots and stems, rhizomes and pseudobulbs are specialized vegetative structures that function in storage of food. Plants possessing these modified plant parts are generally herbaceous perennials in which the shoots die down at the end of a growing season and the plant survives in the ground as dormant, fleshy organ that bears buds to produce new shoots in the next season. These specialized organs are used in vegetative propagation.

4.4.10.6. MICRO PROPAGATION:

It refers to propagation of plants mainly through tissue culture techniques.

4.4.11. PROVIDING SHADES IN THE NURSERY:

Most of the tree species need shade in the early stage of germination while the seedlings are still tender. Studies have shown that the shade is crucial before and after the monsoon, and had a great effect in increasing the survival of seedlings. Dry grass, bamboo mat, palm leaves or wheat straw can be used as shading material but tin sheets should be avoided. Shade should be slanting towards North-South to protect the seedbeds or seedlings from the hot sun.

4.4.12. MULCHING:

Mulch refers to plant residues and other materials used as a covering for the soil to conserve moisture, reduce run-off and erosion, check weed growth, protect from winter climate or improve the soil. Mulching materials are usually cut grass, foliage, straw etc. Mulching is beneficial, before and after the monsoon, to protect the surface of seedbeds against becoming hard, and thereby inhibiting seedlings in breaking through resulting in delaying or leading to poor germination.

4.4.13. PREPARATION OF POTTING MIXTURE:

The potting mixture should be prepared with meticulous care and control. A fine mixture of soil, sand and manure in the ratio of 6:1:3 should be prepared. Before mixing, the soil and sand should be sieved and pebbles and other undesirable material separated. The manure should not be sieved but rubbed with hands to make it fine and twigs and other impurities should be removed. Insecticides in the prescribed proportion should be mixed in the mixture. The main characteristics of a good potting mixture are- a) It must be light in weight, b) It must be well drained and not hold too much water, c) It must be free from insects, diseases and weed seeds, d) It must not contain clay soil or large amount of ashes and e) All materials must be well decomposed.

4.4.14. FILLING OF POLYTHENE BAGS:

The polythene bags should be punched with a sharp punching tool to make sufficient number of holes, to enable drainage of excess water. By using a pincer like punch, twenty or thirty bags can be punched together. A scoop can be used for filling the potting mixture into the polythene bags or it can be made from locally available materials. After first fill, the bags should be struck on ground to let the soil settle in and firm in and then the pot should be filled again. If loosely filled, soil will settle later and make polybags limp, resulting in dislodgement of roots and heavy mortality of plants during handling. Atleast half to one inch from top of the pot should be kept empty to avoid spillage. Filled polybags should be placed erect within the sunken beds meant for the purpose.

4.4.15. TRANSPLANTING OF SEEDLINGS:

Plants sown in germination beds have to be transplanted into polybags. Transplanting age and time vary, but on an average, it has been seen that earlier transplants are more successful. Too big plants in germination beds may have their roots entangled, and disentangling them may cause seedlings to die. As a general guide to transplanting age, 20 to 30 days (excluding germination period) is adequate for most of the species. For transplanting, a scoop may be used to lift a group of plants with soil. From this soil the individual plantlets can be separated and inserted into holes made in the polybag soil by thrusting a sharp punch. The depth of the hole should be equal to the length of the root of the seedling, so that the root does not bend while being pushed into the hole. After inserting the plantlet roots, the hole is closed over up to the collar of the plantlet. The transplanting work should be done in the afternoon so as to avoid mortality of plants in hot sun. The bed of polybags is gently irrigated after all the polybags have been transplanted in. If transplanting is done in hot weather, proper shade should be provided over the beds to prevent the tender seedlings from getting scorched to death.

4.4.16. AFTER CARE OF SEEDLINGS:

Young seedlings are vulnerable to many factors and major losses can occur if these are not taken care of. Seedlings require after care till they are planted out in the field. This includes weeding, watering, manuring, hardening, protection against adverse climate, diseases and insect pests.

4.4.17. WEEDING:

Weeds come with manure, clay or sand transported from outside. This operation should be carried out at the earliest opportunity after the weeds have become visible. If two seedlings of the species sown have come up in a polythene bag, one of these should be immediately pricked out and transplanted into another polybag. If any clutter or muck fills up the bags, these should be cleaned. In the mother beds, it is also desirable to hoe the soil periodically, apart from removing the weeds. These seemingly simple operations matter a great deal in determining the growth of plants.

4.4.18. WATERING:

The soil surface of the seedlings should not be allowed to dry. Seedbeds and transplant beds should be watered twice a day. Excess watering promotes the growth of fungi by decreasing the temperature and increasing soil moisture. In the exposed surface of the nursery bed, soil surface temperatures can rapidly rise to over 45°C on a warm sunny day. It can damage the root-collar area and kill the seedlings. To prevent damage, the soil surface should be kept cool by proper watering. There are a number of methods of watering. The one most commonly used is sprinkling water by a rose can or through hoses.

4.4.19. PEST CONTROL:

Periodical spray of insecticides and fungicides is essential to control insect and fungal diseases in the nursery. Some of the common fungicides and insecticides are Captan, Zineb, Blitox, Cumin, Dithane M-45, Thimet, Chloropyrophos etc. These should be used immediately when disease or insects appear as per the recommendations.

Considerable damage is caused by white ants and rats in the nurseries. White ants colonies increase rapidly, where vegetative waste is available. In order to control them, Chlorpyriphos 20 EC should be sprayed after mixing 3 to 4 litres of this insecticide in 1000 litres of water. For the control of rats zinc phosphide or aluminum phosphide should be used.

4.4.20. SHIFTING AND GRADING OF PLANTS:

It is essential to provide adequate growing space in the beds for speeding up the growth of plants in the nursery. Therefore, the surplus plants should be removed carefully and planted in new beds. The beds should be irrigated before the shifting and grading operations. The ultimate spacing between the plants at the time of final shifting should be 15x22 cm. While shifting, plants should be graded according to their heights and put in the beds grade wise.

While shifting the polythene bags, the roots of the plants protruding outside the bags should be cut with sharp scissors. It is better to keep these bags over a polythene sheet to avoid roots penetrating the soil. However, keeping such bags on mounted beds gives better result and avoids root coiling by facilitating air pruning of roots.

4.4.21. PRUNING:

Some species grow very fast in the nursery. Sometimes tall seedlings do not have enough roots to support the many leaves. When these seedlings are planted in the field, they may grow slowly or even die because of roots cannot supply enough water to the leaves. In order to avoid this problem, cut off the tops of seedlings that have grown too tall. Use a sharp knife to trim the tops of these species. For example Casuarina, Eucalyptus, Leucaena, Gliricidia, Azadirachta (Neem), Sesbania etc. Root pruning is also essential to avoid deep penetration of roots in the soil and in the process, the plant gets hardened. Pruning of roots helps in the development of tertiary roots.

4.4.22. HARDENING OFF OF SEEDLINGS:

Life is easy for the plants in the nursery since they receive good care there. However, once planted in the field, life is much harder for them. They may not have enough water or food to live very well. Therefore, seedlings must be made tough to survive well in the field. This is called hardening off. It is achieved by gradually reducing the frequency of watering before one month of planting. However, care must be taken that seedlings are not burnt in the process.

4.4.23. REPLACEMENT OF DEAD/DAMAGED PLANTS:

Care should be taken to replace the dead or damaged plants immediately by sowing of fresh seed or replacing the dead or damaged plants from the existing seedling beds.

4.4.24. TRANSPORTATION OF SEEDLINGS:

Seedlings are very delicate and should be handled properly. The polybag seedlings should always be held by the bag and never by the plant itself. Seedlings should be watered thoroughly before carrying them to the field. Seedlings should be transported in the trays, boxes or baskets and not tied in bundles with strings or grass. In case of stumps, they should be bundled, wrapped with a wet sack and transported to the field. The plants should be kept in shade and plants not planted the same day should be sprinkled with water in the morning and evening.

While transporting bare root seedlings, the nursery beds from which the plant is taken should be irrigated so as to facilitate making of ball plants. After making ball plants, they should be graded according to their height and put in shade. In order to keep the earthen balls around the roots intact, the balls should be wrapped in grass and tied by sutli (Thick thread).

4.5. LAND DEVELOPMENT AND IRRIGATION INFRASTRUCTURE:

The marginal, degraded and wastelands needs to be developed before sanctioning of afforestation or horticulture plantation in the beneficiary/revenue land. The land development works are:

i) Bush clearance

ii) Boulder removal

iii) Construction of farm bunds

iv) Construction of farm ponds

v) Construction of dug wells

vi) Construction of trenches (Continuous Contour Trench (CCT), Staggered Contour Trench (SCT), Cattle Proof Trench (CPT), Trench cum Bund (TCB)

vii) Strengthening the boundary bunds

viii) Low cost boundary fencing to avoid grazing by stray cattle. For example: growing thorny species such as agave or live fencing.

In areas wherein the boulders are in large number and size, and where work is not at all possible manually, in such cases, use of tractor mounted compressor hammer for rocky strata and lifting device/chain pulley (motorized) as prescribed in the circular issued by MoRD, can be allowed (refer to circular No. 11011/09/2014–Re–I, issued by MGNREGA Division, MoRD, dated 25.08.2014. While conducting an operation through machines it must be ensured that it does not lead to soil erosion, cutting of trees, water pollution etc.

4.6. PLANTING TECHNIQUES:

The planting techniques adopted for raising tree plantation is discussed in brief hereunder:

4.6.1. SELECTION OF SITE:

The selection of site and selection of species are interdependent. The selection of site is however more important, as the selection of species depends upon the selection of site. The site selected for planting should be suitable for the growth of species desired to be planted. While executing planting, factors such as the prevailing soil type, soil depth, local weather factors and advice of the local villagers should be considered.

4.6.2. SELECTION OF TREE SPECIES:

In general, while selecting the species for planting the following points should be considered:

i) Suitability of soil and climatic conditions for a particular tree species,

ii) Purpose of planting a species e.g. to control soil erosion and recharge of ground water,

iii) To meet immediate needs of the community (Fruit, fuelwood, fodder, timber etc.) living in the vicinity of the area,

iv) Selection of species based on the type of plantation undertaken, like roads, canals, farm bunds, wastelands etc.,

v) Addressing the ecology and bio-diversity of the area.

vi) Addressing livelihood opportunities as well as industrial requirements.

It should be borne in mind that the growth behaviour of any plant is considerably influenced by availability of sunlight, temperature and fertility of the soil. Some species have low moisture requirement such as Bakain, Khair, Amaltas, Tungla etc. and can be grown on South facing slopes; as these slopes are comparatively drier due to their exposure to direct sun. Contrary to this, North facing slopes are much humid. Here species like Banj oak, Kafal, Anyar, Burans, Pangar and Maple etc. can be grown successfully.

Maintaining a Biodiversity register also helps to know the indigenous species existing/existed in the given Gram Panchayat. Plant species that are in the endangered category need to be conserved and propagated, to sustain ecological balance and livelihood opportunities of the community living in the vicinity.

4.6.3. SITE DEVELOPMENT:

Land development works such as clearance of planting site, soil and moisture conservation measures (like construction of trenches, earthen bunds, boulder check dams on 'nalas') should be carried out before marking of pits for planting of saplings.

In addition, demarcation of boundary wall or fencing should be carried out. In hilly areas, Lantana shrubs should be cut at one inch height from the ground. These should not be uprooted to avoid soil erosion. Parthenium and other invading shrubs should be uprooted and burnt before the onset of rains. While developing the site for planting, care should be taken to retain all indigenous species of trees and shrubs that are naturally growing in the area. They should not be cut and burnt along with weeds and thorny species. Preferably they should be adopted in the plantation and also circular basin (thanwalas) should be made around each of these plants for retention of moisture.

4.6.4. DIGGING OF PITS:

After land development and before digging of pits, pit sites should be demarcated by using a measuring tape or with graduated sticks to ensure the desired spacing. Pit size depends on the type of specie proposed to be planted. Pits should be dug well in advance. Pits are dug to ensure that the roots of the plants do not curl up once the planting material is placed in it. The soil dug from the pits should be dumped close to the pit. While digging stones, roots of trees, grass or shrubs, if any, should be separated so that while filling the dug up soil back in the pits, these are not mixed with the soil. In slope and hilly areas the pits should always be

Figure 4-1: Digging of pits

4.6.5. PROTECTION OF PLANTATION SITES:

Appropriate fencing of plantation areas is essential to protect the seedlings from damage by the cattle. The choice of fencing depends on the type of terrain, soil depth and nature of soil. Since most of the afforestation programmes are employment oriented, a fence type with high labour input is preferred. Effective fencing is another important criterion, to ensure better survival rate. Some of the common fencing types are discussed below:

4.6.5.1. STONE-WALL FENCING:

A stonewall fence is the ideal choice in hilly areas where stones are generally available in abundance and local people are able to make it themselves. Dry stone masonry wall of sufficient height and width is constructed to keep cattle out. The cost of stone wall fence depends upon the availability of stones and the average distance of their transportation. Sometimes stones may have to be quarried using the crowbar, in which case the cost may go up. The stone wall does not last long because it is built dry therefore it should be fortified with live fencing by planting agave or euphorbia species. For this purpose planting can be done at a spacing of 50 cm along the outer periphery of the walls during the rainy season.

4.6.5.2. CATTLE PROOF TRENCHING:

Cattle proof trench (CPT) along the boundary of a plantation checks cattle infiltration and trespassing. It not only works as a fencing but also recharges ground water. CPT should be promoted in areas, which are facing scarcity of water. In constructing CPT, the side slope in the trench and bund constructed inside the planting area should be maintained as per the angle of repose of the type of soil as referred at para 3.3.2.3. of this manual. The CPT should not be continuous and there should be breaks of low height at an interval of 10-15 metres to check channelization of water.

4.6.5.3. LIVE FENCING:

Live fencing is more preferred in humid climatic conditions as it leads to generate biomass to enrich the soils fertility, environment management, nutrition balance, employment generation and economic security. Unpalatable plants are raised as live fence to avoid grazing and entry of stray cattle. It is a cost effective fencing as compared to other fencings. Also refer advisory issued by MoRD on “Live fencing to protect crops from wildlife depredation” vide No. J-I1017/4012011-MGNREGA (UN), dated 5th July, 2012.

4.6.5.4. SOCIAL FENCING:

In community areas and areas close to habitations, local villagers must be encouraged to resolve among themselves by not sending their cattle in plantation areas and protect trees, grasses growing in the plantation areas. Stall feeding to be promoted and the grasses so produced can be shared by the villagers as per a mutual agreement.

4.6.5.5. TREE GUARDS:

Among tree guards, bamboo tree guards where bamboo is locally available, should be promoted (refer advisory No. No. J-11017/ 40/2011-MGNREGA (UN), issued by MoRD, dated 11th January, 2012). In dry regions, twigs of thorny species such as Prosopis juliflora acts, as protectors for the saplings. The twigs of the thorny species are tied along the sapling which protects saplings from grazing by the stray cattle. The stem of lantana camara and Jatropha can also be used to weave the tree guards.

4.6.6. FILLING OF PITS:

The dug soil dumped near the pits should be filled back as per the schedule of activity for the plantation say in the month of May or before a month of monsoon, so that the pit and the soil to be filled are exposed to sunlight. Insecticides may also be mixed in the soil while filling back into the pit. The pit should be filled a little above the ground level so that the soil gradually settles in the upper surface of the pit, comes to the level of the ground thus avoiding any water logging. While filling the pits, the area surrounding the pit should be scraped with spade to remove grasses or weeds. Top soil should be filled in the bottom of the pit and after this, subsoil should be filled.

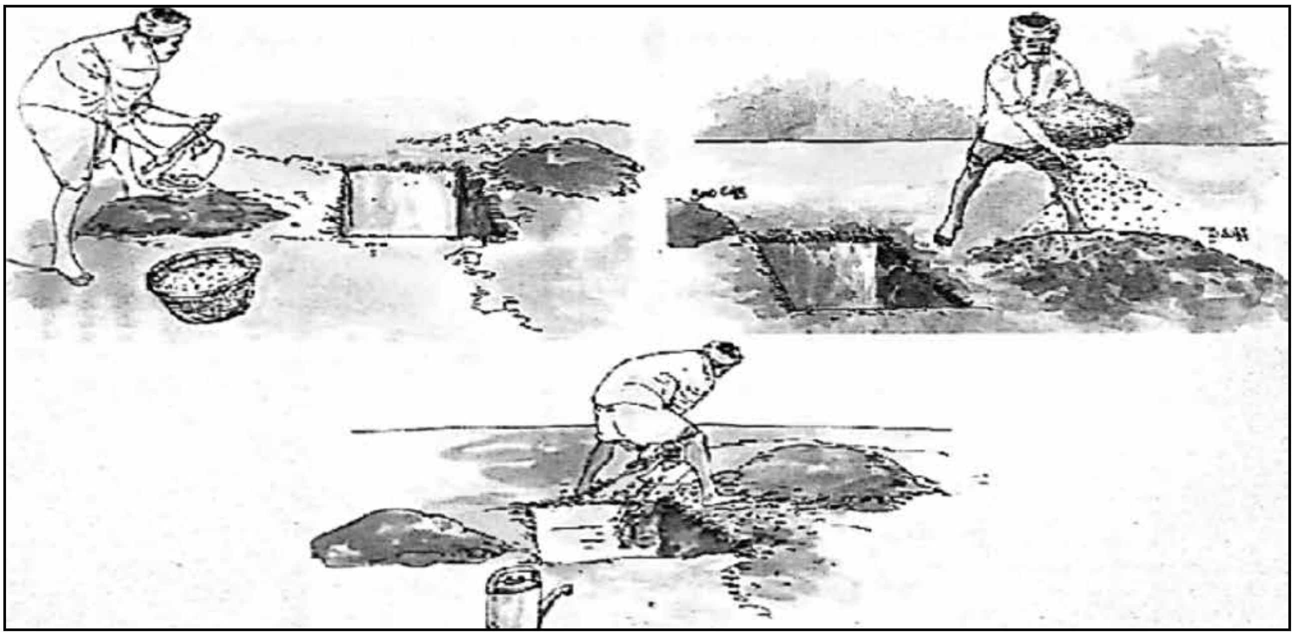


Figure 4-2: Filling of pits

4.6.7. PLANTING OF SAPLINGS:

The plantation of sapling must be done in the first week of the month when monsoon rain has begun. Planting of naked root plants should be completed as early as possible so as to take full advantage of the rain. The planting work should be done either in the afternoon or during light rain or cloudy sky. The roots of the plants should be kept straight and the plant put straight in vertical position. For this a hole should be made with the help of a stick or small crow bar. The collar of the plant should be kept at the surface level of the pit. After planting the sapling, the soil around it should be firmly pressed by hands and while doing so the plant should be pulled about half inch to make sure that its roots are not bending. Species suitable for naked root planting are Pangar, Akhrot, Angu, Utis, Deodar etc.

Image 4-4: Different stages of planting

Bagged plants should be sprayed with water before planting. The polythene should be carefully removed so that the plant is not damaged. The plant with the soil intact should then be placed in the pit in straight position, the collar of the plant being in level with the ground. The soil around the plant should then be pressed firmly by hands only. The planted saplings should be of suitable thickness and height. Just after planting, the plant should be irrigated up to the extent that the water reaches up to the depth of pit excavated. Ideal planting size of some species is given below in Table 4-4.

Table 4-4: Ideal planting size of some species

Sr. No.	Species	Height (cm)	Age (Months)
1	Fir	45	40
2	Chir	25	9
3	Deodar	40	26
4	Khair	25	4
5	Bakli	45	4
6	Neem	50	12
7	Shisham	45	12
8	Tun	25	12
9	Acacia	40	6

(Source:- Forest Works Manual and Schedule of Rates for Forestry related works in Uttarakhand, under MGNREGA, Ministry of Rural Development (MoRD), Govt. of India.)

4.6.8 WINTER PLANTING:

Species like Akhrot, Angu, Maple, Pangar, Poplar, Salix, Utis etc. are planted in winter months. Most of these species remain leaf less during winter. These can be planted in January or beginning of February. By March the buds sprout. If at the time of planting there is lack of moisture in the soil, it is advisable to irrigate the plants once or twice after sprouting to ensure the success of the plantation.

4.6.9. REPLACEMENT OF DEAD PLANTS:

Dead, dying or dry plants should be replaced within 15 days of completion of planting work. This operation is called beating up.

4.6.10. SOIL WORKING AND WEEDING:

Basin (Thanwalas) should be made around all the seedlings having inward slopes. For this purpose a semicircular pit about 15 cm deep, 25-30 cm apart from the plant should be dug. The earth taken out from the pit is put around the base of the plant. This has double advantages; firstly, there will be no water logging at the base of the plant which may otherwise cause damage to the plant; secondly, the rain water collected around the plant will help in retaining the moisture for the plant. Naturally growing species which have been adopted at the time of site development should also be included in basin (Thanwala) making and weeding / hoeing operations.

After the rains are over, capillary actions begin in the pits. This causes loss of moisture due to evaporation in the hot sun. To check this, weeding and hoeing should be done in and around the pits. During this operation, grasses and weeds should be removed and the earth clumps should not be broken.

4.6.11. MAINTENANCE AND AFTER CARE:

As per MGNREGA guidelines under afforestation, tree plantation and horticulture, usufruct benefits will be enjoyed by the para V households. If the trees are allotted to the beneficiaries then they will maintain/ safeguard the plants. They can do it individually or in groups after the planting work is over. The individual beneficiary or self-help group to whom the trees are allotted, should do periodical watering, weeding, and manuring following the schedule of activities prescribed by the concerned line department and which will be monitored by the Gram Panchayat. For example amount of manure and water required etc. will all be calculated for every individual tree species and presented in a tabular form for easy understanding of the beneficiary. If necessary, training will also be imparted to the beneficiaries for effective management of the plantation. They will also repair the tree guard/fencing whenever find necessary to protect the plantation area from grazing and damage by stray cattle and trespassing. For plant nutrition, as per the nature of tree species and availability FYM, Vermi-compost, Nadep compost, liquid bio- fertilizers should be promoted

4.6.11.1. JEEVAMRUTHA:

It is a liquid bio fertilizer. For preparing 200 litres of Jeevamrutha, ten litres of cow urine, 10 kg cow dung, 2 kg Jaggery, 2 kg powder of any pulse, and small quantity of soil of the respective area is needed. All are mixed nicely by a stick. The prepared solution should be used within two to seven days period. The approximate cost per litre comes to be Rs 0.90 (Cow urine per litre, Rs 5, Cow dung per kg, Rs 3, Jaggery per kg, Rs 30, Pulse powder per kg, Rs 20).

4.6.11.2. MAINTENANCE IN SUBSEQUENT YEARS:

The schedule of activities prescribed by the concerned line department and monitored by the Gram Panchayat should be followed for the subsequent years also. Gap filling works should be carried out in the second and third year. In this operation the dead plants are replaced by planting fresh saplings immediately at the onset of monsoon rains. Under normal conditions not more than twenty per cent plants are required to be planted during the gap filling operation in the second year, and ten percent in the third year. The reasons for mortality should be ascertained. The dead plants should be replaced by the healthy saplings. Till the fifth year the schedule of activities should be followed so as to get a healthy plantation.

There is a need to maintain a plantation journal recording the activities undertaken in each financial year.

4.7. CONVERGENCE:

MoRD has insisted on convergence for gap filling and value addition with the line departments such as Agriculture, Horticulture, Forestry, Water resources, Irrigation, PMGSY, NRLM and other programmes to facilitate in enhancing the quality and durability of the assets created under MGNREGS.

Table 4-5: Possible areas for Convergence

Sl. No.	Area of Convergence	For Technical & Managerial expertise
1.	Central / State Finance Commission Grants	Concerned line department and GPs
2.	National Rural Livelihood Mission (NRLM)	RD&PR Department
3.	Integrated Watershed Management Programme (IWMP)	Watershed Department/RDD
4.	Backward Region Grant Fund (BRGF)	RD&PR Department
5.	Rashtriya Krishi Vikas Yojana (RKVY)	Agriculture Department
6.	National Afforestation Programme (NAP)	Forest Department
7.	Green India Mission	Forest Department
8.	Lac Development Scheme	Forest Department
9.	Schemes pertaining to Silk Board and Sericulture	Sericulture Department
10.	Pradhan Mantri Gramin Sadak Yojana (PMGSY)	RD&PR Department
11.	Action Plan for Roadside Tree Plantation under MGNREGA	MGNREGA/ PMGSY /National Highway Authority of India (NHAI)
12.	National Horticulture Mission (NHM)	Horticulture Department
13.	Schemes of National Horticulture Board	NHB
14.	Expansion of Area under Coconut (AEP) scheme	Coconut Development Board
15.	Schemes of National Bamboo Mission	State Bamboo Development Agencies (BDA)/Forest Development Agency (FDA)
16.	Schemes for the promotion of cashew Development	Cashew Development Board
17.	Schemes of Rubber Board	Rubber Board
18.	Schemes funded from State budget	Concerned line department and GPs
19.	Mission for Integrated Development of Horticulture (MIDH)	Horticulture Department

(Convergence guidelines issued for S.No. 3, 5, 6, 7, 10, 11, 12, 14, 17 can be referred in para 4.10)

4.8. SCHEDULE OF RATES (SOR):

As per the Act, each state has formulated their own Schedule of Rates (SoR) depending on variation in geology and climatic conditions. Payment for all the works executed under MGNREGS, will be made as per the State specific MGNREGA SoR. In case, SoR of any work taken up under convergence is not available in the MGNREGA SoR, the SoR of the concerned line department can be considered to make the payments.

4.9.DO'S AND DON'TS:

• DO'S:

- Cartage of seedlings by head load from nursery should be in trays or baskets to planting site. Similarly If planting site is far away, then from nursery to transport and from transport to planting site to avoid damage,
- Local species should be selected based on the agro-climatic condition
- Local wisdom should be explored while selecting the species.
- In drought prone areas and rain shadow regions planting of exotic species may be avoided.
- Pitting should be completed at least one month before onset of monsoons
- Raising of nursery should be done well in advance so as to get desired age of seedling/saplings before planting.
- While watering in a nursery do remember:
    a. Do not water at a fixed time each day, but do water when the plants need it.
    b. All species do not require the same amount of water
    c. Small seedlings don't need much water as compared to large plants which need more water and more often
    d. Plants growing in the shade need less water as compared to plants growing in the sun which need more water and more often.
    e. Plant need more water, often on windy days.

• DON'TS:

- Do not place the freshly collected seeds in the sun to avoid loss of seed viability
- Do not leave seeds in damped conditions, to avoid seed mortality
- Avoid dumping of seeds in a gunny bag to restore the seed viability.
- Wrong selection of species such as planting of deodars at low altitudes.
- Planting of weak and damaged saplings.
- Untimely planting of saplings.
- Untimely watering to the seedlings.
- Avoid application of fertilizers and pesticides on rainy days.

4.10. LIST OF ADVISORY/CIRCULARS/GUIDELINES ISSUED BY MINISTRY OF RURAL DEVELOPMENT RELATED TO AFFORESTATION/ HORTICULTURE ARE AT ANNEXURE-XX.

CHAPTER 05

AGRICULTURE INFRASTRUCTURE UNDER MGNREGA




CHAPTER 05

AGRICULTURE INFRASTRUCTURE UNDER MGNREGA

5.1. INFRASTRUCTURE FOR PROMOTION OF LIVESTOCK

5.1.1. POULTRY SHELTER

5.1.1.1. Backyard poultry helps in supplementing income as well as for providing much needed nutritional inputs for rural households. Poultry birds suffer from very poor shelter infrastructure available in villages leading to their poor health and frequent illnesses. High mortality amongst bird's results in high losses and unpredictable low income. To protect the birds from predators and frequent illnesses, a pucca structure is required to act both as a shelter and to provide protection to birds and eggs from predators.

5.1.1.2. A shelter of 7.50 sqm (length 3.75 m and width 2 m) would be suitable for 100 birds. On the longer sides, the shelter will have a 30 cm high and 20 cm thick brick masonry wall up to plinth level. From the plinth to the top of the shelter there is a wire mesh supported by brick masonry pillars of size 30cmx30cm. The shorter side will have a 20 cm thick brick masonry wall with an average height of 2.20m. The roof will be supported by MS angles (wood/ bamboo). The roof will have galvanised iron corrugated sheets. The base of the floor will be constructed by hard moorum filling. The floor will be built by using 2nd grade bricks with masonry in 1:6 ratio of cement mortar.

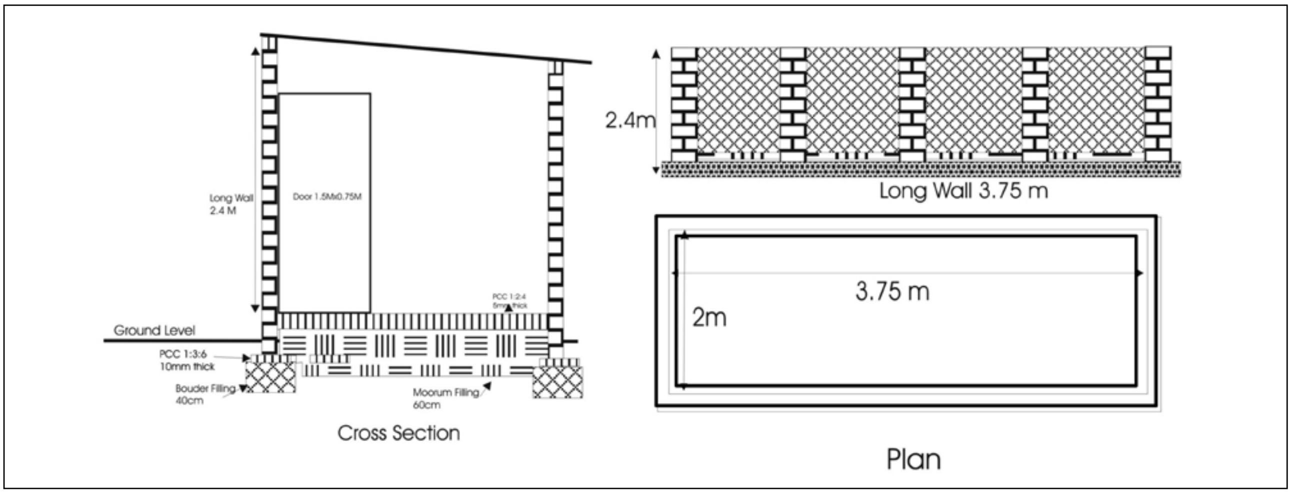


Figure 5-1: Typical Drawings for poultry shed

Table 5-1: Typical estimate of poultry shed for 100 birds

S. No.	Detail	No.	L	W	H/D	Qty.	Unit	Rate	Amount
1	Excavation in Hard Soil for Foundation								
	Long Wall	2	4.25	1	0.5	4.3			
	Short Wall	2	2	1	0.5	2.0			
	Floor	1	3.75	2	0.3	2.3			
	Total Excavation in Hard Soil					8.5	cum	67.8	576
2	Excavation in Hard Moorum for Foundation								
	Long Wall	2	4.25	1	0.5	4.3			
	Short Wall	2	2	1	0.5	2.0			
	Total Excavation in Hard Moorum					6.3	cum	100	625
3	Boulder filling for foundation								
	Long Wall	2	4.25	1	0.6	5.1			
	Short Wall	2	2	1	0.6	2.4			
	Total Boulder filling for foundation					**7.5**	cum	277.6	2082
4	PCC for foundation in 1:3:6								
	Long Wall	2	4.25	0.3	0.1	0.3			
	Short Wall	2	2	0.3	0.1	0.1			
	Total PCC for foundation in 1:3:6					**0.4**	cum	1943.2	729
5	Brick Massonary in 1:4 upto DPC level								
	Long Wall	2	3.95	0.2	0.3	0.5			
	Short Wall	2	2	0.2	0.3	0.2			
	Total Brick Massonary in 1:4 up to DPC level					**0.7**	cum	2509.2	1792
6	DCC for Wall in 1:3:6								
	Long Wall	2	3.95	0.2	0.05	0.08			
	Short Wall	2	2	0.2	0.05	0.04			
	Total DPC for wall 1:3:6					**0.1**	cum	1943.2	231
7	Brick Massonary in 1:4 for superstructure								
	Short Wall	2	2	0.2	2.2	1.8			
	Pillar for long wall	8	0.3	0.3	2.2	1.6			
	Deduction for Door	1	2	1	0.2	-0.4			
	Total Brick Masaonary in 1:4 for superstructure					2.9	cum	2620.7	7715
8	Flooring with 2nd grade bricks packing in 1:6 CM								
	Floor 1	3.75	2		7.5				
	Total					7.5	sqm	210.2	1577
9	Plastering 10mm thick in 1:4 CM								
	Long Wall	32	0.3	2.2		21.1			
	Short Wall	2	2	2.2		8.8			
	Deduction for Door	1	2	1		-2.0			
	Total Plastering 10mm thick in 1:4 CM					27/9	sqm	66.3	1851
10	Ventilator 1M x 2M					8	No.	1000	8000
11	Door 2M x 1M							2000	
12	Provision for GI Roofing Sheet 0.63 mm thick with complete fitting and fabrication	1	4	2.7		**10.8**	sqm	411.6	4445
13	Angle for roof support								
	65mm x 65mm x 6mm					93.96	Kg		
	50mm x 50mm x 5mm					22.8	Kg		
	Total					**116.76**	Kg	52.6	6142
	Total Cost **Rates are taken from SORRES, MGNREGA Dewas District MP applied form July 2011**								**37765**
						Labour		**7006**	**19%**
						Material		**30759**	**81%**

5.1.2. GOAT SHELTER:

5.1.2.1. Most of the poor rural households, who depend on small ruminants, lack the resources to construct and provide for an adequate and safe living space for their cattle. It is well known that for the tribals of Central India, goats and poultry are often more important as a means of livelihood than even minor forest produce. Lack of a safe living space leads to their poor health, frequent illnesses and to their maintaining a very low and uneconomical herd size. In the integrated farming systems of tribal households, the “waste” from livestock systems, such as goat litter and urine are important organic inputs into agricultural farms, increasing soil fertility and raising crop output. Poor shelter infrastructure leads to low and inefficient collection of dung, litter and urine, which is a waste of valuable and locally available organic inputs to farming. Thus, provision of better shelter facilities for goats offers a win-win situation by which animal health and soil health can be improved simultaneously, with very low initial investments. It is one of the most suitable and accepted means of livelihood for the landless.

5.1.2.2. A 7.5 sqm shelter (length 3.75 m and width 2 m) would be suitable for 10 goats. The 4 walls will be raised to an average height of 2.20m. The walls will be of brick masonry using 1:6 cement mortar. The roof will be supported by M.S. angles. The roof will have galvanised iron corrugated sheets. The floor will be of hard moorum.

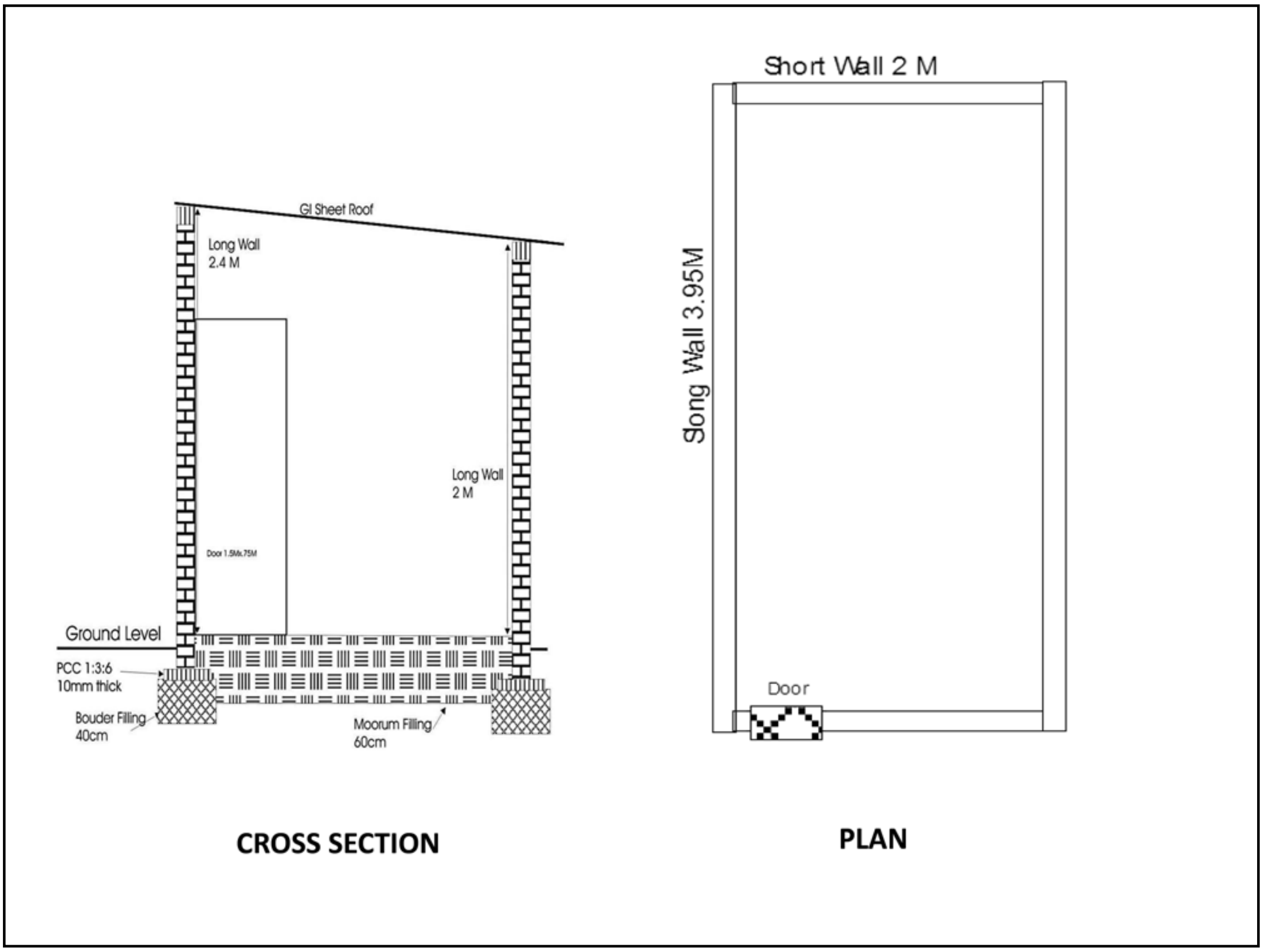


Figure 5-2: Typical Drawings for Goat shelter

Table 5-2: Typical Estimate for Goat shelter

S. No.	Detail	No.	L	W	H/D	Qty.	Unit	Rate	Amount
1	Excavation in Hard Soil for Foundation								
	Long Wall	2	4.25	1	0.5	4.3			
	Short Wall	2	2	1	0.5	2.0			
	Floor	1	3.75	2	0.3	2.3			
	Total Excavation in Hard Soil					8.5	cum	67.8	576
2	Excavation in Hard Moorum for Foundation								
	Long Wall	2	4.25	1	0.5	4.3			
	Short Wall	2	2	1	0.5	2.0			
	Total Excavation in Hard Moorum					6.3	cum	100	625
3	Boulder filling for foundation								
	Long Wall	2	4.25	1	0.6	5.1			
	Short Wall	2	2	1	0.6	2.4			
	Total Boulder filling for foundation					**7.5**	cum	277.6	2082
4	PCC for foundation in 1:3:6								
	Long Wall	2	4.25	0.3	0.1	0.3			
	Short Wall	2	2	0.3	0.1	0.1			
	Total PCC for foundation in 1:3:6					**0.4**	cum	1943.2	729
5	Brick Massonary in 1:4 upto DPC level								
	Long Wall	2	3.95	0.2	0.3	0.5			
	Short Wall	2	2	0.2	0.3	0.2			
	Total Brick Massonary in 1:4 up to DPC level					**0.7**	cum	2509.2	1792
6	DCC for Wall in 1:3:6								
	Long Wall 2	3.95	0.2	0.05	0.08				
	Short Wall 2	2	0.2	0.05	0.04				
	Total DPC for wall 1:3:6					**0.1**	cum	1943.2	231
7	Brick Massonary in 1:4 for superstructure								
	Short Wall	2	2	0.2	2.2	1.8			
	Pillar for long wall	8	0.3	0.3	2.2	1.6			
	Deduction for Door	1	2	1	0.2	-0.4			
	Total Brick Masaonary in 1:4 for superstructure					2.9	cum	2620.7	7715
8	Flooring with 2nd grade bricks packing in 1:6 CM								
	Floor 1	3.75	2		7.5				
	Total					7.5	sqm	210.2	1577
9	Plastering 10mm thick in 1:4 CM								
	Long Wall	32	0.3	2.2		21.1			
	Short Wall	2	2	2.2		8.8			
	Deduction for Door	1	2	1		-2.0			
	Total Plastering 10mm thick in 1:4 CM					27/9	sqm	66.3	1851
10	Ventilator 1M x 2M					8	No.	1000	8000
11	Door 2M x 1M							2000	
12	Provision for GI Roofing Sheet 0.63 mm thick with complete fitting and fabrication	1	4	2.7		**10.8**	sqm	411.6	4445
13	Angle for roof support								
	65mm x 65mm x 6mm					93.96	Kg		
	50mm x 50mm x 5mm					22.8	Kg		
	Total					**116.76**	Kg	52.6	6142
	Total Cost **Rates are taken from SORRES, MGNREGA Dewas District MP applied form July 2011**								**37765**
						Labour		**7006**	**19%**
						Material		**30759**	**81%**

5.1.2.3. GOAT SHELTERS CONSTRUCTED UNDER SA PPLPP IN MADHYA PRADESH:

As an alternative to the above and to facilitate construction of a greater number of eco-friendly sheds at a lower cost , Aga Khan Rural Support Programme (India) (AKRSP(I)) designed a goat shelter with proactive participation of the local community, using South Asia Pro Poor Livestock Policy Programme (SA PPLPP) project funds for the purpose. The low cost alternative, which has a larger floor area, and an attached sky-open enclosure, was completed at about 50% of the cost incurred under MGNREGS (for INR 19,110 only).

The model is cost effective, labour intensive and usage of local material & green technology, therefore vide Ministry letter No. J-11017/40/2011-MGNREGA (UN), dated 3rd December, 2014, it has been advised to consider adoption of the model if found suitable and wherever, such material is locally available.

i) The advantage of this locally evolved design are summarised below.

a) For the goats housed in the shelter

- More area inside the shelter, so less crowding.
- Freedom of movement inside and out side of the shelter, with the option of being in the open air enclosure or so running as required.
- Moderation of temperature in winter and summer as the wood and mud plastering does not trap heat/cold inside.
- Better ventilation and humidity control.
- Closure to nature feel and look.

b) For the goat-rearer

- Ease of construction and possibility of undertaking repairs without having to rely on skilled labour (mason)
- Lesser dependence on external support for financing and construction.
- Higher acceptability among goat rearers, and probability of the shed being used for the purpose designed (most families in poor, rain fed areas lack pucca houses for their habitation and chances of a pucca goat shelter being used for housing the family are higher, leaving the goats without any shelter).
- Higher sense of ownership as labour and material sourcing is done by the owner.
- Use of locally available and eco-friendly material for construction.
- Better housing and management of goats overall, leading to reduced losses from morbidity and mortality, effectively increased contribution of animal husbandry to the GDP.

Table 5-3: Analysis of material and labour costs involved in construction of goat shelter

Sl. No.	Particulars	As per locally evolved design by AKRSP(I) Dimension (LxBxH) in ft. (14x12x8)			
		Quantity	Unit	Rate	Amount
1.	Bricks	-	-	-	-
2.	Cement	-	-	-	-
3.	Aggregates	-	-	-	-
4.	Sand	-	-	-	-
5.	Door	-	-	-	-
6.	Hole pass	-	-	-	-
7.	Windows	-	-	-	-
8.	Flag stone	-	-	-	-

Sl. No.	Particulars	As per locally evolved design by AKRSP(I) Dimension (L*B*H) in ft. (14*12*8)			
		Quantity	Unit	Rate	Amount
9.	Sheet for roof	-	-	-	-
10.	Angle for support	-	-	-	-
11.	Roof tiles	315	No	11.1	3,500
12.	Wooden planks(for floor)	6	6ft. Length	1,000	6,000
13.	Metal strip	1	No	90	90
14.	Nails	-	No	50	50
15.	Wooden logs (large)	15	No	200	3,000
16.	Wooden logs (small)	25	No	150	3,750
17.	Soil (for mud plastering)	1	Tractor trip	300	300
18.	Moorum	-	Tractor trip	350	350
19.	Provision for manger	1	Lump sum	150	150
20.	Mason (skilled labour)	-	-	-	-
21.	Carpenter	1	No of days	350	350
22.	Unskilled labour	10	No of days	1570	1,570
23.	Grand total	Under SA PPLPP project (by AKRSP(I)			19,110

5.1.3. CONSTRUCTION OF PIGGERY SHELTER:

Most of the poor rural households, who depend on small ruminants, lack the resources to construct and provide for an adequate and safe living space for their pigs. It is well known that in many rural areas, piggery is often important as a means of livelihood than even minor forest produce. Lack of a safe living space leads to their poor health and frequent illnesses. Poor shelter infrastructure leads to low and inefficient collection of dung, litter and urine, which is a waste of valuable and locally available organic inputs to farming. Thus, provision of better shelter facilities for pigs offers a win-win situation by which animal health and soil health can be improved simultaneously, with very low initial investments. It is one of the most suitable and accepted means of livelihood for the landless.

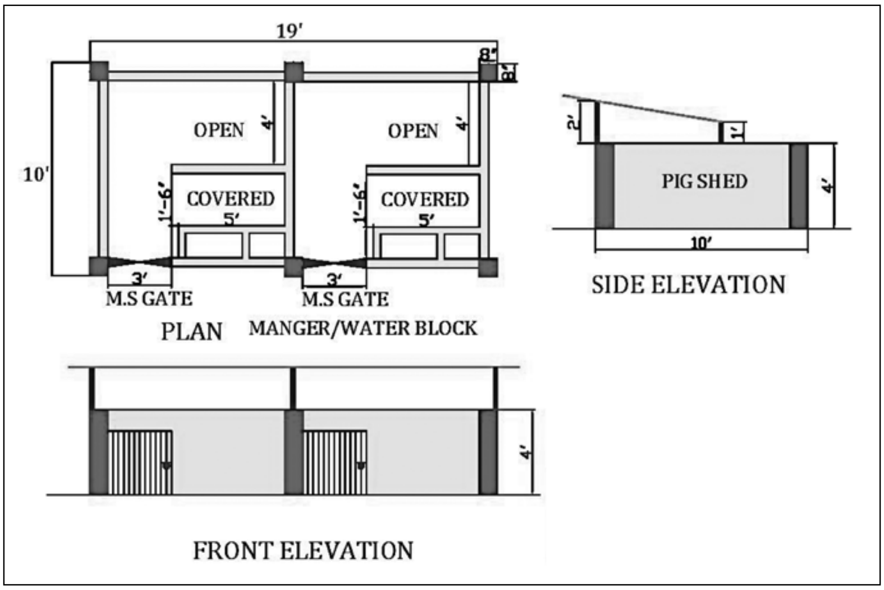


Figure 5-3: Drawings for Piggery Shelter

Table 5-4: Typical Estimate for the construction of Piggery Shelter

ESTIMATE FOR THE CONSTRUCTION OF A LOW COST PIG SHED (2 Units).				
Sl	Particulars	Quantity	Rate	Amount
1	Manpower engaged for jungle clearance, site levelling including throwing of spoils etc all complete.			
	3 labours x 2 days = 6.00 mandays	6.00	200 /mday	₹ 1200
2	Earth work in excavation by mechanical means (Hydraulic Excavator)/ manual means in foundation trenches or drains (not exceeding 1.5 m in width or 10 sqm on plan) including dressing of sides and ramming of bottoms, lift upto 1.5 m, including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50 m.			
	Column			
	6 x 0.60 x 0.60 x 1.20 = 2.59 cum			
	Floor area: 3.00 x 5.80 x 0.30 = 5.22 cum			
	= 7.81 cum	7.81 cum	164.740 /cum	₹ 1287
3	Providing and laying hand packed stone soling in building works with clean hard selected stones all complete.(Manual Means)			
	Footing: 6 x 0.60 x 0.60 x 0.15 = 0.32 cum			
	Floor area: 3.00 x 5.80 x 0.15 = 2.61 cum			
	= 2.93 cum	2.93 cum	560.280 /cum	₹ 1644
4	Providing & Laying in position cement concrete of 1:3:6 mix, including compacting curing etc.(stone aggregate 20mm down) all complete.			
	Footing: 6 x 0.60 x 0.60 x 0.07 = 0.15 cum			
	Floor area: 3.00 x 5.80 x 0.10 = 1.74 cum			
	= 1.89 cum	1.89 cum	3821.970 /cum	₹ 7228
5	Providing and laying in position 1:2:4 mix reinforced cement concrete excluding the cost of form work, finishing & reinforcements but including curing etc. all complete.			
	Foundation base			
	6 x 0.60 x 0.60 x 0.10 = 0.22 cum			
	Pyramid			
	6 x $\frac{0.30}{3}$ x (0.60) = 0.36 cum			
	RCC columns:			
	6 x 0.20 x 0.20 x 2.40 = 0.58 cum			
	= 1.15 cum	1.15 cum	4849.11 /cum	₹ 5586
6	Providing, fixing and removing form work for casting R.C.C items as indicated below: (with locally available timber)			
	Columns upto top:			
	2 x 6 x 1.20 x 0.25 = 3.60 sqm	3.60 sqm	608.86 sqm	₹ 2192
7	Supplying, bending and placing in position of tor steel reinforcement in all R.C.C works i/c cost of binding wires all complete.			
	v.i.no.(5) = 1.15 cum			
	@ 80.00 kg /cum			
	= 92.16 kg. = 0.92 qtl.	0.92 qtl.	6728.30 /qtl	₹ 6201
8	Providing U shaped drain of 23 cm (ht.) x 23 cm (width) internal dimension with 1:2:4 Plum concrete (1cement, 2 clean coarse sand, 4 clean hard selected stone chips of size 20 mm and down nominal gauge) in side walls thickness of 23 cm both side and 1:3:6 c.c mix complete, as per the direction of Engineer-in-charge.			
	= 6.00 mtr	6.00 mtr	694.290 /mtr	₹ 4166
9	Providing and laying first class brick work in half brick thick in superstructure of standard size bricks with 1:4 cement mortar (1 cement and 4 coarse sand) including carriage of bricks upto work site and curing etc. all complete.			
	4 x 2.55 x 1.20 = 12.24 sqm			
	1 x 2.55 x 0.90 = 2.30 sqm			
	2 x 1.65 x 1.20 = 3.96 sqm			

						=	18.50 sqm	18.50 sqm	639.14 /sqm	₹ 11821
10	Providing and laying in position Plum concrete in 1:2:4 mix with stone aggregate of size 20mm down all complete.									
	Manger and Water Blocks:									
	2	x	1.50	x	0.30 x 0.10	=	0.09 cum			
	4	x	0.45	x	0.30 x 0.10	=	0.05 cum			
							0.14 cum	0.14 cum	3441.42 /cum	₹ 496
11	Providing and laying 12 mm thick cement plaster of 1:3 mix in single coat including finishing even & smooth and curing etc. all complete.									
	v.i.no.(9)		=		18.50 x 2 side	=	36.99 sqm	36.99 sqm	132.300 /sqm	₹ 4894
12	Supplying, fabricating, fitting and fixing steel tubular trusses including cutting, hoisting, fixing in position and applying a priming coat of approved steel primer, welded and bolted including special shape washer etc as per the standard specification and design and direction of Engineer - in- Charge all complete.									
	MS Tubular pipe (Square pipes):									
	Columns (38x38)mm, 2.6mm thick:									
					3 x 0.75	=	2.25 Rm			
					3 x 0.45	=	1.35 Rm			
	Purlins (38x38)mm, 2.6mm thick:									
					5 x 2.4	=	12.00 Rm			
					3 x 6	=	18.00 Rm			
						=	33.60 Rm			
					33.60 x 2.73 kg/mtr	=	91.73 kgs	91.73 kgs	65.580 /kgs	₹ 6016
13	Providing, fitting, fixing of 24 BWG GCI sheet roofing with lapping of 150mm (two corrugation) with G.I. hooks, bolts and nut 8mm dia with bitumen, GI limpet washers filled with white bad including coat of approved steel primer and two coats of approved paint, on overlapping of sheet excluding carriage all complete.									
			1	x	6.40 x 2.44	=	15.62 sqm	15.62 sqm	853.440 /sqm	₹ 13327
14	Providing, fitting & fixing of MS gate all complete.									
			MS Gate (0.75x0.9)m:			=	2.00 nos.	2.00 nos.	1000 /nos	₹ 2000
15	Carriage of stock materials on the surfaced road excluding loading and unloading of materials all complete.									
	Cement		15	Kms						
	v.i.no.(4)			=	1.89 x 4.400	=	8.32 bags			
	v.i.no.(5)			=	1.15 x 6.400	=	7.37 bags			
	v.i.no.(8)			=	6.00 x 0.254	=	1.52 bags			
	v.i.no.(9)			=	18.50 x 0.213	=	3.94 bags			
	v.i.no.(10)			=	0.14 x 3.200	=	0.46 bags			
	v.i.no.(11)			=	36.99 x 0.147	=	5.44 bags			
						=	27.06 bags			
					say		27.00 bags			
					say	=	13.53 qtls			
	Steel									
	v.i.no.(7)					=	0.92 qtls			
						=	14.45 qtls			
						=	1.44 MT	1.44 MT	83.550 /MT	₹ 121
	(carriage of materials per MT/Km.)					=	5.57			
a)	Loading and unloading of cement or steel by manual means and stacking.									
								1.44 MT	153.580 /MT	₹ 222
16	Carriage of non stock materials on surfaced road all complete.									
A)	Sand:		15	Kms						
	v.i.no.(4)			=	1.89 x 0.470	=	0.89 cum			
	v.i.no.(5)			=	1.15 x 0.450	=	0.52 cum			

v.i.no.(8)	=	6.00	x 0.063	=	0.38 cum			
v.i.no.(9)	=	18.50	x 0.030	=	0.55 cum			
v.i.no.(10)	=	0.14	x 0.223	=	0.03 cum			
v.i.no.(11)	=	36.99	x 0.015	=	0.55 cum			
				=	2.93 cum			
				=	5385.82 kgs			
				=	5.39 MT	5.39 MT	83.55 /MT	₹ 450
(carriage of materials per MT/Km.)				=	5.57			
Loading and unloading of stone boulders / stone aggregates / sand / kankar / moorum.						2.93 cum	87.000 /cum	₹ 255
B) Stone	5	Kms						
v.i.no.(3)	=	2.93	x 0.950	=	2.79 cum			
v.i.no.(8)	=	6.00	x 0.115	=	0.69 cum			
v.i.no.(10)	=	0.14	x 0.500	=	0.07 cum			
					3.55 cum			
				=	7808.46 kgs			
				=	7.81 MT	7.81 MT	27.85 /MT	₹ 217
(carriage of materials per MT/Km.)				=	5.57			
Loading and unloading of stone boulders / stone aggregates / sand / kankar / moorum.								
						3.55 cum	87.000 /cum	₹ 309
C) Stone chips	15	Kms						
v.i.no.(4)	=	0.00	x 0.890	=	0.00 cum			
v.i.no.(5)	=	1.15	x 0.890	=	1.03 cum			
v.i.no.(8)	=	6.00	x 0.106	=	0.64 cum			
v.i.no.(10)	=	0.14	x 0.445	=	0.06 cum			
					1.73 cum			
				=	3545.61 kgs			
				=	3.55 MT	3.55 MT	83.55 /MT	₹ 296
(carriage of materials per MT/Km.)				=	5.57			
Loading and unloading of stone boulders / stone aggregates / sand / kankar / moorum.								
						1.73 cum	87.000 /cum	₹ 150
							Structure Cost=	₹ 70077
							Deduction of 7.5% Contractors' Profit=	₹ 5256
							Total=	**₹ 64822**

(Rupees Sixty Four Thousand Eight Hundred and Twenty Two) Only.

5.1.4. CONSTRUCTION OF CATTLE SHED:

5.1.4.1. Usually, cattle are kept in sheds with kuchha floor. The place where cattle rest often gets messy with cow dung, cattle urine and water. In particular, during rainy seasons the kuchha floor becomes unhealthy and causes several infectious diseases for the cattle. Also, cattle urine and cow dung are important resources that could enhance soil fertility. **If the floor of the cattle shed is constructed as pucca floors with cement and stones/ bricks, this would enable better collection of dung and cattle urine as well as protect cattle from infections.** A tank constructed for urine collection could be used to make liquid manure to enhance soil fertility. A fodder trough would facilitate proper feeding of cattle and minimise waste of fodder.

5.1.4.2. The area of the cattle shed floor for 6 heads of cattle is 26.95 sqm (7.7mx3.5m). For constructing the cattle shed floor in cement concrete, a 1 cum fodder trough (7.7mx 0.4m x0.65m) and a cattle urine collection tank of 250 litres.

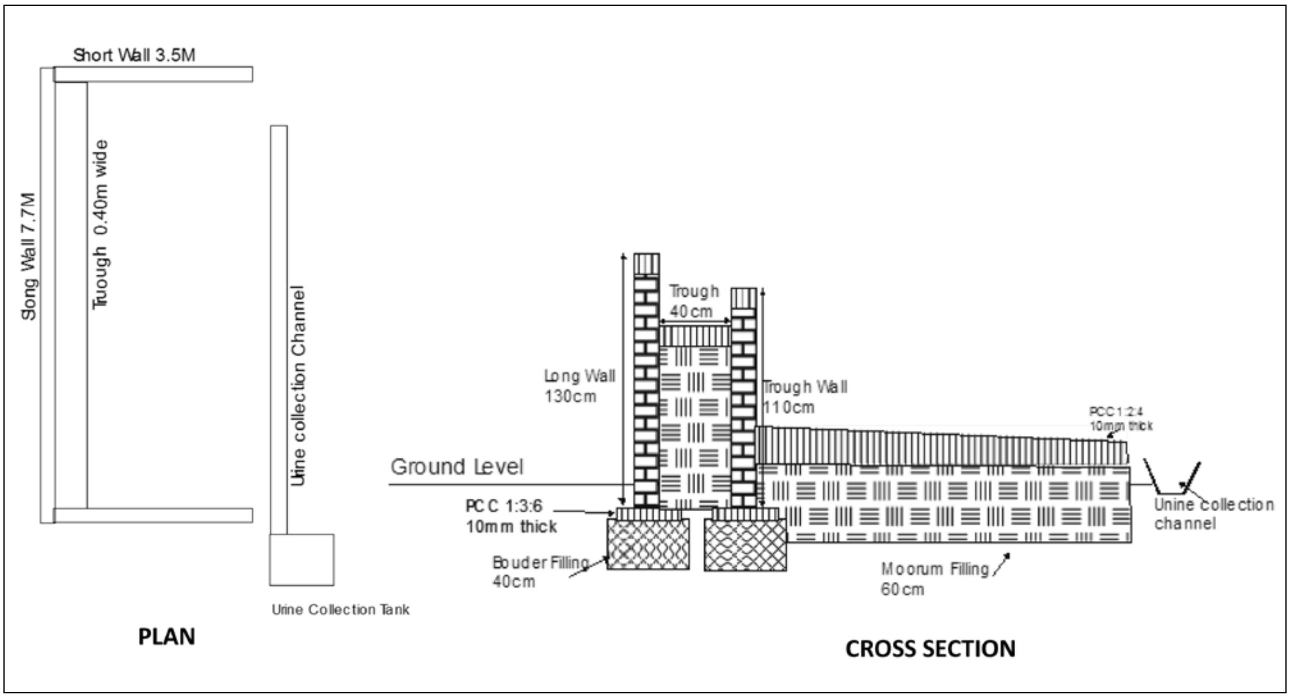


Figure 5-4: Typical drawing for cattle shed

Table 5-5: Typical Cost Estimate for Cattle shed for 6 cattle

Sr. no.	Detail	No.	Length	Width	Height/ Depth	Qty.	Unit	Rate	Amount
1	Excavation in Hard Soil for Foundation								
	Long Wall-1	1	8	1	0.5	4			
	Long Wall-2	1	8	1	0.2	1.6			
	Sort Wall	2	3.5	1	0.5	3.5			
	Floor	1	7.3	3	0.3	6.57			
	Total Excavation in Hard Soil					**15.67**	cum	73.4	1150
2	Excavation in Hard Moorum for Foundation								
	Long Wall-1	1	8	1	0.5	4			
	Sort Wall	2	3.5	1	0.5	3.5			
	Total Excavation in Hard Moorum					**7.5**	cum	97.7	733
3	Moorum filling for foundation								
	Floor	1	7.3	3	0.6	13.14			
	Total Moorum filling for foundation					**13.14**	cum	131.4	1727
4	Boulder filling for foundation								
	Long Wall-1	1	8	1	0.6	4.8			
	Sort Wall	2	3.5	1	0.6	4.2			
	Total Boulder filling for foundation					**9**	cum	330.2	2972
5	PCC for Foundation in 1:3:6								
	Long Wall-1	1	7.7	0.4	0.1	0.308			
	Long Wall-2	1	7.7	0.4	0.1	0.308			
	Sort Wall	2	3.5	0.4	0.1	0.28			
	Total PCC for Foundation in 1:3:6					**0.896**	cum	2249.4	2015
6	Brick Masonry in 1:6 up To DPC Level								
	Long Wall-1	1	7.7	0.2	0.7	1.078			
	Long Wall-2	1	7.7	0.2	0.7	1.078			
	Sort Wall	2	3.5	0.2	0.7	0.98			
	Total Brick Masonry in 1:7 up To DPC Level					**3.136**	cum	3000.1	9408
7	DCC for Wall in 1:3:6								
	Long Wall-1	1	7.7	0.2	0.05	0.077			
	Long Wall-2	1	7.7	0.2	0.05	0.077			
	Sort Wall	2	3.5	0.2	0.05	0.07			
	Total DPC for Wall in 1:3:6					**0.224**	Cum	2249.4	504

Sr. no.	Detail		No.	Length	Width	Height/ Depth	Qty.	Unit	Rate	Amoun
8	Brick Masonry in 1:4 for supper structure									
	Long Wall-1		1	7.7	0.2	3	4.62			
	Pillar for Long Wall-2		2	0.2	0.2	2.5	0.2			
	Sort Wall		2	3.5	0.2	2.75	3.85			
	Trough		1	7.7	0.2	0.65	1.001			
	Deduction for ventilator		-4	1.2	0.2	0.6	-0.576			
	Total Brick Masonry in 1:6 for supper structure						**9.095**	cum	3143.8	28593
9	PCC in 1:2:4									
	Floor		1	7.7	3.5	0.1	2.695			
	Top of Trough		1	7.7	0.2	0.1	0.154			
	Total PCC in 1:2:4						**2.849**	cum	2926	8336
10	Plastering 12 mm thick in 1:4 CM									
	Long Wall-1		1	7.7	1.5		11.55			
	Sort Wall		2	3.5	1.5		10.5			
	Trough		2	7.7	1.5		23.1			
	Total Plastering 12 mm thick in 1:4 CM						**45.15**	sqm	167	7540
11	Roof with 0.63 mm GI sheet		**1**	**8**	**4.1**	**-**	**32.8**	sqm	433.5	14219
12	Provision of 65x65x5mm MS angle for GI Sheet Laying (Shorter Span)		2	4.1	-	-	**40.2**	Kg	69.2	2780
13	Provision of 40mm dia MS pipe for GI Sheet Laying (Longer Span)		3	8			**86.6**	Kg	69.2	5995
14	Ventilator 1.2m x 0.6m						**4**	No.	750	3000
15	Drinking Water Tank 1000 Lit									5000
16	Urine Collection Tank 250 Lit									1250
17	Clamp and other hard ware item							LS		1000
	Total Cost									**96223**
	Note: Rates are taken from MP RES SOR applicable from 06 August 2012									
		Labour cost								**19526 (20%)**
		Material Cost								**76697 (80%)**

5.2. INFRASTRUCTURE FOR PROMOTION OF FISHERIES:

5.2.1. FISH DRYING YARDS:

5.2.1.1. Fish drying yards in coastal areas are concrete surfaces constructed in connection with fish landing centres and fishery harbours for hygienic drying of fish in a traditional way. For this purpose, a yard is constructed on the seashore of 10m x 10m size with 15 cm thick plain cement concrete and brick protection work of 20cm thickness. This yard is covered by a net for protection of fish.

5.2.1.2. This is an activity that can be undertaken both on public land and private land. In the latter case, this activity is only for those households eligible under MGNREGA for work on private land.

5.2.2. FISHERIES IN SEASONAL WATER BODIES ON PUBLIC LAND:

5.2.2.1. Fisheries, as a livelihood activity for the poor, have immense scope. Many small reservoirs, tanks, water harvesting ponds created under MGNREGA are ideally suited for fish production. In the flood plains of Bihar, Uttar Pradesh and West Bengal, there are a large number of small water bodies with potential for fisheries development. These water bodies are mainly fed by surface run-off rain water from local catchments. Varying water spread area, pronounced seasonality of filling, high dependence on rainfall and competitive claims on stored water for irrigation are some of the characteristics of these water bodies.

5.2.2.2. There is a large gap in the potential and actual yields in these rain fed water bodies. There is scope for enhancing the fish production by 3 to 5 times from the current productivity levels. Adopting culture based fisheries with advanced fingerlings (100 mm and above) at stocking rates of 500-1000 fingerlings per ha can substantially increase productivity in the water spread area in small reservoirs, estimated at 1.2 million ha in the country.

5.2.2.3. The activities involved include digging and landscaping of the bed of the water body to suit fish production, ensuring year round dead-storage, protecting the spill-ways and provision of small fish nursery ponds with assured water for rearing fingerlings. A 500 cum fish nursery pond and excavation of 15,000 cum in an existing tank bed, along with a fish drying platform of 30 sqm

The common pool nature of these water bodies makes fish production in them a complex task. This will need to be tackled through appropriate arrangements at the local level, which may require facilitation, especially in the initial stag

5.2.2.4. Typical drawing and estimate of Fish ding pond are given below:

Table 5-6: Typical estimate for fish breeding pond

Sl. No.	Description	No's	L	B	D	Qty (cum)
1	Unskilled labour charges for Earth Work Excavation and dumping earth for bund formation in hard soil with lead of 10mts. And lift of 2mts.	1x4	(25.00+21.00)/2	(15.00+11.00)/2	2.00	2392.00

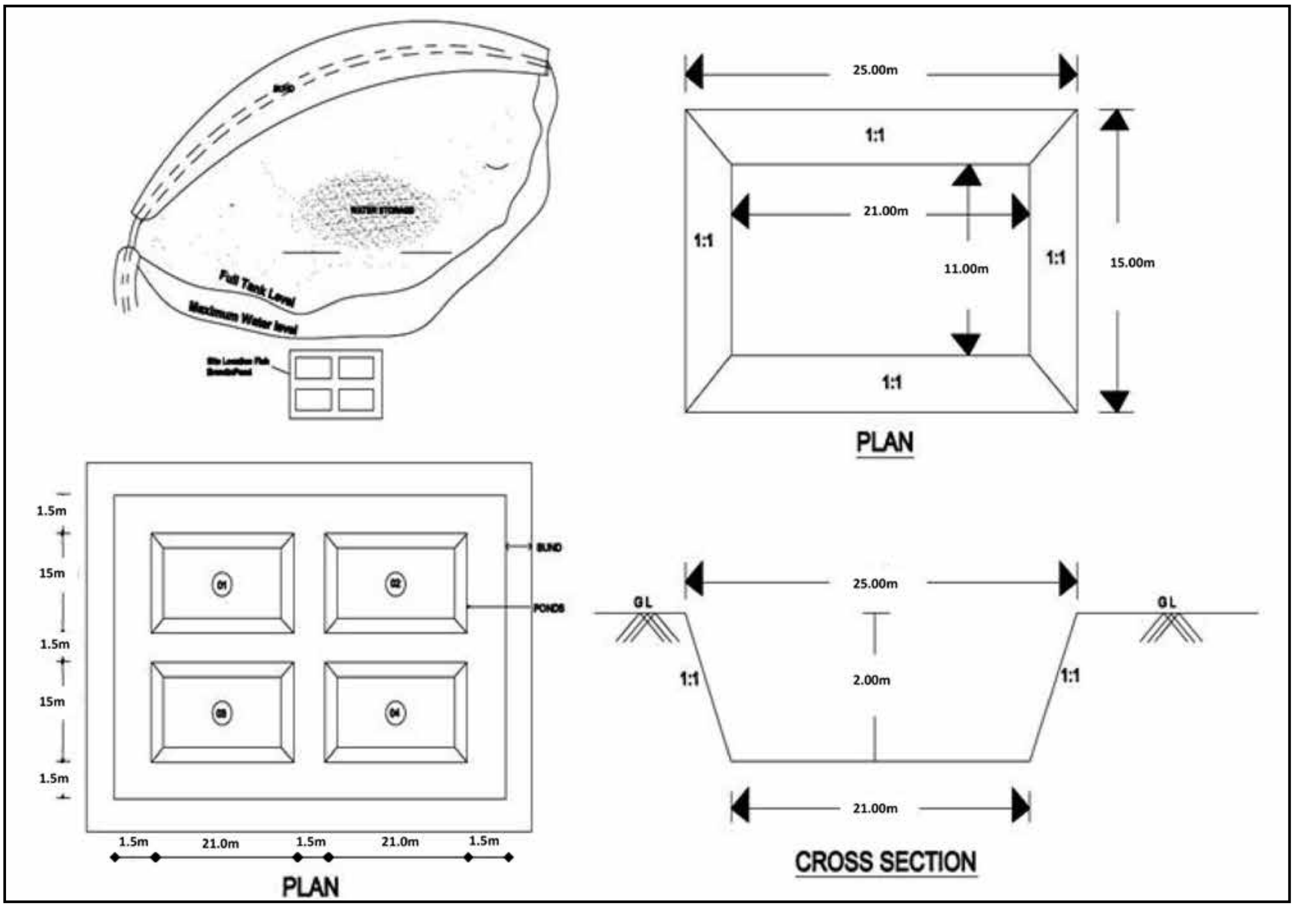


Figure 5-5: Typical Drawing for fish breeding pond

5.3. INFRASTRUCTURE FOR PROMOTING AGRICULTURAL PRODUCTIVITY:

5.3.1. NADEP COMPOSTING:

5.3.1.1. Revitalizing soil health holds the key to improving productivity of Indian agriculture. Composting is a process of utilising and processing solid waste through which its organic component is biologically decomposed to a humus-like state that can be used as fertiliser. Solid wastes usually contain the entire range of micro-organisms in large numbers. Under appropriate conditions, the microbial population grows and in doing so, degrades the organic portion of the waste.

5.3.1.2. NADEP composting involves the construction of a 3.6mx1.5mx1.0m compost trough, which can produce 1 tonne of composted manure in each cycle. This manure is sufficient to cover 0.25 hectare of agricultural land. The NADEP pit is usually constructed with a lattice brick wall to ensure proper aeration. Inside this trough a series of layers of agricultural waste, dung and soil are successively heaped upon each other. About 100-110 kg of agricultural waste is first placed on the ground in a layer which is about 6 inches high. 4 kg of dung mixed in 125-150 litres of water is applied on top of this layer (the quantity of water used varies with the seasonal temperature, more water being necessary in the summer months). On top of the second layer, cleaned and sifted soil (roughly half the weight of the agricultural waste used, i.e. 50-55 kg) free of stones, glass etc. is spread, on which a little water is also sprinkled. In this manner successive layers are heaped to a height of about 1.5 ft. above the top of the trough. After this the top of the pile is sealed with a 3 inch plastering of soil mixed with dung (400-500 kg). Within 2-3 months dark brown, friable, soft and moist compost, free of all foul odour is ready. It has been generally estimated that by the NADEP method, one head of cattle produces 80 tonnes of manure in a year. The nutrient status of this manure is Nitrogen 0.5-1.5%, Phosphorous 0.5-0.9% and Potassium 1.2-1.4%.

5.3.1.3. Typical drawing and estimate for NADEP compost pit are given below

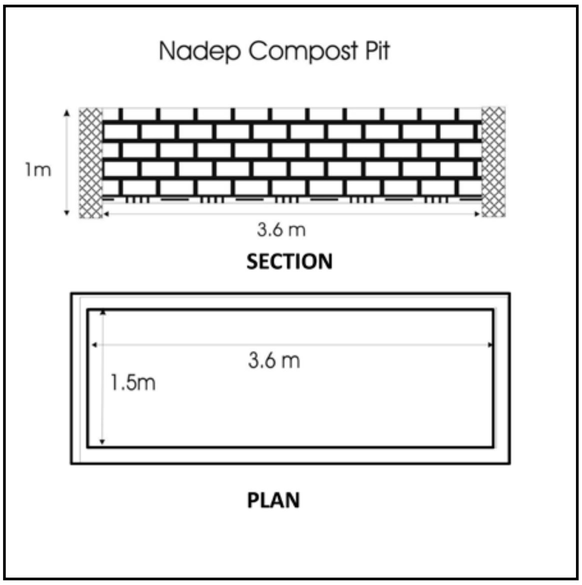


Figure 5-6: Design of NADEP compost pit, Op-1

Table 5-7: Typical estimate for NADEP compost pit, Op-1

	Cost estimate of Nadep compost Pit size								
S. No.	**Detail**	**No.**	**L**	**W**	**H/D**	**Unit**	**Qty**	**Rate**	**Amount**
1	Excavation for foundation in Hard Soil								
	Long Wall	2	4.4	0.3	0.3	cum	0.792		
	Short Wall	2	1.5	0.3	0.3	cum	0.27		
	Total					cum	**1.0672**	67.8	72.0
2	Boulder laying in foundation								
	Long Wall	2	4.4	0.3	0.1	cum	0.264		
	Short Wall	2	1.5	0.3	0.	cum	0.09		
	Total					cum	**0.354**	358.5	126.9
3	Brick Masonry in 1:4 Cement Mortar upto Ground level								
	Long Wall	2	4	0.2	0.2	cum	0.32		
	Short Wall	2	1.5	0.2	0.2	cum	0.12		
5	Brick Masonry in 1:4 Cement mortar above ground								
	Long Wall	2	4	0.2	1	cum	1.6		
	Short Wall	2	1.5	0.2	1	cum	0.6		
	Total Brick Masonary						**2.64**		
	Deduction for Aeration 10% of Masanary work						-0.264		
	Net Masonary work						2.904	2509.2	7286.7
	Plastering at top 1:4 Cement motor								
	Long Wall	2	4	0.2		sqm	1.6		
	Short Wall	2	1.5	0.2		sqm	0.6		
	Total Plastering					sqm	**2.2**	89.8	197.6
	Cost of Nadep Compost								7683
					Labour			**1849**	**24%**
					Material			**5834.2**	**76%**

Rates are taken from SoR RES, MGNREGA Dewas District MP applied from July 2011

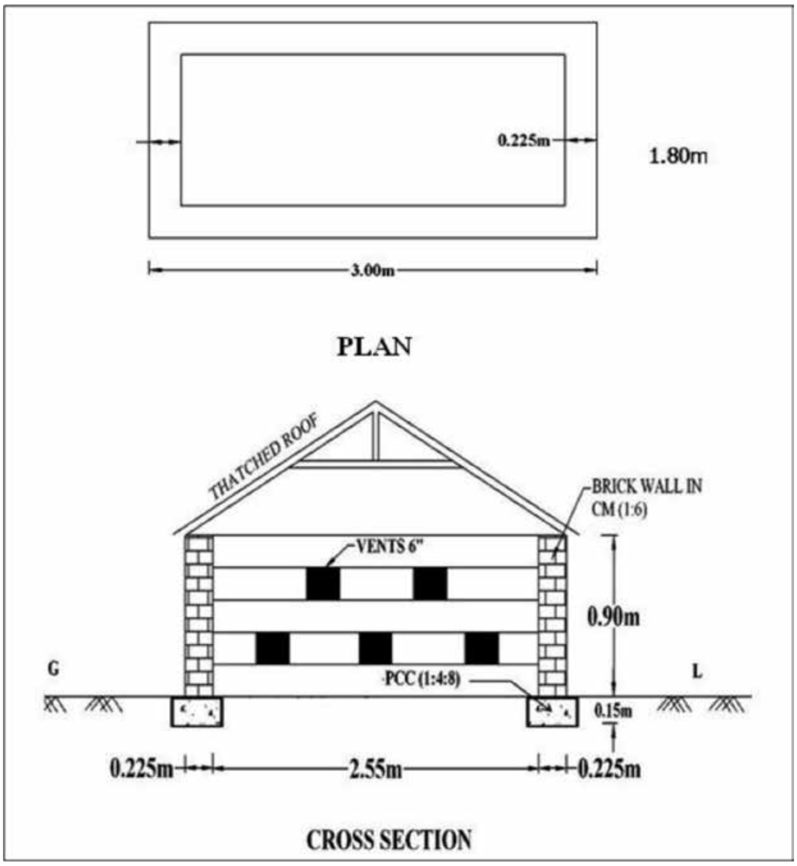


Figure 5-7: Design of NADEP compost pit, Op-2

Table 5-8: Estimate for NADEP compost pit, Op-2:

Sl. No.	Item	No	L (m)	B (m)	H/D (m)	Volume/Area
1	Unskilled Labour Charges for earth work excavation to compost pit brick work foundation	1x1	3.00	1.80	0.15	0.81 cum
2	Plain Cement Concrete C C (1:4:8) with 40mm HBG metal for brick work foundation including cost and conveyance of 40mm metal, sand, cement and water for mortar and curing and masonry charges	1x2	(3.00+1.80)/2	0.30	0.15	0.432 cum
3	Country brick masonry with red earth/ cement blocks in cement mortar 1:6 including cost and conveyance of bricks, sand, cement and water for mortar and curing and masonry charges					
	Long Wall	1x2	3.00	0.225	0.90	1.22
	Short wall	1x2	1.35	0.225	0.90	0.55
	Total Qty					**1.761 cum**

Sl. No.	Item	No	L (m)	B (m)	H/D (m)	Volume/Area
4	Plastering with CM 1:5 including Cost and conveyance of Sand, Cement and water for mortar and curing and masonry charges					
	1) Out of the compost pit	1x1	9.60	.....	0.90	8.64 sqm
	2) Inner side of the compost pit	1x1	7.80	....	0.90	7.02 sqm
	3) Top of the compost pit	1x1	3.00	0.225	....	1.35 sqm
	4) Top of the short wall	1x1	1.35	0.225	....	0.60 sqm
	Total Qty					**17.61 sqm**

5.3.2. VERMI-COMPOSTING:

5.3.2.1. Vermi-composting uses earthworms to turn organic wastes into very high quality Compost. In ideal conditions worms can produce at least their own weight of organic matter in a day. The micro-organisms in the worm casts promote healthy plant growth. Usually, a twin pit model is used for vermi-composting, with the pit size of 3.6m* 1.5m* 0.76 m and with a dividing wall in the middle. Vermi-composts are best suited for intensive application in kitchen gardens and small vegetable plots. One vermi-compost pit produces 0.15 tonne of compost, which is sufficient for enhancing productivity of 0.25 hectare (2500 sq.m.).

5.3.2.2. Typical drawing and estimate for Vermi Compost pit are given below:

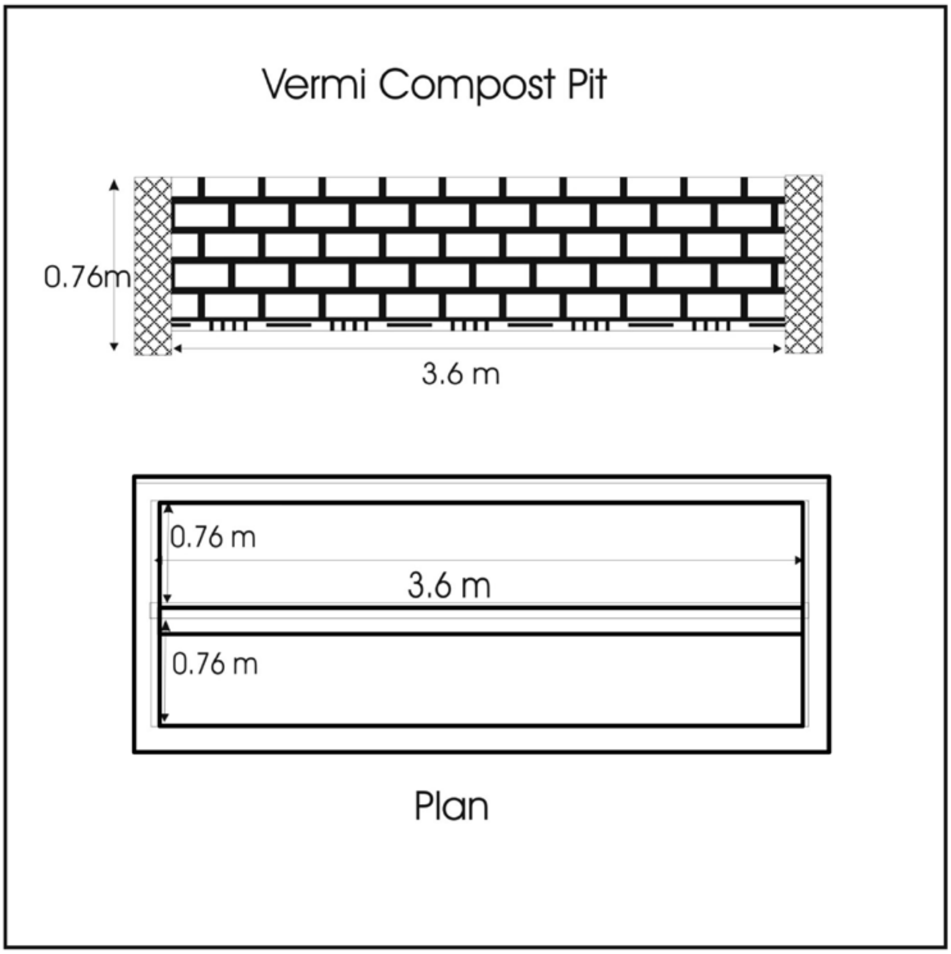


Figure 5-8: Typical drawing of Vermi Compost pit

Table 5-9: Typical estimate of Vermi Compost pit

Cost estimate of Vermi compost Pit (Twin-Pit Model)									
S. No.	**Detail**	**No.**	**L**	**W**	**H/D**	**Unit**	**Qty**	**Rate**	**Amount**
1	Excavation for foundation in Hard Soil								
	Long Wall	3	4.4	0.3	0.3	cum	1.188		
	Short Wall	2	1.5	0.3	0.3	cum	0.27		
	Total					cum	**1.458**	67.8	98.9
2	Boulder laying in foundation								
	Long Wall	3	4.4	0.3	0.1	cum	0.396		
	Short Wall	2	1.5	0.3	0.	cum	0.09		
	Total					cum	**0.486**	358.5	174.2
3	Brick Masonry in 1:4 Cement Mortar upto Ground level								
	Long Wall	3	4	0.2	0.2	cum	0.48		
	Short Wall	2	1.5	0.2	0.2	cum	0.12		
5	Brick Masonry in 1:4 Cement mortar above ground								
	Long Wall	3	4	0.2	0.76	cum	1.824		
	Short Wall	2	1.5	0.2	0.76	cum	0.456		
	Total Brick Masonary						**2.88**	2509.2	7226.5
6	Plastering at top 1:4 Cement motor								
	Long Wall	2	4	0.96		sqm	7.68		
	Short Wall	2	1.5	0.96		sqm	2.88		
	Cost of Nadep Compost								7683
7	PCC 1:2:4 CM for flooring	2	3.6	0.76	0.05	cum	0.2736	2507.5	686.1
	Cost of Vermi Compost Pit								9134
					Labour			**2363.1**	**26%**
					Material			**6770.8**	**74%**

Rates are taken from SoR RES, MGNREGA Dewas District MP applied from July 2011

5.3.3. LIQUID BIO-MANURES: SANJEEVAK OR AMRIT PAANI:

Sanjeevak is a liquid manure application based on cattle-urine. This low cost and effective method has immense potential to improve plant nutrition. In a brick masonry pit of 1.0mx1.0mx1.0m, 50 kg of cow dung, 20 litres of cattle urine, 1 kg jaggery and 1 kg of chickpea flour is mixed with 1000 litres of water. This solution is fermented for 5 to 7 days. This solution should be shaken regularly three times a day. After 7 days, the liquid manure of 1000 litres is diluted and applied on the field. This liquid manure can be mixed with irrigation water (fertigation) at the time when crops are irrigated. This ensures an even spread of the manure in the field. It can also be used in vegetable plots and kitchen gardens. The pit can be filled again and within the next 15 days another round of Sanjeevak can be applied to the crop.

5.4 INFRASTRUCTURE FOR IRRIGATION (DUG WELLS):

5.4.1. WELLS:

A well is a hole, usually vertical, extending in to the water bearing layer in the ground. The quantity of water that can be drawn from a well is known as the yield.

Wells classified according to the method of construction: Wells are classified into dug, driven and drilled wells depending on the method of construction used in the making them. The method selected for constructing a well depends largely on the depth to which it must be carried, the elevation of the ground water table, and the nature of the material through which the hole is to dug. **As per Para 4. II. (i) of Schedule-I, MGNREGA, construction of Dug Wells are permitted under MGNREGS.**

5.4.2.DUG WELLS:

Dug wells are dug down to the water bearing strata. The open excavation is usually circular in shape, the diameter varying from 1.5 to 4.5 m (5 to 15ft.).The wells derive their water from unconfined aquifers. They may be lined or unlined. They can yield relatively large quantities of water from shallow sources. Their large diameters permit the storage of large quantities of water.

i) Dug wells are usually constructed by hand using pick axe and shovel. The earth at the bottom is loosened and collected in buckets. The bucket when full is lifted up by means of rope and pulley.

ii) In unstable material considerable care must be exercised to prevent cave-ins, which may result in serious or fatal injury. Large dug wells can be constructed rapidly with portable excavating equipment such as clam-shell and orange-peel buckets.

iii) Dug wells must be deep enough to extend about 4 to 10m (15 to 35 ft.) below the water table in dry weather.

5.4.2.1. LOCATION OF DUG WELLS:

i) Investigate the existing supplies in the neighborhood of the proposed site as regards depth of hole, quality and quantity of water and pumping head & **go with the advice of the local Ground Water Department.**

ii) Locate the well under sanitary surroundings. Drainage from barns, poultry shelters, toilets etc., should be away from the well.

iii) Locate the well above flood water elevation.

iv) If possible locate the well as near the point of use as possible.

v) The distance from the existing well in nearby should be more than the radius of influence of the soil formation and texture.

vi) Before finalizing the locating

5.4.2.2. CONSTRUCTION OF DUG WELLS:

Good construction requires the well to be lined with a casing (often referred to as a "curb") of stones, brick or concrete. At least the upper 3m (10ft.) should be made water-tight with mortar between the stones and sand and cement plaster, or by use of concrete.

i) The portion of the curb surrounded by the aquifer should be perforated or contain openings to permit entry of water. The curb must be firmly seated at the bottom. The space between the curb and the sides of the excavation should, if practically feasible be filled with clean sand and gravel up to the top of the water-bearing stratum, the coarser material being at the bottom.

ii) Surface water will be prevented from moving down along the concrete casing if puddled clay or concrete is used as backfill. The curb should be brought at least 30cm (1ft) above the ground. For drinking water supplies when the water lifting device is a pump, the well should preferably be covered by a concrete platform in which is cast a man-hole, pump base, and pump hole. The man-hole should have a tight fitting iron or concrete cover.

iii) **Quicksand** is a frequent source of trouble in dug wells. While digging, the flow of quicksand can be largely prevented by removing the material with a bucket or pump and keeping the excavation partially full of water. This neutralizes the hydraulic pressure in the quicksand and renders it comparatively solid.

iv) The edge of the temporary or permanent curbing as the case may be should be driven 0.3 to 1.2 m (1 to 4 ft.) below the bottom of the excavation, as the excavation proceeds. After excavation is completed, further entry of quicksand at the bottom can be prevented by placing a thin layer of clean coarse sand and weighting it with several layers of sand or gravel in increasing coarseness; thereby creating a graded sand filter, each layer of which is held in position by the slightly coarser material above it.

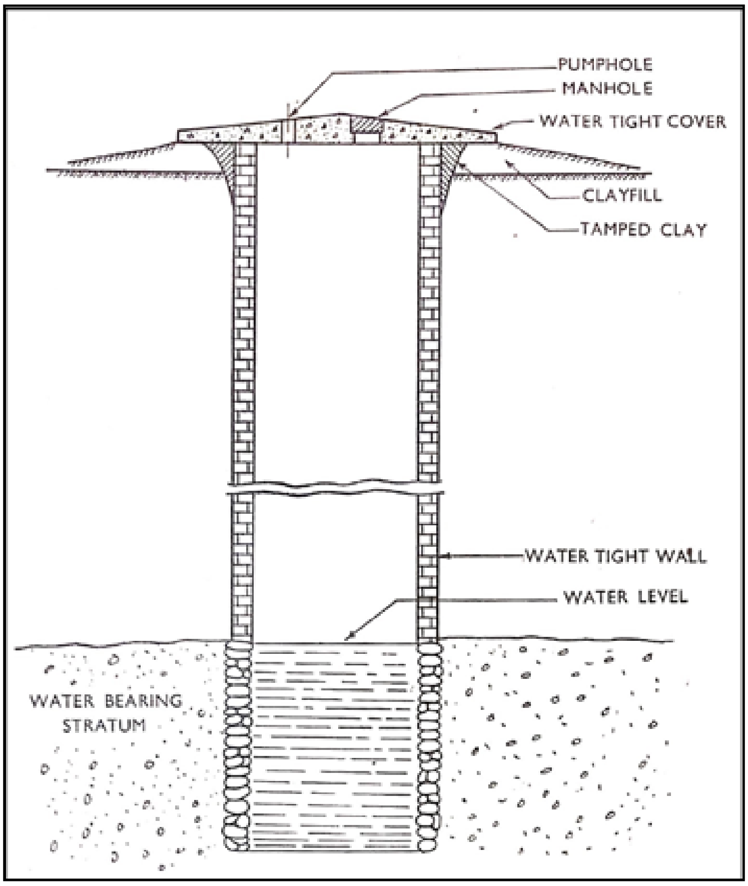


Figure 5-9: Dug well showing details of construction

5.4.2.3. INCREASING YIELD OF DUG WELLS:

i) Sometimes a confined aquifer may lie beneath a dug well. In such cases the yield of a well can be appreciably increased by boring a hole through the impermeable bottom and reaching the artesian aquifer. The bored hole may, if necessary be lined by a pipe. The pipe must be projected 30 to 60 cm (1 to 2 ft.) above the bottom of the well to avoid silting up the connecting pipe line.

ii) Studies conducted in Delhi region by the Geological Survey of India reveal that in many cases the yield of the existing open wells can be increased adequately by driving short lateral tunnels along the fissures in the rocks encountered in the wells below the water table or by sinking bore holes from the bottom of open wells. These lateral or vertical borings in open wells can be done with indigenous boring tools consisting of sharp pointed or twisted bits and extension pieces consisting of 2cm square rods in 1 to 1.5 m lengths with two bolt holes at each end for joining to the adjacent piece. While lateral tunnels are being bored, the water level in the well is maintained below the level of the bore. Boring is done by the twisting and reciprocating motions of the tool.

5.4.2.4. HYDRAULICS OF WELLS:

Static water level: Before pumping starts, the water level in a well is equal to the elevation of the water table (or piezometric surface) and this level is called the static water level.

Radius of influence: When a well is pumped, water is removed from the aquifer surrounding the well and the water table or the piezometric surface, depending upon the type of aquifer, is lowered. The vertical distance to which the water column is lowered is referred to as **drawdown.** The water level in the well, during pumping, after the drawdown is stabilized. The water table (or the piezometric surface) around the well assumes the general form of an inverted cone. This cone in the aquifer which is devoid of water is called the cone of depression. The distance from the center of the well (or radius) within which the original water table (or piezometric surface) is lowered is known as **radius of influence.**

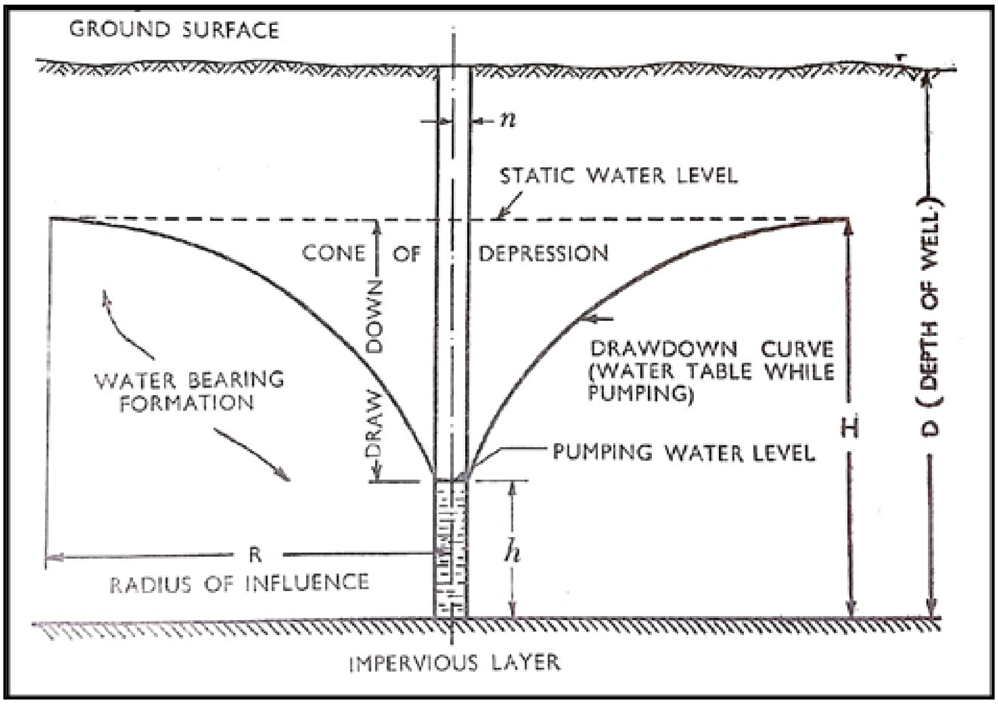


Figure 5-10: Condition while pumping in a well tapping an unconfined aquifer

Table 5- 10: Radius of influence of wells*

S.No	Soil formation and texture	Radius of influence	
		Meter	feet
i.	Fine sand layers with some silt and clay	30-90	100-300
ii.	Fine to medium sand layers fairly clean and free from silt and clay	90-180	300-600
iii.	Coarse sand and fine gravel layers free from silt and clay	180-300	600-1000
iv.	Coarse sand and gravel without silt and clay	300-600	1000-2000

(*Adapted from Bennison)

Rates at which water can penetrate through aquifer depend on the slopes of the water table (piezometric surface) and the permeability of the materials constituting the aquifer. (Permeability is the facility with which soil will transmit water. It may be defined as the hydraulic conductivity of saturated soil. It is usually measured in centimeter or inches per hour or meters or feet per day).

5.4.2.5. For optimum utilization of scare ground water resource, the distance of the proposed Dug Well from the existing well in nearby should be more than the radius of influence of the soil formation and texture existing in the area,as specified above in Table 5-10, to prevent an adverse effect on neighbor wells.

Therefore, this information along with the information of availability of ground water i.e. area falling in dark, grey zone etc. should be collected from the local Ground Water Department, before proposing/ sanctioning construction of Dug Well at a particular location.

CHAPTER

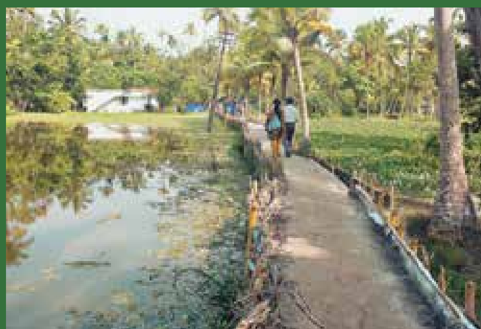
06

RURAL INFRASTRUCTURE UNDER MGNREGA



MGNREGA-2014-15









CHAPTER 06

RURAL INFRASTRUCTURE UNDER MGNREGA

6.1. RURAL SANITATION

6.1.1. CONTEXT:

6.1.1.1. As per Paragraph 4(1) of schedule- I of the MGNREGA, rural sanitation related works such as IHHL, school toilet units, Anganwadi toilets either independently or in convergence with schemes of other Government Departments to achieve 'open defecation free' status and solid and liquid waste management as per prescribed norms were permitted under MGNREGA.

i) In order to give impetus to the programme and to achieve a clean India by 2019, the Swachh Bharat Mission (SBM) has been launched. As per the revised instruction under SBM (G), construction of IHHL through the convergence of MGNREGS & SBM (Gramin) of MDWS has been delinked and construction of IHHL independently under MGNREGA in GP, other than covered under SBM (Gramin), are to be carried out under MGNREGA alone. SLWM are to be carried under MGNREGS in convergence with SBM (Gramin). The School toilet units & Anganwadi toilets are to be constructed by the concerned Ministries.

6.1.2. CONSTRUCTION OF IHHL UNDER MGNREGA:

6.1.2.1. Therefore, as a part of this programme, superseding earlier guidelines/ letters, revised guidelines for construction of Individual House Hold Latrines (IHHLs) under MGNREGA have been issued by the Ministry in **consultation and with the concurrence of Ministry of Drinking Water & Sanitation vide ministry circular No. J-11017/41/2011-MGNREGA (part), dated 25th November, 2014, as follows:**

i) The construction of IHHL under convergence of MGNREGS and Nirmal Bharat Abhiyan (NBA), now renamed as Swachh Bharat Mission -Gramin (SBM- Gramin) is discontinued. In respect of the sanctions issued prior to October 2, 2014, the pre revised guidelines on convergence shall prevail.

ii) The implementation/ management of the scheme of IHHL under MGNREGS shall be done at District level by the District Collector/ CEO, in consultation with District Officers in charge of MGNREGA (DPC) and SBM (G)

iii) The scheme of IHHL under MGNREGS shall be implemented separately from SBM (Gramin) implemented by the MDWS, in different geographical areas, to avoid overlap and duplication. The unit for geographical differentiation/ earmarking for construction of IHHL under MGNREGA shall not be below GP level.

iv) The unit cost of IHHL under MGNREGS will be ₹ 12,000/- as per the enhanced incentive of ₹ 12,000/- for

IHHL under Swachh Bharat Mission (Gramin) by the Ministry of Drinking Water and Sanitation. In respect of the sanctions issued prior to October 2, 2014, the pre revised unit cost shall prevail.

v) The payment shall be based on the actual value of work done, subject to the MGNREGS funds limited to ₹ 12,000/- per IHHL including the wage and material cost. Any expenditure over and above this amount shall be the beneficiary contribution.

vi) For all works taken up by the Gram Panchayats, including the IHHL works taken up based on the above guidelines, the cost of the material component including the wages of the skilled and semi-skilled workers shall not exceed forty percent at the Gram Panchayat level. All other MGNREGA processes and non-negotiables shall be followed.

vii) The design of IHHL shall be as prescribed under Swachh Bharat Mission (Gramin) by Ministry of Drinking Water and Sanitation and will have provision of water for hand wash & toilet cleaning.

viii) All preliminary activities like Inter Personnel Communication (IPC), Information, Education and Communication (IEC), triggering activities for behaviour change and engaging of SwachataDoots and providing other support, will also be covered by Swachh Bharat Mission (Gramin) in the MGNREGA areas to achieve toilet usage and move towards achieving ODF GPs.

ix) All IHHLs constructed under the MGNREGA will be entered on the NREGA – MIS as well as on the NBA-MIS as it is a comprehensive "All India Sanitation Database" for covering all rural households in India.

x) For effective Monitoring and Evaluation mechanisms, every State concerned will set up a monitoring team at the State level. The mobile based monitoring systems would be set up to provide real time information on the progress of works.

6.1.2.2.In continuation to these guidelines, Ministry in consultation & with the concurrence of MDWS vide Ministry circular No. J-11017/ 41/ 2011-MGNREGA (part), dated 19th January, 2015 has also issued the advisory on action plan for Swachh Bharat under MGNREGA, as follows:

i) PROCESS/ NORMS FOR IDENTIFICATION OF GPs:

a) Under this initiative, Gram Panchayats which are taking up labour intensive works and are in a position to take up works with higher material component will be identified for taking up IHHLs on a saturation mode so that the GP as a whole will achieve ODF status.

b) The selection of these GPs will be made at the district level under the Chairmanship of the District Collector in consultation with the District authorities, Swachh Bharat Mission (Gramin) to avoid any overlap with works taken up under SBM (G). The list of these GPs will be communicated by the District Collector to the Additional DPC (MGNREGA) and through him/ her to all the POs at the Block level.

c) The PO (MGNREGA) shall hold a meeting of the concerned Gram Panchayats/ Village Water & Sanitation Committees (VWSCs) to finalise the action plan at the GP level for implementing the programme and appraise all the GPs about the preparatory phase activities.

ii) PREPARATION AND SANCTIONS:

The following preparatory activities shall be done in the selected GPs:

a) Commitment of GP: Each GP will pass a resolution giving their commitment for attaining the ODF status apart from completing construction of the IHHLs as per the Plan.

b) Environment building through Sanitary Mates: In order to bring in popular participation and attitudinal change along with building infrastructure, in addition to the SwachhataDoots for overall sanitation in the GP, 'Sanitary Mates' (SMs) shall be identified at one for every habitation in the selected GPs. The SM shall be a woman MGNREGS worker who worked the highest number of days under MGNREGS in the preceding year, provided she is literate and active. The SM will help in:

- Identification of households without toilets, working in conjunction with the Women Self Help Groups, if any.
- Coordinate with the MGNREGA functionaries for sanction of the work
- Help the selected households in engaging masons,

- Supervise construction as per the specifications.

  Each SM shall be considered as a semi-skilled worker and shall be paid for the days of work as any other Mate in MGNREGA. It is essential that all the SMs are trained in various methods of sanitation and in mobilisation.

c) **Identification of beneficiaries and sanction:** The identification of beneficiaries shall be done on a saturation mode during IPPE/ preparing labour budget on a campaign approach and following the principles laid down under:

- The identification of the beneficiaries will follow the principles of saturation, in such a way that no eligible household is left out.
- However, only those households which have been reported as not having IHHLs in the SBM (G) database are eligible for selection.
- No work for renovation of old toilets is possible under this initiative.
- Based on the above principles, the SMs shall identify the households, through a house-to-house survey and after detailed discussion with the household.
- The list so prepared shall be placed before the Gram Sabha and Gram Panchayat for approval. After approval, it shall be added to the shelf of works.
- All the beneficiaries identified shall be sanctioned the toilet under the MGNREGA within 15 days from the date of shortlisting/ planning. The Programme Officer at the Block level shall be responsible for ensuring this.

d) **Technical design and estimates:** The design of IHHL shall be as prescribed under Swachh Bharat Mission (Gramin) by Ministry of Drinking Water and Sanitation and will have provision of water storage for hand wash & toilet cleaning. The estimate shall be as per standard estimate and technical sanction shall be given at the Block level by the authorised engineer.

e) Ministry of Drinking Water and Sanitation, Governm,ent of India promoted the adoptoin of Ecosan/ Bio toilets/Biodigestors wherever feasible in place of conventional toilets, Annexure-XV illustrates the detailed note on Ecosan Biotoilets with typical plan and sections.

f) **The administrative/technical sanction** shall be accorded in a GP or Block for all IHHLs by the competent authorities under MGNREGA on or before 31st March each year.

g) **Role of SHGs:** National Rural Livelihood Mission (NRLM) under the Ministry of Rural development is being implemented across India through a network of SHGs, Village Organizations (VO) of SHGs in the village, Block level and District level federations of SHGs for improving quality of life. Besides strengthening livelihood options, this network of SHGs may be considered for active involvement in the IEC activities, awareness generation and information dissemination, including demand generation, capacity building, assistance in construction of IHHL& manufacturing construction material and ensuring sustained use of IHHL facilities.

iii) EXECUTION OF WORKS:

It is the responsibility of the PO at the Block level and the functionaries at the GP level to accord high priority to execution of these works. The PO shall ensure that the muster-rolls for these works are issued as and when the beneficiary is ready for execution. The progress of these works shall be monitored every week by the PO and payments made every week for the work done, following the MGNREGA processes such as recording in the M-Book. Further, to make the construction systematic, the following may be done:

a) The entire cost of the IHHL i.e. ₹ 12000/- would be met from the MGNREGA funds.

b) Although Gram Panchayat is the implementing agency, the work would be done by the beneficiary household.

c) GP shall produce/procure and deliver all the material for the construction of the toilets. Beneficiary groups will be involved in this process to ensure quality of materials and reasonableness of the cost of material. For the beneficiary, the material has to be made available free of cost by GP.

d) **Production material for construction:** All walling (bricks/blocks) and flooring (tiles) material required for construction of toilets in the village can be produced as a separate work under MGNREGS in accordance with the guidelines issued for production of building materials for MGNREGA works , vide Ministry letter No. J-11017/26/2008-MGNREGA (UN), dated 13th January, 2014. The material so produced is to be used only for construction of the infrastructure under this initiative; and the cost of producing the building material would be included within the unit cost of IHHL i.e. ₹ 12,000.

e) Production centers for production of alternative building material can be set up from the scheme cost in the GP or in a cluster of GPs, so that good quality material can be made available at reasonable cost.

f) The muster roll will be maintained by the Sanitary Mates and after one week of working will besubmitted to the concerned officer with measurement for payment.

g) The final measurement will be made by the Sanitary Mates and be submitted to the concerned TA/ JE for recording in MB.

h) The payment shall be based on the actual value of work done, subject to the MGNREGS funds limited to ₹ 12,000/- per IHHL including the wage and material cost. Any expenditure over and above this amount shall be beneficiary's contribution.

iv) MONITORING AND QUALITY ASSESSMENT:

a) All IHHLs constructed under MGNREGS will be entered on the SBM (G) database. MGNREGS authorities in the district level i.e. DPC (MGNREGA) & PO (MGNREGA) will coordinate with the SBM (G) district authorities for this work.

b) For effective Monitoring and Evaluation mechanisms, every State concerned will set up a monitoring team at the State level. The mobile based monitoring systems would be set up to provide real time information on the progress of works.

c) The MGNREGA processes and non-negotiables related to transparency, disclosure and Social Audit etc. would continue to apply.

v) TIME SCHEDULE:

The following would be the tentative schedule for the programme for a financial year:

Table 6-1: Tentative schedule for the programme for a financial year

Activity	Agency responsible	Completion date
Identification of GPs for the financial year	District Collector/ DPC/ District authorities, SBM (G)	31st Jan
Identification and training of SMs	GPs & BDOs	15th Feb
Preparation of action plan for each GP	GPs & Mates	15th Feb
Admin sanctions for the IHHLs	DPCs	31st Mar
Starting of construction of IHHLs	GPs & Beneficiaries	1st Apr
Completion of 25% IHHLs of annual target.	GPs & Beneficiaries	30th Jun
Completion of 50% of IHHLs of annual target	GPs & Beneficiaries	30th Sept
Completion of all IHHLs sanctioned for the year	GPs & Beneficiaries	31st Dec

6.1.3. SOLID AND LIQUID WASTE MANAGEMENT (SLWM):

6.1.3.1. CONTEXT:

i) "Any material or liquid that is left over after productive use or which is beyond any use in its current form and is generally discarded as unwanted; it can also be defined as any material linked to human activity in comparison to nature which has its own system of recycling waste such that it eventually becomes a resource: for example, organic matter such as leaves, branches, and so on, decompose to form manure". (World Bank Water and Sanitation Programme (2012).

ii) Hence, Solid and liquid (storm water and sewerage) waste management are part of the essential infrastructure in the rural area to be handled in a more technical approach.

iii) **OBJECTIVES:** a) to protect human health and improve quality of life among people living in rural areas. b) To reduce environment pollution and make rural areas clean. c) To promote recycling and reuse of both solid and liquid waste. d) To convert bio waste into energy for ensuring greater energy security at village level. e) Accelerate sanitation coverage in rural areas by providing privacy and dignity to women.

iv) Effective management of SLWM includes management of biodegradable and non-biodegradable waste, management of all grey water generated in the village and general cleanliness of the village. The activities under SLWM include:

a) Solid Waste Management:

- Construction of compost pits/common compost pits,
- System for collection, transportation, segregation and composting and disposal of remaining garbage at earth fill.

b) Liquid Waste Management:

- Construction of low cost drainage,
- Construction of soakage channels/ pits reuse of waste water,
- Construction of stabilization ponds.

v) Full technical details of the works in this section are available with the Ministry of Drinking Water Supply and Sanitation, Government of India.

6.1.3.2. SLWM UNDER MGNREGA:

i) Guidelines for solid and liquid waste management have been issued by the Ministry of Drinking Water & Sanitation (MDWS), implementing Swachh Bharat Mission-Gramin. To support the MDWS in accelerating the sanitation coverage in the rural areas so as to comprehensively cover the rural community through strategies and saturation approach, rural sanitation works (such as IHHLs, solid and liquid waste treatment) are being carried out under MGNREGA.

ii) **Guidelines for solid and liquid waste management issued by the MDWS are to be followed under MGNREGA also.** However, there are number of activities in SLWM which are of repetitive/ contractual/ replacing unskilled manual labour by machine nature, which are not permitted under MGNREGA. Therefore, for solid and liquid waste management under MGNREGA in a GP should be made on saturation mode i.e. starting from collection to land fill in convergence with SBM (Gramin).

6.1.3.3. There are three key problems associated with improving the SLWM, i.e. lack of institutional capacity, lack of financial resources and public attitude.

i) PARTICIPATORY PLANNING:

a) The data collected is to be analysed along with the representatives of the community.

b) The community should be informed about various technology options for SLWM both at household as well as community level and accordingly technology options should be decided.

c) Based on the discussions with the community, SLWM action plan should be prepared.

ii) SOCIAL MOBILIZATION AND AWARENESS:

a) Generation: It should focus on inter personal communication, focused group discussion, technology demonstration and exposure visits to successful sites.

b) Technology options: Household and community level technological options with approximate cost estimates should be worked out.

c) Operation and maintenance: Success of a technology depends upon properO&M (Operation and Management) at the household and community level. This aspect should be discussed in detail during planning process and incorporated in the action plan.

6.1.3.4. Solid and liquid waste management is a much larger issue which requires a range of options depending on several factors in rural areas particularly density of population, standard of living and consumer habits, availability of land and so on. Therefore, it is necessary to develop situation specific options and launch a massive IEC and capacity building experience.

6.1.3.5. The scale of operation for different types of waste management should be decided based on the following factors:

i) Type of waste (i.e. dry, wet, electronic, etc.)

ii) Quantity of each type of waste generated per day

iii) Technology

iv) Economics of scale

v) Distance from village

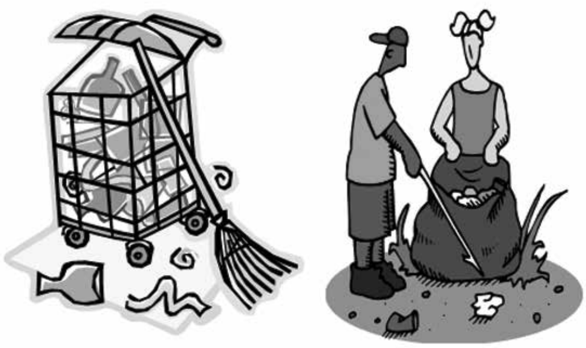
vi) Access and availability of market, processing facilities in the vicinity

vii) Finance

viii) Population/ level of administration

Using administrative boundaries to define the area of service provision is a practical way to operationalize solid waste services. Technology selection at each level of operation should be based on need, affordability, quantity and type of waste generated.

Different type of solid and liquid waste to be managed in the rural areas are solid waste, septage, cattle waste, biomedical waste, plastic waste, hazardous waste, E-waste and industrial solid and liquid (black water and grey water etc.) waste.



6.1.3.6. SPECIFIC APPROACH FOR EACH TYPE OF WASTE:

i) SOLID WASTE MANAGEMENT:

The different elements of solid waste operations/ management are:

a) Generation, segregation & recovery

b) Storage, collection and transportation

c) Processing

d) Disposal

a) Generation, segregation & recovery

At household level, the best way to handle solid waste (Biodegradables and Non-Biodegradables) is to segregate it at source and recover what is possible. E.g. dry waste as paper, plastic, glass, metal and wet organic waste. The solid waste management system can be designed so that recovered dry waste is stored at the household level and then at the GP level for a fixed number of days, after which it is collected by a designated collector for transporting to a market place in the vicinity. From here trader either process the waste or transport it further to a cycling facility.

b) Storage, collection and transportation:

In the case of wet/ compostable waste, primary storage has to be done at the household level and open dumping should be strictly prohibited. The waste can be composted or converted into biogas (mixture of methane and carbon-di-oxide). For transporting refuse (left over garbage after recovery and processing) a different strategy for a group of villages/ GPs (depending on population and the quantity of left over refuse) will have to be developed depending on the availability of landfill facilities in the area. In some cases the closet facility may be municipal facility.

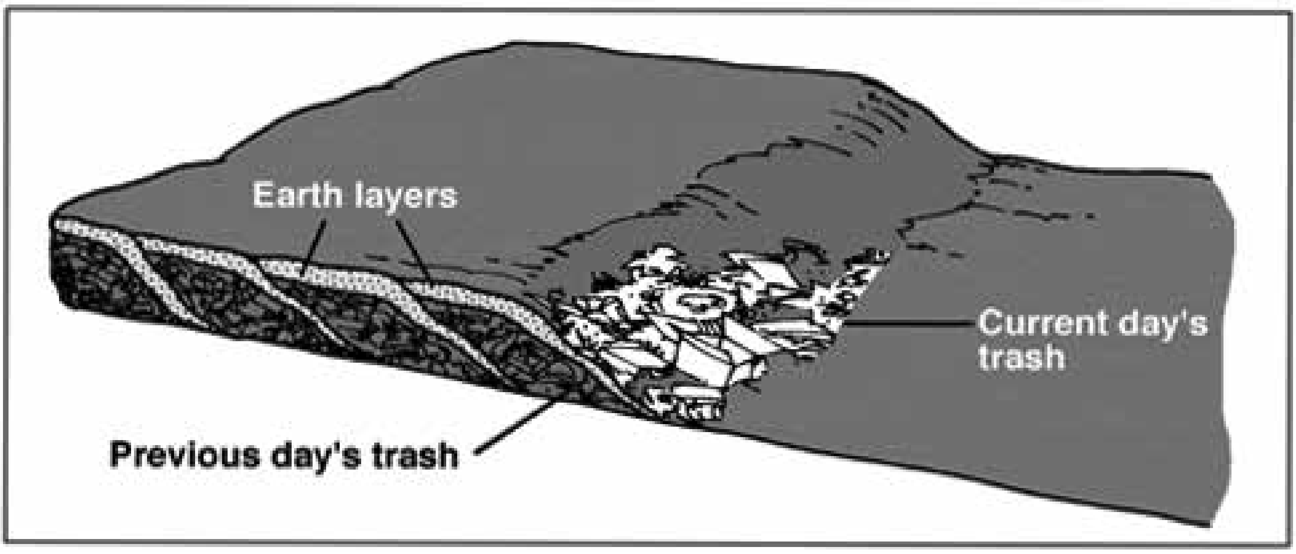
c) Processing:

For wet compostable waste, local processing (at household level, village level or GP level) is the best option. If GPs are located in proximity to an existing facility or if there is a possibility to establish a large composting facility collectively, it could be given preference during the planning phase providing that local community concerns are considered Community, village or GP level biogas plants are also a possibility where there is a willingness to adopt more advanced methods of waste disposal. The viability of any project can only be determined after conducting an extensive feasibility study.

d) Disposal:

Final disposal of refuse which should not exceed 20%, however, with effective segregation, recovery and processing, it can be brought down to less than 10 %, of the total garbage generated. Final disposal should be done at an engineered sanitary landfill site, if available. If such a facility does not exist, efforts may be made to coordinate with the biggest municipality nearby and development of regional engineered landfill site can be advocated for at higher levels of government.

- Sanitary landfills (used for the disposal of non-biodegradable and non-recyclable inorganic solid waste) are facilities for final disposal of rural area solid waste on land, designed and constructed with the objective of minimizing impacts to the environment. The Municipal- Solid waste (Management and Handling) Rules 2000 and draft revised Rules 2013 provide comprehensive regulations on the siting, design and operation of sanitary landfills. Design of Sanitary landfill is given below:



(Source: Carla W. Montgomery, Environental Geology, 5th edition, 1998, Mc-Graw-Hill Companies)

Figure 6-1: Design of Sanitary landfill

- **A modern landfill:** complying with these requirements is a complex facility with various activities to minimize environmental impacts. Sanitary land filling is necessary for the following types of waste:
    - o Waste that is by its nature or through pre-treatment non- biodegradable and inert
    - o Mixed waste not found suitable for waste processing
    - o Pre-processing and post -processing rejects from waste processing plants
    - o Non-hazardous waste not being processed or recycled

- **Site selection for a landfill:** A landfill operation with minimized environmental impacts starts w ith the selection of an appropriate site. The MSWM Rules 2000 and draft revised rules 2013 stipulate that the minimum distance that needs to be maintained from the habitation clusters, forest areas, airports, water bodies, monuments, national parks, wetlands and places of cultural, historical and religious importance and accordingly select an appropriate site. (Areas to be avoided such as Flood plain/wet land, fault, seismic zones, landslide-prone areas)

- **Preparation of the sanitary land-fill:** All the waste that is not bio-degradable (called 'rejects') is to be isolated from the other garbage from contaminating air, water and soil. After segregation of the rejects, it should be sealed in a 'land fill', which a site is specially prepared. This involves digging up, putting clay liner, compacting the rejects in thin layers and sealing it with a 1.5 mm HDPE liner or soil layer (including drainage). The minimum size of sanitary land fill is to handle 250 ton of waste per day and approximately cost Rs. 5 to 8 cr per year depending on the groundwater level and angle of repose.

  Properly designed sanitary landfills shall (a) prevent water infiltration and leaching of toxic fluids (b) Prevent water pollution (c) Reduce Vermin and pests (d) reduce smell, toxic gases and fire hazard.

  Disadvantages: (a) requires space (b) Produce methane gas (c) Not a long term remedy

e) Since the core objective of the MGNREGS is that, "Providing not less than one hundred days of unskilled manual work as a guaranteed employment in a financial year to every household in rural areas as per demand, resulting in creation of productive assets of prescribed quality and durability". Secondly, as per Para 4. (3) of schedule -1, MGNREGA, "works which are non-tangible, not measurable, repetitive shall not be taken up". Therefore first two elements of solid waste management i.e. generation, segregation & recovery and storage, collection and transportation of waste cannot be linked with MGNREGA. The creation of infrastructure for processing and disposal of waste can be linked with MGNREGA.

Figure 6-2: The waste Hierarchy

ii) CATTLE WASTE MANAGEMENT:

a) Cattle waste (both dung and urine) is an important resource in rural areas and thus multiple values in Indian culture. It has many uses including, as a soil conditioner, for biogas generation, as a source of fuel, as a sanitizing cleanser, as a raw material for generating organic compost and as a construction material.

b) The biggest problem with cattle dung comes from its improper collection and storage rather than its use. Improper collection and storage methods lead to the creation of unhygienic conditions in communities and to environmental pollution. A special emphasis must be given to cattle waste management when designing SLWM interventions. The primary responsibility for its management should rest with the households which created it.

c) At Para 4(1) II. (v) of schedule-1, MGNREGA, "Creating infrastructure for promotion of livestock such as, poultry shelter, goat shelter, piggery shelter, cattle shelter and fodder troughs for cattle" are permitted under MGNREGA. Therefore, while constructing such shelters, provision of collection & storage of dung and urine should be kept.

d) At Para 4(1) III. (i) of schedule-1, MGNREGA, "Works for promoting agricultural productivity by creating durable infrastructure required for bio- fertilizers" are permitted under MGNREGA, therefore, infrastructure for liquid bio-manure, and Farm Yard Manure can be constructed under MGNREGA.

iii) PLASTIC WASTE MANAGEMENT:

a) The Plastic Waste (Management and Handling) Rules, 2011. can be used as guiding rules for the management of plastic waste in rural areas.

b) It is expected that establishing a processing centre at a GP will not be financially viable. Responsibility related to segregation at source and temporary storage at home (or property) must rest with households or property owners, whereas, collection and transportation may be carried out by a range of locally based stakeholders including, local youth groups, entrepreneurs, CBOs, scrap dealers etc. A suitable mechanism, for supporting the inclusion of these groups in the process should be developed during the preparation of a GP SLWM plan under SBM-G.

iv) HAZARDOUS WASTE MANAGEMENT:

Hazardous waste shall be handled in accordance with the Hazardous Wastes (Management & Handling) Rules issued by the Ministry of Environment and Forest. Since the hazardous waste that may be generated at village level is likely to be limited in quantity and difficult for the community to identify, emphasis should be placed on educating stakeholders under SBM-G in how to identify such waste and where necessary how to segregate such waste at source ready for the correct disposal. GPs should monitor the situation and create the necessary awareness amongst stakeholders.

v) E- WASTE MANAGEMENT:

As per the E-waste (Management and Handling) Rule, 2011 every producer, consumer or bulk consumer involved in the manufacture, sale, purchase and processing of electrical and electronic equipment and components, collection centres, dismantlers and recyclers of e-waste shall comply with these rules locally. The GP should monitor the implementation of the rule locally and create the necessary awareness amongst stakeholders under SBM-G (NBA).

vi) INDUSTRIAL SOLID AND LIQUID MANAGEMENT:

State Pollution Control Boards (SPCBs) are responsible for the implementation of the legislation relating to the prevention and control of environmental pollution. As such the SPCBs will bear direct responsibility for enforcing regulation on industries located in rural areas. Small and tiny industries engaged in and generating waste should also be handled at the appropriate level as they are larger in numbers and quite often violators. Experience has shown that industries should comply with regulation if proper SLWM is to be expected from the GP.

6.1.3.7. TECHNOLOGIES:

i) CHOOSING TECHNOLOGY:

A particular technology may be perfect technically but unless it works for people socially, institutionally and financially it may be useless. Who should make the decision on which technology to use in a particular context! One of the principles of a participatory approach is that the community should make the decision. The engineer's role is to define the range of feasible technical options and explain them, their advantages and disadvantages, so that the community can make its own choice to suit their circumstances. The external agent should facilitate the process to help the community to define their selection criteria (recognising that the diversity of people in the community) and how they will manage the service.

ii) SPECIFIC TECHNOLOGIES FOR SOLID WASTE MANAGEMENT:

a) Organic solid waste: Composting, either naturally, through vermi-composting or through thermophilic composting is the most effective way to manage organic solid waste. There are many different ways to compost, some require initial infrastructure, and others just require space. Table at Annexure XII outlines the options for composting in rural India. The most appropriate method for a given area is primarily dependent on the type of waste being composted (e.g. does it include human waste or not) and the level of operation and maintenance that people are willing to carry out.

For every GP, if the garbage is assumed to be 50 ton per day, it will require 3 acre of land, which GP has to identify. Once done, this site can be developed for production of bio-fertilizers under MGNREGA. Approximately it will cost Rs. 3 crore for 1 year.

b) Processing of dry waste is not possible at village or GP level due to its economic viability. Instead, district and regional authorities should devise a strategy to promote such facilities either at district level or use the existing (if any) facilities within nearby cities and towns. It will be crucial to link the processing of dry waste (and link GPs) with urban areas nearby, to achieve economies of scale.

c) Bio gas from organic solid waste-
Bio gas is created by the decomposition of organic waste in anaerobic conditions. The resulting gas can be tapped for burning as a fuel. As well as the biogas, the process also produces slurry which can be used as nutrient rich manure. This work can be taken up under the scheme of bio-gas being implemented in the area.

iii) SPECIFIC TECHNOLOGIES FOR LIQUID WASTE MANAGEMENT:

a) Septage management: In case of liquid waste management, approaches for scaling up operations should be decided based on the following factors:

1) Type of liquid waste
2) Quantity of liquid waste
3) Technology available
4) Finance
5) Geography and geology

b) Under normal circumstances, designing and implementing the interventions should be done at village or cluster of village/ GP level. The situation however, will differ for large and peri urban villages with more urban characteristics. Considering that some GPs are large, treating multi-village liquid waste may not be economically feasible. Table at Annexure-XI outlines the options for septage management in rural India

c) The 3 main types of wastewater are grey, black and septage. Each type contains different pathogens and requires different types and levels of treatment to make it safe to return to the environment. The types of technology required to collect and transport the wastewater depends on the type of wastewater in the system. For example, for grey water only, open drains can be used but if grey water is mixed with black water all the water has to be considered as black water and a closed system should be used.Annexure-XIII and Annexure-XIVoutline different options for collecting and treating waste water at the household level and at community level respectively.

d) The scale of operation may be decided based on suitability of technology in a given area e.g. soak pits, leach pits, sullage stabilization ponds or duckweed treatment ponds take a lot of land but can serve multiple villages in the vicinity, and such works can be taken up under MGNREGA. Ideally, household level and a village or cluster of village level systems should be the primary consideration for the most effective management of liquid waste.

e) Stabilization pond technology for liquid management in rural areas, (successfully implemented in Punjab):

- Under this technology pond is emptied, de silted and divided in to 3 to 4 compartments by using earthen embankments.
- The grey water collected via drainage system is passed to large shallow basins or ponds excavated at suitable land site and placed serially as a stabilization system in which grey water is stabilized.
- Its pathogenicity is reduced and the stabilized water becomes useable.
- In this system, the collected grey water is stabilized by natural processes involving algae, bacteria and natural oxidation processes. Hot climate is very suitable, solar radiation and light is good for efficient functioning of this system.
- In this technology, 4 ponds constructed in series as given below:

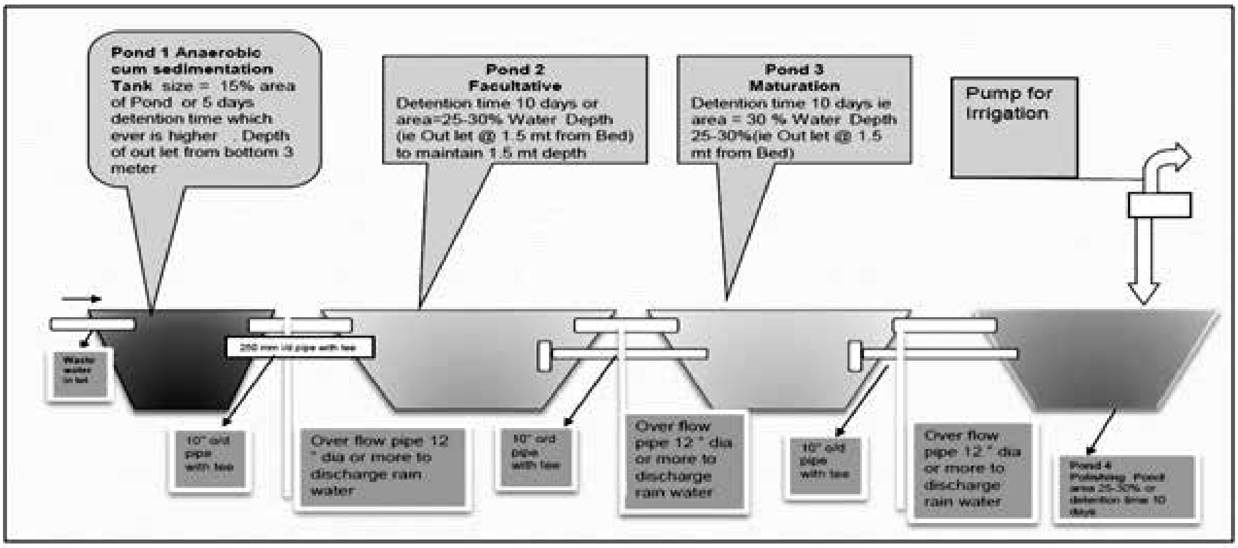
1) Anaerobic cum Sedimentation pond : The depth of water in the pond is kept at 10 feet for the sedimentation of suspended solids and decomposition of organic matter under anaerobic conditions to reduce BOD /COD .The surface area of the tank shall be equal to approx. 15% area of the existing pond area and having 5 days retention time.

2) Facultative Pond: In this tank over flow of anaerobic pond is being discharged and BOD/COD shall reduce under aerobic conditions. Depth of water is kept at 1.5m. The outlet of this tank is fixed at 1.5m from the bed of tank to ensure that water depth does not exceed 1.5m. Its area is 25% of the existing pond area.

3) Maturation / Polishing Pond: (2 numbers) in this tank over flow of Facultative pond is being discharged, where pathogen load if any shall be reduced. Depth of water is kept at 1.5m. The out let of this tank is fixed at 1.5m. from the bed of tank to ensure that water depth does not exceed 1.5m. Its area should be 25% of the existing pond area.

4) Outflow: Normally in addition to evaporation, treated water is absorbed in the pond. The treated water is also used for irrigation purpose by the farmers.

- Design for Ponds:
  - Preliminary survey was carried out, for each pond renovation area required was 2.50 acres. Total funds required for this pond was approximately Rs. 7.50 Lakhs.
  - Slope of the embankments is kept stable with slope of 1 vertical to 1.5 horizontal.
  - Top surface of the embankments is around 2.5m due to big area of pond
  - Embankment is properly compacted to make it stable.
  - PVC pipe used is of 6 kg/cm^2 pressure rating.
  - Over flow pipe used is RCC pipe NP2 grade
  - Grass is planted on the top of embankments and slopes to protect against erosion during rains or otherwise.
  - Pucca floor is provided below inlet pipe in all the ponds to avoid soil erosion in the pond.
  - Landscaping. Trees are planted around the pond.
  - Size of ponds with respect to population



(Source: Department of water supply and sanitation, Government of Punjab)

Figure 6-3: Flow Diagram of Stabilization Pond

- Renovated Ponds:

Image 6-1: Renovated ponds, Village Issewal Block Ludhiana II District Ludhiana (Punjab)-1

Image 6-2: Renovated ponds, Village Issewal Block Ludhiana II District Ludhiana (Punjab)-2

- Benefits of stabilization pond technology:
    - Improved sanitation in the Village
    - Filthy ponds will become clean areas for recreation
    - Acts as rain water Harvesting structure
    - Treated water can be reused for irrigation.
    - Extra storage capacity is created due to renovated pond harvest excess rain water which prevents flooding of low lying areas of the village
    - Waste stabilization pond technology is suitable to handle grey water in the village
    - It helps in solving sanitation problems in the village
    - It helps in rain water harvesting and recharging

6.1.3.8. ACTION PLAN FOR RURAL SANITATION:

i) To start with number of GPs will be identified as advised vide Ministry letter No. J-11017/41/ 2011-MGNREGA (part), dated 19th January, 2015 to make these GPs open defection free and carry out solid and liquid waste management. The work will be planned and carried out GP wise on project approach.

ii) To prepare GP wise project following data will be collected:

a) Total number of household, out of which how many are without IHHL and how many are proposed to be covered under MGNREGS

b) On an average how much wet compostable solid waste is available for composting

c) On an average, how much is the refusal for disposal in land fills

d) Availability of land for composting and for group of GPs land fill

iii) The technical and financial norms for toilets specified by the Ministry of Drinking Water & Sanitation will be followed.

iv) Different suitable options for creating infrastructure for treatment of solid and liquied waste at the household level and at community level will be worked out from the different options mentioned at **Annexure XI to XIV.** The costing of infrastructures will be worked out based on the specifications as per the requirement of the area and resources available.

6.2. ALL –WEATHER RURAL ROAD CONNECTIVITY:

Entry (ii) in para-4(1) IV. of Schedule-I of Mahatma Gandhi Employment Guarantee Act (MGNREGA) reads as: **"Providing all-weather rural road connectivity to unconnected villages and to connect identified rural production centres to the existing pucca road network; and construction of pucca internal roads or streets including side drains and culverts within a village;"** the rural road connectivity will be usable in all-weather, only when the required technical inputs are given in construction of road connectivity.

In this regard, vide circular No. J-11060/1/2011-MGNREGA -1, dated 18th October 2011; amendment in Para 6.1.1 (viii) of MGNREGA Operational Guidelines, related to rural connectivity, vide circular even No., dated 6th January 2012, use of cement concrete interlocking block for construction of village internal roads under MGNREGA and vide circular even No., dated 24th April, 2012, width of village internal roads under MGNREGA; has also been issued, so that the roads constructed are durable and usable in all weather. For good quality and all- weather roads under MGNREGA following technical inputs should be given.

6.2.1 ACTIVITIES WHICH CAN BE CARRIED OUT UNDER THIS CATEGORY OF WORK:

i) **ROADS THAT CONNECT A VILLAGE TO ANOTHER VILLAGE OR TO A MAIN ROAD:** Gravel road/ MittiMoorum road including culverts/ causeway for cross drainage.

ii) **INTERNAL ROADS** (within the residential area of villages): As per local availability of material and requirement of the area for construction of roads within the village (not roads connecting habitations) stone kharanja or brick kharanja or cement concrete or cement concrete interlocking blocks may be used, with proper drainage arrangement**.**

6.2.1.1. ROADS THAT CONNECT A VILLAGE TO ANOTHER VILLAGE OR TO A MAIN ROAD:

i) SURVEY, PLANNING, DESIGNING AND ESTIMATION:

a) Project for Rural Connectivity to provide all weather access should be prepared Gram Panchayat wise after conducting reconnaissance survey. In this project all the required/ possible proposal of rural connectivity in G.P. should be included and after prioritization in the Gram Sabha should be included in the MGNREGA perspective plan. If the perspective plan has been made then the AWP will be broadly based on the perspective plan.

b) The roads selected under MGNREGA should be interconnected and all selected roads must connect one or more important roads to take the products of the areas to the nearby market.

c) In preparing proposal/ estimate of a road, the required topographical survey for longitudinal section of the land strip/ existing path, track/ kachcha-rasta, proposed for construction of road under MGNREGA should be carried out, to work out the height of the road at every 30m length and design for the size and bed slope of side drains.

d) While doing topographical survey of a road, demarcation on the land proposed for road should be made with the help of the concerned Tehsildar/ Patwari/ Amin and boundary pillar fixed at 30-50m interval.

e) Road should be planned and designed so as to have minimum number of curves and the total number of curves in one kilometre should generally be less than 6.

f) Cross drainage with proper engineering design i.e. hydrological; hydraulic and structural design should be the part of the estimate and constructed simultaneously for the durability and all weather access. **For more details, design and specification should follow the "Specifications for Rural Road" issued by MoRD.**

g) Looking to the availability of land, the formation width should be at least 6 meter with carriageway 3.75m with minimum 1.25m wide side shoulders/ berms.

h) Proper camber, gradient and requisite widening of the formation on the turning should be provided.

i) The height of road formation should be minimum 1.0m above the existing ground level and 0.6m above the highest flood level.

j) Proposal for Technical Sanction (TS) prepared by the concerned Junior Engineer/ Technical Assistant and TS issued should carry- Technical note, survey sheet of the land strip i.e. longitudinal section of the land strip where construction of road is proposed, drawing of cross section of road, details of specifications, design and drawing of drainage structures i.e. Culverts/ Causeway etc. and arrangement of construction materials with lead etc., with detailed estimate.

ii) CONSTRUCTION MATERIAL:

a) Soil: The only material that can be used for the sub-grade is natural soil. All soils are composed of sand, silt and clay in varying proportions; the proportions of the material and their properties affect their stability under load. An ideal road material is one in which all these are present in proper proportions so as to obtain the maximum stability.

An intimate and compact mixture of the following will make a stabilized soil:

Sand	70 to 85%,
Silt	10 to 20%,
Clay	5 to 10%,

It will be usually sufficient to have 70% sand and 30% clay and silt.

b) Gravel: Gravel roads are a layer of compacted gravel (or crushed rock) graded from fines to pebbles, containing binding stuff (clay) in the fines. Sandy and gravel material shpuld meet the grading requirement. The size and grading of the gravels should vary from 50mm at the bottom to 12mm at the top. If grading is not possible, the following proportions may be taken:

25 mm to 20 mm	15%
20 mm to 6mm	75%
Below 6 mm	10%

Washed gravel is devoid of the fines needed to bind the material, and will require the admixture of pulverized clay, about 5 to 10% to act as a binder or alternatively, the proportion of fines passing a 75 micron mesh should be about 10 to 15 percent and sufficient to fill the voids in the gravels. The sand content in the fines should be at least twice as great as the clay content.

c) Moorum: Moorum for road should be in crystal form, strong and hard. The soil content in it should be negligible. The clods of moorum should not be more than 3cm.

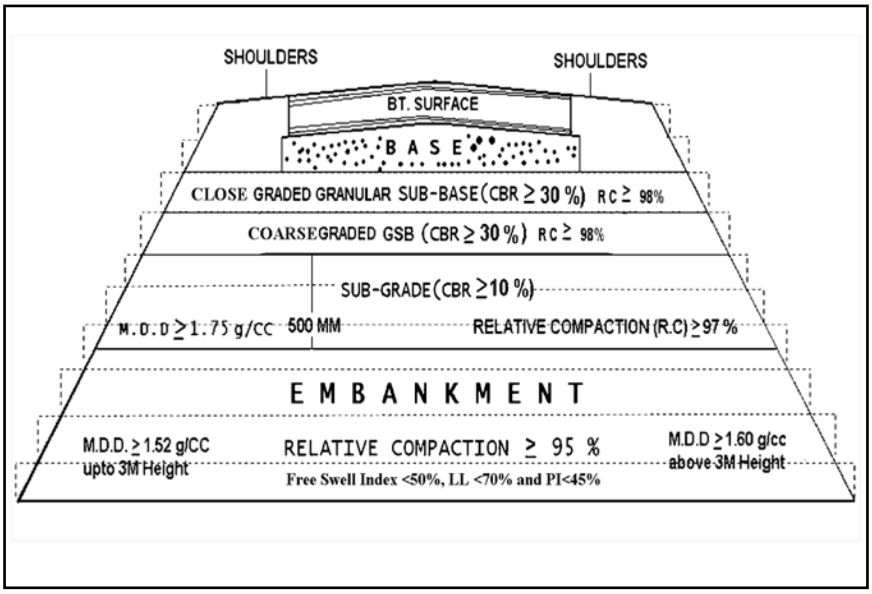


Figure 6-4: Typical Road Profile

iii) CONSTRUCTION:

a) Alignment:

- The alignment of road should be decided in such a way so that the distance is minimal, as far as possible on higher elevation and the cutting of vegetation is minimal. It should be insured that there is no hindrance to electricity, telephone and water lines.
- The existing alignment should also be examined and if it is convenient, technically fit and economical than it should be used.

b) Earthen embankment (sub-grade):

- The proper preparation of earthen embankment i.e. sub-grade for any road is of utmost importance before the road structure (pavement) is laid over it. Unless the foundation is hard and firm and properly shaped, the resulting road will be bad and will remain bad. Special attention must be given to the compaction of the sub-grade and its drainage.
- The soil should be excavated from both the sides of the road, if land is available and suitable in such a way, so that the pits after excavation of soil are linked with each other and side drains are formed. The borrow pit should be at least 1.5m away from toe of the embankment and the depth of borrow pit should not be more than 1.0m.

c) Compaction of earthen embankment:

- All large clods should be broken up in the borrow pits and no clods larger than a man's fist should be brought on the embankment. Ramming is not enough for crushing the large clods completely, which can be done effectively only by heavy rollers. Each layer should be rolled well until all clods are flattened. Any roots, grass, jungle or other rubbish should not be buried in the embankment with the earth.
- The organization of filling, spreading and rolling should be such that newly deposited fill is spread and rolled smooth immediately in order to minimize the loss of moisture.
- Generally the depth of loose soil for compaction should not exceed 15 to 23 cm. If more material is to be compacted it should be done in layers. Rolling should commence at the edges and progress towards the center. Each pass of the roller should be uniformly overlapping not less than one-third of the track made in the preceding pass.
- It has been observed that at some areas there is confusion on use of machine. In this regard the Para 22 of schedule I, MGNREGA is referred herewith, that: "As far as practicable, works executed by the programme implementation agencies shall be performed by using manual labour and no labour displacing machines shall be used". The required density of earthen embankment and gravel layer is not possible without use of power roller; therefore, for compaction of earthen embankment to achieve the required density, power roller should be used.

  Also in this regard, vide Ministry letter No. J-11011/09/2014-RE-I, dated 25th August, 2014 clarification & a suggestive list of such task and type of machines which can be used under MGNREGA have been issued.

Image 6-3: Trailer Mounted Water Browser

Image 6-4: Static Smooth Wheeled Roller

d) Laying gravel/ Moorum:

- Gravel roads are generally built in two courses, foundation course and surface course. A thickness of about 15 cm after compaction is required for light traffic and about 30 cm after compaction is required for heavy traffic.
- Moorum roads are generally built in one course and thickness of about 20 cm after compaction is required for light traffic.
- Every 15 to 20 cm. thick moorum/ gravel layer should be compacted with static smooth-wheeled roller of 8 to 20 ton weight for prescribed density at optimum moisture content by sprinkling water with trailer mounted water browser.
- Camber: The road surface is normally shaped to fall away from the center line to either side. The camber is necessary to shed rain water and reduce the risk of passing vehicles colliding. The slope of the camber is called the cross fall. On sharp bends the road surface should fall directly from the outside of the bend to the inside which is called 'super elevation'.
- Camber (cross slope) is necessary so that rain water does not stagnate on the road, therefore in gravel/ moorum road 3.5% camber in low rainfall area (Annual Rainfall less than 1000 mm) and 4% camber in high rainfall area (Annual Rainfall more than 1000 mm) should be provided.
- Before the gravel road is opened to traffic, the surface should be lightly sanded with coarse sand/ quarry dust etc. so as to have a cover of 6 mm to 12 mm over the whole surface.
- Structures for cross drainage should be constructed simultaneously after giving proper layout for the durability of the road and all weather access. Minimum earthen cushion over the pipe for its safety should be ensured.
- On side walls of culvert/ causeway, plaster is not required, pointing is sufficient. On top of the side walls, copping should be made for the durability of the culvert/ causeway.
- For more field details and live illustrations refer to page No. 73-84 of MGNREGA Works Field Manual, issued by the Ministry and available on 'nrega.nic.in' web site.

6.2.1.2. INTERNAL ROADS:

i) STONE/ BRICK KHARANJA:

a) The base under the Kharanja pavement must be properly levelled; hollow patches filled up and consolidated with hard core, cambered and cross-falls or longitudinal slopes given. There should be no soft spots present either in the base or the sub grade.

b) Looking to the drainage system and plinth area of houses on both the side of internal road, level of Kharanja should be kept. The moorum should be compacted with DURMUT by adding water in the moorum.

c) After laying 1:6 cement mortar on the moorum layer, the 3 inch thick floor stones/ bricks in width i.e. 4.5 inch should be fixed in diamond shape and the joints should be filled up with 1:3 cement mortar.

d) Drain/ Nali at proper elevation with proper slope should also be constructed simultaneously.

ii) CEMENT CONCRETE ROAD:

a) The width of such internal roads taken up under MGNREGA should not be more than 3.0 meter.

b) The construction of drain (Nali) should be as per availability of land. If land is not available than the slope should be given from outer boundary towards center of the road i.e. the camber is to be given towards center of road.

c) The top level of the road should be decided looking to the plinth level of the houses and drainage of the water from the houses.

d) It is very essential to have a good solid foundation of well consolidated and non-absorptive material under a concrete road. The load carrying capacity of a concrete road structure lies mainly in the structural rigidity of the slab and the uniformity of sub grade support. It is therefore necessary to prepare the base in such a way that the concrete slabs are supported as uniformly as possible. The base of concrete pavement should be made smooth before laying the concrete so as to reduce the co-efficient of friction between the concrete slab and the base.

e) The base under the concrete pavement must be properly levelled; hollow patches filled up and consolidated, cambered and cross-falls or longitudinal slopes given. There should be no soft spots present either in the base or the sub grade.

f) The excavation for drain should also be carried out as per requirement.

g) Cement concrete by mixing in mechanical mixer should be laid on the surface of sub base after sprinkling water on it and it should be compacted with vibrator or 20 mm diameter rod.

h) After every 4 m length of concrete slab, 5 mm wide and 70 mm deep Expansion & Contraction joint should be given. This joint should be filled up with sand and bitumen.

i) As per requirement for cross drainage, PVC pipe of 100-150 mm diameter should be laid.

j) On both side of the concrete road, as per availability of land, 20 cm layer of moorum should be filled up.

k) The curing of the road should be carried out for 15 days.

6.2.2. NOT TO DO:

i) Earthen roads become muddy in rainy season and dusty in summer. Such roads do not provide all weather access, therefore, should not be constructed under MGNREGA.

ii) If the work is being executed without proper levelling, without breaking of clods, without sectioning, this results in slipping of slopes, reducing of formation width and getting uneven riding surface.

iii) Power roller is a must for consolidation/ compaction of embankment and surfacing, whereas, in most of the cases it is not being used in execution. This results in the damage of road in a short time besides having uneven surface from the beginning affecting the durability of road.

6.2.3. TO DO:

i) Sectioning and breaking of clods must be made as a separate task after separating from earth work and must be ensured in execution.

ii) Proper berms should be provided (minimum of 60cm or equal to height of formation) for the durability and safety of shoulder of the roads.

iii) Slopes must be trimmed with designed side slope as per the type of soil and preferably covered with top soil of the trench or borrow pit, which will have high percentage of vegetation.

iv) Compaction with power roller in layers at optimum moisture content should be done and monitored to ensure that the desired density of soil and granular material for construction of embankment/sub grade has been achieved.

6.2.4. CONVERGENCE:

i) For gap filling and value addition, ongoing schemes in the area like BRGF and State schemes on roads etc. should be converged with MGNREGS as is being done in Madhya Pradesh State. Detailed additional convergence guidelines MGNREGS and PMGSY in continuation of convergence guidelines issued vide Ministry letter No. Dy. 178/ SRD/ 09-MGNREGA, dated 9th February, 2009, have also been issued vide Ministry letter No. J-11060/1/2011-MGNREGA, dated 7th November, 2013.

ii) Under convergence with other schemes, activities to be carried out manually with material component, can be carried out while maintaining material component of projects including the wages of the skilled and semiskilled workers such that it does not exceed 40% of the total project costs at the level of each Gram Panchayat. If GP is implementing agency and at the level of District if line Deptt is implementing agency. Activities like clearing and grubbing road land including uprooting wild vegetation, dismantling of existing structures, excavating, collecting, loading, transporting, unloading, spreading in uniform layers, and compacting with smooth wheel roller to achieve the desired density of soil and granular material for construction of embankment/sub grade, earthen shoulder and granular sub-base and road side plantation can be carried out under MGNREGS.

iii) Activities like providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification, surfacing, cross- drainage works and road appurtenances etc. required for completion of road can be carried out in the schemes to be converged with MGNREGS.

iv) Construction of road is a specialized job, which requires use of machines and testing instruments etc., therefore, all the activities carried out under MGNREGS and under the schemes should be carried out by the agency implementing the scheme on roads to be converged with MGNREGS.

v) Improvement of features, like grade, curvature and widening of cross drainage works at a later date under convergence can be very expensive and sometimes impossible in remote and hilly area. It is therefore necessary that if roads proposed under MGNREGA falls under the selection criteria/ norms of the scheme proposed for convergence than ultimate geometric requirement of rural road specified under that scheme should be followed right from the beginning.

vi) The construction of road with convergence of other schemes and MGNREGS will be subject to all MGNREGA processes and conditionalities.

The activities proposed under MGNREGS and the activities proposed under the scheme to be converged, have to be incorporated in the estimate/ projects separately. However, with every project report, a statement showing different activities proposed under different programmes i.e. MGNREGS and PMGSY/ BRGF/ State Scheme etc. should be enclosed so that there is no duplicity and no activity is left out.

6.2.5. PIPE CULVERT:

A typical drawing and estimate of pipe culvert are given below:

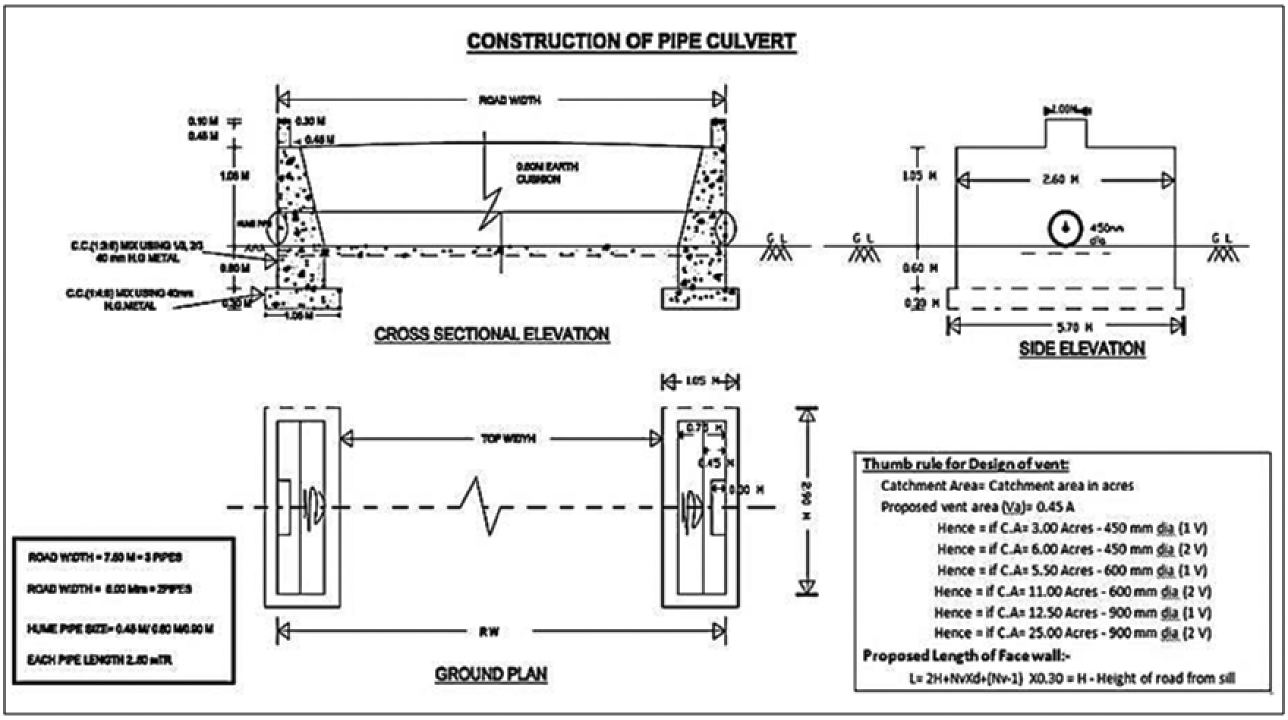


Figure 6-5 : Construction of Pipe Culvert

Table 6-2: Typical Estimate for construction of 450 mm dia Pipe Culvert

Name of Work: Construction of 450 mm dia Pipe Culvert						
S.N.	**Description**	**No**	**Length**	**Breadth**	**Depth**	**Qty**
1	Uprooting and removing juliflora at proposed site 50% void	1x1	5	10	-	50.00 sqm
			(-) Voids deduction		50%	25.00 sqm
Total Qty						**25.00 sqm**
2	Uprooting and removing stumps including disposal 30-99 cm	1x10	-	-	-	10 Nos
3	Earth work Excavation and depositing on bank with an initial lead of 10 mts, initial lift of 2 mts in hard gravel soil					
	a) For foundation of face work	1x2	2.9	1.05	0.9	5.481 cum
	b) under pipes, below 150mm sill	1x1	5.7	0.45	0.15	0.385 cum
	c) Up struction removal	2x3	1.5	1.05	(0.60+0.90/2)	4.725 cum
Total Qty						**10.591 cum**
4	Filling Foundation with C.C.1:4:8 using 40 mm gauge hard granite crushed metal, including cost of all material, labour, curing complete excluding conveyance of material					
	a) For foundation of face wall	1x2	2.9	1.05	0.3	0.913 cum
	b) Under pipes	1x1	6	0.45	0.15	0.405 cum
Total Qty						**1.318 cum**
5	Super structure, with C.C.1:3:6 prop using 60% 40mm and 40% 20mm crushed metal including cost of all material, labour, curing, but excluding convey of all material					
	a) Face walls below sill	1x2	2.6	0.75	0.6	2.340 cum
	b) Face walls above sill level	1x2	2.6	(0.75+0.45)/2	1.05	3.276 cum
	c) Parapet walls	1X2	1	0.3	0.45	0.270 cum
Total Qty						**5.886 cum**
	Deduct vent portion 2x1x22/7x050x0.50x(0.75+0.60/2)					0.265 cum
Total Qty						**5.621 cum**
6	C.C.1:2:4 prop. Using 20mm gauge H.G.Crushed metal including cost and labour charges					
	Top of Parapet	1x2	1	0.3	0.1	0.06 cum
7	Cost of R.C.C hume pipe of NP3 class at factory to standard of required dia 450 mm	1	7.5			7.50 Rmt

8	Cost of R.C.C. collars to suit above dia R.C.C. pipes 450 mm dia	11x2				2 Nos
9	Conveyance of RCC hume pipes and collar from factory to proposed site including loading unloading and stocking at site (450 mm dia)	1	7.5			7.50 Rmt
10	Laying,aligning,jointing of R.C.C H.Ps of NP3 class (450)dia including cost of jointing materials etc.,	1*1	7.5			7.50 Rmt
11	Rough Stone dry packing for revetment using of 225mm thick broken H.G. rough stone for revetment (approach U/S, D/S excluding conveyance)	2*2	2.5	0.225	1.5	3.375 cum
12	Earth work Excavation in gravel soils with an initial lead of 10m and lift of 2.0m,and loading into tractor (for approaches)	2	20	(7.5+10.0) /2	(0.6+0)/2	105.0 cum
13	Conveyance of stable earth, including unloading and spreading	as above				120 cum
14	Conveyance of sand from quarry to site including loading unloading	As per requirement sheet				3.527 cum
15	Conveyance of 40 mm gauge H.D. crushed material for all terms	As per requirement sheet				4.221 cum
16	Conveyance through stone 225 size	3.375x1.10				3.712 cum
17	Conveyance 20 mm crushed metal					2.833 cum

6.3. CONSTRUCTION OF PLAY FIELDS:

As per Para 4. (1) IV. (iii), construction of play fields in rural areas is permitted under MGNREGA. Ministry has issued detailed guidelines for construction of playground vide Ministry letter No. J-12055/1/2007-NREGA dated 11th February, 2013.The main issues mentioned in the guidelines are:

6.3.1. PARAMETERS:

i) Not more than one play ground in one village,

ii) The playground will be for the games/ sports, such as football, volleyball, hockey, kabbadi etc. and the size of playground should be constructed accordingly.

iii) The playground will be fenced by constructing ditch cum bund with plantation on ditch/ bund.

6.3.2. NON-NEGOTIABLES IN WORK EXECUTION:

i) The construction of play grounds will be subject to all MGNREGA processes and conditionalities, such as:

ii) Muster Rolls to be maintained on worksite, with copies in Gram Panchayat and to be electronically maintained on nrega.nic.in,

iii) Social Audits to be done through Gram Sabhas,

iv) Wage payments will be through banks/ post office accounts.

v) No contractor and machine will be deployed.

6.3.3. CONFORMITY TO MAHATMA GANDHI NREGA PROCESSES IN PLANNING AND EXECUTION:

i) Works for play grounds shall be approved by the Gram Sabha and the Gram Panchayat and shall also be part of the annual shelf of projects identified under MGNREGS.

ii) The Administrative & Financial sanction for the play grounds to be constructed under MGNREGS will follow the process defined for MGNREGA works.

6.3.4. ESTIMATES:

i) After approval of works by the Gram Panchayat, the concerned Technical Assistant/ Junior Engineer of the Gram Panchayat will prepare estimate of the work as per drawing/ design/ specification of the playground and prevailing Schedule of Rates (SoR) for MGNREGA works in the area.

ii) In leveling of the playground the estimates will be prepared by working out cutting and filling, so that the cutting is equal to filling. In estimate only the cutting will be charged if filling is within the maximum lead permitted in the SOR, if filling is beyond the permitted lead only then lead extra will be charged.

iii) The TS for these works will be issued by the concerned as per norms/ power delegated for MGNREGA works.

6.3.5. EXECUTION:

i) For construction of playground, the concerned GP will be the Implementing Agency.

ii) Every play ground constructed will be treated as independent work. The PO will issue muster roll to the GP accordingly.

iii) Mate will be deployed only if the quantum of other works taken up in the Panchayat justifies their need.

iv) The measurement/ assessment of the work carried out will be made weekly and after the work is completed, as per the task / activities specified in the estimate by the concerned J.E. /TA. The entries of measurement with assessment of work will be entered in measurement book as well in the muster roll.

v) Maintenance of the playground and its proper use will be the responsibility of the Gram Panchayat.

6.4. DISASTER PREPAREDNESS:

6.4.1. DEEPENING AND REPAIR OF FLOOD CHANNELS:

In many flood-prone villages, drainages are in a state of disrepair or have become silted up or have been encroached upon. These channels play a crucial role in directing flood waters out of the village. Both field channels (connecting farms to the main channel) and the main channel(s) of the village need to be repaired and deepened. The unskilled labour: material ratio is 100:0. The technical details on drainage has been given in chapter-3 at Para 3.3.2 under the head Drainage System.

6.4.2. CHAUR RENOVATION:

Waterlogged lowlands, known as chaurs in Bihar, are the natural, saucer-shaped, topographically low- lying areas where rainwater accumulates. They can play a major role in flood mitigation because they act as natural “sponges” for flood waters. The surface area of a chaur can be very large, covering portions of several villages. Renovated chaurs could be used as multi-purpose farm ponds. The mud excavated from the chaur can be raised on the side as embankments on which crops like banana, papaya, mango, pigeon pea and cashew nut can be grown. The pond water can be used to irrigate the non-waterlogged, upland area. Experiments have shown that in waterlogged areas, cultivation of water chestnut (Trapabispinosa) can be quite profitable.

6.5. CONSTRUCTION OF RURAL BUILDINGS:

i) CONTEXT:

To strengthen the building infrastructure at the Gram Panchayat and the block level, Ministry has expanded the scope of building works under schedule 1, Para 4 (I) to include construction of different types of buildings, they are:

a) Gram Panchayat (covered area-130 sqm / 1400 sft)

b) Anganwadi centres (covered area at least -56 sqm / 600 sft)

c) Village Haats

d) Crematoria

e) Women self-help groups' federation

f) Cyclone shelter

g) Common work-sheds for livelihood activities of self-help groups

h) Post-harvest facilities including pucca storage facilities for agricultural produce

i) Houses sanctioned under the IAY (minimum built up area at least 20 sqm / 215 sft)

ii) APPROACH AND STRATEGIES:

a) The Paragraph 13 (a) of Schedule I (as revised in Jan 2014) of Mahatma Gandhi National Rural Employment Guarantee Act mandated use of labour intensive and cost effective technologies and local materials in construction. A National Workshop was conducted between 19th to 21st Feb 2014 to operationalise this mandate.

b) The National Workshop has passed a resolution that it is possible to construct labour intensive, durable and good quality buildings using the designs which are in tune with the local culture, and respect the traditional practices of construction. It was concluded in the workshop that use of eco-friendly locally available building materials in construction and reducing the use of cement, sand & steel, and recycling of building materials is not only feasible but is also essential in the context of the climate change and for environmental improvement. The workshop emphasized on the need for involving communities in construction of buildings under MGNREGA and the need to upgrade their skills to take up construction without dependence on contractors and to make them self-sustained.

c) Considering the above, and to improve the wage component in wage: material components ratio in the MGNREGS works, the following directive under section 27 of MGNREGA have been issued vide Ministry letter no. 1011/5/2006-NREGA (part-ii), dated 18th March, 2014 for implementation in all the MGNREGA buildings and other construction works.

- The appropriate technologies for buildings under MGNREGA and IAY shall be in accordance with the local building traditions, while keeping in view the durability.
- The use of cement, sand and steel in construction shall be substantially reduced through:
  - Use of local material, local practices for stub foundations or arch foundations or under reamed piles, with suitable design and specifications to address the needs of the relevant seismic zone.
  - Avoiding the use of columns and beams wherever the span of construction is less than 4 meters and where the soils permit by using alternate appropriate technologies.
  - Use of rat-trap bond walls using bricks or blocks 250 mm X 120 mm X 85 mm or equivalent sizes as locally adopted.
  - Avoiding cement plastering to the extent possible on both sides of the wall.
  - Use of filler slabs using tiles or local material to reduce the concrete.
  - Avoiding RCC sunshades (chajjas) and replacing with stone/ ferro-cement or suitable materials locally available.
  - Replace windows with honeycomb structures wherever local climate permits.
  - Use of local materials like stone or precast units etc., for door and window frames and minimise the use of wood.
  - Use of local material like stone, bricks etc., for flooring.
  - Use of appropriate mud- based technologies.
  - (etc.)

- Suitable building materials shall be selected for each building (indicative list below) and produced at the site of construction (using the MGNREGA workers i.e., job card holders) such that the labour component in the building shall reach nearer to 40% of the total cost of the building in addition to the utilisation of the local conventional materials: (Guidelines for field trials for production of building materials only for MGNREGA works have been issued vide Ministry letter no. j-11017/26/2008-MGNREGA (UN), dated 13th January, 2014)
  - Mud block
  - Stone and renewable wood (e.g. casuarina)
  - Compressed and stabilised earth blocks (after due treatment and curing)
  - Bamboo material (with suitable treatments)
  - Fal-G bricks using the fly ash
  - Filler blocks
  - Micro concrete roofing
  - Funicular roofing, etc.
  - Brick Arch Lintels
  - (etc.)
- The State Government may consider setting up of a centre for design, technology and training for eco-friendly building technologies as part of SIRD. Government of India would consider supporting capacity building of these centres by sourcing expertise available in alternate technologies for the following activities:
  - Designing buildings suitable for the local conditions.
  - Constructing model buildings using the above principles.
  - Training the communities, implementing personnel in using them and promoting artisans in producing the material.
  - Disseminating the technologies in the local communities and IEC material preparation.
  - Monitoring adoption of the above designs in actual construction.

d) With these directives, State Governments have been requested to develop draft design & estimates of different buildings permitted under MGNREGA in combination of technologies as appropriate to different locations in the State with following guidelines.

- Providing greater role to the Panchayats especially at the village level in the planning and implementation of the building works;
- Materials and technologies approved by reputed organizations like HUDCO, BIS, BMPTC, IITs, Engineering colleges and eminent NGOs in the field of building construction could be used;
- Roof top rain water harvesting system as appropriate locally should also be set up on every building with Storage Structures;
- Land proposed for the buildings under MGNREGA, other than IAY, must be owned by the Gram Panchayat/ Government.

iii) DESIGN AND CONSTRUCTION STANDARDS:

a) Typical proto-type designs of different buildings permitted under MGNREGA are enclosed herewith. The prototype designs can be adapted to suite local conditions, subject to the basic functional spatial concept of the prototype design. There would be local design variations depending upon the geo-climatic conditions, preferred construction technology and the availability of construction material and skills.

b) In areas prone to natural calamities, disaster resilient features should be built in.

c) Natural factors such as rain fall, wind directions, sun movement, availability of local construction materials, site topography, vegetation etc., should be factored in to building design.

iv) CONFORMITY TO MGNREGA PROCESSES IN PLANNING AND EXECUTION:

a) The construction of buildings in so far as it is funded under MGNREGA, will be subject to all MGNREGA processes, through job card holders and without the use of manpower replacing machinery and contractor.

b) Muster rolls will be maintained for public scrutiny on site. Clear record will be maintained on the employment generated in the process of construction of buildings.

c) Material procurement will be through a transparent procurement process whose details will be uploaded on MGNREGA MIS. Wage: Material component ratio of 60: 40, of all the works in a financials year will be maintained at GP level, if GP is the PIA (Programme Implementing Agency) and at District level if line department is PIA.

v) FUNDING:

a) Construction of buildings with or without convergence when implemented by GP, the wage:material component ratio will have to be within 60:40 in the overall estimated cost of the works taken up in the G.P. to the extent of MGNREGA funds.

b) In respect of buildings taken up by the line departments in convergence with MGNREGS, the overall wage: material component ratio will have to be within 60:40 of the district expenditure to the extent of MGNREGA funds.

vi) MONITORING AND REPORT:

a) Engineers at Gram Panchayat/ Block level should supervise and inspect during course of construction of buildings at every stage of construction like, marking lay out, laying of foundation, DPC, plinth level, lintel level, roofing etc.

b) The State Government should put in place a system of quality monitoring to guide and assist the field staff in achieving satisfactory quality in respect of the following:

- Site selection
- Use of appropriate cost effective technology;
- Selection of design and materials for construction, such that the negative environmental impacts are reduced;
- Quality of workmanship which ensures longevity and user comfort;
- Finishing including electrical, plumbing and sanitary systems of the locality;

c) States may put in place a system to assess environmental friendly buildings through a simple set of indicators. This could be a measure against a baseline of a standard building utilizing conventional inputs such as bricks and cement concrete, with flat roofs and typical construction design.

d) At the state level, state government will nominate Nodal Engineer/ Engineers preferably from the state group, participated in National workshop on use of appropriate technologies in Kerala from 19th to 21stFeb 2014, These officers would be in charge and manage all building works under MGNREGA in the state and will be link between State and Ministry.

6.5.1. BUILDING WISE GUIDELINES:

Directives for the construction of 9 types of buildings, permitted under MGNREGA (mentioned in paragraph-6.5.(i), are given bellow. **Typical floor plans** for all the 9 buildings and **Sample specification report** with **typical estimate** for Gram Panchayat buildings have been provided, for reference.

6.5.1.1. GRAM PANCHAYAT:

i) For the construction of Gram Panchayat buildings, the instructions issued by the Ministry for construction of 'Bharat Nirman Rajiv Gandhi Sewa Kendra' (BNRGSK) at the Gram Panchayat level vide letter no.

J-11013/2/2009- NREGA (PT.), dated 30th December, 2009 and subsequent amendments thereon shall be followed.

ii) On a broad estimate the covered area for the building will be approximately 130 sqm (1400 sft), inclusive of toilet.

iii) Typical plan and Sample specification report for Gram Panchayat building with rat trap masonry and stub foundation are given below; Sample estimation for the same building is provided in **Annexture-XVI.**

a) Typical plan for Gram Panchayat building is as given below:

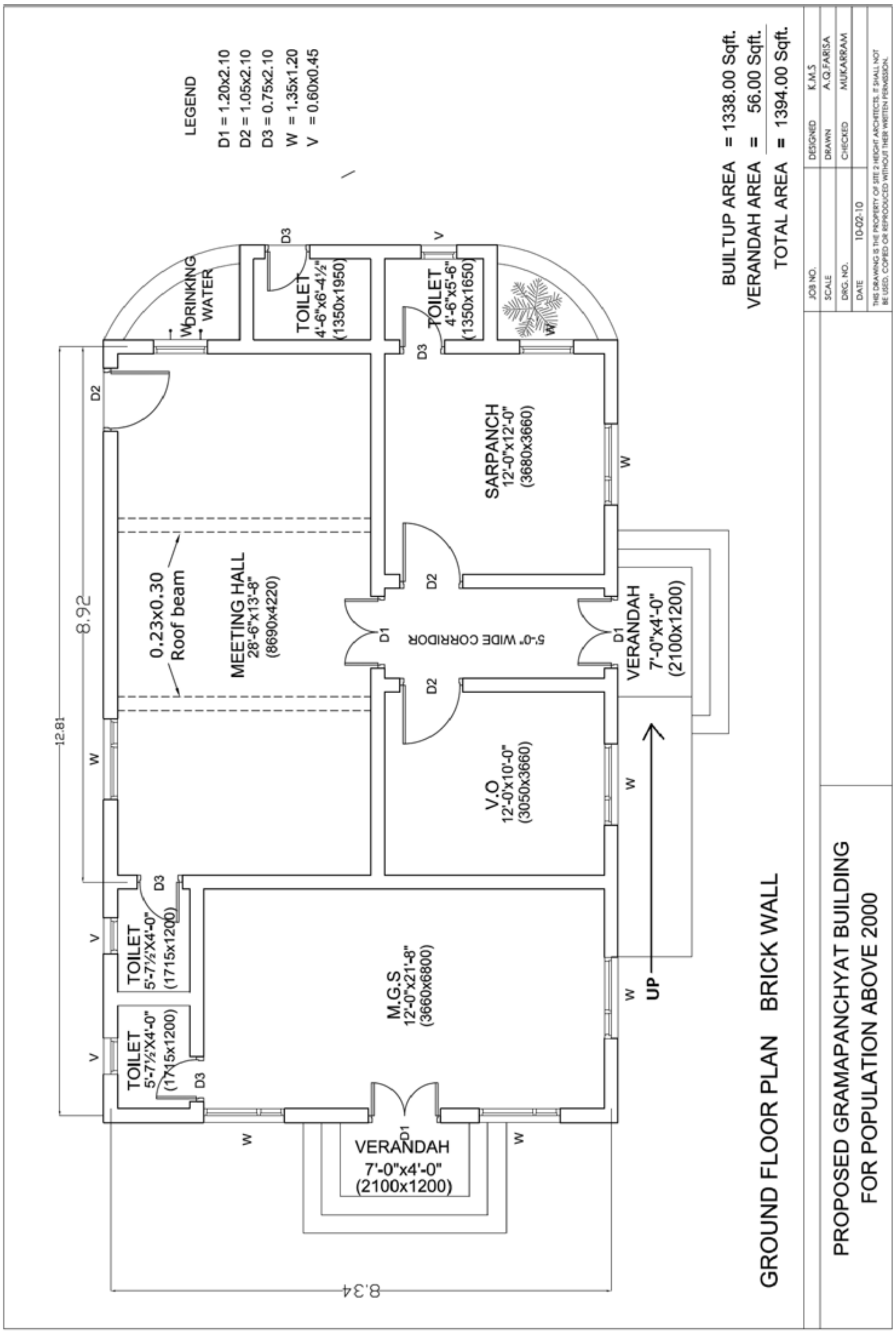


Figure 6-6: Typical Plan for Gram Panchayat Building

b) Sample Specification Report - Construction of Gram Panchayat building with, Stub Foundations- RR Masonry for footings & for basement - Solid Brick wall @ room Corners & under beams 0.90m length - Rat-trap brick masonry with 2nd class bricks-Bearing plastering 20mm thick-Ellis Pattern flooring.

Safe Bearing Capacity (SBC) of Soils = 150kN/m2	
Type of Foundation - Stub Foundations with RR Masonry in CM(1:6)	
Depth of foundation - 0.90m below Ground Level	
Levelling course - PCC(1:5:10) of 150mm thick below RR Masonry	
Basement Height - 0.60m above Ground Level	
Clear floor height - 3.30m	
Basement filling with sand / gravel	
VRCC M20 grade - Plinth beams, Roof beams, 125mm thick slab, lintels & sunshades	
PCC(1:2:4) for sill level & lintel level bands	
Reinforcement - HYSD - Fe 415	
Brick Masonry in CM(1:6)	
Super structure - Brick Masonry in CM(1:6)	
Bearing Plastering - top of the brick masonry and below slab	
Flooring - Ellis pattern PCC(1:5:10) 100mm thick	
Plastering -	a) for internal walls - plastering with 12mm thick in CM(1:4) single coat b) ceiling plastering - plastering with 8mm thick in CM(1:4) single coat
Painting -	a) External walls - with water proof cement paint in 2 coats over primer of exterior grade one coat - total 3 coats b) internal walls and ceiling - with white lime in 2 coats
Doors:	a) D1 with seasoned salwood frame and shutters with door fixtures b) D2 with seasoned salwood frame and flush shutters & door fixtures
Windows: with seasoned salwood frame and shutters with fixtures	
RCC Ventilators	
Impervious coat	
LS provision for Electrification, Water supply & Sanitary items @ 7.5%	
Provision for VAT @ 5% (On Value of Work)	
QC charges @ 0.5% (On Value of Work)	
LS Provision for unforeseen items, variation in depth of foundations, undulations in ground levels etc.	

6.5.1.2. ANGANWADI CENTRES:

i) Anganwadi Centres under MGNREGA will be constructed to serve the objectives of pre-school, nutrition centre, semi-formal public health unit, community centre located in the heart of settlements i.e., to serve, first out post at the habitation level for nutrition, health, early childhood development and learning & to provide crèche facility to MGNREGA workers.

ii) The designs/ specifications would adhere to instruction/guidelines issued by the Ministry of Women & Child Development, GOI, from time to time.

iii) The Ministry of Women & Child Development has issued guidelines stating that AWCs should be child friendly with all relevant infrastructures, separate sitting room for children/ women, separate kitchen, store for storing food items, child-friendly pictorial compound walls and child friendly toilets and space for playing of children (indoor and outdoor activities) with safe drinking water facilities and the space should be at least 600 sft.

iv) For construction of Anganwadi Centres under MGNREGS, there may be two funding facilities as mentioned in para 6.5 (v)

v) Typical plan for Anganwadi Centre at figure-6.7

6.5.1.3. VILLAGE HAAT AT THE VILLAGE OR BLOCK LEVEL:

i) Rural artisans and farmers do not have resources to connect themselves to the market as they lack adequate capacity, market intelligence and negotiation skills. Construction of buildings for village Haat would help them to bridge these inadequacies. Permanent marketing Centres will help them to promote marketing of their produce and will boost socio-economic development.

ii) Village Haats may be constructed at the existing place of marketing in the villages or blocks where weekly haats already exist. The land for the proposed village haats must be owned by the Gram Panchayat/ Government.

iii) The basic structure/ facilities which may provide at these village haats are as under.

   a) Open raised platforms & covered platform

   b) Toilets (separate for women and men)

   c) Drinking water facility

   d) Drains

   e) Brick / stone soling in the moving space

   f) Garbage pits at corner

   g) Office block

   h) Storage (small size)

   i) Boundary wall/ fence with two gates one for incoming and second for out going

   j) Parking space

   k) Drinking water facilities for cattle.

iv) Typical plan for designs of Village Haat at figure-6.8

6.5.1.4. CREMATORIA:

i) The location of Crematoria should be outside the village and easily approachable.

ii) Crematoria should consist of:

   a) Raised covered platform, but open from all the sides

   b) Toilets & bathrooms

   c) Drinking water facility

   d) Drains

   e) Brick / stone soling in the passage

   f) Garbage pits at corner

   g) Office & store room

   h) Boundary wall/ fence with gate

   i) Waiting shed

iii) A typical plan for Crematoria is given at figure 6.9.

6.5.1.5. WOMEN SELF-HELP GROUPS' FEDERATION:

i) Building for Women Self-Help Group's (WSHG) federation is to serve the purpose of shelter for the meetings and various activities of WSHGs.

ii) A typical plan of a building for Women Self Group's federation is given at figure-6.10.

6.5.1.6. CYCLONE SHELTER:

i) In the areas, where cyclone is common and recurring frequently, the cyclone shelters may be constructed under MGNREGA.

ii) Location and alignment of the cyclone shelter should be such that it is easily approachable and with respect to the wind direction and intensity of the cyclone occurring in the area.

iii) Typical plans of Cyclone shelters are given at Figures 6-11 and 6-12.

6.5.1.7. COMMON WORK-SHEDS FOR LIVELIHOOD ACTIVITIES OF SELF-HELP GROUPS:

i) Women Self Help Group federation & Common work sheds for livelihood activities of Self Help Groups serves the same purpose. Therefore a typical plan Figure-6.10 of a building for Women Self Help Group's federation may be referred for common work-sheds for livelihood activities of Self Help Groups.

6.5.1.8. POST-HARVEST FACILITIES INCLUDING PUCCA STORAGE FACILITIES FOR AGRICULTURAL PRODUCE:

i) Typical plan for post-harvest facilities including pucca storage facilities for agricultural produce is given at Figure-6.13.

6.5.1.9. UNSKILLED WAGE COMPONENT IN CONSTRUCTION OF HOUSES SANCTIONED UNDER THE INDIRA AWAS YOJANA (IAY):

i) To take up unskilled wage component under MGNREGA in construction of houses sanctioned under IAY, the guidelines on IAY last issued by Ministry, on June 2013 and subsequent amendments thereon, will be followed.

ii) The plinth area of rural housing to be covered under MGNREGA will be as per the plinth area prescribed under IAY i.e. Minimum built up area of at least 20sqm (215sft).

iii) The unit cost of an IAY house is Rs. 70,000/- for plain areas and Rs. 75,000/- for hilly states difficult areas & IAP districts. Under MGNREGA 90 unskilled man days for plain area and 95 man days for hilly states difficult areas & IAP districts, will be permitted under MGNREGA (for details refer Ministry circular No. J-11017/40/2011-MGNREGA (UN) dated 30th June 2014). Remaining amount required in construction of rural house will be the beneficiary contribution.

iv) Typical plans for IAY house are given at figure-6.14 and 6.15

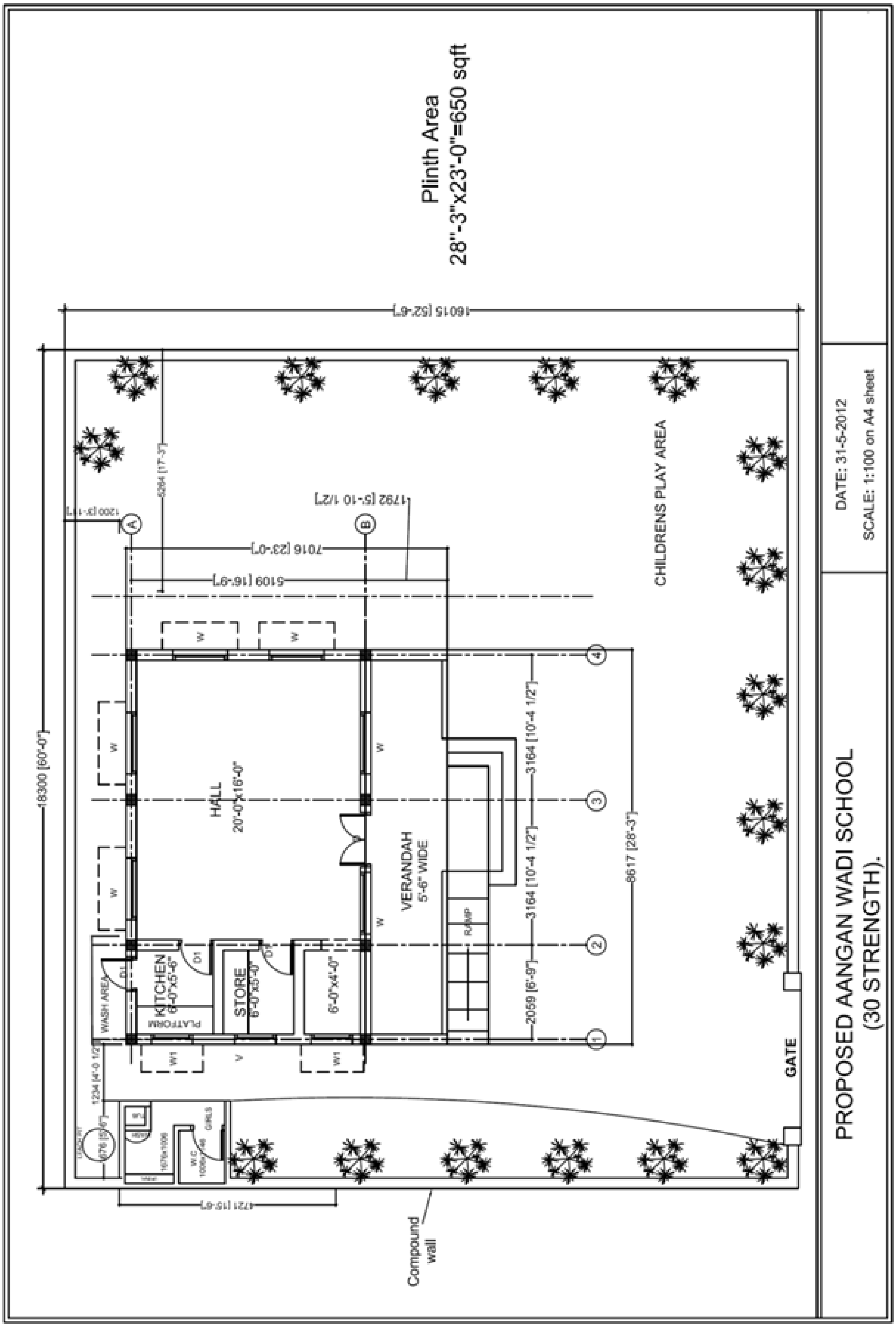


Figure 6-7: Typical Plan for Anganwadi Building

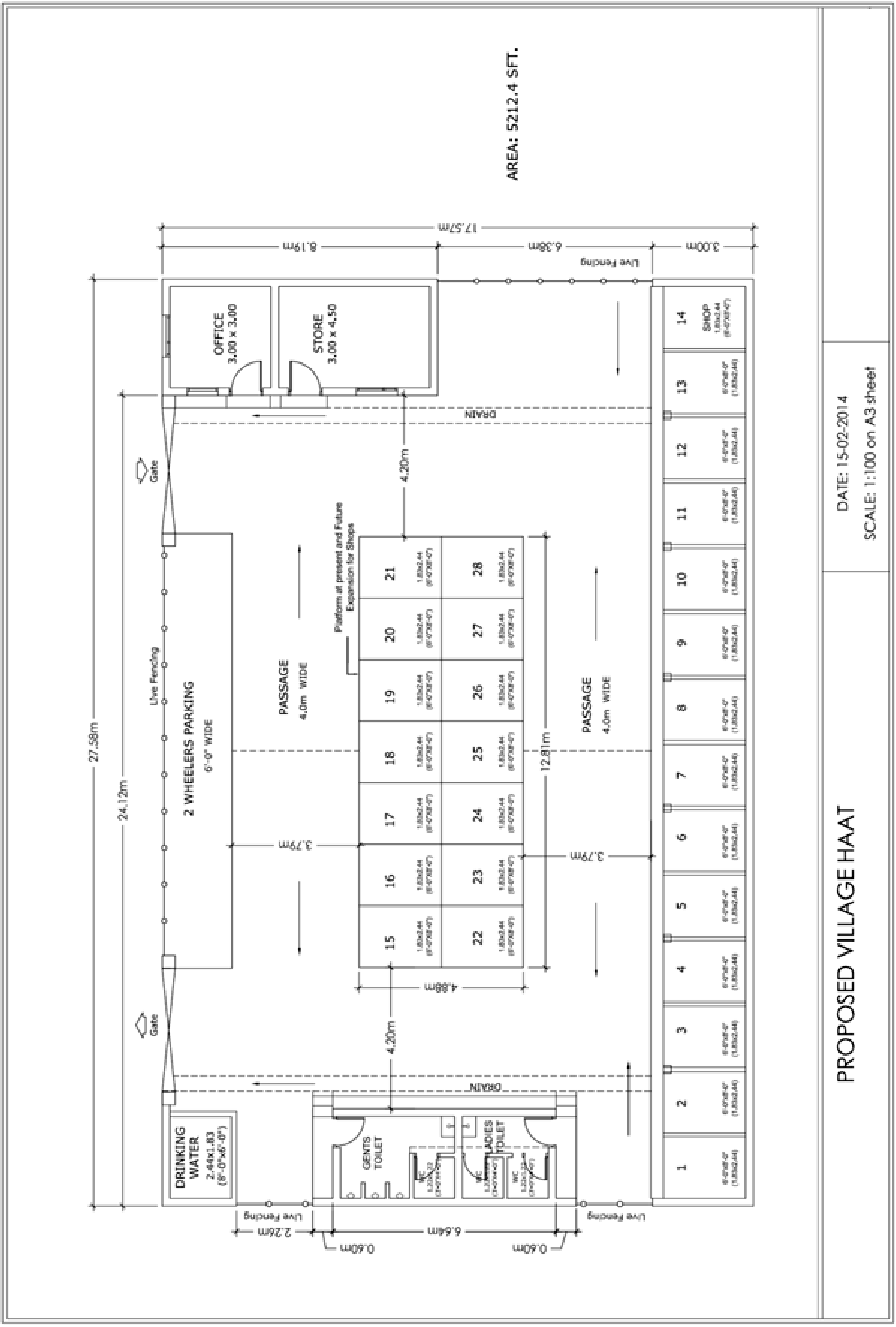


Figure 6-8: Typical Plan for Village Haat

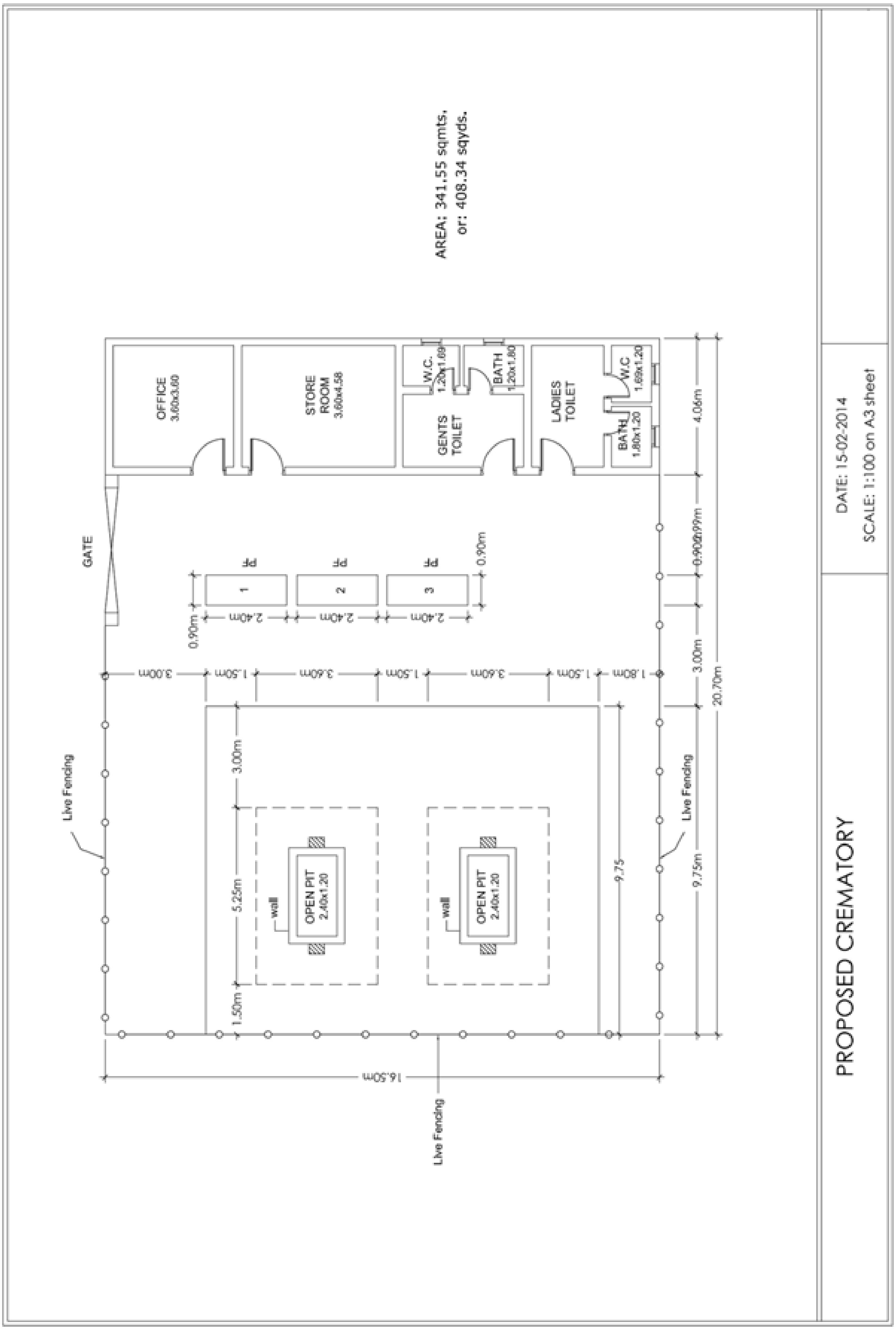


Figure 6-9: Typical Plan for Crematoria

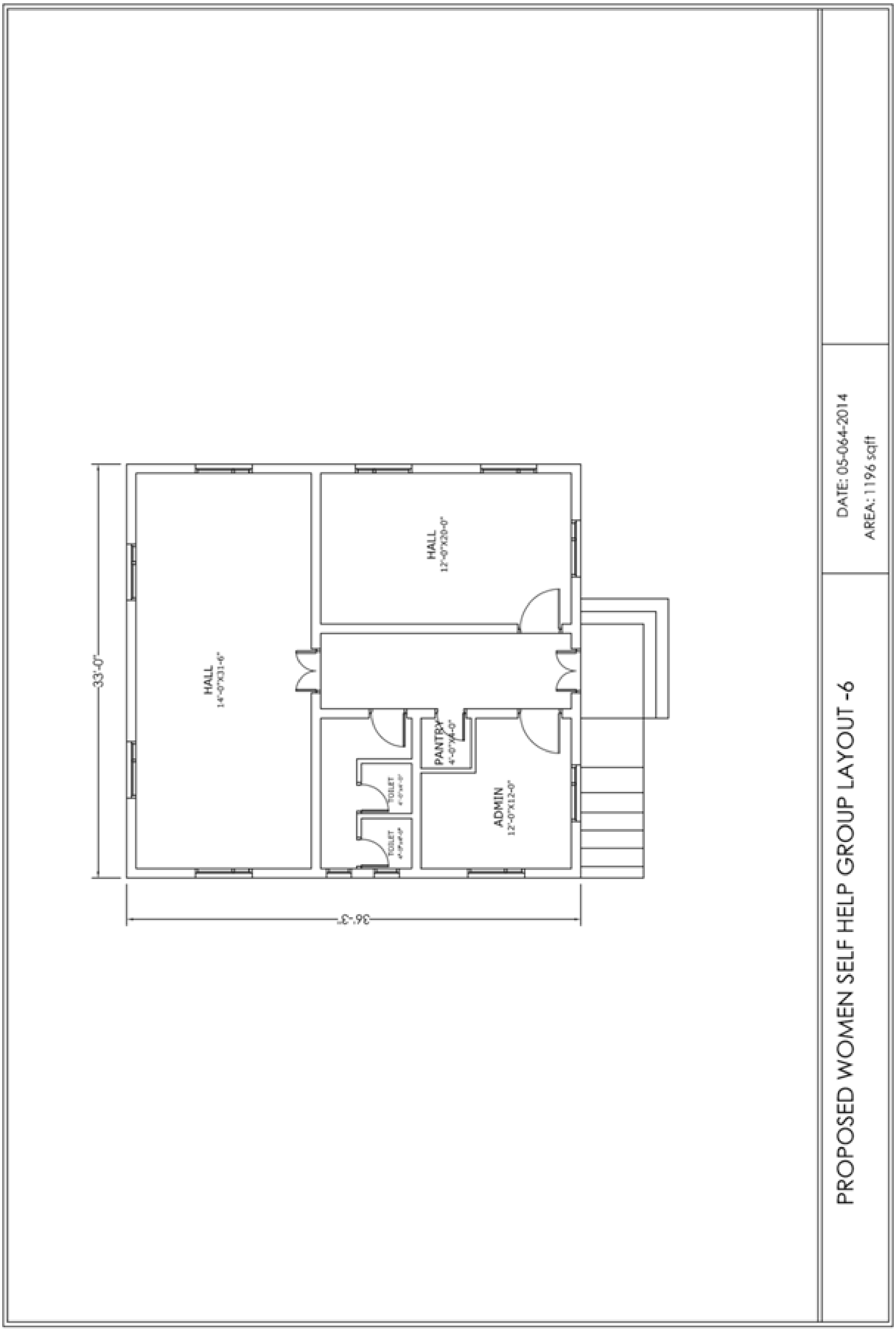


Figure 6-10: Typical plan of building for Women Self Help Groups' federation

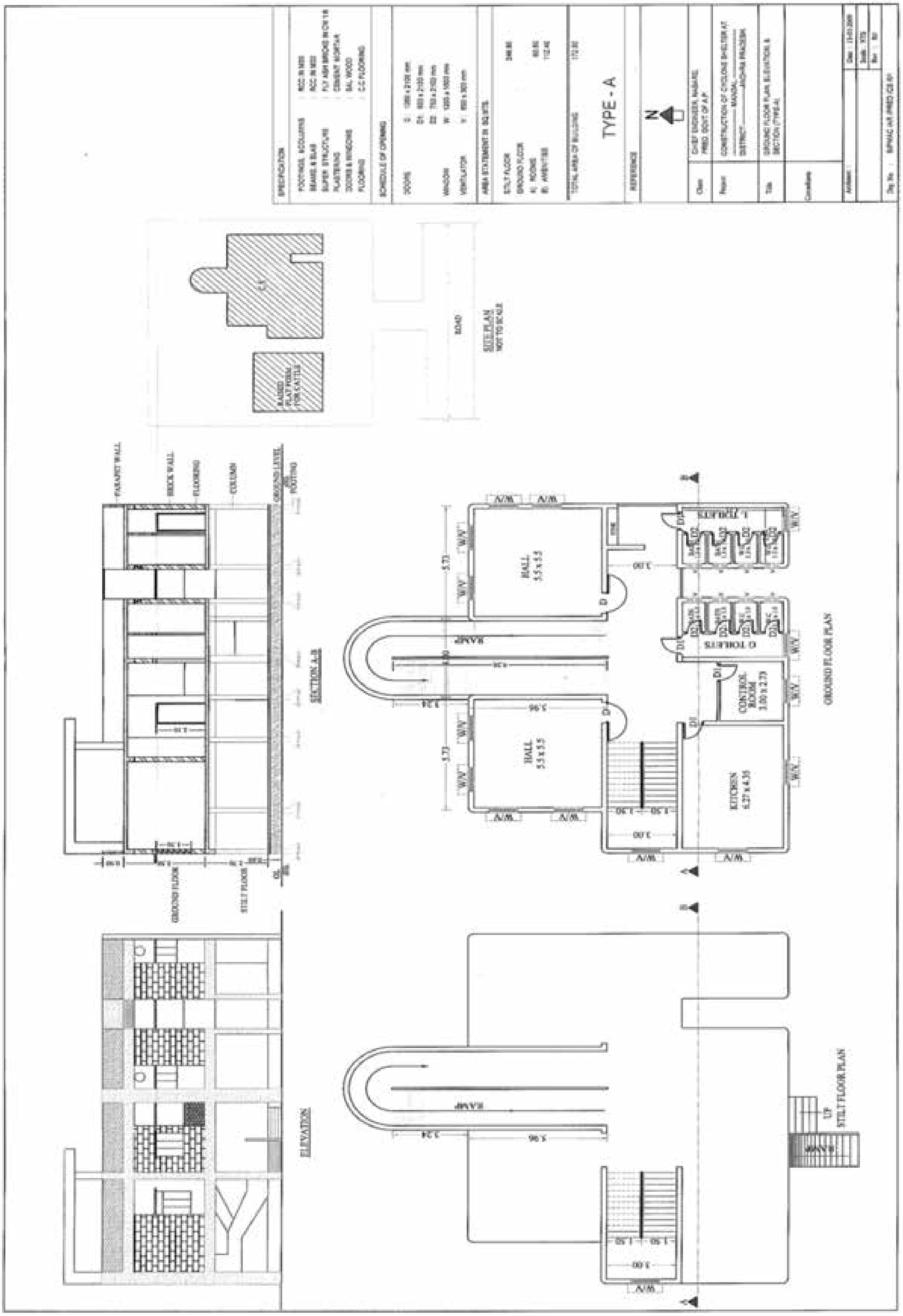


Figure 6-11: Typical plan for Cyclone shelter, Opt-1

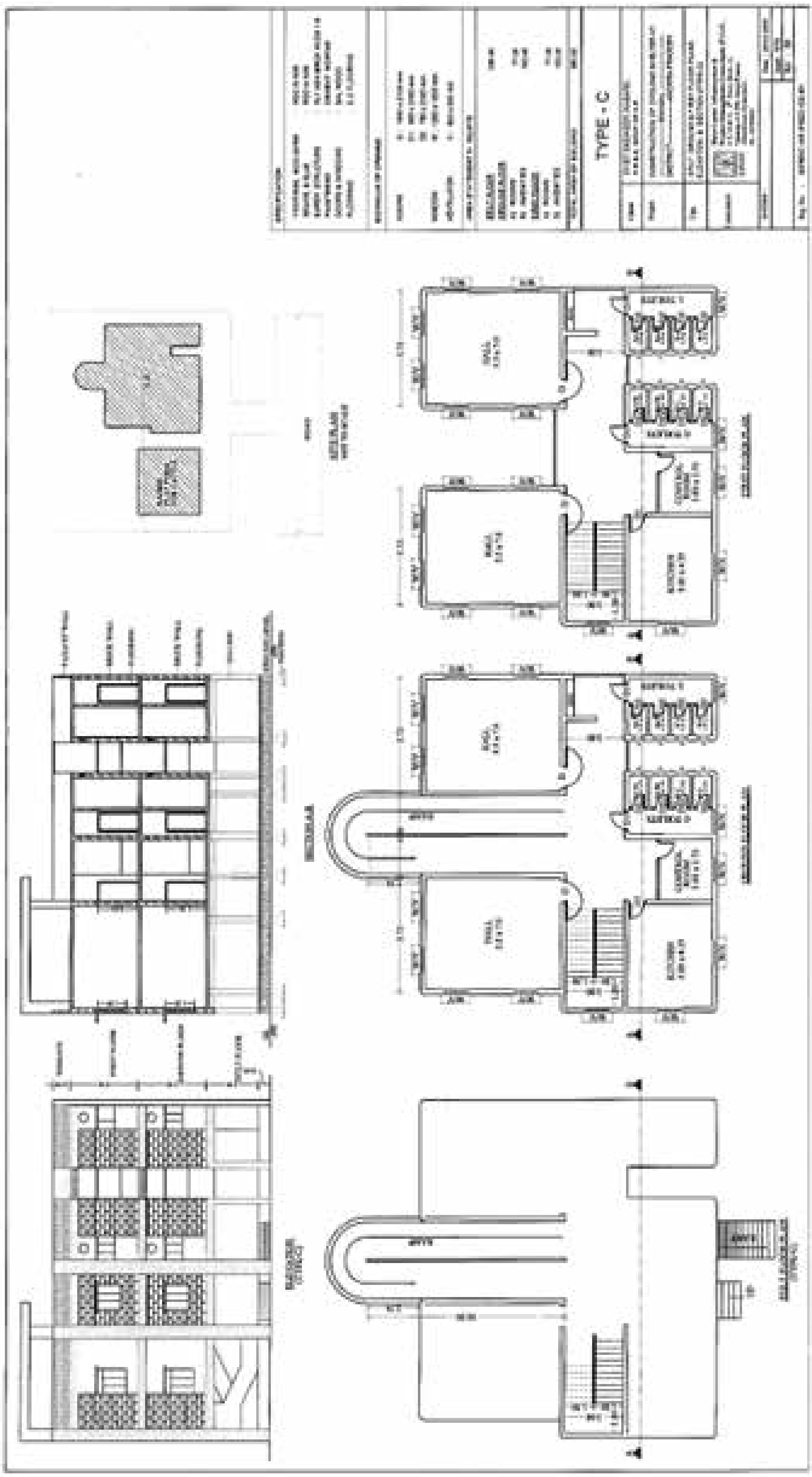


Figure 6-12: Typical plan for Cyclone shelter, Opt-2

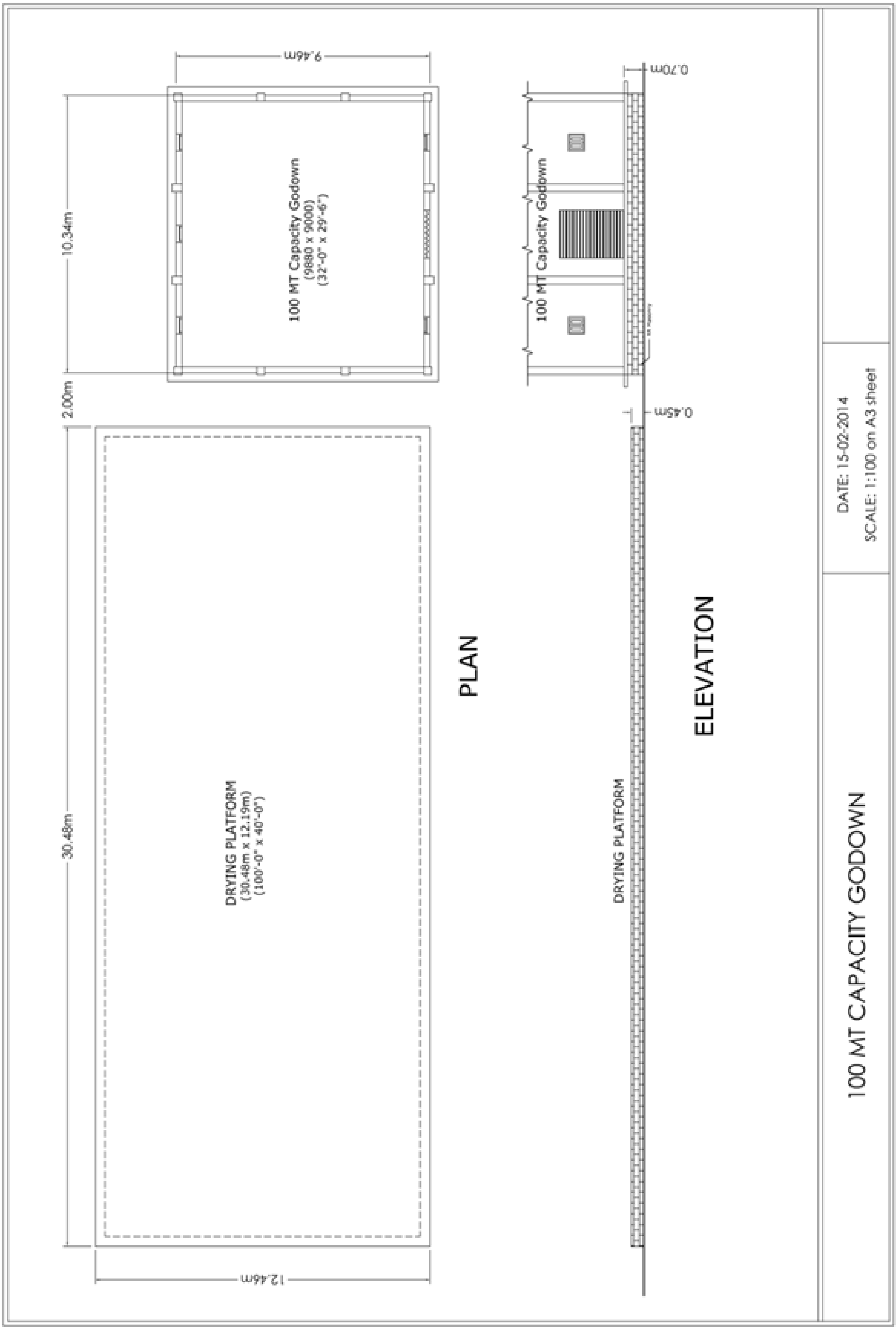


Figure 6-13: Typical plan for post-harvest facilities including pucca storage facilities for agricultural produce

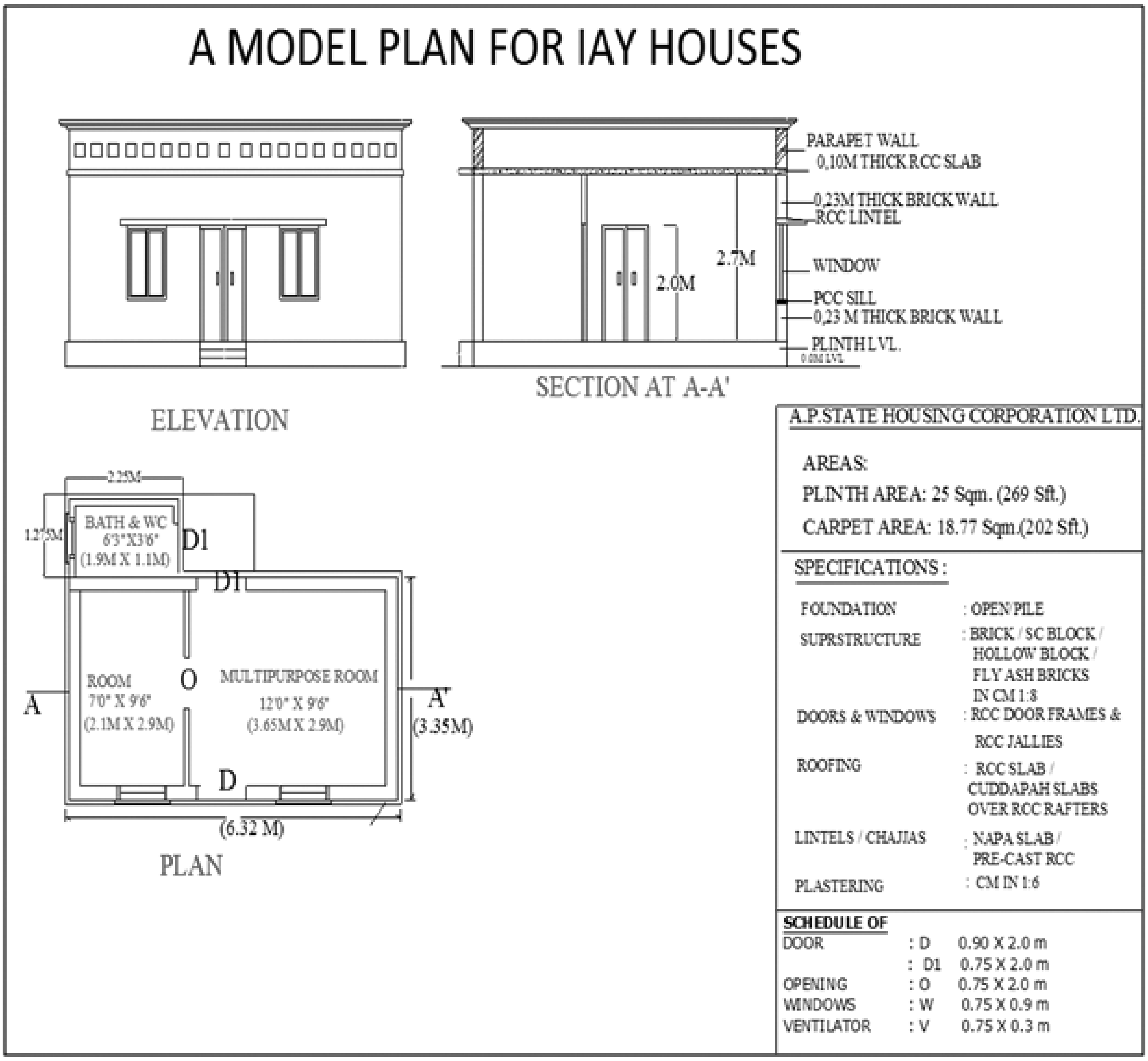


Figure 6-14: Typical plan for house under IAY, Opt-1

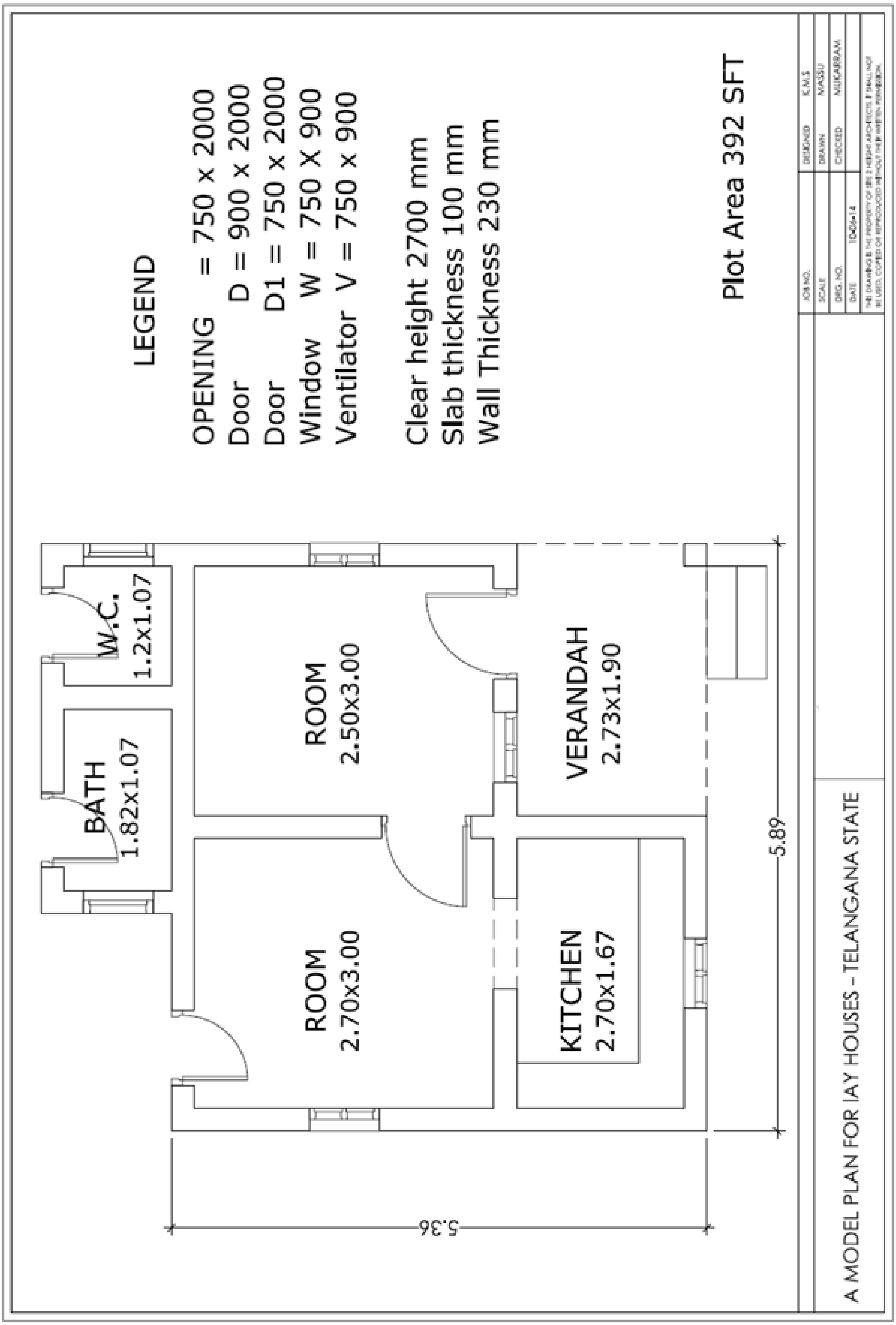


Figure 6-15: Typical plan for house under IAY, Opt-2

6.5.2. APPROPRIATE CONSTRUCTION TECHNOLOGIES:

6.5.2.1. RAT-TRAP:

The rat trap bond is a masonry technique, where the bricks are used in a way that creates a cavity within the wall, while maintaining the same wall thickness as for a conventional brick masonry wall. In a conventional English bond or Flemish bond, bricks are laid flat where as, in a Rat trap bond, they are placed on edge forming the inner and outer face of the wall, with cross bricks bridging the two faces.

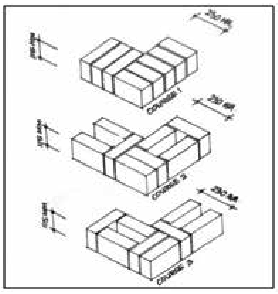


Figure 6-16: Isometric Rat-Trap masonry

i) CONSTRUCTION AND DESIGN:

a) The principal requirement for rat-trap brickwork is the availability of good quality bricks. The following may be considered as a guiding principle for ensuring strength of bricks for Rat-trap brickwork:

Type of building construction – Span not exceeding 4.2 meters, Roof/ floor loads as per IS 875	Recommended compressive strength of brick	
	Best Practice	Minimum allowable
Load bearing, double storied	More than 50 kg/cm^2	40 kg/cm^2
Load bearing, single storied	More than 40 kg/cm^2	35 kg/cm^2
Infill masonry in frame structure, no restriction on number of stories	Minimum 35 kg/cm^2	

b) Typical Junction details in Rat-trap bond brick work:

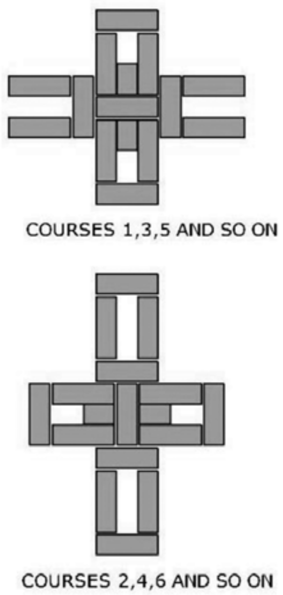


Figure 6-17: Cross joint

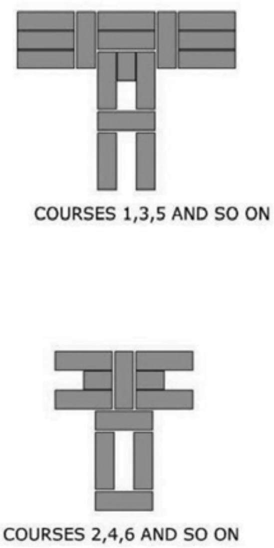


Figure 6-18: T-joint

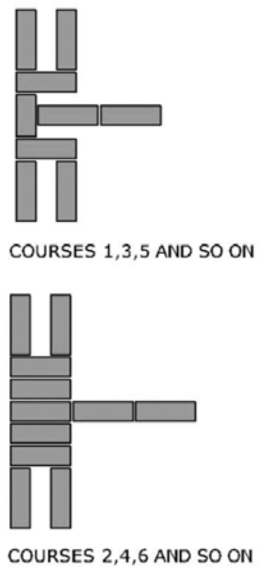


Figure 6-19: T-joint with 3" Wall

Figure 6-20: End situation at opening

c) To prevent mortar from falling into the cavities a wooden strip may be used while laying mortar on each course (Figure 6-21).

d) Rat-trap brickwork is modular in nature (Figure 6-22). Follow a modular design for length of walls and sizes of door-window openings – the module size depends on the available bricks. If this is done, need for half or quarter bricks in rat-trap masonry can be avoided.

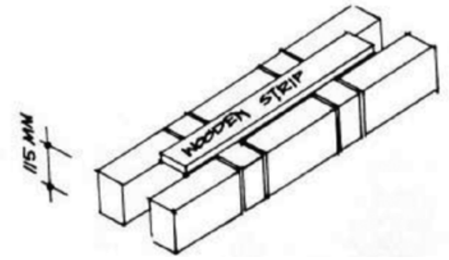


Figure 6-21: Wooden strip while laying mortar

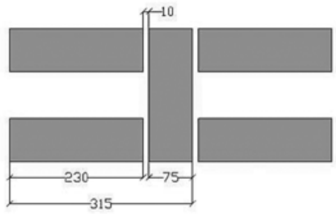


Figure 6-22: Module of Rat Trap masonry

e) Always lay the first 2 courses of brickwork in a dry run (without mortar) to ensure the exact location and size of openings as per the rat-trap module and to ensure that joints in the remaining courses will be properly staggered with the first 2 courses.

f) A solid course of brickwork should be laid at plinth, door and window sill/lintel level and roof level.

g) In case of exposed brick masonry, pointing should be done, with the mortar joints finished with rich cement mortar.

ii) QUANTITY REQUIRED:

Data for 1.00 Cubic meter of rat-trap bonded brick masonry with wire cut bricks in 1:6 cement mortar.

Description	Unit	Quantity
Bricks	No.	400
Cement	kg	36
Coarse Sand	cum	0.15
Scaffolding	cum	1
Labour		
Skilled	Man day	1.56
Un-Skilled	Man day	3.95
Curing Labour	Man day	0.50
Job Card Holders at G.O.I. Rate approved under MGNREGS for preparation of bricks	Man day	6.25

iii) ADVANTAGES:

a) Economy in use of bricks- generally, as compared to 500 bricks per Cu meter of brick wall for English bond masonry wall, 400 bricks are needed in Rat-trap bond masonry. This also results in saving in quantity of cement and sand because lesser mortar is needed.

b) Provides better thermal comfort because of the air cavity in the brickwork - the building interior remains cooler in summer and warmer in winter.

c) Compressive strength of the wall is similar to any other brick bond, even after reduction in number of the bricks.

d) Rat-trap brickwork with good pointing has an aesthetic appearance and should not be plastered – which is further saving in cost.

6.5.8.2. FILLER SLAB:

In simply supported RCC slab, Concrete above the neutral axis takes care of compressive forces and Steel below the neutral axis takes care of tensile forces. Concrete in the bottom half do not satisfy any structural purpose, instead it increases dead load of the RCC slab. In a filler slab this unnecessary concrete is replaced with a filler material which can be a waste material to ensure economical advantage over an RCC slab.

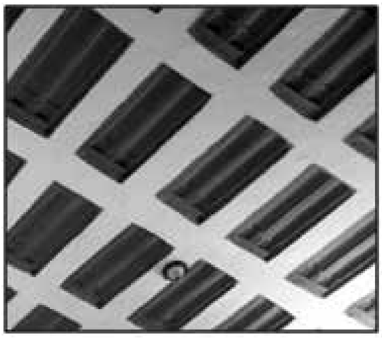


Image 6-5: Roof ceiling with filler slab

Image 6-6: Construction of filler slab

i) DESIGN AND CONSTRUCTION:

a) The filler slab can be designed like a conventional RCC slab as per IS456-2000 design guidelines, after taking into account the dead load reduction due to the filler material and the spacing of reinforcement as per the size of the filler material. There can be a conflict between filler size and the minimum spacing of reinforcement as per the code, which needs attention while selecting the filler material.

b) The thickness of filler material should not exceed the depth of the neutral axis. Generally speaking, for a slab thickness of 125mm, the filler material depth should not exceed 60mm.

c) The size and shape of the filler material are governed by factors like code guidelines for slab thickness, local availability of the filler material, desired ceiling finish, etc. and must be carefully selected.

d) Quantity of concrete in the tension zone (bottom half) of the slab that can be replaced by a filler material depends on the shape of the filler material available and the thickness of the solid slab.

S. No.	Type of filler material	Size of portion of slab using filler material		
		L (mm)	B (mm)	T (mm)
1.	Double Mangalore tile (one on top of another)	410	260	65-70
2.	Stabilized mud block	230	230-350	50-100
3.	Burnt clay brick	230	230	75
4.	Hollow Concrete Block	400	150-200	100

e) Once the filler material is identified, Shuttering for the filler slab is just like for a conventional RCC slab.

f) After erecting the shuttering, the designed reinforcement is laid with a minimum bottom cover of 15mm. This forms a grid and the filler material is placed centrally in each space of the grid. Ensuring the linearity of the tiles, fix the tiles in position using lumps of the concrete mix on all four sides.

g) No filler material is provided in bands of concrete along the edge of the slab. The width of this band depends on the actual slab dimensions, thickness of slab and the edge conditions. The reinforcement spacing in these bands will be closer than spacing around the filler materials depending upon the design.

h) After all the filler materials have been placed, any conduits, such as for concealed electrical work, should be placed in the spaces between the filler material i.e., along grid line and not on top of filler material

i) After the filler material has been completely laid, concrete is laid to completely fill in the spaces between filler materials and on top of the filler material to achieve the slab thickness.

j) In most cases, it is not advisable to use the concrete vibrator to compact the concrete in the bottom portion of the slab which contains the filler material. This may disturb the placement of the filler materials. Therefore, special care must be taken to compact this concrete manually with tamping rods. The concrete on top of the filler materials is compacted with plate vibrator.

ii) FILLER SLAB DETAILS:

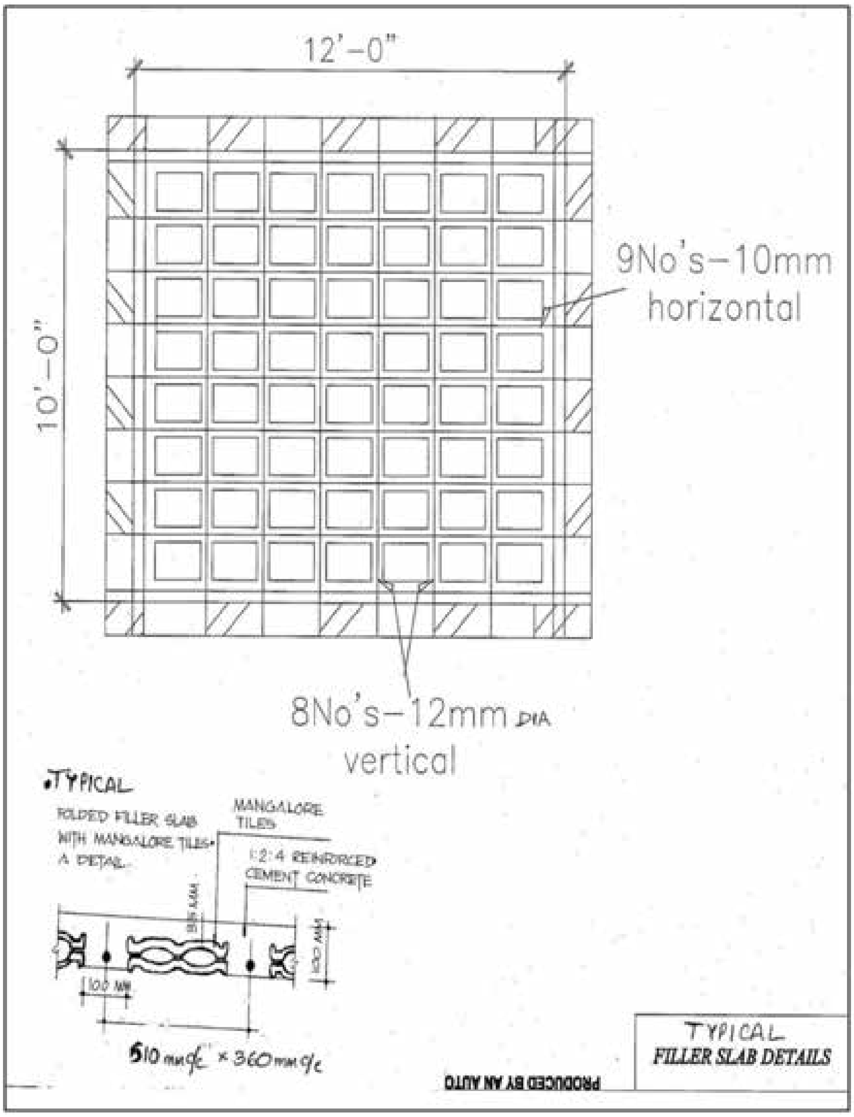


Figure 6-23: Filler slab detail

iii) QUANTITY REQUIRED:

- Room size 3.05 m x 3.66 m – internal dimensions (10' x 12')
- Filler material – 2 Mangalore tiles placed one on top of another. Total thickness of tiles will be considered as 65mm to 70mm. Size of each tile is considered as 16"x10".
- Mix of Concrete – 1:2:4
- Reinforcement spacing: Main reinforcement 12mm at 510mm spacing. Distributionreinforcement 10mm at 360mm spacing.
- No. of grids along longer dimension is 144" / 20" = 7
- Total no. of tiles required is 7x8 = 56 x 2 = 112Nos.
- Concrete replaced in place tiles = 56 x 3"x16"x10" = 15.55cft = 0.44 cum
- However 20% reduction of concrete is taken into consideration for practical purpose

Data for Filler Slab of size 3.51 X 4.12 X0.10m (outer to outer and 3.05 X 3.66m inner dimensions) with Mangalore tiles:

Quantity: 1.446cum

Description	Unit	Quantity
Cement	bags	8
Mangalore tiles	Nos.	112
Coarse Sand	cum	0.53
Aggregate 20mm	cum	0.71
Aggregate 10mm	cum	0.354
Total aggregates		1.064
12mm steel	kg	31
10mm steel	kg	29
Binding wire	kg	1.5
Labour		
Mason 1st class	Man day	2.14
Unskilled	Man day	5.38
Curing labour	Man day	1.76
Bar bender	Man day	1.19

- Depending up on tile size, the no. of tiles will vary and also reinforcement spacing will vary.
- **Data for 1cum of concrete (Filler Slab) other than mangalore tiles:**
  - Cement – 6.6bags
  - Coarse sand – 0.37cum
  - Aggregate 20mm size – 0.50cum
  - Aggregate 10mm size – 0.25cum
  - Total Aggregates -0.75cum

Labour:

- Mason 1st class – 1.67Nos.
- Unskilled labour -3.72nos.
- Curing labour - 1.22Nos.
- Bar bender – 0.82Nos

iv) ADVANTAGES:

a) It enhances the thermal comfort inside the building due to heat resistant qualities of the filler materials used. In the case of waste roofing tiles as filler, the air gap in between the tiles makes it a good heat insulator.

b) Reduction (about 20%) in the use of concrete results in saving in the cost of cement and aggregate compared to cost of tiles. Therefore it saves cost when compared to conventional slabs.

c) Ceiling of this slab can be given an attractive appearance with the filler material and therefore, a ceiling plaster is not needed

d) Masons who are familiar with conventional RCC slab construction can easily adapt to filler slab construction

e) Filler slabs can be used wherever RCC is used, for example, as floor slabs for multi-storied buildings, for sloping roofs, etc

v) LIMITATIONS:

a) Since vibrators cannot be used in spaces between the filler materials, therefore extra care is needed to manually compact the concrete in this space. Inadequate manual compaction can lead to poor quality concrete

b) It is feasible only in regions where suitable filler material is available which is cheaper than concrete.

6.5.2.3. COMPRESSED STABILISED EARTH BLOCK (CSEB):

Earth is one of the oldest and the most abundantly available building material and there are many examples all over the world which prove the durability of well-constructed earthen buildings. Stabilized Compressed Earth Blocks (CSEB), are an improved version of earth based masonry blocks. These masonry blocks are made by compressing earth/ soil mixed with Suitable stabilizer (cement) at optimum moisture content by simple mechanical means. IS code related to CSEB is IS 1725.

Image 6-7: Compressed Stabilised Earth Blocks

i) PRODUCTION:

a) The first and the most critical step in CSEB technology is identification of soil which is suitable for block production and will be available locally in the required quantity. Recommended specification for suitable soil or soil-sand mixture is as follows:

S. No.	Details	Limiting value
1	Granular Composition of soil or soil sand mixture:	
	a) Clay Fraction (< 0.002 mm)	5% - 18%
	b) Silt fraction (0.002 - 0.075 mm)	40% - 10%
	c) Sand fraction (0.075 - 4.75 mm)	50% - 80%
	d) Gravel fraction (4.75-6mm)	0% - 10%
2	Liquid limit	0% - 30%
3	pH	6.5 – 8.5

b) Accordingly Site (i.e. borrow pit) for the source of raw material (soil) to be identified by specific field tests and Laboratory tests.

c) Then soil to be sieved in a 4mm sieve to remove stones and lumps of clay.

d) Sand or quarry dust to be mixed to correct the clay sand percentage in the soil.

e) Suitable stabiliser to be added (cement or cement and lime) in appropriate proportions and mix thoroughly in dry condition.

f) Moisture to be sprinkled on to the mixture and further mixed thoroughly till the mixture is homogenous. Test for optimum moisture by trying to make a ball of soil in the hand. If a ball can be made without the soil sticking to the hand the moisture content is right.

g) The correct quantity of moist soil to be weighed such that a fresh block density of 2.05 gm/cc can be achieved. The weighed soil is to be poured in a soil compaction press, and moulded in a CSEB. Blocks are then stacked in a five or six block high stack and cured for next 21 days to complete the block making process.

h) Blocks thus produced ready to be used for masonry with cement mortar 1:6, cement-lime-mortar 1:1:6, cement-soil mortar 1:2:6 or 1:2:7 or mud mortar.

i) In case of exposed SCEB masonry, the joints should be pointed with 1:3 mortar or 1:1:2 (cement-soil-fine sand) mortar to prevent water absorption/ leakage through the joints.

ii) QUANTITY REQUIRED:

Data for producing 1000 numbers of Cement Stabilised Earth Blocks based on hand book of Vidyalayam

Size: 230 X 108 X76

	Materials	Quantity	Labour	Days
1.	Soil	3.5 cum	1. Unskilled	9.0 man days
2.	Cement	212 kg		
3.	Main and dep.	1% of total cost		

Data for 1.00 cubic meter of CSEB masonry in 1:4:8 cement-soil mortar: 520 Nos. for size of brick 230mm X 108mm X76mm

No.	Materials	Quantity	Labour	Days
1	CSEB	425 Numbers	1. Skilled	1.05 Man days
2	Soil	0.24 Cubic meters	2. Unskilled	2.2 Man days
3	Cement	37.5 Kilograms		
4	Sand	0.08 Cu meters		

iii) ADVANTAGES:

a) Can be very cost effective, especially when the blocks are produced at the site

b) Soil is an easily available resource in rural housing

c) Provides a uniform good strength of around 50 kg/cm2

d) Provides good thermal comfort provides aesthetical wall finish, no plaster required

e) Creates additional local employment in block production

f) Can be made with locally available earth which makes it cost effective.

g) Thermally comfortable, aesthetically pleasing and one of the most environment friendly alternatives for wall construction.

iv) LIMITATION:

a) Requires a good understanding of the type of soil available for block production and how it can be improved/ stabilized.

b) Availability of soil in adequate quantity from a single source, can be a limitation.

c) Needs careful design and detailing of the building to ensure that the walls are not damaged by rain.

6.5.3. BROAD DOS AND DONTS OF CONSTRUCTION OF BUILDING PRACTICES

S.N.	Dos	Don'ts
I	**Site Selection :**	
	• Site Investigation including properties of the soil, type of soil strata, Safe Bearing Capacity of the soil shall be ensured before giving layout.	• Preferably low lying, water logged areas shall be avoided. • Do not mark layout without proper site investigation.
II	**Production/ procurement of Building Materials :**	
	• Assess locally available materials. • Test properties and justify its suitability for construction purpose. • Strength of the materials shall be ensured when locally available materials are utilized. • Sand should be free from silt and clay. • Bricks compressive strength shall be not less than the designed compressive strength. • Drying of Mud bricks / Fly ash bricks / Sand cement blocks/ stone blocks shall be laid on hard and even surface. • Steel / cement shall be as per IS code specifications.	Avoid procuring materials from faraway places. Avoid utilization without ensuring the suitability of materials for construction. Improper planning of production of materials will prolong the construction period. It will also lead to wastage of materials. Drying of Mud bricks should not be laid on loose and uneven surface.
III	**Design**	
	Foundations: • Design should be based on the SBC of soil and its parameters. • Typical estimates for SBCs of 100kN/m2, 150kN/m2& 200kN/m2 are annexed. And different types of foundations viz., Conventional load bearing & framed type, Stub, Pile foundations. • In case of BC soils are met with provide Pile foundations. If conventional type of foundations in BC soils adopted, sand cushion of at least 0.60m to be provided under the PCC levelling course. • If the SBC is less than $100kN/m^2$, and if filled up/ marshy soils are met with, proper foundation design shall be done before marking layout. • If the SBC is more than $200kN/m^2$ foundation design can be suitably modified before marking layout.	• Designs should not be done without ensuring SBC and its parameters. • If SBC is less than $150kN/m^2$, BC Soils & in Coastal areas avoid stub foundations. • Where conventional type of foundations adopted in BC soils avoid refilling the left over portions of the trenches with excavated soils. Refill with Gravel/ Sand. • Improper clear cover in RCC items will lead to exposure of steel and reduction of strength of the member. • Improper curing leads to low compressive strength, bonding in case of masonry foundation. It ultimately leads to unequal settlements.

	• Mixing of concrete shall be on hard surface prepared with lean concrete as concrete pavement. • Proper curing shall be done.	• Mixing of concrete shall not be done directly on earthen surface / loose surface.
IV	**Plinth & Basement**	
	• Basement top level shall be higher than the road level to avoid flooding of buildings. • In Food Grain Storage Godowns: a) provide rat protection slab outside all-round the Godown at Plinth level as per the norms of Ware housing & Marketing department. b) Provide minimum basement height of 0.90m. • Provide Damp Proof course at top of the basement (when two different materials are used for basement and superstructure). • Provide band all around, if same material is used for both basement and super structure • Better to construct steps together with basement to avoid separation. • Proper curing shall be done.	• Avoid Basement top level lower than the road level. • Superstructure shall not be started without Damp Proof course at top of the basement. • Food Grain Storage Godown: a) Godowns shall not be constructed without rat protection slab. b) Basement height shall not be less than 0.90m. • Improper curing will reduce the strength of the structure.
V	**Superstructure**	
	• Types of super structure: Conventional method, Rat trap bond • In conventional method RCC Bands are to be provided at sill & lintel level • Rat trap bond solid layers i.e., brick on edge/ solid layers to be provided at a) First layer above basement b) layer just below the window sill level c) lintel level d) below slab level e) below& above the opening areas. • Solid brick masonry to be provided below bed blocks of the beams • Preplanning for electrical concealed conduiting and plumbing lines whenever rat trap masonry is done. • In rat trap bond, proper brick bearings on either side shall be ensured in brick jollies. • In conventional load bearing structures, at the corners provide solid brick masonry of minimum 230mm.	• In conventional method for super structure don't avoid RCC Bands at sill & lintel level. • Without proper planning in case of Rat trap bond concealed conduiting is not feasible. • In case of Brick jollies (replacement of windows) improper brick bearings will leads to diagonal cracks, collapse of bricks.

	• Cement Concrete to be provided as bed blocks under lintels, beams and also fixing hold fasts of doors and windows. • Proper curing shall be done.	
4	Door & Window Openings • Seasoned wood shall be used for frames & shutters • Lintel length shall be length of opening plus 230mm on either side	• Avoid unseasoned wood for door & window frames and shutters. • If proper bearings are not provided it will lead to upward corner cracks.
5	Beams & Slab • Cover blocks with same concrete grade of slab shall be provided for placing of reinforcement in beams & slab as per clause 26.4 of IS 456-2000. • At beam slab junctions proper shuttering shall be done. • Stirrup hook shall be as per SP 16 and as per IS 13920 – 2002 angle of stirrup hook shall be 135 degrees and hook length shall be 10 times the diameter of the stirrup in earth quake zone. • Earthquake designing may be adopted for Zone III to Zone V • Proper curing shall be done as per clause 5.40 of IS 456-2000. • Development length shall be maintained as per clause 26.2.1 of IS 456 - 2000. • Use coarse sand for concrete. • Props shall be placed @ 2 feet centre to centre in all directions under the beams and slabs. • Form work stripping shall be as per clause 11.3.1 of IS 456 – 2000. • In filler slab place the filler material below neutral axis i.e., in tension zone.	• Improper clear cover will lead to sapling of concrete. • Improper shuttering will lead to wastage of concrete and formation of honey combs particularly at junction points. • In column beam junctions overlapping shall not be done. • In columns overlapping of rods shall not be done at one point and 50% shall be staggered. • In beams for top rods overlapping of rods shall not be done at support and for bottom rods overlapping shall not be done at mid span. • Not to use fine sand. • Avoid concreting without verification of form work and reinforcement. • Form work stripping time shall not be before clause 11.3.1 of IS 456 – 2000. • Avoid placing of filler material in compression zone in filler slab. • Avoid using of broken / cracked tiles.
6	Flooring: • Adopt local practices. • Locally available natural stones shall be adopted except for Food Grain Storage Godown. • Maintain proper levels. • Flooring shall be over Cement Mortar bed. • Apply cement slurry properly. • Proper cement jointing shall be done.	• Avoid flooring directly over sand. • Avoid improper levels.

7	Finishing	
	i) Plastering: a) use fine screened sand. b) Surface shall be maintained to plumb. ii) Painting: Check smoothness of the surface before painting.	• Don't use coarse sand and sand with silt and clay.

6.5.4. STANDARDS AND SPECIFICATIONS:

Specifications for some of the cost effective and environmentally sensitive appropriate construction technologies are given below:

Sr.no	Technologies	Specifications	Category
1	Stabilised soil blocks in general building construction - specification	IS 1725	Wall
2	Specification for precast concrete stone masonry blocks	IS 12440	Wall
3	Construction of walls using precast concrete stone masonry blocks-code of practice	IS 14213	Wall
4	Code of practice for application of lime plaster finish	IS 2394	Wall finishes
5	Specification for precast concrete lintels and sills	IS 9893	Fenestrations
6	Specification for stone lintels	IS 9394	Fenestrations
7	Bamboo based construction technologies		
a.	Preservation of bamboo for structural purposes – code of practice	IS 9096	Bamboo technologies
b.	structural design using bamboo – code of practice	IS 15912	Bamboo technologies
8	Code of practice for design and construction of floor and roof with precast reinforced concrete planks and joists	IS 13994 & Standards and Specifications BMTPC_CT10	Roof
9	Specifications for precast doubly- curved shell units for floors/ roofs	IS 6332 & Standards and Specifications BMTPC_CT10	Roof
10	Code of practice for construction of reinforced Brick Slab (RB) and Reinforced Brick Concrete (RBC) slabs for floors and roofs	IS10440 & Standards and Specifications BMTPC_CT8	Roof
11	Pre-fabricated brick panel and partially precast concrete Joist for flooring and roofing – Specification	IS14143 & Standards and Specifications BMTPC_CT9	Roof
12	Specifications for precast reinforced concrete door and window frames	IS 6523 & Standards and Specifications BMTPC_BC5	Fenestrations
13	Specifications for Fero-cement roofing channels	Standards and Specifications BMTPC_CT10	Roof
14	Specifications for micro concrete roofing (MCR) tiles	Standards and Specifications BMTPC_BM08	Roof
16	Specifications for Ferro cement door shutters	Standards and Specifications BMTPC_BC6	Fenestrations

6.6. CONSTRUCTION OF FOOD GRAIN STORAGE STRUCTURES:

6.6.1. Food grain storage structures for implementing the provisions of the National Food Security Act 2013 (20 of 2013)-

6.6.2. Under MGNREGA, scientific Food Grain Godowns for 250MT & 500MT capacities may be taken up. Roofing will be either with truss roofing or with proflex sheet roofing.

6.6.3. While designing specifications, the “National or State warehouse manual for operationalising warehousing (Development & Regulation) Act or guidelines issued either by GoI or States” with subsequent amendments there on shall be followed.

6.6.4. TYPICAL SPECIFICATION REPORT FOR ESTIMATE:

i) For estimation, foundation depth is taken as 1.20m beneath ground level for ordinary soils and 1.50m for BC soils. Sand filling is proposed in partially delta areas where there is a possibility of encountering of BC soils below footings.

ii) For framed structure R.C.C. footings, pedestals, columns, plinth beams at basement level, tie beams at 2.40m height above basement level, roof beams at 4.20m height and roof beam depth 0.3m are proposed for 250MT & 500MT capacity godowns.

iii) Basement is proposed at 0.90m height from Ground level & Random Rubble masonry is proposed for basement.

iv) Plinth protection of about 1m wide and 100mm thick is proposed all around the building at ground level.

v) Basement up to 0.47m is to be filled with available excavated earth, if excavated earth is useful for refilling. Otherwise it should be filled with carted gravel or with sand whichever is available at low rate. Top 0.23m depth of basement is filled exclusively with sand in order to avoid uneven settlements.

vi) Flooring: Base coat of 150mm thick with PCC (1:5:10) using 40mm size HBG metal, top coat of 50mm thick with PCC(1:2:4) using 40mm & below HBG metal in order to with stand the loads.

vii) Super structure i.e., walls are proposed with the following options/ alternatives.

   a) Brick Masonry in CM (1:6) using 2nd class bricks of 0.23m thick & plastering 20mm thick in single coat in CM(1:4) on uneven surface and 12mm thick in single coat in CM (1:4) on even surface.

   b) Flay ash brick masonry in CM (1:6) using fly ash bricks of 0.20m thick & plastering for this masonry is done with 12mm thick in single coat in CM (1:4) on both the sides.

   c) Mud Brick masonry of 0.23m thick in CM(1:6) using mud bricks manufactured at site & plastering to this to be done with 20mm in two coats i.e., base coat of 16mm thick in CM(1:6) & top coat of 4mm thick in CM(1:4).

viii) Sun shade is proposed over windows (box type shade all around the window), over rolling shutters at tie beam level and continuous sun shade at roof beam level over ventilators to protect the building form entry of rain water inside.

ix) Major openings i.e., doors – rolling shutters of size 1.80x2.40m is proposed as per act, windows (0.62x0.62m), ventilators (1.00x0.45m) are proposed on each bay on both the sides of long walls except on gable wall sides.

x) Roofing: Estimation is done for roofing with proflex sheeting and within that amount even truss roofing Galvanised sheet can be executed.

xi) Painting: Internal walls with white lime in two coats (Suryacem or equivalent) and external walls with Water proof cement paint (Snowcem) in two coats.

xii) Looking to the technical input required in construction of scientific food grain godowns it is advisable that the implementing agency for this work should be Regular engineering department.

xiii) Typical plans for 250 MT & 500 MT capacity Godowns are given in figure 6.6.1 and 6.6.2. The estimated cost will vary place to place based on local MGNREGA / State SoRs and lead for the supply of construction material.

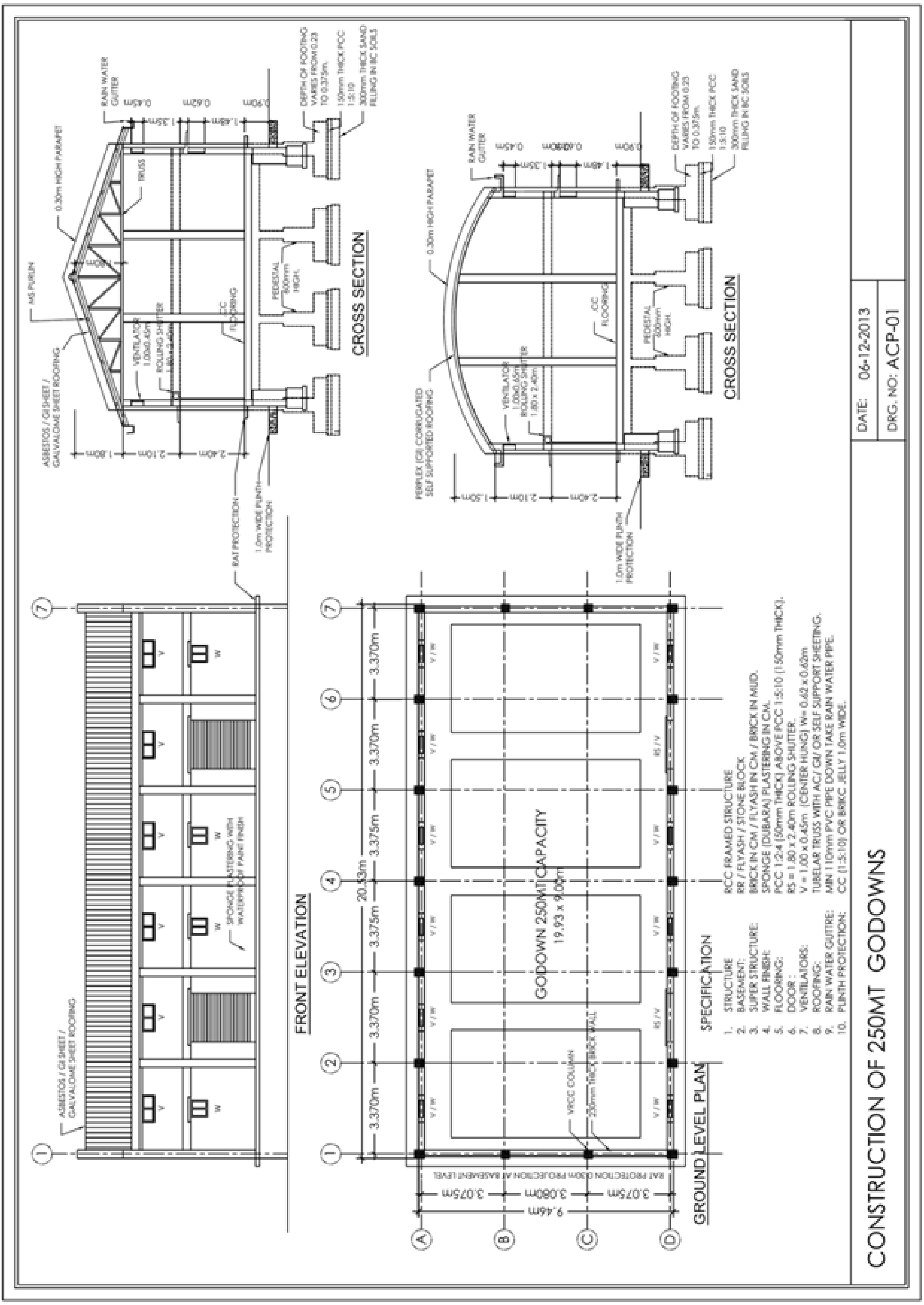


Figure 6-24: Typical plan for construction of 250mt Godowns

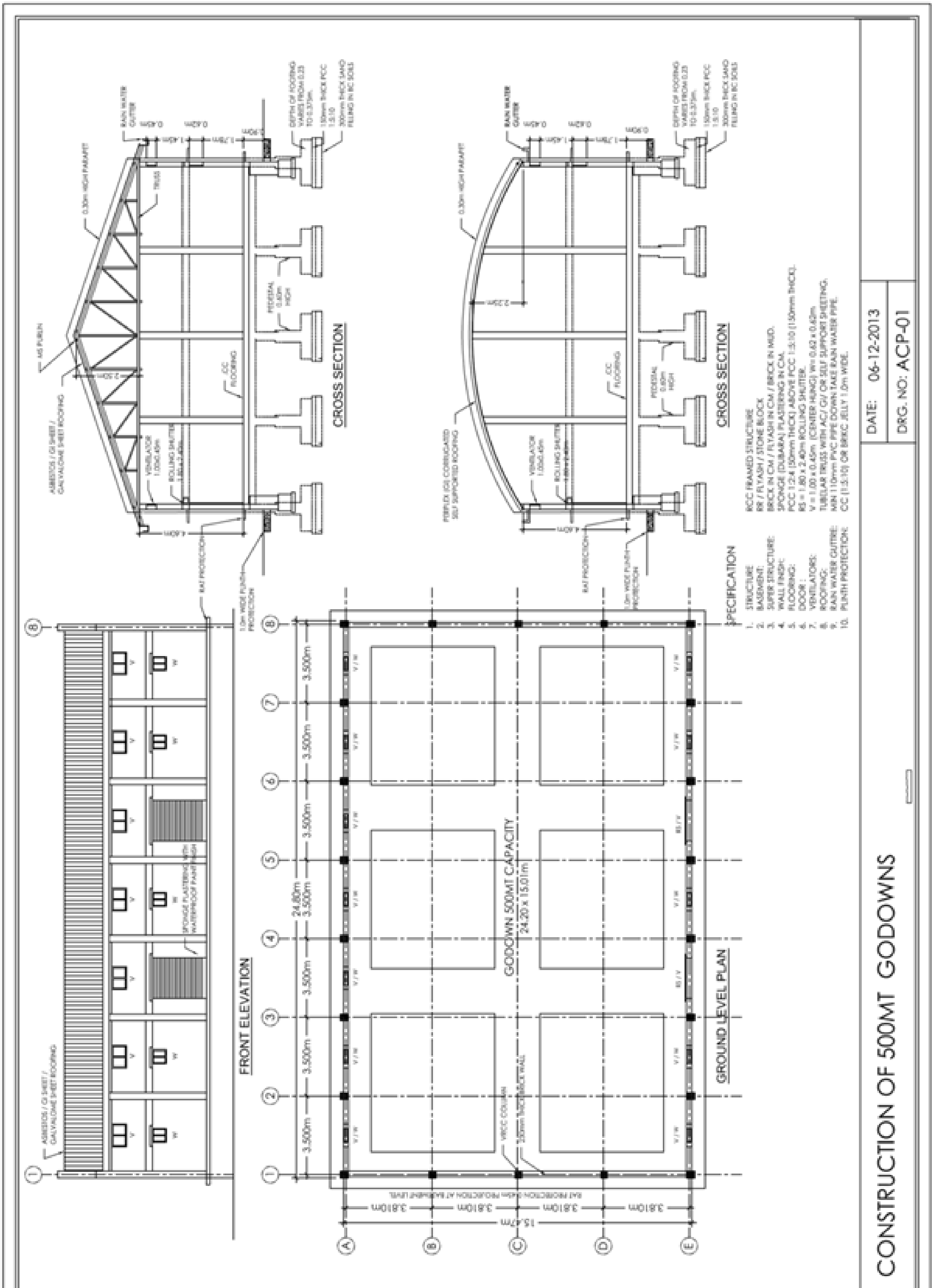


Figure 6-25: Typical plan for construction of 500mt Godowns

6.7. PRODUCTION OF BUILDING MATERIALS:

6.7.1. CONTEXT:

Vide Notification dated 3rd January 2014, Ministry of Rural Development, Government of India has expanded the scope of works listed in Schedule 1, Para 4 (i) of MGNREG A and included a number of material intensive works that promote livelihoods such as construction of rural buildings, infrastructure for promotion of Livestock, fisheries & agriculture productivity etc.

6.7.2. As per Para 20 of Schedule I, of MGNREGA, the 60:40 ratio for wage and material costs is required to be maintained at GP level for all works to be taken up by GP and at the District level for works to be taken up by all other agencies.

6.7.3. Several states have represented that in a number of new works that are now allowed to be taken up under MGNREGA, clay bricks; hollow bricks, tiles, metal (grit) etc., are used. While production of such building material provides employment to unskilled labour, the entire cost of such building material including the cost of unskilled labour, is counted towards material cost for the purpose of computing the labour-material ratio. This creates an anomaly in terms of the labour-material ratio.

6.7.4. Taking into account, the factors listed above, production of building material required in execution of MGNREGA works, as one of the activities under MGNREGA has been included in schedule-1, MGNREGA at Para 4.(1) (vii). Pursuant to this, the guidelines for production of building material has been issued vide Ministry letter No. J-11017/26/2008-MGNREGA (UN) dated 13th January, 2014 and are as follows:

6.7.5. Building Materials which can be taken up for field trials are mud blocks, reinforced mud blocks, clay bricks, hollow bricks, cement inter locking tiles, metal (grit), pipes, etc., in production of which sufficient number of unskilled labour is required and can be produced locally with locally available material.

6.7.6. PRODUCTION OF BUILDING MATERIAL AS AN ACTIVITY IN WORK EXECUTION:

Implementing Agency (as defined in Section 2 (g) of the Act) that is entrusted with the task of executing MGNREGA works, may take up, production of building material as a part of construction of the work in a labour intensive manner, following these guidelines. But such production shall not be a standalone activity.

6.7.6.1. PLANNING & EXECUTION:

i) From the annual development plan of the GP, works for field trials should be carried out and the total requirement of building materials for MGNREGA works to be used should be ascertained. The production of building materials should be spread in such a manner that building materials are not allowed to be stored for long period and this would affect the quality and lead to breakage/ wastage.

ii) The location where building material will be produced shall be selected based on the availability of water and the required quality of material/ soil etc.

iii) For unskilled labour required in production of building material, workers that hold job cards only will be engaged. The un-skilled tasks under different activities in production of building material to be carried out by an un-skilled labour should be worked out by the State, quickly.

iv) Self Help Groups of MGNREGA workers, interested in building material production will be formed in the Block. The DPC will arrange required training on building material production to these Self Help Groups, through the concerned agencies, before the building material production is taken up and such SHGs will be engaged, whenever building material production is taken up in the Block.

v) Some existing willing building material manufacturers may be identified as non-commercial ‘resource persons’ who can work as ‘mates’ for the programme. These identified mates may select the places and train the wage seekers in basic processes before starting the production of building material.

vi) All processes and non-negotiable required under MGNREGA will be followed in engaging MGNREGA workers for building material production under these guidelines.

6.7.6.2. QUALITY ASPECTS:

It is necessary to ensure that prescribed quality standards are adhered to. If the building material production is not of the quality required, not only should the field trial be discontinued, such building material should not be used for construction at all. Sizes, strength required and tests to be performed as per Indian Standard Specifications.

States must deploy all required inspection/monitoring processes so as to ensure that building material produced are of acceptable quality.

6.7.6.3. COSTING:

In building material production cost, un-skilled labour component (shall not be less than 33%) and skilled/ semi-skilled/ material component, will be worked out by the State, based on actual costs of inputs, wage rates and work output.

6.7.6.4. CAPITAL INVESTMENT:

Procurement of capital items should be avoided. If it is absolutely necessary to procure small items, then the same can be procured following procurement procedures laid down by the State Government. However, it is advised that a decision for procuring capital items shall not be a level below that of DPC.

6.7.6.5. ACCOUNTABILITY ARRANGEMENT:

On every building material production site all accountability arrangements as prescribed under MGNREGA will be followed. Material at site (MAS) register with details of raw material and produced material will be maintained in the format as detailed at Format-1 & Format -2 respectively.

6.7.6.6. COMPLIANCE WITH RULES/ REGULATIONS AND ENVIRONMENTAL LAWS

All other conditions such as compliance with Rules / Regulations including those relating to Environmental aspects should be strictly adhered to. All building material shall follow 'green' (environmental friendly) technology and processes.

6.7.6.7. MISCELLANEOUS:

It needs to be re-iterated here that building material production is not permitted as a "stand alone" activity meaning thereby that building material production cannot be made under MGNREGA and used for works other than the works taken up under MGNREGA or for sale in the open market.

6.7.6.8. DOCUMENTATION AND MONITORING:

The regular and systematic documentation of field trials on building material production at District level will be made by the implementing agency under the guidance of DPC. The State will monitor the field trials taken up for building material production and will ensure that the regular and systematic documentation is made on field trials and will give regular feed back to the Ministry. After 4 months of starting field trial, reports may be sent to MoRD, wherever possible teams from the Ministry will visit the building material production sites to study and assess the possibility of up scaling the activity. A final decision on up scaling would be taken after assessment of performance.

FORMAT-1

MATERIAL AT SITE (MAS) REGISTER FOR RAW MATERIAL PROCURED FOR PRODUCTION OF BUILDING MATERIAL FOR MGNREGA WORKS

Name of Site/ GP/ Block/ District:

Name of building material to be produced:

Name of the implementing agency producing building material:

S.NO.	RAW MATERIAL	UNIT	QUANTITY	SOURCE	DATE OF RECEIPT	AMOUNT SPENT (₹)	DATED SIGNATURE OF THE VERIFYING AUTHORITY
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

FORMAT-2

MATERIAL AT SITE (MAS) REGISTER FOR BUILDING MATERIAL PRODUCED

Name of Site/ GP/ Block/ District:

Name of building material to be produced:

Name of the implementing agency producing building material:

S.NO.	NAME OF MATERIAL PRODUCED	UNIT	QUANTITY	UNSKILLED MAN DAYS USED	S.NO.	RAW MATERIAL USED			PRODUCTION COST PER UNIT	TOTAL PRODUCTION COST	FINISHED MATERIAL USED FOR		DATED SIGNATURE OF THE VERIFYING AUTHORITY
						MATERIAL	UNIT	QUANTITY			NAME OF WORK	TOTAL QUANTITY USED	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)

CHAPTER 07

QUALITY CONTROL & MAINTENANCE OF WORKS UNDER MGNREGA


M.G.NREGA
RENOVATION OF DOLING LAKE
NAME OF WARD - BARFUNG
NAME OF G.P.U - BARFUNG - ZARRONG
SANCTION AMOUNT - ₹ 163264
DATE OF COMMENCEMENT - 23.06.2011
DATE OF COMPLETION - 18.11.2011

CHAPTER 07

QUALITY CONTROL & MAINTENANCE OF WORKS UNDER MGNREGA

7.1. QUALITY CONTROL OF MGNREGA WORKS:

CONTEXT: As per **Para 3, schedule I of MGNREGA** one of the core objectives of the Mahatma Gandhi NREG Act is 'strengthening the livelihood resource base of the poor, through creation of productive assets of prescribed quality and durability' and for this purpose, the selection of work site, design and the execution of each work has to be done in a manner, so as to maximise the outcomes. This has to be monitored by measuring the 'expected' and 'actual' outcomes of the work.

Optimum utilization of scarce available resources in creating durable & productive assets under MGNREGA and optimizing outcome of MGNREGA work will be possible only when required quality management of MGNREGA works is carried out in a timely manner and systematically, so that the MGNREGA works are economical, durable, and productive/ giving optimum outcomes after completion. To achieve it, following parameters are to be kept in mind and steps/ activities are to be carried out in selecting work, feasible site, survey, planning, designing, layout, execution, monitoring and follow up.

7.1.1. ECONOMICAL:

To carry out a work there may be different alternative sites, from where we can get better output per unit expenditure. For illustration, while locating water harvesting structure (WHS) there may be different available sites where different storage capacities are available, therefore among these alternate sites we have to select a site, where the size of WHS i.e; length and height required to be constructed is minimal and water storage capacity is optimum. This can be quantified by working out construction cost per cubic meter of water storage. **The site where the construction cost per cubic meter of water storage is minimal will be selected.**

7.1.2. DURABLE:

The assets will be durable ie; usable and productive till its estimated life or more, only when the work site is properly selected, required survey, design & planning has been carried out/ made, proper layout has been given and all required norms have been followed in execution of work etc.

7.1.3. PRODUCTIVITY/ OUTCOME:

7.1.3.1. While selecting a work and the site, the outcome/ utility of the work have to be spelled out and quantified. For illustration if a WHS is proposed to be constructed, how many open/ bore wells will be benefited or how much area will come under irrigation etc. Whether it will lead in expansion of crop area and change in cropping pattern- which may fetch more income, should also be spelt out while selecting a work site for WHS. If plantation is proposed in an area, than in how many years, how much production / income it will generate

7.1.3.2. The 'expected outcomes' and 'actual outcomes shall be quantifiable and measurable and shall be arrived at in the following manner:

i) INDIVIDUAL ASSET: In case of a work for creating or upgrading an individual asset, the outcome shall be defined in terms of the physical outcome/ benefit and expected additional income to the household after execution of the work.
For illustration, if a proposal is to do contour bunding on a beneficiary field then how much, soil from erosion will be checked, rain water will be conserved & percolate, increase in productivity and expected additional income to the household will be there after execution of work.

ii) COMMUNITY ASSET: In case of a work creating or upgrading a community asset, the outcome shall be defined in terms of number of households it would benefit and the net additional income to the community that is expected from execution of that work.

For illustration, if we are constructing a pond, then the outcome shall be that how many households would benefit for bathing/ washing/ drinking water for cattle or fisheries, how many wells will be recharged/ how much area will come under irrigation and net additional income to the community that is expected from constructing pond.

7.1.4. MONITORING OUTCOME:

The productivity/ outcome should be strictly monitored by measuring the 'expected' and 'actual' outcomes from executing a work in the following manner:

i) Before any work is placed before the Gram Sabha for approval, there should be a statement quantifying the expected outcomes from executing the work, as stated above at Para 7.1.3.2.

ii) No work should be moved to the shelf of projects without quantifying the 'expected outcomes' from that work; and no work should be closed without measuring the 'actual outcomes' from execution of the work.

iii) On conclusion of the work, the 'actual outcomes' achieved should be measured and quantified by the Programme Officer or by a team deputed by him; and should be placed before the Gram Sabha.

iv) In case the 'actual outcomes' are below the 'expected outcomes', and that is attributed to negligence either in design or in execution either by the social audit or in the quality inspections or in the verification done by the Programme Officer, the personnel responsible should be proceeded against in the manner as defined in the disciplinary rules governing their service.

v) Action taken on such personnel should be reported to the Gram Sabha in the next meeting and should be monitored by the District Programme Coordinator.

vi) In this regard Ministry has also issued instructions vide letter No. J-11011/02/2010-MGNREGA (Policy) (10093) dated 5th August, 2014.

7.1.5. TYPICAL UNITS:

Typical units of expected economy, durability, and outcome/ productivity of MGNREGA works are at table-7.1. However, it may vary place to place depending on local agro-climatic and hydro-geological conditions.

7.1.6. RESPONSIBILITIES:

As per the chapter on "Quality management of MGNREGA works" of the MGNREGA Operational Guidelines 2013, all these activities are to be carried out by the implementing agency through the internal quality supervision team. The State Government will prescribe roles and responsibilities of the Technical Assistants at GP level and the technical staff at Block/ District level to carry out these activities, supervise, provide guidance and monitor whether activities are being performed at levels prescribed and specify norms for each of the activities.

i) The authority issuing technical sanction has to examine the proposal and ensure that the proposal received for technical sanction carry all the required details i.e. technical note with expected outcome/ increase in productivity, survey sheet, design, drawing and detailed estimate indicating the cost per unit output and are in order.

ii) Outcome orientation is important to ensure that unproductive works are not taken up for execution and the quality of works is maintained as per standards. States will prepare a module to guide the functionaries on the expected outcomes for each type of work and train the functionaries in using it.

iii) Programme Coordinators shall organize suitable training programmes to all the functionaries and stakeholders in correctly estimating and measuring the outcomes as per the module developed by the State.

7.1.7. FOLLOW UP:

Under quality monitoring by external monitors, the SQMs of the district will visit and check 25% of the works being carried out in the district at least once, based on structured (based on categories of works) random sampling in life time of work execution.

i) Under follow up, on the inspection/ monitoring / social audit, if there is a shortfall in the activities to be performed to make the asset economical, productive and durable and affecting adversely on the asset, as identified by the inspecting officer/ SQMs or in the Social Audit, the concerned authority issuing Technical Sanction or concerned official executing the work, who ever held responsible will be penalized under section 27(2) of MGNREGA.

ii) To begin with, NREGA software has been modified to capture the expected outcomes in the technical sanctions.

Table 7-1: Typical units of expected economy, outcome/ productivity and durability of MGNREGA asset

S. NO.	MGNREGA WORKS	ECONOMY	DURABILITY	OUTCOME/ PRODUCTIVITY
(1)	(2)	(3)	(4)	(5)
1	Water conservation & water harvesting works	Cost of construction per unit of storage of water/ unit area benefited	i) Pucca work- 15-25 years ii) Kachha work- 5-10 years	Number of wells recharged/area brought under irrigation/increase in production and increase in Ground Water Table.
2	Afforestation & tree plantation	Cost per unit area/ plant till the tree is grown up (3-4 years)	Afforestation trees, 20-25 years	Benefit per tree till its total age i.e. 20-25 years.
3	Irrigation canal including micro and minor irrigation	Cost per unit area brought under irrigation	15-25 years	Increase in productivity in a year by taking number of crops in a year
4	a) Irrigation facility/ horticulture/ plantation/ b) farm bunding/ land development	Cost per unit area brought under irrigation/ plant till it is productive/unit area developed	a) 15-25 years b) 10-15 years	Area covered under irrigation/plantation/ land development/ Increase in productivity in a year by taking number of crops in a year
5	Renovation/ repair of traditional water bodies including desilting of tanks	Cost per unit increase in storage capacity of water/cum silt removed	10-15 years	Increase in storage capacity of water and Ground water Table

(1)	(2)	(3)	(4)	(5)
6	Land development	Cost per unit area developed	15-25 years	Area developed/ increase in productivity per annum
7	Flood control & Flood protection works	Cost per unit area developed	10-15 years	Area developed/ increase in productivity per annum
8	Road connectivity (a) CC roads (b) Gravel/ WBM road	Cost per Km. length of connectivity	(a) 10-15 years (b) 5-10 years	Number of villagers & villages benefitted
9	Building works	Cost per unit covered area	45-60 years	Number of villagers & villages benefitted
10	Agriculture related infrastructure works	Cost per unit capacity of producing manure at a time	5-10 years	Capacity to produce kg. of compost/ manure per annum
11	Livestock related works	Cost per unit covered area	10-15 years	Number of poultry/ goat/cattle benefitted
12	Fishery related works	Cost per unit fish produced per annum	5-10 years	Quintals of fish produced per annum
13	Works in coastal areas a) fish drying yards b) belt vegetation	a) Cost per unit covered area b) Cost per unit covered area/ number of plants	a) 10-15 years b) 15-25 years	a) Quintals of fish can be dried per annum b) area benefitted
14	Rural drinking water related works such as soak pits, recharge pits	Cost per unit cum water recharged/ earth excavated	a) 3-5 years	Area benefitted/ quantity of water recharged
15	Rural sanitation related works	Cost per unit toilet/ ton solid/litre liquid waste management	a) 10-15 years	Number of persons benefitted

7.2. MAINTENANCE OF WORKS UNDER MGNREGA:

The asset after creation will remain durable and strengthen the livelihood resource base of the rural poor only when it is maintained as per its schedule, kept in good shape in all times, restored in cases of damage in natural calamities. If the maintenance of asset is carried out in time as per its schedule/ and restored when damaged in natural calamities, the maintenance cost will be minimal and if it is delayed, the maintenance cost will increase and the durability of the asset will be affected adversely.

7.2.1. CATEGORY OF ASSETS AND LIABILITY FOR MAINTENANCE:

i) CURRENT PROVISIONS

a) Public assets: Assets created on common/public land are public assets. As per Para 4. (1) IV. (viii) Of schedule-1, MGNREGA, "Maintenance of rural public assets created under the Act" are permitted under the Act. Whereas, Para 7.3.7 of MGNREGA Operational Guidelines 2013 reveals that, "The maintenance of assets should generally be undertaken only for those works and assets that have been created under MGNREGA. In case MGNREGA funds are to be used to rehabilitate assets created from schemes other than MGNREGA, the full details of previous work done along with date, copy of estimate and measurement book should be placed as part of the MGNREGA work record before administrative approval is granted.

It will be the duty of the agency that has executed these assets to provide all required details and documents to the GP. PO will ensure that an entry to this effect is made against each such work in the list of works placed before the Gram Sabha. She/he will ensure that copies of documents are also made available to the DPC before administrative approval is accorded and details are made available to the implementing agency along with the commencement letter/ work order.

b) Assets created on land or homestead owned by individual households (as per Para 4(1) of schedule I, MGNREGA) are individual assets. The beneficiaries of the assets shall carry out the maintenance of individual assets as per the schedule of maintenance worked out for different type of individual assets. The beneficiary, while applying for MGNREGA work on his land or homestead will give an undertaking for regular maintenance of asset as per schedule of maintenance. A typical format of an application by the beneficiary for MGNREGA work on his land or homestead is at **Annexure-XVII.**

ii) NEED FOR MAINTENANCE:

a) Maintenance of works has to follow a specific schedule for being retained in working condition. However, release of funds for maintenance of works in State Governments is neither predictable nor adequate. As a result, many assets get damaged wasting the investments made in creation of assets. Besides, maintenance of assets also provides employment required to meet the demand for works.

b) During natural calamities, public assets get damaged and non-restoration of these in time dislocates the normal life and livelihoods. Restoration after natural calamities requires substantial investments in short periods, which State Governments do not always succeed in investing.

iii) IN VIEW OF THE ABOVE, THE FOLLOWING STEPS SHOULD BE TAKEN:

a) Provisions for Maintenance:

- There should be a schedule for maintenance of assets created under MGNREGA and asset once created should necessarily be maintained as per the schedule.
- The maintenance of individual asset created under MGNREGA should be maintained by the concerned beneficiary after completion, as per schedule for maintenance. Gram Panchayat should oversee this work and enclose a report in each year's labour budget on the maintenance of these assets.
- The maintenance of MGNREGA public works and public assets that have been created under MGNREGA will be funded under MGNREGA. However, the maintenance work will be considered as a separate work with pre- measurement and post-measurement, following all the norms under MGNREGA for new work like labour: material ratio etc.
- The maintenance schedule for assets shall depend on the nature and category of asset.

iv) FOR THIS PURPOSE, ASSETS CREATED UNDER MGNREGA ARE CLASSIFIED INTO 5 CATEGORIES:

a) Plantation works: Plantation works such as, horticulture, plantation and belt vegetation in coastal areas on individual land and drought proofing including afforestation and tree plantation on common/ public land should be maintained under MGNREGA as follows:

Category	**Period**
Horticulture and plantation species	Up to 3-5 years depending on species
Forestry species	Up to 3-4 years depending on the species

Thereafter, the regular maintenance of plantation on individual land should be carried out by the beneficiary and plantation on common land under MGNREGA by the Gram Panchayat.

b Earth works on public lands: Water conservation and water harvesting structures, irrigation works, land development, flood channels, traditional water bodies on public/common land, gravel/ WBM road should be maintained every year by the GP.

c) **Earth works on private lands:** Dug out/ farm pond, land development on individual land, farm bunding, water conservation and water harvesting structures on private lands benefiting individual farmers should be maintained every year by the beneficiary.

d) **Works with material component on individual lands:** Works with material component on private lands which are expected to have at least 5-15 years of life - such as, NADEP composting pit, Vermi composting pit, liquid bio- manure pit, poultry shelter, goat shelter, cattle shed, fish drying yard, individual household latrines on land or homestead owned by an individual (as per Para 5 of schedule I, MGNREGA) should be maintained by the beneficiary after completion as per schedule for maintenance.

e) **Works with material components on public lands:** Works with material component on public lands which are expected to have at least 15 -25 years of life / Check/ Stop dams, pucca works for rural connectivity, AWC, BNRGSK buildings on common/ public land should be maintained once in every 3 years after completion by the Gram Panchayat.

7.2.2. The damages due to natural disaster on individual land should be repaired under MGNREGA funds, after duly survey, justification and approval of DPC on area/ project approach.

7.2.3. A detailed typical schedule of maintenance is given at **Annexure-XVIII,** However, it will vary place to place depending on local agro-climatic and hydro-geological conditions

7.2.4. SURVEY, PLANNING, ESTIMATION, SANCTIONING, EXECUTION & MEASUREMENT OF MAINETANANCE WORK:

i) **Typical estimates for maintenance part of execution of work** should be prepared by the respective states for different type of works based on local agro- climatic, hydro-geological conditions and design of works. The estimate for execution of MGNREGA new works should be in two parts, one part should be estimate for execution of new works and second part should be for routine maintenance to be carried out simultaneously/ in continuation of execution of works.

ii) **Estimates for maintenance works** other than **routine maintenance** (to be carried out simultaneously/ in continuation as a part of execution of works), should be prepared after conducting inspection/ required sample survey.

iii) **Administrative & financial sanction** for maintenance work other than **routine maintenance** (to be carried out simultaneously/ in continuation as a part of execution of works) should be issued by the authority, authorised for new MGNREGA works and **technical sanction** should be issued by the one higher authority, authorised to issue technical sanction for new MGNREGA works.

iv) **Measurement** should be taken before maintenance (pre-measurement) and after maintenance and should be recorded in the M/B and accordingly quantum of work carried out should be worked out and payment should be made after due checking by the competent authority.

v) **Task of different type of maintenance works** to be carried out by MGNREGA worker should be worked out by carrying out systematic time motion studies.

vi) **Maintenance team** of 4 Job Card holders households willing to carry out maintenance work for a group of **public** assets should be formed, so that each of these 4 job card holder households can be assigned maintenance work for 100 days in a year in rotation. This will help in continuity of availability of labour, in fixing the responsibility of particular households and quality in maintenance.

vii) **Asset maintenance registers** the GP should maintain record of maintenance work carried on public assets and individual assets in the public asset maintenance register and individual asset maintenance register separately, in the format prescribed at **Annexure-XIX** and **Annexure-XX** respectively.

CHAPTER 08

CONVERGENCE MGNREGS WITH ONGOING OTHER SCHEMES IN THE AREA FOR FILLING & VALUE ADDITION

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CONVERGENCE MGNREGS WITH ONGOING OTHER SCHEMES IN THE AREA FOR FILLING & VALUE ADDITION

8.1. WHY CONVERGENCE:

To improve the quality of assets created under MGNREGA and to bring synergy between MGNREGS and schemes of other line departments including technical support and fund support.

As per Para 6 of schedule-1, MGNREGA, effective inter-departmental convergence till the last milestone implementation level of the works under the Scheme with other Government Schemes/ programmes has to be made, so as to improve the quality and productivity of assets, and bring in synergy to holistically address the multiple dimensions of poverty in a sustainable manner.

i) FOR GAP FILLING:

Filling the gap in creation of durable & productive asset by utilization of MGNREGS funds and funds from other schemes.

For illustration

- Grant for house under IAY in plain area Rs. 70,000/-
- Unskilled man- day's requirement i.e. 90 man days in plain areas and 95 man days in hilly areas from MGNREGA, to meet out the cost of constructing of an IAY house.

ii) FOR GAP FILLING AS WELL AS VALUE ADDITION (FORWARD LINKAGE)

For illustration

- Plantation of host plants of Silkworms under MGNREGA in convergence with the Catalytic Development Programme (CDP) of Central silk Board, Ministry of Textiles i.e. gap filling
- Cocoon processing for silk under the CDP scheme of Central Silk Board, Ministry of Textile i.e. value addition

8.2. WHY CONVERGENCE WITH MGNREGS:

i) Most of the works required in rural area are permitted under MGNREGA

ii) It is open ended i.e. no physical & financial norms

iii) Follow physical, technical & financial norms of the scheme to be converged with

iv) No limit of budget, it is as per demand for work under MGNREGA

v) MGNREGS is being implemented in every GP of the country

vi) Every house hold in rural area can have Job Card for unskilled work and can work under MGNREGA

8.3. CONVERGENCE GUIDELINES ISSUED SO FAR, ARE AT ANNEXURE XXI

8.4. NON NEGOTIABLE IN CONVERGENCE

i) Works to be taken up in Rural areas

ii) Only job Card holders employed for the unskilled part

iii) Equal wages to men and women

iv) Muster Rolls maintained on the worksite by the implementing agency

v) Wage payments done only through banks/post office accounts, unless exempted by MoRD.

vi) No contractor and labour displacement machine deployed.

vii) All works to be approved by Gram Sabha, Block Sabha, and ZPP.

viii) The overall cost of material component of projects including the wages of the mate, skilled and semi-skilled workers under the scheme not exceed forty percent at GP level, when GP is implementing agency and at district level when line department is implementing agency, in a financial year.

ix) The individual household beneficiary shall be from a household eligible under MGNREGA

x) Record of employment generated under convergence will be maintained separately.

xi) The lands of SC/ST/BPL taken on priority. Once works on lands of SC/ST/BPL are saturated in a GP, works on land of Small and Marginal Farmer (SF/MF) is considered

xii) Every work/ project/ cluster treated as a MGNREGA project for the purpose of:

a) Giving a unique work ID

b) Entry in Works and Asset register

c) Social Audit by Gram Sabha

d) Evaluation by Vigilance and Monitoring Committee

xiii) Each GP will maintain all record/ documents related to MGNREGA

xiv) MGNREGS funds will not be used as a substitute for departmental plan funds

8.5. ‘:

In operational terms, convergence of different programmes with MGNREGA will require coordination between the converging programmes and MGNREGS at following steps of implementation:

i) Planning

ii) Work Execution

iii) Management (Institutional arrangements)

8.5.1. PLANNING:

i) The concerned line department identify suitable land / eligible beneficiaries after assessing technical feasibility & prepare project report

ii) Put up in Gram Sabha for approval & inclusion in annual plan & shelf of project

iii) The works shall be part of GP shelf of works.

iv) Design & Specification adhere to the norms of the scheme converged with

v) AS& FS by DPC

vi) TS by the authorised technical personal for MGNREGS for MGNREGS part and authorised technical personal of the line department, of the scheme being converged with.

vii) The convergence projects should be comprehensive enough to ensure time bound execution.

viii) Wage material ratio should be maintained as 60:40 at the GP level, when GP is implementing agency and at District level when line Department is implementing agency.

ix) DPC/PO should share the list of works to be taken up with concerned department so that they can indicate appropriate activities/technologies for each work for value addition during planning process

x) If the source of funding is more than one, other than MGNREGS then both departments will prepare a composite statement clearly defining activities with source of funding which will be attached with the project of each scheme so that there is no duplicity and no activity is left out (a typical exercise is attached herewith).

xi) The parent department of the converging programme should provide necessary technical expertise to the Gram Panchayat in planning, preparation of DPR & execution, so that convergence takes place in a complementary manner and the activities are dovetailed into a well-linked programme.

xii) The projects that are identified for convergence with MGNREGA should be discussed in the Gram Sabha located in the project area.

xiii) Activities/structures/tasks identified for execution under MGNREGA should be included in the annual shelf of works for MGNREGA and will be part of the labour budget.

xiv) The planning will be village based, holistic, diagnostic, outcome oriented, etc.

xv) In the planning process, identification of works will be identified by the IPPE and proposed in the Gram Sabha. GP to consider the recommendations of Gram Sabha and Ward Sabha.

xvi) Estimates will be prepared by the staff of implementing agency and after due examination & the technical feasibility the TS will be issued by the competent authorities.

xvii) The District Collector/DPC will accord administrative sanction.

xviii) Implement the works as and when the demand arises.

xix) The status of a work proposed for convergence would be one of the following: completed or ongoing. Convergence should be planned as per the status of the work

xx) At the district level, the overall head for the convergence project is the District collector/DDO/CEO ZP. S/he oversees the planning and implementation of these projects

xxi) For effective implementation of convergence, it would be necessary to ensure that works to be taken up from MGNREGS for convergence with other schemes, are given the required priority by the Gram Sabha

xxii) Planning for works and managing the convergence would require institutional arrangements for proper coordination at District, Block and village level.

8.5.2. WORK EXECUTION:

i) For MGNREGA part GP is the Implementing Agency, however, line department can also be the Implementing Agencies

ii) For converged scheme part, line department is the Implementing Agency, however GP can also be the Implementing Agency

iii) On request for M/R (Muster Roll) through GP, PO will issue M/R

iv) Weekly M/R (Muster Roll) & M/B (Measurement Book)entries

v) Pay orders will be generated as per executed quantities recorded in the measurement book

vi) Wage payments will be made to wage seekers accounts directly.

8.5.3. MANAGEMENT, MONITORING & REPORTING:

i) Entry of all details in MGNREGA soft

ii) Convergence wise development of format, jointly

iii) Quarterly progress review meeting by DPC & Nodal Officer of the scheme in the District

iv) Following monitoring structure at different level is to be maintained as below:

   a) SLTC: State Level Technical Consortium
   b) DLTC: District Level Technical Consortium
   c) BLTC: Block Level Technical Consortium
   d) VLRG: Village Level Resource Groups

v) In this monitoring structure, following experts are to be the member.

   a) Experts from different departments
   b) Experts from Technical wings
   c) Individual Experts

vi) All processes of MGNREGA such as Social Audit, Account Maintenance, MIS reporting applicable to MGNREGA expenditure to be followed

8.6. TYPICAL EXERCISE FOR PLANNING CONVERGENCE

8.6.1. FOR PLANNING A WORK:

Sl. No.	Line Department	Work Type	Activities		Physical	Financial		Funding	
			By MGNREGA	By Line Department			By MGNREGA	By Line Department	Benefeioary contribution
1	2	3	4	5	6	7	8	9	10

i) The State Convergence plan (SCP) has to be prepared district wise in the concerned state

ii) The line departments who are converging works with MGNREGS have to prepare district wise plans indicating their share in the project amount which will be involved in the programme.

iii) These district plan are to be approved by the Chief Secretary of the State

8.6.2. FOR PLANNING A PROJECT

A typical exercise to identify all the works/ activities to be covered under MGNREGS and under watershed development programme / other similar programme, separately, with the size of area/ work, estimated cost and the year in which proposed.

Name of Watershed: ------------, Area of Watershed: --- ha. --------- Name of Village: ----------------, Name of Panchayat/Block/District: -------------------

S. No.	Work/Activity	Kind of Area	Size of area/work	Estimated cost (lakh)	Programme under which proposed	Year in which Proposed			
						1st Year	2nd Year	3rd Year	4th Year
A	Watershed Management								
	a. **RIDGE AREA TREATMENT:** All activities required to restore the health of the catchment are by reducing the volume and velocity of surface runoff, including regeneration of vegetative cover in forest and common land afforestation, staggered trenching, contour and graded bunding, bench terracing etc.	Individual land/ Common land/ Forest land			MGNREGS	Y			
	b. DRAINAGE LINE TREATMENT: with a combination of vegetative and engineering structure, such as **1) earthen checks,** **2) brushwood checks,** **3) gully plugs,** **4) loose boulder checks,** **5) gabion structures,** **6) underground dykes etc.**	Individual land/ Common land/ Forest land			MGNREGS			Y	
	7) Pucca check dam/ Anicut / Drop spillway/ Stop dam/ Stop dam cum causeway **8)** Subsurface water harvesting structure in coastal area	Individual land/ Common land/ Forest land			IWMP/RKVY				
	c. DEVELOPMENT OF WATER HARVESTING STRUCTURES: such as – **1) farm ponds,** **2) nalla bunds,** **3) percolation tanks and** **4) ground water recharge through wells, bore wells** and other measures	Individual land/ Common land/ Forest land			MGNREGS		Y		
	d. NURSERY RAISING: for fodder, fuel, timber and horticulture species	Individual land/ Common land/ Forest land			MGNREGS	Y			
	e. LAND DEVELOPMENT: including in –situ soil and moisture conservation and drainage management measures like **1) field bunds,** **2) contour and graded bunds fortified with plantation,** **3) bench terracing in hilly terrain etc.**	Individual land/ Common land/ Forest land			MGNREGS	Y			

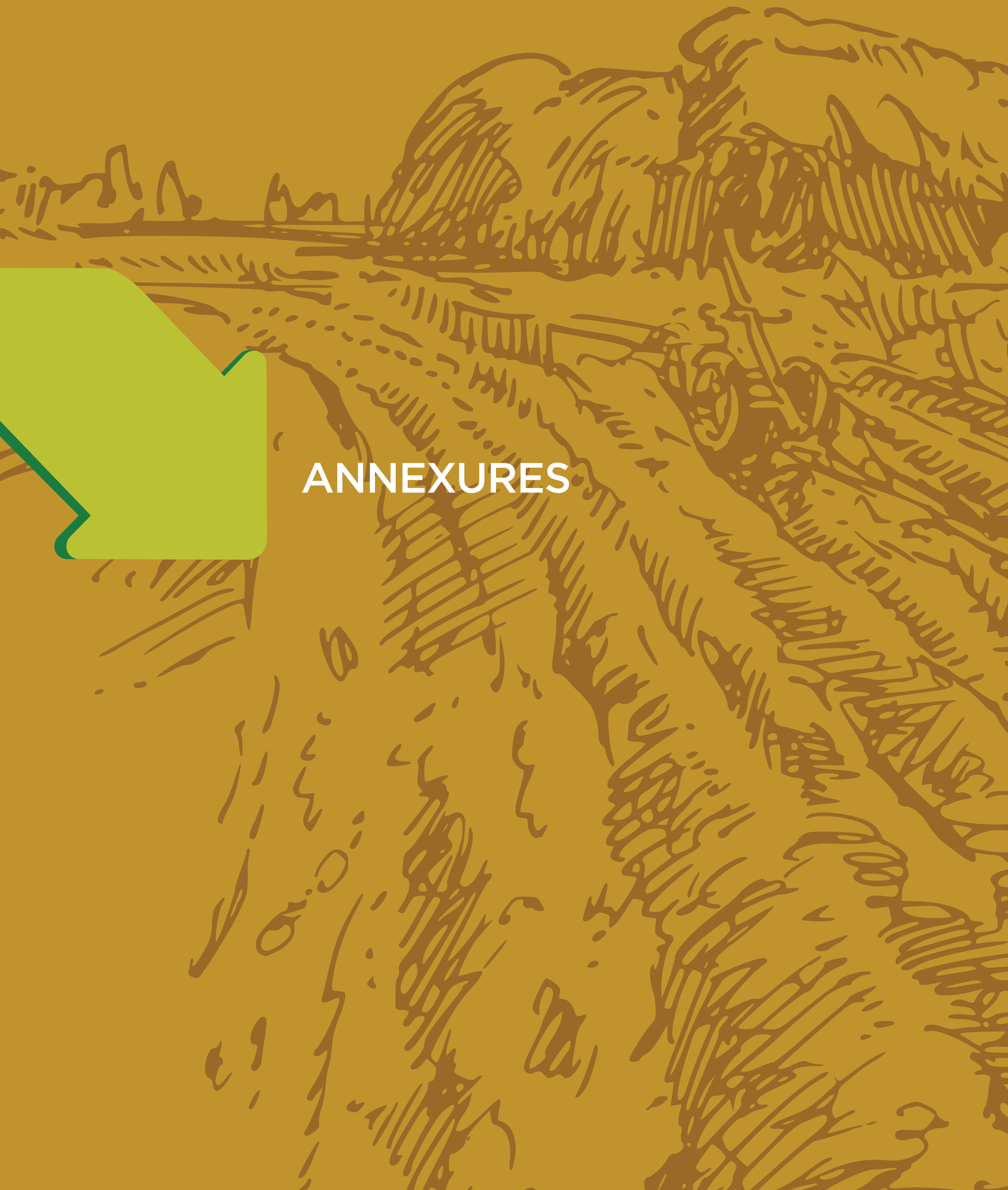
S. No.	Work/Activity	Kind of Area	Size of area/work	Estimated cost (lakh)	Programme under which proposed	Year in which Proposed			
						1st Year	2nd Year	3rd Year	4th Year
	f. CROP DEMONSTRATION: for popularizing new crops/ varieties, water saving technologies such as drip irrigation or innovative management practices	Individual land/ Common land/ Forest land			IWMP/RKVY		Y	Y	Y
	g. PASTURE DEVELOPMENT: sericulture, bee keeping, back yard poultry, small ruminant, other livestock and micro-enterprises	Individual land/ Common land/ Forest land			IWMP/RKVY/ Infrastructre under MGNREGS	Y	Y	Y	Y
	h. VETERINARY SERVICES: for livestock and livestock improvement measures	Individual land/ Common land/ Forest land			IWMP	Y	Y	Y	Y
	i. FISHERIES DEVELOPMENT: in village ponds/ tanks, farm ponds etc.	Individual land/ Common land/ Forest land			MGNREGS	Y	Y	Y	Y
	j. PROMOTION AND PROPAGATION OF NON-CONVENTIONAL ENERGY SAVING DEVICES: energy conservation measures, bio fuel plantation etc.	Individual land/ Common land/ Forest land			IWMP	Y	Y	Y	Y
B	**a) TREE PLANTATION** 1) Boundary plantation 2) Agro forestry	Individual land as permitted at Para 5 of schedule-1, MGNREGA/ Common land			MGNREGS		Y	Y	Y
	1) Boundary plantation 2) Agro forestry	Individual land of other than permitted under MGNREGA			IWMP/RKVY		Y	Y	Y
	b) HORTICULTURE PLANTATION 1) Block plantation 2) Agro horticulture plantation	Individual land as permitted at Para 5 of schedule-1, MGNREGA/ Common land			MGNREGS		Y	Y	Y
	1) Block plantation 2) Dry horticulture plantation	Individual land of other than permitted under MGNREGA/ Common land			IWMP/ RKVY		Y	Y	Y
C	**LAND DEVELOPMENT**								
	a) Reclamation of salt affected land	Individual land as permitted at Para 5 of schedule-1, MGNREGA/ Common land			MGNREGS	Y	Y		
	b) Reclamation of salt affected land	Individual land of other than permitted under MGNREGA			IWMP/RKVY	Y	Y		

8.6.3. CHECKLIST FOR CONVERGENCE:

Sl. No.	Activity	Time Line		Status/Progress Remarks
		Start Date	End Date	
	Management:			
1.	Constitution of DRG Headed by DPC(DC/CEO)			
2.	Orientation of the DRG			
3.	Consolidation of Existing data base of NREGA & Other schemes			
	Planning:			
	i) Resource Mapping			
4.	Block and Gram Panchayat wise mapping of existing assets to be created			
5.	Location of Work			
	Blocks(Numbers and Location)			
i.	No. / Quantity of Assets for Value Addition			
ii.	No. / Quantity of New Assets to be created			
iii.	No./ Quantity of Assets for Gap Filling			
iv.	Person days to be generated under each Activity			
v.	Estimated Cost			
	Gram Panchayats (Nos. & Location)			
i.	No. / Quantity of Assets for Value Addition			
ii.	No. / Quantity of New Assets to be created			
iii.	No./ Quantity of Assets for Gap Filling			
iv.	Person days to be generated under each Activity			
v.	Estimated Cost			
6.	Identification of Programmes for Convergence			
7.	Identification of Programme Activities for Convergence			
8.	Identification of Component to be taken up under NREGA			
9.	Identification of component to be taken up under other schemes			
10.	Resources to be made available from NREGA for convergence projects			
11.	Available Resources from other schemes			
12.	Developing of Technical Feasible norms including sequencing, costs, designs			
	ii) IEC Training			
13.	Training of personnel implementing works			
14.	IEC & Capacity building under taken by DRG & BRG & VRGfor stake holders including PRI functioneries and Villagers			
	iii) Participatory Planning Process through Facilitation by VRG, BRG, DRG			
15.	Convening Gram Sabha, Identification and Recommendation of Works			
16.	Plan Consolidated by G.P.			
17.	Shelf of Projects submitted to I.P.			
18.	P.O. consolidate plan and submit to I.P.			

19.	Approval by I.P. and submission to District Panchayat			
20.	Approval of DPP/ AWP			
	Implementation (as per specific activities)			
21.	Type of NREGA work / Category for convergence			
22.	Activities to be taken up under NREGA			
23.	Person days to be generated			
24.	Activities to be taken up by the Department with which the convergence is being considered			
25.	Person days to be generated			
26.	Total cost of the project			
27.	Estimated Cost for funding through NREGA			
	a) Wage cost			
	b) Material cost			
28.	Estimated cost for funding through the scheme with which the convergence is being considered			
	Monitoring			
29.	Mechanism set up for joint monitoring by the Department implementing NREGA and the department with which convergence is being under taken			
30.	Indicators developed for monitoring the progress and the performance			
	NREGA Norms for works taken up under the scheme			
31.	Wage : Material ratio			
32.	No contractor or mechinery			
33.	At least 50% of works under NREGA to be executed by G.P.			
34.	Participatory Planning Process Followed:			
35.	Only Job Card Holders to be employed for NREGA			
36.	Muster Rolls to be maintained at work site with copies in G.P.			
37.	Muster Rollselectronically maintained on nrega.nic.in			
38.	Social Audits to be done through Gram Sabha			
39.	Wage payments will be through no frills accounts in Banks and Post Offices			

ANNEXURES



ANNEXURES

ANNEXURE I: WATER BUDGETING OF A TYPICAL VILLAGE

i) Annual availability of water in the village:

Formula to be used Q=CRA

Sl. No.	Particular	Unit	Quantity
(1)	**(2)**	**(3)**	**(4)**
1	Catchment area (A)	Ha.	790
2	Average Rainfall (I)	m	0.9
3	Co efficient of Runoff (C)	0.4	0.4
4	Total runoff Water (Q) =790*0.9*0.40	Ha.-M	284.4
5	Water can be harvested =75 % of Q	Ha.-M	213.3

ii) Water Requirement

A. Water requirement for Domestic purpose

Sl. No.	Population	Expected Population (after 10 years)	Daily Water requirement for individuals (Ltr)	Annual Water Requirements in Cum (3x4)x365days/1000
(1)	**(2)**	**(3)**	**(4)**	**(5)**
1	825	908	45	14,914

B. Water requirement by livestock

Sl. No.	Type of Animal	Total Animal No.	Daily Water requirement per animal	Annual Water Requirements in Cum (3x4)x365days/1000
(1)	**(2)**	**(3)**	**(4)**	**(5)**
1	Cow	65	135	3202.875
2	Buffalo	95	155	5374.625
3	Bullocks	106	135	5223.15
4	Calf	65	70	1660.75
5	Goat	110	8	321.2
6	Sheep	2	8	5.84
	Grand Total	**443**	**551**	**15788.44**

C. Water Requirement for Agriculture

Sl. No.	Season	Type of Crops grown	Area	Depth of Irrigation in (CM)	Total Water Requirement In (Ha-M), (4x5)/100
(1)	(2)	(3)	(4)	(5)	(6)
1	Khariff	Maize	3.87	20	0.774
		Groundnut	1.35	20	0.27
		Red gram	3.24	20	0.648
		Soya bean	346.72	20	69.344
		Millet	0.1	20	0.02
2	Rabi	Wheat	135.35	45	60.9075
		Chickpea	160.59	15	24.0885
		Onion	3.2	45	1.44
		Potato	0.55	60	0.33
		Garlic	7.6	40	3.04
		Mustard	2.5	25	0.625
		Total			**161.48**

iii) Total water to be harvested as per plan

Harvested Water in the Village									
Sl. No.	**Structure**	**Unit**	**No. of Structure**		**Storage Capacity Cum**		**Effective Storage Capacity (7)* no. of refilling in a year**		**Capacity in (Ha. M)**
			Existing	**Proposed**	**Existing**	**Proposed**	**Existing**	**Proposed**	**Total**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
1	Contour Trench	RM	0	6000	0	3000	0	30000	3
2	Contour Bund	RM	0	2500	0	3350	0	33500	3.35
3	Boulder Check	No.	0	50	0	500	0	7500	0.75
4	Farm Bunding	RM	0	99820	0	133758.8	0	1337588	133.7588
5	Stop Dam	No.	0	3	0	30000	0	90000	9
6	Renovation of Stop Dam	No.	0	1	0	10000	0	30000	3
7	Earthen Dam	No.	0	8	0	84000	0	168000	16.8
8	Farm Pond	No.	0	5	0	10000	0	30000	3
						Grand total	**0**	**1726588**	**172.7**

iv) Annual Water Budget of Village:

S. No.	Availability of Water	Requirement of water		Total Harvested Water in (Ha-M)
		Type of requirement	Quantity of water requirement (Ha-M)	
(1)	**(2)**	**(3)**	**(4)**	**(5)**
A	213.30	Domestic	1.49	172.7
B		Livestock	1.58	
C		Agriculture	161.48	
Total	**213.30**		**164.55**	**172.7**

So the water to be harvested as per the plan is able to meet up the requirement of village.

ANNEXURE II: STATEMENT SHOWING THE VELOCITY & DISCHARGES AT DIFFERENT DEPTHS AND SLOPES FOR WATERCOURSE

BED WIDTH = 0.30 m
SIDE SLOPE = 1.5: 1
ROUGHNESS COEFFICIENT (n) = 0.03
V = VELOCITY in m/sec.
Q = DISCHARGE in lps
V = $(R^{2/3} \times s^{1/2}) / n$
Q = A x V

S. No.	Hydraulic Grade NT	Depth in Meters							
		0.15		0.16		0.17		0.18	
		V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1 : 500	0.3074	24.21	0.3180	27.48	0.3283	30.97	0.3383	34.71
2	1 : 550	0.2931	23.08	0.3032	26.20	0.3130	29.53	0.3226	33.10
3	1 : 600	0.2806	22.10	0.2903	25.08	0.2997	28.28	0.3088	31.69
4	1 : 650	0.2696	21.23	0.2789	24.10	0.2879	27.17	0.2967	30.44
5	1 : 700	0.2598	20.46	0.2688	23.22	0.2775	26.18	0.2859	29.34
6	1 : 750	0.2510	19.77	0.2597	22.43	0.2680	25.29	0.2762	28.34
7	1 : 800	0.2430	19.14	0.2514	21.72	0.2595	24.49	0.2675	27.44
8	1 : 850	0.2358	18.57	0.2439	21.07	0.2518	23.76	0.2595	26.62
9	1 : 900	0.2291	18.05	0.2370	20.48	0.2447	23.09	0.2522	25.87
10	1 : 950	0.2230	17.56	0.2307	19.93	0.2382	22.47	0.2454	25.18
11	1 : 1000	0.2174	17.12	0.2249	19.43	0.2321	21.90	0.2392	24.54
12	1 : 1050	0.2122	16.71	0.2194	18.96	0.2265	21.37	0.2335	23.95
13	1 : 1100	0.2073	16.32	0.2144	18.52	0.2213	20.88	0.2281	23.40
14	1 : 1150	0.2027	15.96	0.2097	18.12	0.2165	20.42	0.2231	22.89
15	1 : 1200	0.1984	15.63	0.2053	17.74	0.2119	19.99	0.2184	22.41
16	1 : 1250	0.1944	15.31	0.2011	17.38	0.2076	19.59	0.2140	21.95
17	1 : 1300	0.1907	15.01	0.1972	17.04	0.2036	19.21	0.2098	21.53
18	1 : 1350	0.1871	14.73	0.1935	16.72	0.1998	18.85	0.2059	21.12
19	1 : 1400	0.1837	14.47	0.1900	16.42	0.1962	18.51	0.2022	20.74
20	1 : 1450	0.1805	14.22	0.1867	16.13	0.1928	18.19	0.1987	20.38
21	1 : 1500	0.1775	13.98	0.1836	15.86	0.1895	17.88	0.1953	20.04
22	1 : 1550	0.1746	13.75	0.1806	15.61	0.1865	17.59	0.1921	19.71
23	1 : 1600	0.1719	13.53	0.1778	15.36	0.1835	17.32	0.1891	19.40
24	1 : 1650	0.1692	13.33	0.1751	15.13	0.1807	17.05	0.1862	19.11
25	1 : 1700	0.1667	13.13	0.1725	14.90	0.1780	16.80	0.1835	18.82
26	1 : 1750	0.1643	12.94	0.1700	14.69	0.1755	16.56	0.1808	18.55
27	1 : 1800	0.1620	12.76	0.1676	14.48	0.1730	16.32	0.1783	18.29
28	1 : 1850	0.1598	12.59	0.1653	14.28	0.1707	16.10	0.1759	18.05
29	1 : 1900	0.1577	12.42	0.1631	14.09	0.1684	15.89	0.1735	17.81
30	1 : 1950	0.1557	12.26	0.1610	13.91	0.1662	15.68	0.1713	17.58

S. No.	Hydraulic Grade NT	Depth in Meters							
		0.15		0.16		0.17		0.18	
		V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
31	1 : 2000	0.1537	12.11	0.1590	13.74	0.1641	15.49	0.1692	17.36
32	1 : 2050	0.1518	11.96	0.1571	13.57	0.1621	15.30	0.1671	17.14
33	1 : 2100	0.1500	11.81	0.1552	13.41	0.1602	15.11	0.1651	16.94
34	1 : 2150	0.1483	11.68	0.1534	13.25	0.1583	14.94	0.1631	16.74
35	1 : 2200	0.1466	11.54	0.1516	13.10	0.1565	14.77	0.1613	16.55
36	1 : 2250	0.1449	11.41	0.1499	12.95	0.1548	14.60	0.1595	16.36
37	1 : 2300	0.1433	11.29	0.1483	12.81	0.1531	14.44	0.1577	16.18
38	1 : 2350	0.1418	11.17	0.1467	12.67	0.1514	14.29	0.1561	16.01
39	1 : 2400	0.1403	11.05	0.1452	12.54	0.1498	14.14	0.1544	15.84
40	1 : 2450	0.1389	10.94	0.1437	12.41	0.1483	13.99	0.1528	15.68
41	1 : 2500	0.1375	10.83	0.1422	12.29	0.1468	13.85	0.1513	15.52

S. No.	Hydraulic Grade NT	Depth in Meters							
		0.19		0.20		0.21		0.22	
		V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1 : 500	0.3481	38.69	0.3577	42.92	0.3670	47.40	0.3762	52.14
2	1 : 550	0.3319	36.89	0.3410	40.92	0.3499	45.20	0.3587	49.72
3	1 : 600	0.3178	35.32	0.3265	39.18	0.3350	43.27	0.3434	47.60
4	1 : 650	0.3053	33.93	0.3137	37.64	0.3219	41.57	0.3300	45.73
5	1 : 700	0.2942	32.70	0.3023	36.27	0.3102	40.06	0.3180	44.07
6	1 : 750	0.2842	31.59	0.2920	35.04	0.2997	38.70	0.3072	42.57
7	1 : 800	0.2752	30.59	0.2828	33.93	0.2902	37.47	0.2974	41.22
8	1 : 850	0.2670	29.67	0.2743	32.92	0.2815	36.36	0.2885	39.99
9	1 : 900	0.2595	28.84	0.2666	31.99	0.2736	35.33	0.2804	38.86
10	1 : 950	0.2525	28.07	0.2595	31.14	0.2663	34.39	0.2729	37.83
11	1 : 1000	0.2461	27.36	0.2529	30.35	0.2595	33.52	0.2660	36.87
12	1 : 1050	0.2402	26.70	0.2468	29.62	0.2533	32.71	0.2596	35.98
13	1 : 1100	0.2347	26.09	0.2411	28.94	0.2474	31.96	0.2536	35.15
14	1 : 1150	0.2295	25.51	0.2358	28.30	0.2420	31.26	0.2481	34.38
15	1 : 1200	0.2247	24.97	0.2309	27.70	0.2369	30.60	0.2428	33.66

S. No.	Hydraulic Grade NT	Depth in Meters							
		0.19		0.20		0.21		0.22	
		V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
16	1 : 1250	0.2202	24.47	0.2262	27.14	0.2321	29.98	0.2379	32.98
17	1 : 1300	0.2159	23.99	0.2218	26.62	0.2276	29.40	0.2333	32.34
18	1 : 1350	0.2118	23.55	0.2177	26.12	0.2234	28.85	0.2290	31.73
19	1 : 1400	0.2080	23.12	0.2137	25.65	0.2193	28.33	0.2248	31.16
20	1 : 1450	0.2044	22.72	0.2100	25.20	0.2155	27.83	0.2209	30.62
21	1 : 1500	0.2010	22.34	0.2065	24.78	0.2119	27.37	0.2172	30.10
22	1 : 1550	0.1977	21.97	0.2031	24.38	0.2085	26.92	0.2137	29.62
23	1 : 1600	0.1946	21.63	0.1999	23.99	0.2052	26.50	0.2103	29.15
24	1 : 1650	0.1916	21.30	0.1969	23.63	0.2020	26.09	0.2071	28.70
25	1 : 1700	0.1888	20.98	0.1940	23.28	0.1990	25.71	0.2040	28.28
26	1 : 1750	0.1861	20.68	0.1912	22.94	0.1962	25.34	0.2011	27.87
27	1 : 1800	0.1835	20.39	0.1885	22.62	0.1934	24.98	0.1983	27.48
28	1 : 1850	0.1810	20.11	0.1859	22.31	0.1908	24.64	0.1956	27.11
29	1 : 1900	0.1786	19.85	0.1835	22.02	0.1883	24.32	0.1930	26.75
30	1 : 1950	0.1763	19.59	0.1811	21.73	0.1858	24.00	0.1905	26.40
31	1 : 2000	0.1740	19.35	0.1788	21.46	0.1835	23.70	0.1891	26.07
32	1 : 2050	0.1719	19.11	0.1766	21.20	0.1813	23.41	0.1858	25.75
33	1 : 2100	0.1699	18.88	0.1745	20.94	0.1791	23.13	0.1838	25.44
34	1 : 2150	0.1679	18.66	0.1725	20.70	0.1770	22.86	0.1814	25.18
35	1 : 2200	0.1659	18.44	0.1705	20.46	0.1750	22.60	0.1794	24.86
36	1 : 2250	0.1641	18.24	0.1686	20.23	0.1730	22.35	0.1773	24.58
37	1 : 2300	0.1623	18.04	0.1668	20.01	0.1711	22.10	0.1754	24.31
38	1 : 2350	0.1606	17.85	0.1650	19.80	0.1693	21.86	0.1735	24.05
39	1 : 2400	0.1589	17.66	0.1632	19.59	0.1675	21.64	0.1717	23.80
40	1 : 2450	0.1573	17.48	0.1616	19.39	0.1658	21.41	0.1700	23.56
41	1 : 2500	0.1557	17.30	0.1599	19.19	0.1641	21.20	0.1682	23.32

S. No.	Hydraulic Grade NT	Depth in Meters							
		0.23		0.24		0.25		0.26	
		V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1 : 500	0.3852	57.15	0.3941	62.42	0.4028	67.97	0.4114	73.80
2	1 : 550	0.3673	54.49	0.3758	59.52	0.3841	64.81	0.3922	70.37
3	1 : 600	0.3517	52.17	0.3598	56.99	0.3677	62.05	0.3756	67.37
4	1 : 650	0.3379	50.12	0.3456	54.75	0.3533	59.62	0.3608	64.73
5	1 : 700	0.3256	48.30	0.3331	52.76	0.3404	57.45	0.3477	62.38
6	1 : 750	0.3145	46.66	0.3218	50.97	0.3289	55.50	0.3359	60.26
7	1 : 800	0.3045	45.18	0.3116	49.35	0.3184	53.74	0.3252	58.35
8	1 : 850	0.2955	43.83	0.3023	47.88	0.3089	52.13	0.3155	56.61
9	1 : 900	0.2871	42.60	0.2937	46.53	0.3002	50.67	0.3066	55.01
10	1 : 950	0.2795	41.46	0.2859	45.29	0.2922	49.31	0.2985	53.54
11	1 : 1000	0.2724	40.41	0.2787	44.14	0.2848	48.07	0.2909	52.19
12	1 : 1050	0.2658	39.44	0.2719	43.08	0.2780	46.91	0.2839	50.93
13	1 : 1100	0.2597	38.53	0.2657	42.09	0.2716	45.83	0.2774	49.76
14	1 : 1150	0.2540	37.68	0.2599	41.16	0.2656	44.82	0.2713	48.67
15	1 : 1200	0.2487	36.89	0.2544	40.29	0.2600	43.88	0.2656	47.64
16	1 : 1250	0.2436	36.14	0.2492	39.48	0.2548	42.99	0.2602	46.68
17	1 : 1300	0.2389	35.44	0.2444	38.71	0.2498	42.16	0.2551	45.77
18	1 : 1350	0.2344	3478	0.2398	37.99	0.2451	41.37	0.2504	44.92
19	1 : 1400	0.2302	34.15	0.2355	37.31	0.2407	40.62	0.2459	44.11
20	1 : 1450	0.2262	33.56	0.2314	36.66	0.2365	39.92	0.2416	43.34
21	1 : 1500	0.2224	32.99	0.2275	36.04	0.2326	39.24	0.2375	42.61
22	1 : 1550	0.2188	32.46	0.2238	35.45	0.2288	38.61	0.2337	41.92
23	1 : 1600	0.2153	31.95	0.2203	34.90	0.2252	38.00	0.2300	41.26
24	1 : 1650	0.2121	31.46	0.2169	34.36	0.2217	37.42	0.2265	40.63
25	1 : 1700	0.2089	30.99	0.2137	33.85	0.2185	36.86	0.2231	40.03
26	1 : 1750	0.2059	30.55	0.2107	33.37	0.2153	36.33	0.2199	39.45
27	1 : 1800	0.2030	30.12	0.2077	32.90	0.2123	35.83	0.2168	38.90
28	1 : 1850	0.2003	29.71	0.2049	32.45	0.2094	35.34	0.2139	38.37
29	1 : 1900	0.1976	29.32	0.2022	32.02	0.2066	34.87	0.2110	37.86
30	1 : 1950	0.1951	28.94	0.1996	31.61	0.2040	34.42	0.2083	37.37
31	1 : 2000	0.1926	28.57	0.1970	31.21	0.2014	33.99	0.2057	36.90
32	1 : 2050	0.1903	28.22	0.1946	30.83	0.1989	33.57	02032	36.45
33	1 : 2100	0.1880	27.89	0.1923	30.46	0.1966	33.17	0.2007	36.01
34	1 : 2150	0.1858	27.56	0.1900	30.10	0.1943	32.78	0.1984	35.59

S. No.	Hydraulic Grade NT	Depth in Meters							
		0.23		0.24		0.25		0.26	
		V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
35	1 : 2200	0.1837	27.24	0.1879	29.76	0.1920	32.41	0.1961	35.18
36	1 : 2250	0.1816	26.94	0.1858	29.43	0.1899	32.04	0.1939	34.79
37	1 : 2300	0.1796	26.65	0.1837	29.11	0.1878	31.69	0.1918	34.41
38	1 : 2350	0.1777	26.36	0.1818	28.79	0.1858	31.35	0.1898	34.04
39	1 : 2400	0.1758	26.08	0.1799	28.49	0.1839	31.03	0.1878	33.69
40	1 : 2450	0.1740	25.82	0.1780	28.20	0.1820	30.71	0.1858	33.34
41	1 : 2500	0.1723	25.56	0.1762	27.92	0.1801	30.40	0.1840	33.01

S. No.	Hydraulic Grade NT	Depth in Meters							
		0.27		0.28		0.29		0.30	
		V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1 : 500	0.4199	79.92	0.4282	86.32	0.4364	93.02	0.4445	100.02
2	1 : 550	0.4003	76.20	0.4083	82.31	0.4161	88.69	0.4239	95.37
3	1 : 600	0.3833	72.96	0.3909	78.80	0.3984	84.92	0.4058	91.31
4	1 : 650	0.3682	70.09	0.3755	75.71	0.3828	81.59	0.3899	87.73
5	1 : 700	03548	67.54	0.3619	72.96	0.3688	78.62	0.3757	84.53
6	1 : 750	0.3428	65.25	0.3496	70.48	0.3563	75.95	0.3630	81.67
7	1 : 800	0.3319	63.18	0.3385	68.24	0.3450	73.54	0.3514	79.07
8	1 : 850	0.3220	61.29	0.3284	66.21	0.3347	71.35	0.3409	76.71
9	1 : 900	0.3129	59.57	0.3192	64.34	0.3253	69.34	0.3313	74.55
10	1 : 950	0.3046	57.98	0.3106	62.63	0.3166	67.49	0.3225	72.56
11	1 : 1000	0.2969	56.51	0.3028	61.04	0.3086	65.78	0.3143	70.73
12	1 : 1050	0.2897	55.15	0.2955	59.57	0.3012	64.19	0.3068	69.02
13	1 : 1100	0.2831	53.88	0.2887	58.20	0.2942	62.72	0.2997	67.43
14	1 : 1150	0.2769	52.70	0.2823	56.92	0.2878	61.34	0.2931	65.95
15	1 : 1200	0.2710	51.59	0.2764	55.72	0.2817	60.05	0.2870	64.56
16	1 : 1250	0.2655	50.55	0.2708	54.60	0.2760	58.83	0.2812	63.26
17	1 : 1300	0.2604	49.56	0.2656	53.54	0.2707	57.69	0.2757	62.03
18	1 : 1350	0.2555	48.64	0.2606	52.53	0.2656	56.61	0.2705	60.87
19	1 : 1400	0.2509	47.76	0.2559	51.59	0.2608	55.59	0.2657	59.77
20	1 : 1450	0.2465	46.93	0.2514	50.69	0.2563	54.62	0.2610	58.74
21	1 : 1500	0.2424	46.14	0.2472	49.84	0.2520	53.71	0.2567	57.75

S. No.	Hydraulic Grade NT	Depth in Meters							
		0.27		0.28		0.29		0.30	
		V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
22	1 : 1550	0.2385	45.39	0.2432	49.03	0.2479	52.83	0.2525	56.81
23	1 : 1600	0.2347	44.68	0.2394	48.26	0.2440	52.00	0.2485	55.91
24	1 : 1650	0.2311	43.99	0.2357	47.52	0.2402	51.21	0.2447	55.06
25	1 : 1700	0.2277	43.34	0.2322	46.82	0.2367	50.45	0.2411	54.24
26	1 : 1750	0.2244	42.72	0.2289	46.14	0.2333	49.72	0.2376	53.46
27	1 : 1800	0.2213	42.12	0.2257	45.50	0.2300	49.03	0.2343	52.72
28	1 : 1850	0.2183	41.55	0.2226	44.88	0.2269	48.36	0.2311	52.00
29	1 : 1900	0.2154	41.00	0.2197	44.28	0.2239	47.72	0.2280	51.31
30	1 : 1950	0.2126	40.47	0.2168	43.71	0.2210	47.10	0.2251	50.65
31	1 : 2000	0.2099	39.96	0.2141	43.16	0.2182	46.51	0.2223	50.01
32	1 : 2050	0.2074	39.47	0.2115	42.63	0.2155	45.94	0.2195	49.40
33	1 : 2100	0.2049	39.00	0.2089	42.12	0.2130	45.39	0.2169	48.81
34	1 : 2150	0.2025	38.54	0.2065	41.63	0.2105	44.86	0.2144	48.23
35	1 : 2200	0.2002	38.10	0.2041	41.15	0.2081	44.35	0.2119	47.68
36	1 : 2250	0.1979	37.67	0.2019	40.69	0.2057	43.85	0.2096	47.15
37	1 : 2300	0.1958	37.26	0.1996	40.25	0.2035	43.37	0.2073	46.64
38	1 : 2350	0.1937	36.86	0.1975	39.82	0.2013	42.91	0.2051	46.14
39	1 : 2400	0.1916	36.48	0.1954	39.40	0.1992	42.46	0.2029	45.65
40	1 : 2450	0.1897	36.10	0.1934	39.00	0.1972	42.02	0.2008	45.19
41	1 : 2500	0.1878	35.74	0.1915	38.61	0.1952	41.60	0.1988	44.73

(Source: Design manual of Chambal Command Area Development, Kota, Rajasthan, April, 1998)

ANNEXURE III: STATEMENT SHOWING THE VELOCITY & DISCHARGES AT DIFFERENT DEPTHS AND SLOPES FOR DRAIN

BED WIDTH = 0.60 m
SIDE SLOPE = 1:1
ROUGHNESS COEFFICIENT (n) = 0.04
V = VELOCITY in m/sec.
Q = DISCHARGE in cum/sec.
V = ($R^{2/3}$ x $s^{1/2}$) / n
Q = A x V

S. No.	Hydraulic Grade NT	Depth in Meters											
		0.60		0.65		0.70		0.75		0.80		0.85	
		V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1 : 500	0.5159	0.3714	0.5374	0.4366	0.5581	0.5079	0.5784	0.5856	0.5981	0.6698	0.6173	0.7608
2	1 : 550	0.4919	0.3542	0.5123	0.4163	0.5322	0.4843	0.5514	0.5583	0.5702	0.6387	0.5886	0.7254
3	1 : 600	0.4709	0.3391	0.4905	0.3986	0.5095	0.4637	0.5280	0.5346	0.5460	0.6115	0.5635	0.6945
4	1 : 650	0.4525	0.3258	0.4713	0.3829	0.4895	0.4455	0.5073	0.5136	0.5245	0.5875	0.5414	0.6673
5	1 : 700	0.4360	0.3139	0.4541	0.3690	0.4717	0.4293	0.4888	0.4949	0.5055	0.5661	0.5217	0.6430
6	1 : 750	0.4212	0.3033	0.4387	0.3565	0.4557	0.4147	0.4722	0.4781	0.4883	0.5469	0.5040	0.6212
7	1 : 800	0.4079	0.2937	0.4248	0.3452	0.4413	0.4015	0.4572	0.4629	0.4728	0.5295	0.4880	0.6015
8	1 : 850	0.3957	0.2849	0.4121	0.3349	0.4281	0.3896	0.4436	0.4491	0.4587	0.5137	0.4734	0.5835
9	1 : 900	0.3845	0.2769	0.4005	0.3254	0.4160	0.3786	0.4311	0.4365	0.4458	0.4993	0.4601	0.5671
10	1 : 950	0.3743	0.2695	0.3898	0.3167	0.4049	0.3685	0.4196	0.4248	0.4339	0.4859	0.4478	0.5520
11	1 : 1000	0.3648	0.2627	0.3800	0.3087	0.3947	0.3591	0.4090	0.4141	0.4229	0.4736	0.4365	0.5380
12	1 : 1050	0.3560	0.2563	0.3708	0.3013	0.3852	0.3505	0.3991	0.4041	0.4127	0.4622	0.4260	0.5250
13	1 : 1100	0.3478	0.2504	0.3623	0.2944	0.3763	0.3424	0.3899	0.3948	0.4032	0.4516	0.4162	0.5129
14	1 : 1150	0.3402	0.2449	0.3543	0.2879	0.3680	0.3349	0.3814	0.3861	0.3943	0.4417	0.4070	0.5017
15	1 : 1200	0.3330	0.2398	0.3469	0.2818	0.3603	0.3279	0.3733	0.3780	0.3860	0.4324	0.3985	0.4911
16	1 : 1250	0.3263	0.2349	0.3399	0.2761	0.3530	0.3212	0.3658	0.3704	0.3782	0.4236	0.3904	0.4812
17	1 : 1300	0.3199	0.2304	0.3333	0.2708	0.3461	0.3150	0.3587	0.3632	0.3709	0.4154	0.3828	0.4718
18	1 : 1350	0.3140	0.2261	0.3270	0.2657	0.3397	0.3091	0.3520	0.3564	0.3640	0.4076	0.3757	0.4630
19	1 : 1400	0.3083	0.2220	0.3211	0.2609	0.3336	0.3035	0.3456	0.3500	0.3574	0.4003	0.3689	0.4547
20	1 : 1450	0.3029	0.2181	0.3155	0.2564	0.3278	0.2983	0.3396	0.3439	0.3512	0.3933	0.3625	0.4468
21	1 : 1500	0.2979	0.2145	0.3102	0.2521	0.3222	0.2932	0.3339	0.3381	0.3453	0.3867	0.3564	0.4393

S. No.	Hydraulic Grade NT	Depth in Meters											
		0.90		0.95		1.00		1.05		1.10		1.15	
		V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1 : 500	0.6361	0.8588	0.6546	0.9639	0.6727	1.0763	0.6905	1.1962	0.7079	1.3239	0.7252	1.4594
2	1 : 550	0.6065	0.8188	0.6241	0.9190	0.6414	1.0262	0.6583	0.1405	0.6750	1.2623	0.6914	1.3915
3	1 : 600	0.5807	0.7839	0.5975	0.8799	0.6141	0.9825	0.6303	1.0920	0.6463	1.2085	0.6620	1.3322

S. No.	Hydraulic Grade NT	Depth in Meters											
		0.90		0.95		1.00		1.05		1.10		1.15	
		V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
4	1 : 650	0.5579	0.7532	0.5741	0.8454	0.5900	0.9440	0.6056	1.0492	0.6209	1.1611	0.6360	1.2800
5	1 : 700	0.5376	0.7258	0.5532	0.8146	0.5685	0.9096	0.5835	1.0110	0.5983	1.1189	0.6129	1.2334
6	1 : 750	0.5194	0.7012	0.5345	0.7870	0.5492	0.8788	0.5638	0.9767	0.5780	1.0809	0.5921	1.1916
7	1 : 800	0.5029	0.6789	0.5175	0.7620	0.5318	0.8509	0.5459	0.9457	0.5597	1.0466	0.5733	1.1536
8	1 : 850	0.4879	0.6586	0.5020	0.7392	0.5159	0.8255	0.5296	0.9175	0.5430	1.0154	0.5562	1.1193
9	1 : 900	0.4741	0.6401	0.4879	0.7184	0.5014	0.8022	0.5146	0.8916	0.5277	0.9867	0.5405	1.0878
10	1 : 950	0.4615	0.6230	0.4749	0.6993	0.4880	0.7808	0.5009	0.8678	0.5136	0.9604	0.5261	1.0588
11	1 : 1000	0.4498	0.6072	0.4629	0.6816	0.4757	0.7610	0.4882	0.8459	0.5006	0.9361	0.5128	1.0319
12	1 : 1050	0.4390	0.5926	0.4517	0.6651	0.4642	0.7427	0.4765	0.8255	0.4885	0.9136	0.5004	1.0071
13	1 : 1100	0.4289	0.5790	0.4413	0.6498	0.4535	0.7256	0.4655	0.8065	0.4773	0.8925	0.4889	0.9839
14	1 : 1150	0.4194	0.5663	0.4316	0.6355	0.4435	0.7097	0.4553	0.7888	0.4668	0.8729	0.4782	0.9623
15	1 : 1200	0.4106	0.5543	0.4225	0.6222	0.4342	0.6947	0.4457	0.7722	0.4570	0.8545	0.4681	0.9420
16	1 : 1250	0.4023	0.5431	0.4140	0.6096	0.4254	0.6807	0.4367	0.7566	0.4477	0.8373	0.4586	0.9230
17	1 : 1300	0.3945	0.5326	0.4059	0.5978	0.4172	0.6675	0.4282	0.7419	0.4391	0.8210	0.4497	0.9051
18	1 : 1350	0.3871	0.5226	0.3984	0.5866	0.4094	0.6550	0.4202	0.7280	0.4308	0.8057	0.4413	0.8882
19	1 : 1400	0.3802	0.5132	0.3912	0.5760	0.4020	0.6432	0.4126	0.7149	0.4231	0.7912	0.4334	0.8722
20	1 : 1450	0.3735	0.5043	0.3844	0.5660	0.3950	0.6320	0.4055	0.7024	0.4157	0.7774	0.4258	0.8570
21	1 : 1500	0.3673	0.4958	0.3779	0.5565	0.3884	0.6214	0.3986	0.6906	0.4087	0.7643	0.4187	0.8426

S. No.	Hydraulic Grade NT	Depth in Meters									
		1.20		1.25		1.30		1.35		1.40	
		V	Q	V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	1 : 500	0.7421	1.6030	0.7588	1.7548	0.7753	1.9151	0.7079	1.3239	0.7252	1.4594
2	1 : 550	0.7076	1.5284	0.7235	1.6732	0.7393	1.8260	0.6750	1.2623	0.6914	1.3915
3	1 : 600	0.6775	1.4633	0.6927	1.6019	0.7078	1.7482	0.6463	1.2085	0.6620	1.3322
4	1 : 650	0.6509	1.4059	0.6656	1.5391	0.6800	1.6797	0.6209	1.1611	0.6360	1.2800
5	1 : 700	0.6272	1.3548	0.6413	1.4831	0.6553	1.6186	0.5983	1.1189	0.6129	1.2334
6	1 : 750	0.6059	1.3088	0.6196	1.4328	0.6331	1.5637	0.5780	1.0809	0.5921	1.1916
7	1 : 800	0.5867	1.2673	0.5999	1.3873	0.6130	1.5140	0.5597	1.0466	0.5733	1.1538
8	1 : 850	0.5692	1.2294	0.5820	1.3459	0.5947	1.4688	0.5430	1.0154	0.5562	1.1193
9	1 : 900	0.5531	1.1948	0.5656	1.3080	0.5779	1.4274	0.5277	0.9867	0.5405	1.0878
10	1 : 950	0.5384	1.1629	0.5505	1.2731	0.5625	1.3894	0.5136	0.9604	0.5261	1.0588

S. No.	Hydraulic Grade NT	Depth in Meters									
		1.20		1.25		1.30		1.35		1.40	
		V	Q	V	Q	V	Q	V	Q	V	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
11	1 : 1000	0.5248	1.1335	0.5366	1.2409	0.5483	1.3542	0.5006	0.9361	0.5128	1.0319
12	1 : 1050	0.5121	1.1062	0.5237	1.2110	0.5350	1.3216	0.4885	0.9136	0.5004	1.0071
13	1 : 1100	0.5003	1.0807	0.5116	1.1831	0.5227	1.2912	0.4773	0.8925	0.4889	0.9839
14	1 : 1150	0.4893	1.0570	0.5004	1.1571	0.5112	1.2628	0.4668	0.8729	0.4782	0.9623
15	1 : 1200	0.4790	1.0347	0.4898	1.1327	0.5005	1.2362	0.4570	0.8545	0.4681	0.9420
16	1 : 1250	0.4694	1.0138	0.4799	1.1099	0.4904	1.2112	0.4477	0.8373	0.4586	0.9230
17	1 : 1300	0.4602	0.9941	0.4706	1.0883	0.4809	1.1877	0.4391	0.8210	0.4497	0.9051
18	1 : 1350	0.4516	0.9755	0.4618	1.0680	0.4719	1.1655	0.4308	0.8057	0.4413	0.8882
19	1 : 1400	0.4435	0.9580	0.4535	1.0487	0.4634	1.1445	0.4231	0.7912	0.4334	0.8722
20	1 : 1450	0.4358	0.9413	0.4456	1.0305	0.4553	1.1246	0.4157	0.7774	0.4258	0.8570
21	1 : 1500	0.4285	0.9255	0.4381	1.0132	0.4476	1.1057	0.4087	0.7643	0.4187	0.8426

(Source: Design manual of Chambal Command Area Development, Kota, Rajasthan, April, 1998)

ANNEXURE IV: AREA IDENTIFICATION FOR DIFFERENT TYPE OF PLANTATION THROUGH SURVEY/IPPE IN THE VILLAGE/GRAM PANCHAYAT

Type of Plantation	Area/length identified for planting in hectares/km	Number of beneficiaries identified	Khasra No./Plot No.
(1)	(2)	(3)	(4)
Roadside Tree Plantation i) PMGSY roads			
ii) Other rural roads			
iii) National Highways			
Bund Plantation			
Afforestation			
i) Forest land			
ii) Common land			
iii) Individual land			
Horticulture			
i) Common land			
ii) Individual land			
Sericulture			
i) Common land			
ii) Individual land			
Lac Culture			
i. Common land			
ii. Individual land			
School Premises			
Temple premises			
Educational Institutions			
Burial ground premises			
Hospital premises			
Other Govt. Institution premises			
Individual lands			

ANNEXURE V: BASIC INFORMATION (INFORMED CHOICE OF SPECIES) ON FORESTRY AND HORTICULTURE TREE SPECIES, SUITABLE AS PER THE AGROCLIMATIC CONDITION WITH INDICATIVE PHYSICAL ESTIMATES (GRAM PANCHAYAT WISE)

Type of Plantation	Name of tree specie	Length/ Area for 1 km / hectare	Spacing (m)	Pit size (m)	Number of plants (in nos.)	Recom mended age for planting the seeding	Reco mended height for planting the seeding	Period of planting
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Roadside Tree Plantation	1.Mango (Banganpalli) 2.Mango (Totapuri) 3.Mango (Dashahri)	1km	10x10	1x1x1	1000	2 yrs.		
Bund Plantation								
Afforestation								
Horticulture								
Sericulture								
Lac Culture								
School Premises								
Temple premises								
Educational Institutions								
Burial ground premises								
Hospital premises								
Other Govt. Institution premises								

ANNEXURE VI: INDICATIVE MONTH WISE SCHEDULE OF ACTIVITIES FOR TREE PLANTATION AND THE RESPONSIBLE STAKEHOLDERS

Year	Month	Schedule of Activities for tree plantation	Responsible Stakeholders
(1)	(2)	(3)	(4)
0 year	April to July	Training programmes for the Officials of implementing agency/volunteers/Resource persons/beneficiaries, regarding MGNREGA operational guidelines/ planning process, convergence guidelines/circulars/ to take up proper planning exercise for the preparation of work plan and labour budget.	Officials of Rural Development Department (RDD), Elected representatives/Officials of concerned line departments.
	August	Initiate Planning through Gram Sabha (IPPE), Identification of suitable lands for conducting various types of plantations like roadside, canal side, tank foreshore, Institutional lands, Waste lands, barren lands. Degraded lands etc. on Individual/ Common/Forest lands. Identification of beneficiaries for providing usufruct rights, Estimating demand of species from beneficiaries (out of the recommended species as per agro-climatic condition), Working out for nursery preparation etc. Working out convergence possibilities with other schemes.	Gram Panchayat elected representatives and Officials of RDD, and Officials of concerned line Departments,
	Sept. to Dec.	Ratification by Gram Sabha – preparation of estimate and obtaining technical and administrative sanctions.	Gram Panchayat elected representatives and Officials, PO, DPC
1st year	Jan	Issue of Work Order	Programme Officer (PO)
		Surveying & clearing of the area	Beneficiary with the support of GRS (Field Assistant) and wage seekers
	Feb	Soil test of selected tree planting site. Land development – removal of boulders (if any), Construction of bunds, Digging of pits and trenches.	Beneficiary with the support of GRS (Field Assistant) and wage seekers
	March	Digging of pits, Applying insecticides in the dug pit. Procurement of eco-friendly locally available material for fencing or live fencing or opting for social fencing.	Beneficiary with the support of GRS (Field Assistant and wage seekers
	April	Purchase of Farm Yard Manure (FYM), Fertilizers	Beneficiary with the support of GRS
	May	Filling up of pits with FYM, and soil, onsite training to beneficiaries, on how to do plantation.	Line Department/ Officials of Rural Development Department
	June	Transportation of plants and planting of saplings and live fencing, Watering, weeding and hoeing	Beneficiary with the support of GRS (Field Assistant and wage seekers
	July	Transportation of plants and planting of saplings and live fencing, Watering, weeding and hoeing	Beneficiary with the support of GRS (Field Assistant and wage seekers
	August	Transportation of plants and planting of saplings and live fencing, Watering, maintenance	Beneficiary with the support of GRS (Field Assistant and wage seekers

	Sept.	Weeding, hoeing and watering 4 times	Beneficiary with the support of GRS (Field Assistant and wage seekers
	Oct.	Weeding, hoeing and watering 4 times	Beneficiary with the support of GRS (Field Assistant and wage seekers
	Nov	Weeding, hoeing and watering 4 times	Beneficiary with the support of GRS (Field Assistant and wage seekers
	Dec.	Weeding, hoeing and maintenance	Beneficiary with the support of GRS (Field Assistant and wage seekers
2nd year	Jan	Weeding, hoeing and maintenance	
	Feb	Weeding, hoeing and maintenance	
	March	Watering 4 times.	
	April	Watering 6 times	
	May	Watering 6 times	
	June	Watering 6 times	
	July	Casualty replacement (20% of the total plants), weeding, maintenance.	
	August	Weeding, maintenance.	
	Sept.	Watering 2 times, maintenance	
	Oct.	Watering 2 times, maintenance	
	Nov	Watering 2 times, maintenance	
	Dec	Maintenance	
3rd Year	Jan	Maintenance	
	Feb	Maintenance	
	March	Watering 4 times, maintenance	
	April	Watering, maintenance	
	May	Watering, maintenance	
	June	Watering, maintenance	
	July	Casualty replacement (10% of the total plants), watering, Maintenance	
	August	Watering, maintenance	
	Sept.	Watering, maintenance	
	Oct.	Watering, maintenance	
	Nov	Watering, maintenance	
	Dec	Watering, maintenance	

4th year & 5th Year	Jan Feb	Watering, maintenance Watering, maintenance	
	March	Watering, maintenance	
	April	Watering, maintenance	
	May	Watering, maintenance	
	June	Watering, maintenance	
	July	Watering, maintenance	
	August	Watering, maintenance	
	Sept.	Watering, maintenance	
	Oct.	Watering, maintenance	
	Nov	Watering, maintenance	
	Dec	Watering, maintenance	

(**Source:** A Plan of Action for Roadside Tree Plantation under MGNREGA, issued by Ministry of Rural Development, (MGNREGA Division) dated 31st July 2014)

ANNEXURE VII: REGION WISE LIST OF TREE SPECIES BASED ON AGRO-CLIMATIC CONDITIONS RECOMMENDED BY IRC FOR DIFFERENT STATES.

Trees Suitable for Arid and Dry Regions:

S. No.	Botanical Name	Common Name
1.	Ailanthus excelsa	Maharukh
2.	Azadirachta indica	Neem
3.	Alstonia scholaris	
4.	Acacia auriculiformis	
5.	Butea monosperma	Palas
6.	Bombax ceiba	
7.	Cassia fistula	Labermum/Amaltas
8.	Cassia siamea	Siamese Cassia
9.	Callistemon viminalis	Bottle brush
10.	Callistemon citrinus	
11.	Ceiba pentandra	
12.	Cochlospermum religiosum	
13.	Casuarina equisetifolia	
14.	Dalbergia sissoo	Shisham
15.	Erythrina variegata	
16.	Ficus spp	Peepal, Bargad, Pakur etc
17.	Gmelina arborea	Gambhari
18.	Heterophragma adenophyllum	
19.	Moringa oleifera	Sahjan
20.	Melia azardirachta	Bakain
21.	Millingtonia hortensis	
22.	Pongamia pinnata	Karanj/Papari
23.	Plumeria sp.	
24.	Parkinsonia aculeata	
25.	Syzygium cumini	
26.	Tecoma undulata	Roheda
27.	Tamarindus indica	Imli
28.	Terminalia sp.	

Trees suitable for Moist Areas

Moist locality consists of areas where rainfall is high and of longer duration. The soil remains moist but not necessarily waterlogged. High humidity pervades the atmosphere. Trees suitable for moist areas are:

1. Alstonia scholaris
2. A. macrophylla
3. Amherstia nobilis
4. Barringtonia acutangula

5. Barringtonia racemosa
6. Bauhinia variegata
7. Bauhinia pupurea
8. Brownea coccinea
9. B. ariza
10. Cassia marginata
11. Cassia javanica
12. Cassia nodosa
13. Colvillea racemosa
14. Delonix regia
15. Dillenia indica
16. Guaiacum officinale
17. Lagerstroemia speciosa
18. L. thorelli
19. Millettia peguensis
20. Peltophorum ferrugineum
21. Samanea saman
22. Polyalthia lognifolia
23. P. Pendula
24. Pongamia pinnata
25. Putranjiva roxburghi
26. Saraca asoca
27. Terminalia arjuna
28. Tamarindus indica

Trees Suitable for Marshy Areas

Areas which remain waterlogged for a considerable period of the year come under this ecological environment. Trees suitable for such areas are:

1. Barringtonia acutangula
2. Barringtonia racemosa
3. Eucalyptus rostrata
4. Hibiscus tilliaceus
5. Salix babylonica
6. S. tetrasperma
7. Tamarix articulata

Of the above species Eucalyptus rostrate can not only grow under marshy conditions, but has capacity to draw up large quantities of water for transpiration. Sometimes this species is used for drying up marshy land.

Trees Suitable for Saline Tracts

Saline tract is present along the coastal areas where the tidal waves submerge the land periodically. Besides, vast saline tracts are met within the country where water logging is a perennial problem. Here the accumulated body of water finds release mainly into the atmosphere through evaporation leaving behind the salts on the surface. This condition for decades, or even for centuries, has turned the soil very saline. Trees suitable for such tracts are those that can stand drought as well as high concentration of salinity. The example of such trees are:

1. Acacia auriculifomis
2. Butea monosperma
3. Casuarina equisetifolia
4. Cochlospermum religiosum
5. Eucalyptus Citriodora
6. Heritiera macrophylla
7. Inga dulcis
8. Perkinsonia aculeata
9. Pongamia pinnata
10. Samanea samna
11. Tamarix articulata
12. Thespesia populnea
13. Tamadrindus indica
14. Terminalia arjuna

Plants disliked by Cattle and can be used as live fencing

Truly speaking, this grouping of trees does not belong to the ecological classification. But this group is useful where stray cattle are plenty and pose a problem for the protection of trees, particularly at the young age. Selection of plants that are disliked by cattle will help toward off the menace from these animals. Some trees under this group are:

1. Cassia fistula
2. C. nodosa
3. C. javanica
4. C. siamea
5. C. renigera
6. C. multijuga
7. C. marginata
8. C. moschata
9. Holarrhena antidysenterica

A. List of Trees suitable for Arid and Dry Regions of South Haryana, Rajasthan, Gujarat, Maharashtra and Central Plateau

1. Acacia auriculoformis
2. Bombax ceiba
3. Callistemon citrinus
4. Ceiba pentandra
5. Cochlospermum religiosum
6. Erothrina variegatum
7. Heterophragma adenophyllum

8. Millingtonia hortensis
9. Plumeria spp
10. Syzygium cumini
11. Casuarina equisetifolia
12. Parkinsonia aculeata

B. Trees suitable for temperate and sub-tropical areas of North-West India, J&K, Punjab, Himachal Pradesh, Uttarakhand, Part of UP:

S. N.	Botanical Name	Common Name
1.	Barringtonia acutangula	
2.	Cedrus Deodara	Devdar
3.	Dillenia indica	Silver Oak
4.	Grevillea robusta	Papri
5.	Holoptelea integrifolia	Akhrot (Walnut)
6.	Juglans regia	
7.	Michelia champaca	
8.	Myrica nagi	Kaphal
9.	Pinus sp	
10.	Pterospermum acerifolium	
11.	Salix sp	Soal
12.	Sapindus mukorossi	Reetha
13.	Taxus baccata	Thuner

C. Trees suitable for Indo Gangetic Plains of Uttar Pradesh, Punjab, Bihar and West Bengal

S.N.	Botanical Name	Common Name
1.	Albizia lebbeck	Siris
2.	Albizia procera	Safed Siris
3.	Butea monosperma	Palash
4.	Bauhinia variegata	Kachnar (Pink)
5.	Cassia fistula	Labernum / Amaltash
6.	Cassia siamea	Siamese cassia
7.	Cedrela toona	Toon
8.	Chikrassia tabularis	Chikasi
9.	Callistemon lanceolatus	Bottle brush
10.	Dalbergia sissoo	Shisham
11.	Emblica officinalis	Aonla
12.	Ficus sp	Peepal, Bargad, Pakur, etc.
13.	Grevillea robusta	Silver Oak
14.	Hardwickia pinnata	Malabar Mahagani
15.	Lagerstroemia thorelli	
16.	Lagerstroemea flos-reginae	Pride of India / Jarul

17.	Morus alba	Shahtoot
18.	Mangifera indica	Desi Mango
19.	Pterospermum acerifolium	Kanak Champa
20.	Putranjiva	
21.	Polyalthia longifolia	Ashok
22.	Syzygium cumini	Jamun
23.	Terminalia arjuna	Arjun
24.	Terminalia belerica	Bahera
25.	Terminalia chebula	Harra/ Myrobalan
26.	Tecoma argentea	

D. List of Trees suitable for North Eastern States, North Bengal, Assam, etc.

S.N.	Botanical Name	Common Name
1.	Alstonia scholaris	Chatuni/Saptaparni
2.	Albizia lebbeck	Siris
3.	Cryptomeria japonica	Dhupi
4.	Colvillea racemosa	
5.	Crateva religiosa	Barna
6.	Cinchona sps	Cinchona (Quinine tree)
7.	Lagerstroemea flos-reginae	Pride of India
8.	Lagerstroemea thorelli	
9.	Michelia champaca	Champa
10.	Pterospermum acerifolium	Kanak Champa
11.	Shorea robusta	Sal

E. List of Trees suitable for Coastal Areas of Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Orissa, etc.

	Botanical Name	Common Name
1	Anacardium Occidentale	Cashew nut
2	Cinnamomum camphora	Kapoor
3	Casuarina equisetifolia	Casuarina
4	Dalbergia latifolia	Rosewood
5	Mangifera indica	Mango
6	Palms	
7	Pterospermum acerifolium	
8	Saraca indica	Sita Ashok
9	Swietenia mahogani	Mahagani
10	Swietenia macrophylla	
11	Tabebuia spectabilis	
12	Tabebuia rosea	

(Source:- IRC:SP:103-2014, Guidelines on Tree Plantation along Rural Roads, Indian Roads Congress, 2014)

ANNEXURE VIII: MODEL ESTIMATE FOR ROAD SIDE TREE PLANTATION UNDER MGNREGS

Estimate for 200 plants for five years

District: Block: Gram Panchayat:

___________________________________(location) to ___________________________________(location)

Spacing _____________________m X ___________m Length ____________________Km.

Name of tree species _______________

S. No.	Description of work	Unit	No of Person days	Rate (Rs)	Amount (RS)
(1)	(2)	(3)	(4)	(5)	(6)
A	Labour component				
1	Survey and demarcation	1 Km	1		
2	Site preparation by cleaning, cutting bushes, weeds and its removal	10,000 m2	16		
3	Pit digging (0.45m X 0.45m X 0.30m)	200 pits	25		
4	Filling pits with manure	200 pits	5		
5	Planting seedlings	200 plants	5		
6.1	Maintenance (upto 100 days as unskilled)	Payment based on survival of plant/task completed per month for 200 plants, for five year @ 15 per plant		15/plant/ month	50000
B	**Material component**	**Quantity**		**Rate (Rs)**	**Amount (Rs)**
6.2	Maintenance (rest of the year as semiskilled)	Payment based on survival of plant/task completed per month for 200 plants, for five years @ 15 per plant		15/plant/ month	130000
7	Cost of Plant material	200 + 40 + 20 = 260		25 /plant	6500
8	Cost of insecticides and Manure (jeevamrutha)				
8.1	Ist year -once at an interval of 15 days		200X24 times =4800	0.9	4320
8.2	2nd Year - once at an interval of 30 days		200X12 times =2400	0.9	2160
8.3	3rd Year - once at an interval of 30 days		200X12 times =2400	0.9	2160
8.4	4th Year - once at an interval of 30 days		200X12 times =2400	0.9	2160
8.5	5th Year - once at an interval of 30 days		200X12 times =2400	0.9	2160
9	Cost of a water carrying trolley	One trolley		5000	5000
10	Cost of mud pots for irrigation	1 pot per plant = 260		50	13000
11	Fencing (tree guard)	using Bamboo poles or other locally available material for 200 plants		350	70000
12	2 % contingency of Total cost				
			Total		
Wage rates are applicable as per the notified wage rates under MGNREGS					
Pit Size and spacing will vary from specie to specie.					

(Source:- A Plan of Action for Roadside Tree Plantation under MGNREGA, issued by Ministry of Rural Development, (MGNREGA Division) dated 31st July 2014)

ANNEXURE IX: A Typical Estimate for Block Plantation in convergence with other Centrally/State sponsored schemes, or without convergence, on Individual beneficiary/Common land

If on individual land, Name of beneficiary ___________________

Name of Village _________ G.P. _________Block_________ District _________

Area: _________ (ha.)Khasra/Plot No.: ___________________

Name of the Plant Specieswith Number:

1. ______________________________

2. _____________________________

3. _____________________________

Spacing: ___mt. X ___ mt.

Name of the Centrally / State Sponsored Scheme (if converged):____________

Proposed Expenditure: First Year ________Second Year________Third Year ______Fourth year ______ Fifth Year ______Total________

S.	Particulars/Activities	Unit	Qty. (Vol. of work)/ Number	SoR for the cluster/ wage	Labour component unskilled		Material Component		Total Amount	Source of fund		
					No. of person days/Qty	Amount No. (Rs.)	No.	Amount (Rs.)		MGN REGS	Other CSS/SSS	Ben ef.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
						First Year						
	A. Labour Cost											
1	Site Clearance – Bush Clearance, Boulder Removal etc.	sqm										
2	Soil & Moisture Conservation works, etc.	cum										
3	Digging of pits (of size __X__X__ for __ Plants)	cum										
4	Pit filling with FYM, Neem cakes (of size __X__X__ for __ Plants)	cum										
5	Planting of seedlings.	No.										
6	Providing staking/shade	No.										
7	Making basins around the plants (of size __X__X__ for __ Plants)	No.										
8	Weeding, hoeing and mulching (____ times in a year)	No.										
9	Irrigation to seedlings (___ times in a year)	No.										
10	Application of fertilizers (____ times in a year)	No.										
11	Application of Plant protection chemicals (---- times in a year)	No.										
12	Drainage and other miscellaneous works	Sq.mt.										
13	Boundary protection – Live fencing/CPT/CPW)	Rmt.										
	Sub total (A)											
	B. Material Cost											
1	Charges for soil sampling and testing	Ha.										
2	Cost of ___ No. of Seedlings (@ of Rs ___ per seedling/ sapling)	No.										
3	FYM (___ kg per Seedling for ___No. of seedlings @ of Rs ___per kg)	Kg.										

4	Neem Cake (___ kg per seedling for ___ seedlings @ Rs ___ per kg)	Kg.										
5	Cost of fertilizers (___ times in a year to ___ No. of seedlings @ Rs ___ per kg) (Dosage ___kg per year for ___ No. of seedlings)	Kg										
6	Cost of plant protection chemicals (___ times in a year @ Rs ___ per round)	Kg/ Litre										
7	Inputs for intercrops i.e. seeds, fertilizers and PPC @ RS ____ per year)	lump sum									(from other CSS/ SSS)	(Benf. Contri.)
8	Tools/implements	lump sum									(from other CSS/ SSS)	(Benf. Contri.)
	Sub total (B)											
	Total (A +B)											
	Second Year											
	C Labour Cost											
1	Planting of seedlings (Gap filling 20%)	No.										
2	Weeding, hoeing and mulching in ___ pits of size __X__X__ (__ times in a year)	No.										
3	Irrigation to ____ seedlings (____ times in a year)	No.										
4	Application of FYM/fertilizers (__ times in a year) to ___ seedlings	No.										
5	Application of Plant protection chemicals (---- times in a year)	No.										
6	Drainage and other miscellaneous works	Sq.mt.										
	Sub total (C)											
	D. Material Cost											
1	Cost of ___ No. of seedlings for Gap filling 20 % (@ of Rs ___ per seedling)	No.										
2	FYM (___ kg per Seedling for ___No. of seedlings @ of Rs ___per kg)	Kg.										
3	Neem Cake (___ kg per seedling for ___ seedlings @ Rs ___ per kg)	Kg.										
4	Cost of fertilizers (___ times in a year to ___ No. of seedlings @ Rs ___ per kg) (Dosage ___kg per year for ___ No. of seedlings)	Kg										
5	Cost of plant protection chemicals (___ times in a year @ Rs ___ per round)	Kg/ Litre										
6	Inputs for intercrops i.e. seeds, fertilizers and PPC @ RS ____ per year)	lump sum									(from other CSS SSS)	(Benf.) Contri.)
	Sub total (D)											
	Total(C +D)											
	Third Year											
	E. Labour Cost											
1	Planting of seedlings (Gap filling 10%)	No.										
2	Weeding, hoeing and mulching in ___ pits of size __X__X__ (__ times in a year)	No.										
3	Irrigation to ____ seedlings (____ times in a year)	No.										

4	Application of FYM/fertilizers (__ times in a year) to ___ seedlings	No.										
5	Application of Plant protection chemicals (---- times in a year)	No.										
6	Drainage and other miscellaneous works	Sq.mt.										
	Sub total (E)											
	F. Material Cost											
1	Cost of ___ No. of seedlings for Gap filling 10 % (@ of Rs ___ per seedling)	No.										
2	FYM (___ kg per Seedling for ___No. of seedlings @ of Rs ___per kg)	Kg.										
3	Neem Cake (___ kg per seedling for ___ seedlings @ Rs ___ per kg)	Kg.										
4	Cost of fertilizers (___ times in a year to ___ No. of seedlings @ Rs ___ per kg) (Dosage ___kg per year for ___ No. of seedlings)	Kg										
5	Cost of plant protection chemicals (___ times in a year @ Rs ___ per round)	Kg/ Litre										
6	Inputs for intercrops i.e. seeds, fertilizers and PPC @ RS ____ per year)	lump sum									(from other CSS SSS)	(Benf. Contri.)
	Sub total (F)											
	Total (E +F)											
	Fourth Year											
	G. Labour Cost											
1	Weeding, hoeing and mulching in ___ pits of size __X__X__ (__ times in a year)	No.										
2	Irrigation to ____ seedlings (____ times in a year)	No.										
3	Application of FYM/fertilizers (__ times in a year) to ___ seedlings	No.										
4	Application of Plant protection chemicals (---- times in a year)	No.										
5	Drainage and other miscellaneous works	Sq.mt.										
	Sub total (G)											
H.	**Material Cost**											
1	FYM (___ kg per Seedling for ___No. of seedlings @ of Rs ___per kg)	Kg.										
2	Neem Cake (___ kg per seedling for ___ seedlings @ Rs ___ per kg)	Kg.										
3	Cost of fertilizers (___ times in a year to ___ No. of seedlings @ Rs ___ per kg) (Dosage ___kg per year for ___ No. of seedlings)	Kg										
4	Cost of plant Protection chemicals (___ times in a year @ Rs ___ per round)	Kg/ Litre										
5	Inputs for intercrops i.e. seeds, fertilizers and PPC @ RS ____ per year)	lump sum									(from other CSS/ SSS)	(Benf.) Contri.)
	Sub total (H)											
	Total (G +H)											

Fifth Year

	I. Labour Cost											
1	Weeding, hoeing and mulching in ___ pits of size __X__X__ (__ times in a year)	No.										
2	Irrigation to ____ seedlings (____ times in a year)	No.										
3	Application of FYM/fertilizers (__ times in a year) to ___ seedlings	No.										
4	Application of Plant chemicals (---- times in a year)	No.										
5	Drainage and other miscellaneous works	Sq.mt.										
	Sub total (I)											
	J. Material Cost											
1	FYM (___ kg per Seedling for ___No. of seedlings @ of Rs ___per kg)	Kg.										
2	Neem Cake (___ kg per seedling for ___ seedlings @ Rs ___ per kg)	Kg.										
3	Cost of fertilizers (___ times in a year to ___ No. of seedlings @ Rs ___ per kg) (Dosage ___kg per year for ___ No. of seedlings)	Kg										
4	Cost of plant protection chemicals (___ times in a year @ Rs ___ per round)	Kg/ Litre										
5	Inputs for intercrops i.e. seeds, fertilizers and PPC @ RS ____ per year)	lump sum									(from other CSS/ SSS)	(Benf. Contri.)
	Sub total (J)											
	Total (I +J)											
	Grand Total											

Total Expenditure on Labour (Rs)
Centrally/ State Sponsored Schemes expenditure -
MGNREGA Expenditure -
Beneficiary Expenditure -
Total -

Total Expenditure on Material (Rs)
Centrally/ State Sponsored Schemes expenditure -
MGNREGA Expenditure -
Beneficiary Expenditure -
Total

Contribution of MGNREG Scheme (Rs)
Expenditure in first year -
Expenditure in second year -
Expenditure in third year -
Expenditure in fourth year -
Expenditure in fifth year -
Total -

Contribution of Beneficiary Scheme (Rs)
Expenditure in first year -
Expenditure in second year -
Expenditure in third year -
Expenditure in fourth year -
Expenditure in fifth year -
Total -

Contribution of Centrally/State Sponsored Scheme (Rs)
Expenditure in first year -
Expenditure in second year -
Expenditure in third year -
Expenditure in fourth year -
Expenditure in fifth year -
Total -

ANNEXURE X: MODEL ESTIMATE FOR NURSERY RAISING UNDER MGNREGS

A)	Labour component							
S. No.	Items of works	Unit	Zone A		Zone B		Zone C	
			Person days	Rates (Rs.)	Person days	Rates (Rs.)	Person days	Rates (Rs.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Clearance of site	Ha	4.11		4.11		4.11	
2	Clearance of Lantana infected areas	Ha	13.7		13.7		-	
3	Digging of soil 25 cm to 30 cm deep two times (New Nursery)	Ha	6.85		8.22		9.59	
4	Digging of soil second time, dressing and levelling (New Nursery)	Ha	17.81		18.49		19.18	
5	Earth work for levelling	Cum	0.21		0.22		0.27	
6	Digging, collection and cartage of soil, sand and manure in a ratio of 4:2:1	100 poly bags. (15cmx 10 cm)	0.34		0.41		0.48	
7	Stone walling for making embankment or ‘Pushta’ in sloping land	Cum	1.23		1.3		1.37	
8	Preparation of nursery beds (3m x 1m)	Bed	0.16		0.18		0.19	
9	Sowing of seed and covering of beds.	Bed	0.02		0.02		0.03	
10	Sieving of soil, sand, removing twigs and green leaves etc. and rubbing the manure with hands for filling in polythene bags	100 bags	0.27		0.34		0.41	
11	Filling of polythene bags with potting mixture and placing them in beds	100 bags	0.34		0.41		0.48	
12	Sowing of seeds in polythene bags	100 bags	0.04		0.04		0.04	
13	Irrigation of nursery beds	ha	28.77		31.51		34.25	
14	Transplanting of seedlings taken from nursery beds in bags/beds	100 seedlings	0.62		0.62		0.68	
15	Maintenance of nursery including watering, weeding, shifting of plants and replacement of mortality.	20,000 plants minimum	6 months		12 months		18 months	
16	Annual ploughing / digging of nursery beds 25 cm - 30 cm deep (old nursery)	ha	41.1		45.21		49.32	
17	Preparing germination beds (3 m x 1m) by putting in soil, sand and manure, 7.50 cm thick including cost of manure for ball plants	Bed	0.14		0.16		0.19	
18	Shifting of ball plants							
a)	After 6 months	100 plants	1.03		1.03		1.03	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
b)	After 12 months	100 plants	1.64		1.64		1.64	
19	Cost of insecticides	100 plants	0.45		0.48		0.52	
20	Spraying of insecticides, when required (Labour)	20,000 plants	0.5		0.5		0.5	
21	Grading and shifting of seedlings (3 times)	100 plants	1.32		1.32		1.32	
22	Preparing root/shoot cuttings of teak, semal, shisham etc. including digging of plants, making ball plants (complete work)	100 plants	0.41		0.41		0.41	
23	Fixing root / shoot cuttings	100 plants	0.41		0.41		0.41	
24	Preparing branch cuttings of poplar, mulberry, pipal, bargad, gular, salix etc. and planting in beds	100 plants	0.41		0.44		0.48	
25	Planting of root / shoot cuttings	100 plants	0.07		0.07		0.07	
26	Making thatch covers for protection of plants from heat/ frost including cost and cartage of thatch grass and labour	bed 3mx1m	0.14		0.15		0.16	
B)	**Material Component (for 20000 plants)**							
	Items	**Quantity**	**Rate (Rs)**	**Amount (Rs)**				
1	Cost of seeds	LS						
2	Cost of insecticides for nursery	L.S						
3	Cost of manure	9 cum						
4	Cost of collection of sand for nursery bed preparation	18 cum						
5	Cost of collection of good soil for filling poly bags	35 cum						
6	Cost of Nursery tools	L.S						
7	Cost of polythene bags (15cm X10cm)	20000 nos						
8	Cost of material for shade and fencing	L.S				Name of Zone	Altitudinal Range	
9	Display board	L.S				Zone A - Tropical	Upto 1000m	
10	2 % Contingency of total cost					Zone B - Sub-tropical	1000 -1500m	
			Total			Zone C - Temperate	1500 -2400m	
		Grand Total						

(*Source of persondays from Forest Works Manual for forestry related works in Uttarakhand, under MGNREGA, 2009. It may vary from State to State. Wage rates are applicable as per the notified wage rates under MGNREGS.)

ANNEXURE XI: DIFFERENT OPTIONS FOR TREATMENT FOR SEPTAGE MANAGEMENT IN RURAL AREAS

Technology	Description	Advantages for septage management	Disadvantages for septage management
(1)	(2)	(3)	(4)
Individual facilities			
Singe pit latrine (Ref: www.appropedia.org/single_pit_latrine)	The Single VIP is a Ventilated, Improved Pit. It is an improvement over the Single Pit because continuous airflow through the ventilation pipe vents odours and acts as a trap for flies as they escape towards the light.	Does not require a constant source of water and thus reduces the volume of septage. Can be built and repaired with locally available materials Can be used immediately after construction. Low (but variable) capital costs depending on materials. Small land area required.	Sludge (septage) requires secondary treatment and appropriate discharge. Emptying full single pit latrines can cause a serious health hazard, as the freshly deposited sludge at the top of the pit will contain many faecal organisms that may be pathogenic Costs to empty may be significant compared to capital costs. If little or no water is used then the septage may be solid and difficult (or impossible) to pump and has to be emptied by hand. Low reduction in BOD and pathogens.
Double pit latrine (Ref: www.who.int/water_sanitation_health/hygieneom/linkingchap8.pdf	This toilet consists of two pits, each covered with a slab with a drop hole and a vent pipe covered with a fly screen, and one superstructure	Twin pit latrines are designed to be emptied without the need to handle fresh excreta. Removal of dried sludge from a pit that has been left undisturbed for two years should be relatively straightforward as the material will have decomposed sufficiently and be relatively safe to handle	Higher cost than simple pit latrine. Needs more space to install.
Septic tank (Ref: www.nesc.wvu.edu)/subpages/septic_defined.cfm	A septic tank is a watertight, on-site treatment system for domestic sewage, consisting of two or more compartments, in which the sanitary flow is detained to permit concurrent sedimentation and sludge digestion.	Higher reduction in BOD and pathogens. Long-lasting facility. High level of comfort for the user (similar to sewerage)	If the septic tank collects all domestic wastewater then the total volume is much higher than for pit latrines. Sludge (septage) requires secondary treatment and appropriate discharge. Higher cost than any pit latrine.

(1)	(2)	(3)	(4)
Septage/Waste stabilization ponds (WSP) Ref: Waste Stabilization Ponds, A Viable Alternative for Small Community Treatment Systems, www.onlinelibrary.wiley.com)	WSP systems comprise one or more series of different types of ponds. Usually the first pond in the series is an anaerobic pond, and the second is a facultative pond. These may need to be followed by maturation ponds, but this depends on the required final effluent quality.	Natural process Capital cost is very low O&M cost is low Can be managed by unskilled manpower	Needs some technical inputs Needs large available land in GP. Flooding can occur during rainy season – needs special management afterwards.
Biogas reactors (anaerobic digestion) (Ref: as mentioned above for Solid Waste Technologies)	Septage is a great source of biogas, as it is very high in organic matter that releases methane upon anaerobic digestion. By capturing and sequestering these greenhouse gases before they can reach the atmosphere, such systems minimize impacts on global warming. Indeed, biogas waste-to-energy systems can actually sell carbon credits on the open market, which may help recover capital or operation costs associated with the facility.	Capturing biogas is also beneficial because anaerobic digestion and the biogases produced form this process can generate odours. Covering and capturing biogas helps control door making these facilities more appropriate in areas that are in close proximity to residential housing.	Expensive Difficult to operate and maintain. Risk of odour.
Composting (Ref: as mentioned above for Solid Waste Technologies)	Compost is defined as "the stabilization of organic material through the process of aerobic, thermophilic decomposition. The resulting humus-like material is suitable as a soil conditioner and source of nitrogen and phosphorus.	Can be used as a soil amendment to reclaim land or used in landscaping or horticulture.	Exposure can occur during the composting process to workers and to people living around the composting site. Agricultural use or use that may include human contact requires detailed laboratory analysis to confirm concentrations of pathogens and heavy metals are within safe limits. Commercial septage (including that from restaurants, fuelling stations, auto repair shops, dentistry offices and jewellery shops, dry cleaning and film processing operations, and other manufacturing or industrial sources), must be segregated

(1)	(2)	(3)	(4)
Lime stabilization (Ref: Lime Stabilization of Septage Waste, www.michigan.gov)	Lime stabilization is the process by which hydrated lime (calcium hydroxide) is added to septage to form a product that can be disposed of on land for use as a fertilizer.	Kills pathogens present and stabilizes the waste thus reducing odours. Stabilized septage can be applied to the land at a rate of 300,000 litres per hectare per year. It can also be used as cover for sanitary landfills	Lime is expensive and difficult to handle
Drying beds (Ref: www.unep.or.jp Unplanted Drying Beds www.akvopedia.org)	Drying beds are either planted or unplanted sealed shallow ponds filled with several drainage layers and designed for the separation of the solid from the liquid fraction of (faecal) sludge. Sludge is dried naturally by a combination of percolation and evaporation.	Dried sludge can be used as fertiliser (either directly in the case of planted beds or after composting in the case of unplanted beds) Easy to operate (no experts, but trained community required) High reduction of sludge volume can achieve pathogen removal can be built with locally available materials	Requires large land area Requires treatment of percolate Only applicable during dry seasons or needs a roof and contour bund Manual labour or specialised equipment is required to remove dried sludge from beds Can cause odour problems

(Source: Guidelines on solid and liquid waste management (SLWM) in Rural Area by Minsitry of Drinking water and Sanitation)

ANNEXURE XII: DIFFERENT OPTIONS OF COMPOSTING IN RURAL INDIA

TechTechnology or Approach	Description	Advantages	Disadvantages	Conditions for use
(1)	(2)	(3)	(4)	(5)
Pile Composting (Ref: Composting at Home, www2.epa.gov/recycle/composting-home)	Composting is done in systematic piles above ground. Organic materials are added in layers and covered in soil to protect it. After 8 weeks the compost is ready for use.	Easy to establish at the household level and low cost. Good in areas with high rainfall as pile needs frequent addition of water.	Requires frequent maintenance (adding water and turning the pile after 2-3 weeks). Turning should not be done in the rain to prevent water-logging Space is needed for piles so method is unsuitable in densely populated areas	Composting works better in higher temperatures. In colder climates piles should be made bigger. During the winter (especially during snowfall) piles should be left without turning until temperature rises. Strong winds and sun have little effect on larger piles but may need more frequent addition of water and a wind breaker can be used if desired.
NADEP method (Ref: NADEP Manual www.rcsdin.org/NADEP%20tech%20manual.pdf)	Composting takes place in a rectangular brick tank with aeration holes. Organic material is added in layers Compost is ready in 3 months	Composting can be done on a larger scale than using piles All nutrients are retained in the tank so resulting compost is more nutrient rich.	Tanks work in 3 month rotations so at least 2 are needed which increases the cost. Large quantities of soil and water are needed which can be difficult to transport in some areas. The entire tank should be filled within a maximum 48 hour period (24hrs is better).	Tanks can be built in all conditions. The thatch roof protects the tank from moisture. Tank should be monitored to check for cracking of seal which would allow moisture to escape. Tanks require space and a lot of initial material so a community approach is better, using a communal space for the tank and agreeing the date for bringing material/ filling the tank.
Bangalore method (Ref: www.urbanindia.nic.in/publicinfo/swm/chapter14.pdf	Waste is composted anaerobically in a pit. Compost is ready in 6-8 months	Can accept municipal waste and night soil. Good for dry areas No O&M is needed	Cannot be used in wet areas as the pit may become waterlogged. Gases produced can smell and the pit requires quite a large space. Composting process is slow	Useful in areas where the use of piles is limited by severe weather conditions e.g. strong winds and sun. Can be done at the household level where

(1)	(2)	(3)	(4)	(5)
				space permits as no O&M is required. Very cheap compared to tank methods as no infrastructure is required.
Indore method (Ref: www.urbanindia.nic.in/publicinfo/swm/chapter14.pdf	Waste is cut into small pieces and spread 10 -15cm thick above ground or in a pit. Compost is ready in 4 months	No infrastructure is needed and process is relatively quick	Nutrients are lost to the soil. Regular turning is needed (every 5 days). Cannot be used in wet areas or areas with heavy rainfall due to waterlogging	Pit/heap is unprotected so may need some protection from animals/children etc. A windbreaker can be used to reduce effects of drying out. Very cheap compared to tank methods as no infrastructure is required.
Coimbatore method	Waste is composted anaerobically in a pit with the addition of rock phosphate to minimize nitrogen loss. Compost is ready in 4 months	Resulting compost is nitrogen rich. Some O&M required after initial 4 weeks (turning and addition of water)	Odour can develop The pit requires space so not useful in densely populated areas	No infrastructure is required but the cost of rock phosphate should be considered. Not suitable in areas with heavy rainfall due to water logging. Pit is protected during first month but afterwards is left open so may need some protection from animals/children etc.
Vermi-composting (Ref: www.vermicompost.net)	Composting using a specific species of worms to break down waste Compost is ready in 3-4 months but compost must be removed in stages as the worms process it	More efficient than normal composting and produces richer compost.	Needs a vermi-tank or vermin-bed and worms need to be bought or grown which increases cost Needs more O&M than normal composting to keep the worms alive.	Worms optimal temperature range is 15- 35 degrees Celsius. Lower temperatures hamper reproduction and higher temperatures kill the worms or make them leave. Worms are very sensitive to drought so use in very dry areas is not recommended unless a reliable water source is available.

(1)	(2)	(3)	(4)	(5)
Chinese high temperature composting (Ref: On-farm Composting Methods, www.fao.org)	Materials are heaped in alternating layers with bamboo poles inserted to make aeration holes. After 5 days the poles are removed and the holes are plastered. Compost is ready in 2 months	Can accept night soil, urine, sewage, animal dung and chopped plant residues. Turning is done once after 2 weeks	Handling of human waste and sewage requires special protective equipment. Additional waste such as ash cannot be added.	Can be used in most locations as heap is protected from weather conditions using mud plaster but water logging should be avoided.
Thermophilic composting	Composting is carried out in a specially designed thermophilic plant Compost is ready in 2 weeks	Composting is very quick compared to all other methods	Daily O&M required (adding compressed air to ensure aerobic conditions) Initial cost of thermophilic plant is high	Can be used in areas with low temperatures or hilly terrain unsuitable for digging. Requires exogenous source of energy.

(Source: Guidelines on solid and liquid waste management (SLWM) in Rural Area by Minsitry of Drinking water and Sanitation)

ANNEXURE XIII: DIFFERENT OPTIONS FOR COLLECTING AND TREATING WASTE WATER AT THE HOUSEHOLD LEVEL

Technology	Description	Advantages	Disadvantages	Conditions for use
(1)	(2)	(3)	(4)	(5)
Soak pit (Ref: www.akvopedia.org/wiki/soak pit)	Dug out pit filled with stones, preferably places over burnt bricks. Porous walls to allow water to slowly soak into the ground and prevent stagnation.	Lowest cost option for treating grey water Uses very little space	Water is lost to environment Not suitable for rocky terrain or areas difficult to dig (e.g. clay soils) Excess water will overflow to surroundings and can result in standing water	Pits should be at least 1.5m above ground water table so approach is not suitable for areas with a high water table. Suitable for use in most temperatures but in areas where the ground freezes water can pool in the surrounding area.
Leach pit (Ref: A Practical Guide to Leaching Pit, www.tbdhu.com)	Brick lined circular pit using honeycomb masonry. Diameter approx. 1m. Water percolates into the ground. Pit should have a proper insect proof cover with water let in using a water seal trap to avoid mosquito breeding.	Can handle larger volumes of water than a soak pit Prevents water stagnation Prevents vector breeding	Some O&M required Not suitable for rocky terrain or areas difficult to dig (e.g. clay soils) Water is lost to environment rather than being reused Excess water will overflow into surroundings and can result in standing water	Pits should be at least 1.5m above ground water table so approach is not suitable for areas with a high water table. Suitable for use in most temperatures but in areas where the ground freezes water can pool in the surrounding area.
Kitchen garden (Ref: www.greywateraction.org)	Grey water is passed through a silt and grease trap to remove debris and into a simple surface irrigation system or into a piped root zone water system. The root system has the added feature of a filter bed around the PVC pipes which further filters the water before it reaches the plants.	Simple and cost effective technology Prevents water stagnation Prevents vector breeding Supports growth of produce for consumption or sale	Requires some O&M More expensive than a pit solution Use of strong detergents/cleaning agents in the home could lead to killing plants in garden	A kitchen garden can be scaled up according to the space available. Produce to grow should be chosen according to the success of different crops in the given location.
Three tank filtration (Ref: www.en.wikipedia.org/wiki/grey water	Grey water passes through a 3 part structure – 1st is a filtration grease trap, 2nd is a treatment chamber filled with gravel, 3rd is a	Most effective form of waste water treatment. Water can be safely stored for periods of drought.	Higher cost compared to other options Regular O&M required including de-sludging and washing of sand and gravel.	Tank system can be used in any climatic conditions but building the tank and storage tank requires a large area to be available. Difficult digging

(1)	(2)	(3)	(4)	(5)
	treatment chamber filled with sand. The remaining water can be safely stored for future use.			conditions (e.g. rocky ground) could make the cost of construction prohibitively expensive.
Open/surface grey water drainage	System of drains connected to each house and collecting waste water for transportation to a treatment site or release into the environment	Relatively simple and easy to operate offsite system. O&M costs are low once the system has been constructed All households can be connected	Requires a master plan and technical knowledge to construct Requires regular O&M	Needs a lot of public support to keep drains free from waste If pollutants enter the enter the water or the drainage system they will be released into the environment
Closed drains (small bore system)	Households are connected via PVC pipes to a series of intercepting tanks which lead onto a main line which transport the waste water to the treatment site	Lower in cost than conventional sewerage Can accept black water Useful in high density areas Comparable in cost to open surface drain Free from other waste/ litter	Requires a master plan and technical knowledge to construct High investment cost compared to household level solutions	Unaffected by differing climatic conditions. User education is vitally important to control what is flushed and prevent blockages.

(Source: Guidelines on solid and liquid waste management (SLWM) in Rural Area by Minsitry of Drinking water and Sanitation)

ANNEXURE XIV: DIFFERENT OPTIONS FOR COLLECTING AND TREATING WASTEWATER AT COMMUNITY LEVEL

Technology	Description	Advantages	Disadvantages	Conditions for use
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Community level systems for water treatment				
Sullage stabilisation pond (Ref: Book - Encyclopaedia of Environmental Pollution, Agriculture & Health Hazards by A. K. Shrivastava)	Grey water from the drainage system is passed through large shallow basins or ponds placed in series	Natural process Capital cost is very low O&M cost is low Can be managed by unskilled manpower	Needs some technical inputs	Needs large area of land to be available Flooding can occur during rainy season – needs special management afterwards. In hot climates scum accumulation rates can be higher which needs more O&M to remove it
Duckweed treatment in connection to aquaculture (fisheries) (Ref: www. documents. worldbank.org Duckweed Aquaculture) www.cpcb.nic.in (Guidelines for Duckweed Based Wastewater Treatment Systems)	Duckweed grows naturally in India and has high bio-accumulation rates for dissolved nutrients, particles and even heavy metals (to some extent). When the duckweed is harvested it removes the undesirable elements.	Duckweed can be used in fishponds Treated water is well below required limits for re-use in agri./ aquaculture No additional materials or equipment is required	Requires daily maintenance to keep duckweed under control otherwise blooms could lead to eutrophication of the water	Climatic conditions will affect the viability of plant and fish growth in outdoor ponds; some species are more tolerant of higher or lower temperatures than others. A viable market for the fish should also be available.
Root zone treatment system or Constructed wetland (Ref: www. sustainable-buildings.org) Root Zone System	The process uses the natural biological process of the reeds and soil to clean the water	Technically simple Ecologically sustainable Water can be re-used in plantations Can handle a large variety of pollutants	Requires some O&M Requires a large space Can become overloaded with organic matter without careful pre-screening.	Can be used in any climatic conditions but in areas prone to freezing process will be less efficient

Technology	Description	Advantages	Disadvantages	Conditions for use
(1)	(2)	(3)	(4)	(5)
Community level systems for water treatment				
Aerobic treatment (can be decentralized – DEWATS) (Ref: www. borda-sea.org) - DEWATS	Grey and black water is passed through a 2 tank sedimentation and filtration system with a continuous air flow (15-16 hours per day)	Quality of effluent is higher than the anaerobic version Process is quicker than the anaerobic version	Maintaining air flow requires continuous electricity (not available in all areas). Expensive compared to stabilization ponds	Can be used in any climatic conditions but maintaining an air flow requires a reliable electricity supply
Anaerobic treatment (can be decentralized – DEWATS) (Ref: www. borda-sea.org) - DEWATS	Grey and black water is passed through a multi-tank (3 or more) sedimentation and filtration system	Water can be safely stored and used when needed	Expensive compared to stabilisation ponds Frequent O&M can be required – removal and cleaning of filtration medium which increases O&M costs	Pumping can be required in some areas so a reliable electricity supply is needed
Rotating biological contactors/ filters (Ref: www. en.wikipedia.org) Rotating Biological Contactors	Fixed bed reactors, partially submerged and rotated as wastewater flows through them.	Compact system so can be used in more densely populated areas Can be used to treat black and grey water or industrial wastewater	Requires skilled staff for construction and O&M Requires a constant electricity supply. Collected sludge requires further treatment and is not high in nutrients so is not useful for agriculture High initial cost of infrastructure and ongoing maintenance costs	Must be protected against sunlight, wind and rain and cannot be allowed to freeze in cold climates.

(Source: Guidelines on solid and liquid waste management (SLWM) in Rural Area by Minsitry of Drinking water and Sanitation)

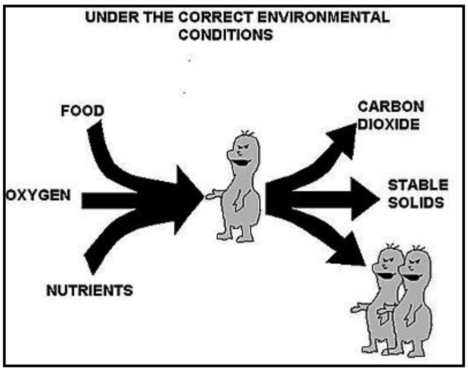
ANNEXURE XV: DETAILED NOTE ON ECOSAN BIO-TOILETS WITH TYPICAL PLAN AND SECTION

i) Existing Sanitation System

- The design of IHHL shall be as prescribed under SBM(G) by Ministry of Drinking Water and Sanitation.
- IHHL ie., the individual sanitary latrine as per SBM (G) is with two leach pit model.
- In this model, the Bio digestion of effluents will be in the Leach pits.
- The construction of leach pits is below the ground level with a cover on the top.
- Leaching of liquid effluents into the ground through perforations or vents left in the brick masonry or concrete lining of the Leach pits.
- The decomposition of organic matter takes place by two processes Aerobic digestion & Anaerobic digestion

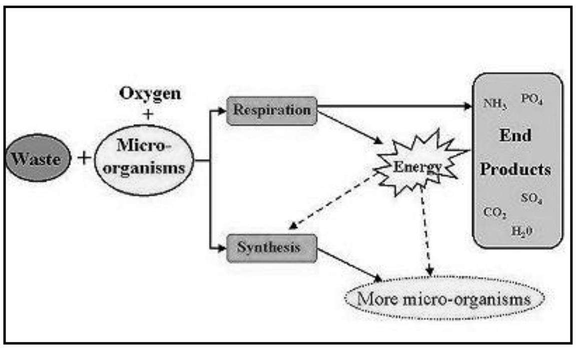
a) Aerobic digestion:

- Aerobic digestion of waste is the natural biological degradation and purification process in which bacteria that thrive in oxygen-rich environments break down and digest the waste.
- During oxidation process, pollutants are broken down into carbon dioxide (CO2), water (H2O), Nitrates, Sulphates and biomass (microorganisms). By operating the oxygen supply with aerators, the process can be significantly accelerated.
- Most efficient method of reducing the organic matter in sewage.
- Requires continuous supply of free dissolved oxygen.
- Aerobic bacteria demand oxygen to decompose dissolved pollutants. Large amounts of pollutants require large quantities of bacteria; therefore the demand for oxygen will be high.



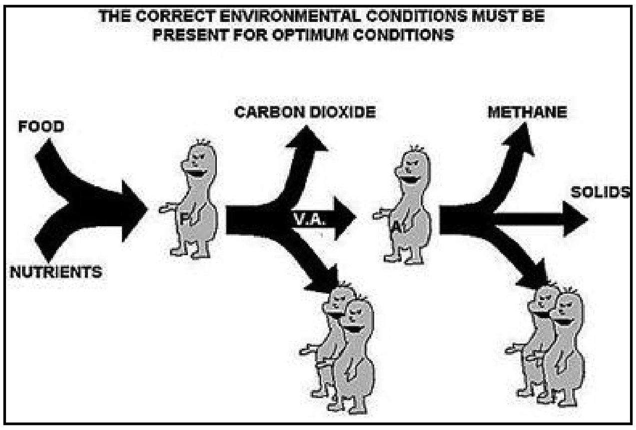
Advantages of Aerobic Digestion:

Aerobic bacteria are very efficient in breaking down waste products. The result of this is; aerobic treatment usually yields better effluent quality than that obtained in anaerobic processes. The aerobic pathway also releases a substantial amount of energy. A portion is used by the microorganisms for synthesis and growth of new microorganisms.



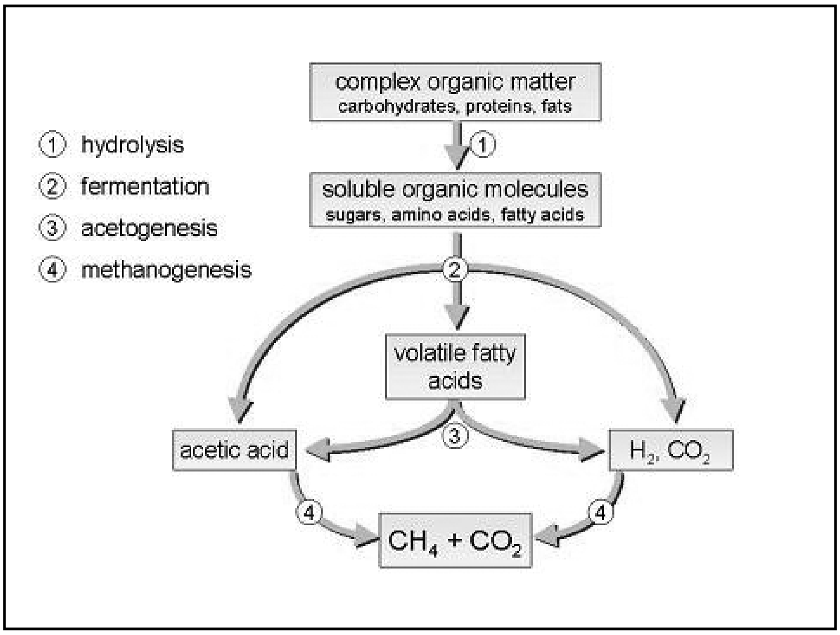
b) Anaerobic digestion:

- Anaerobic digestion is a complex biochemical reaction carried out in a number of steps by several types of microorganisms that require little or no oxygen to live. During this process, a gas that is mainly composed of methane and carbon dioxide, also referred to as biogas, is produced. The amount of gas produced varies with the amount of organic waste fed to the digester and temperature influences the rate of decomposition and gas production.
- Ex: E.Coli, Lactobacillus and clostridium species



- **Anaerobic Digestion occurs in four steps:**

- **Hydrolysis:** Complex organic matter is decomposed into simple soluble organic molecules using water to split the chemical bonds between the substances.
- **Fermentation or Acidogenesis:** The chemical decomposition of carbohydrates by enzymes, bacteria, yeasts, or molds in the absence of oxygen.
- **Acetogenesis:** The fermentation products are converted into acetate, hydrogen and carbon dioxide by what are known as acetogenic bacteria.
- **Methanogenesis:** Is formed from acetate and hydrogen/carbon dioxide by methanogenic bacteria.



- **Factors Affecting Anaerobic digestion**

- Acidic pH i.e. between 4.0 to 4.5.
- Temperature 28ºc to 32ºc.
- Load of Bacteria in the chamber.
- Advantages of Anaerobic Digestion:

Wastewater pollutants are transformed into methane, carbon dioxide and smaller amount of bio-solids. The biomass growth is much lower compared to those in the aerobic processes. They are also much more compact than the aerobic bio-solids.

ii) Deficiencies observed in the present Leach Pit System:

- Less Aerobic & more Anaerobic Digestion
- Insufficient aeration and availability of oxygen.
- Inadequate drying of the solids as the leach pits are underground .
- Incomplete bacterial fermentation of the waste as the process is neither completely aerobic nor completely anaerobic.
- Biodegradation of effluents to un safe levels

iii) Need to adopt New Technology:

- To enable proper biodegradation in the prevailing field conditions and environments such as hilly terrains, bedrock areas, water logged areas and high groundwater table areas.
- The GoI promoted the adoption of Ecosan / Biotoilets / Bio Digesters wherever feasible in place of conventional toilets.

iv) TYPES OF SANITATION SYSTEMS

ON SITE SANITATION	OFF SITE SANITATION
• Simple Pit Latrine • Ventilated Improved Pit (VIP) Latrine • Pour-Flush Latrine • Ecological Sanitation Latrines	• Septic Tanks latrine • Vacuum toilets • Portable toilets • DRDO Bio digester

v) ECOSAN Bio Toilet model:

Salient features :

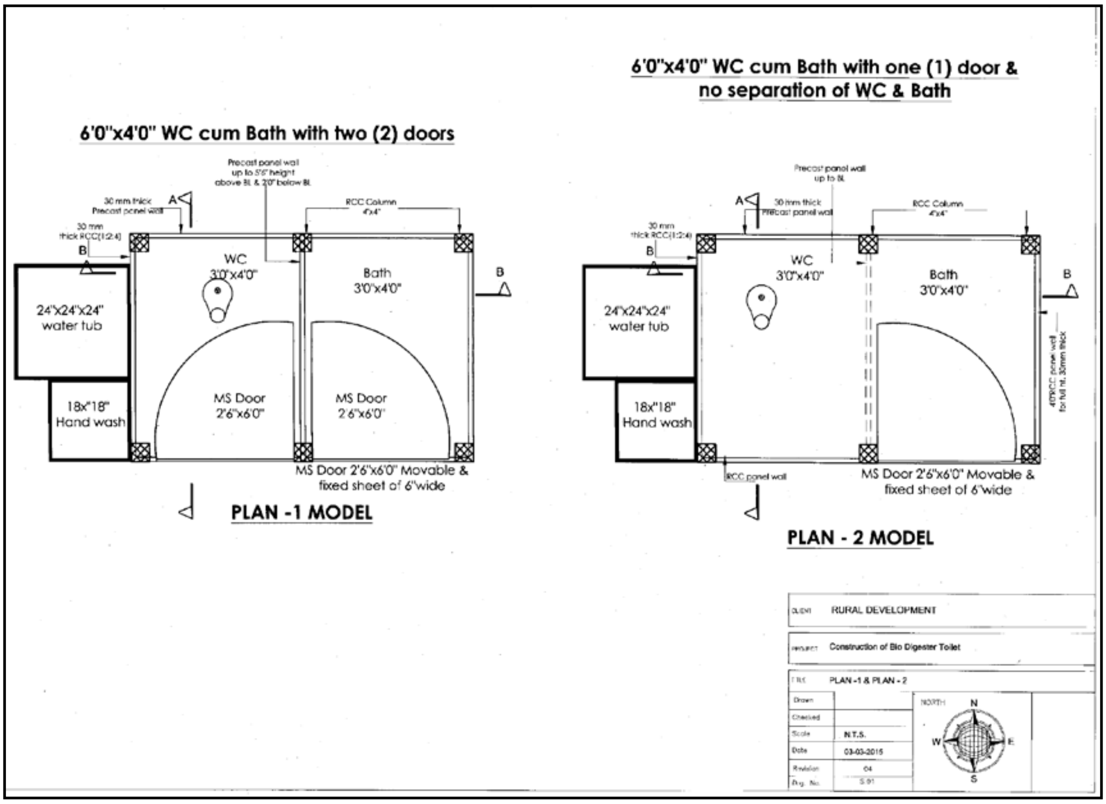
- The structure is a box like model with columns at the 4 corners with two compartments one over the other.
- The first compartment ie., Eco Sanitation Chamber is located above ground level with a height of about 60 cm and covered by a 50 mm thick RCC prefabricated slab.

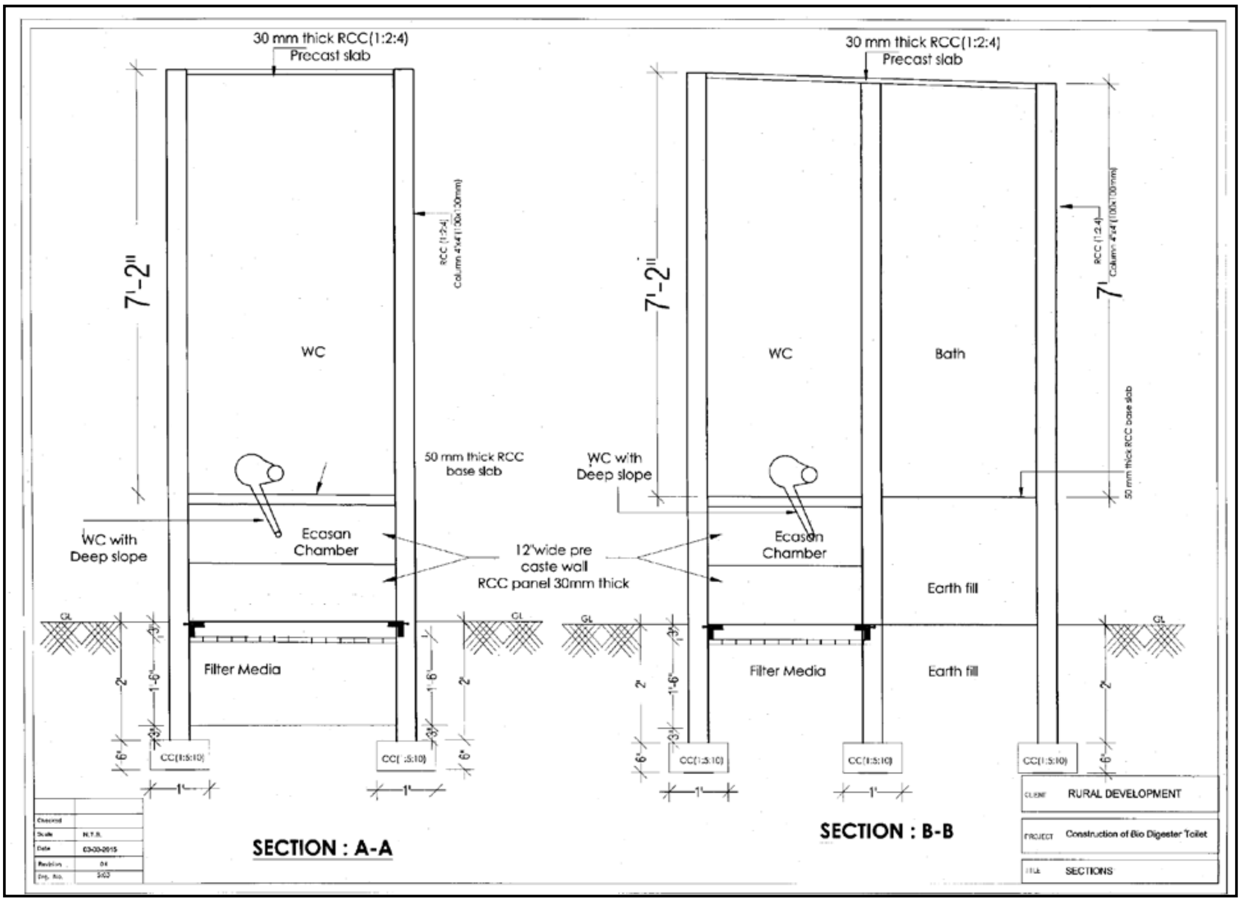
- The volume and shape of the compartment be designed based on the type of bio digestion either aerobic or anaerobic depending upon the location and geographical conditions.

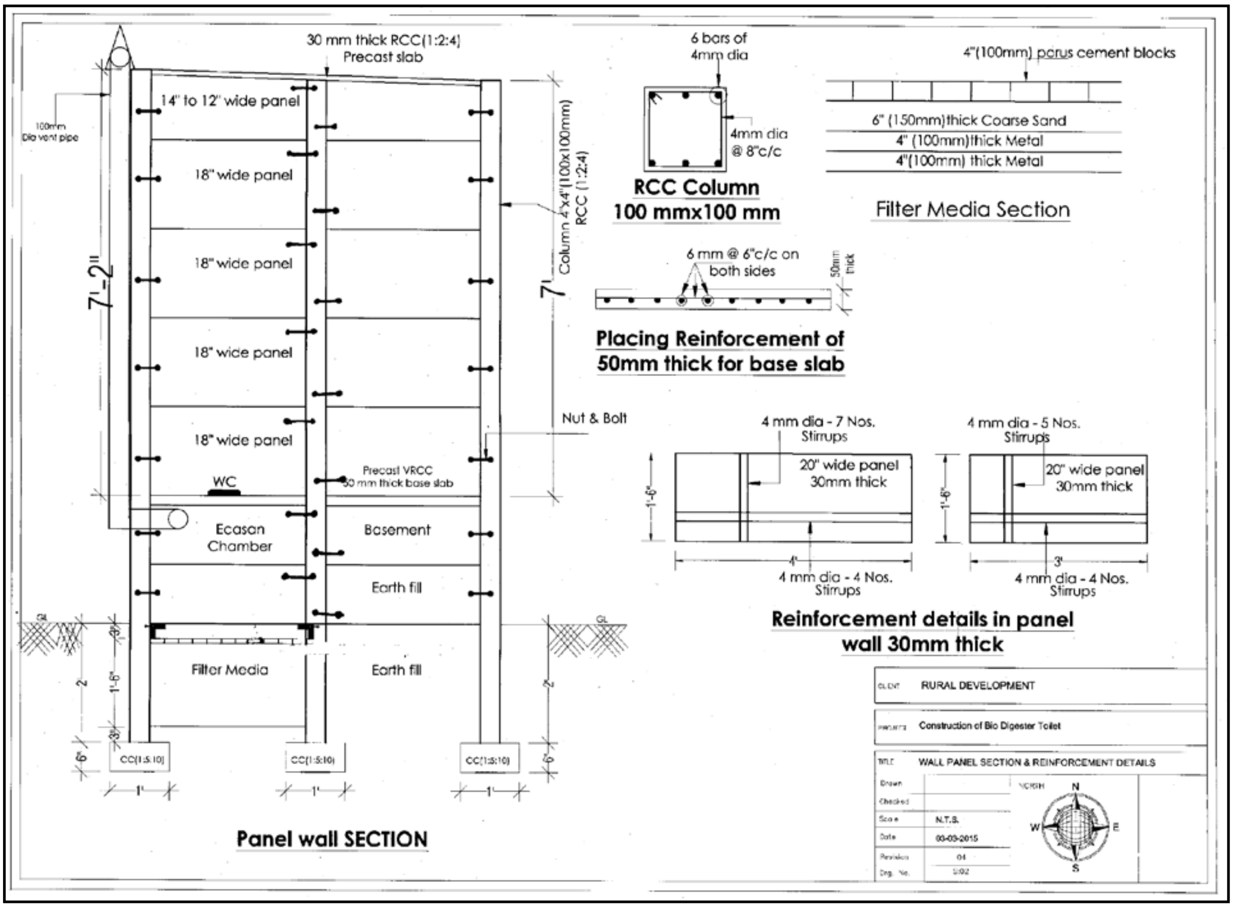
- Below this compartment , ie., below Ground Level, a filter bed having four layers of 40 to 60 cm thick is provided to drain off the liquid into the ground after filtration.

- Top layer of 100mm thick with porous cement blocks
- Second layer of 150mm thickness composed of coarse sand,
- Third layer of 100mm thickness composed of metal and,
- The fourth bottom-most layer of 100mm thickness composed of metal or pebbles.
- The surface of the top layer (i.e. porous cement blocks) is about 3" below the ground level.
- The filter takes care of any solid waste and pathogens entering into surrounding soil and doesn't allow contamination or pollution.

- The Eco Sanitation Chamber has vent pipe located in the top half of its wall, to act as a ventilation pipe for foul gases.
- The washroom and toilet are located above this floor and can be accessed by the user through stepped entrance.
- The second compartment ie., Super structure directly located on the top of Eco sanitation Chamber to accommodate the latrine and bath with door to ensure privacy.
- The walling can be with conventional brick Masonry or with prefabricated wall panels.
- A prefabricated roof over the 2nd compartment for protection from rain and sun.
- The fecal matter deposited into the WC is routed through a P-trap (100mm dia) with water seal directly into the Eco Sanitation Chamber below.
- The Water from Bath area is separated to see that Night soil solids are dried up quickly.
- Proposals are under way to separate urine from Night soil solids.
- The most common treatment options include aerobic digestion, anaerobic digestion and composting.
- In the eco-san system, the fecal materials gets dried up easily as after every use it is proposed to add either saw dust, ash, lime or some fine earth which increases the rate of bio-digestion and it is converted as compost.
- An innovative idea developed where, earthworms are introduced into the bio-digestion chamber to ensure effective drying of effluents and for initiating aerobic digestion.
- In the eco-san system, the fecal materials gets dried up easily as after every use it is proposed to add either saw dust, ash, lime or some fine earth which increases the rate of bio-digestion and it is converted as compost.
- An innovative idea developed where, earthworms are introduced into the bio-digestion chamber to ensure effective drying of effluents and for initiating aerobic digestion.




30 mm thick RCC(1:2:4)
Precast slab
7'-2"
RCC (1:2:4)
Column 4"x4"(100x100mm)
WC
Bath
50 mm thick RCC
base slab
WC with
Deep slope
Ecosan
Chamber
12"wide pre
caste wall
RCC panel 30mm thick
Earth fill
Filter Media
CC(1:5:10)
GL
SECTION : A-A
SECTION : B-B
RURAL DEVELOPMENT
Construction of Bio Digester Toilet
SECTIONS
N.T.S.
03-03-2015


30 mm thick RCC(1:2:4)
Precast slab
100mm
Dia vent pipe
14" to 12" wide panel
18" wide panel
7'-2"
Column 4"x4"(100x100mm)
RCC (1:2:4)
Nut & Bolt
WC
Precast VRCC
50 mm thick base slab
Ecosan
Chamber
Basement
Earth fill
Filter Media
CC(1:5:10)
Panel wall SECTION
6 bars of
4mm dia
4mm dia
@ 8"c/c
RCC Column
100 mmx100 mm
4"(100mm) porus cement blocks
6" (150mm)thick Coarse Sand
4" (100mm)thick Metal
4"(100mm) thick Metal
Filter Media Section
6 mm @ 6"c/c on
both sides
50mm thick
Placing Reinforcement of
50mm thick for base slab
4 mm dia - 7 Nos.
Stirrups
4 mm dia - 5 Nos.
Stirrups
20" wide panel
30mm thick
4 mm dia - 4 Nos.
Stirrups
Reinforcement details in panel
wall 30mm thick
RURAL DEVELOPMENT
Construction of Bio Digester Toilet
WALL PANEL SECTION & REINFORCEMENT DETAILS
N.T.S.
03-03-2015
N
S
W
E

vi) Merits of ECOSAN Bio Toilet model

- Decomposition occurs under both aerobic or anaerobic conditions.
- Digested effluents are converted as compost and hence not affecting the Ground water
- System is largely dry and does not breed mosquitoes. No odour or insects problem
- Designed for cleanliness. Rapid separation of liquid and solids occurs at all times
- No sludge buildup.
- Dehydrated solid residue can be readily used as manure
- Suitable for all soil conditions and coastal regions in particular where ground water table at higher level. As the digester and effluent pipes are always installed above the ground water table, water contamination is completely eliminated.
- Operation and maintenance costs are negligible.
- Composting takes place within a short period.
- The compost generated is a good soil conditioner (humus) and can fix nitrogen in the soil effectively.
- High value safe organic manure is generated for use
- It ensures availability of treated and safe organic solid and liquid manure for gardening/raising crops for production of organic foods.
- Due to the filter media, the liquid is coming out in a non-hazardous form and this will not pollute the ground water
- If prefabricated walling is used, easy assembling when compared with that of conventional system with stone or brick masonry.
- The system is cost effective, requires less space to that of conventional toilet.

ANNEXURE XVI: SAMPLE ESTIMATE FOR CONSTRUCTION OF GRAM PANCHAYAT BUILDING.

Sample Estimate - Construction of Gram Panchayat building with, Stub Foundations- RR Masonry for footings & for basement - Solid Brick wall @ room Corners & under beams 0.90m length - **Rat-trap brick masonry** with 2nd class bricks-Bearing plastering 20mm thick-Ellis Pattern flooring.

DETAILED CUM ABSRACT ESTIMATE

Construction of Gram Panchayat Building - Higher Leads (50km & 60km leads)

SBC >= 100kN/m²	Conventional footings- 125mm thick conventional Slab-RR foundation under walls to a depth of 0.90m-Rat-trap brick masonry with 2nd class bricks-Bearing plastering 20mm thick-Ellis Pattern flooring-With Plastering	Estimate Cost:	Rs. 1275000.00

Probable No. of mandays for unskilled labour @ Rs.169/- =	1887	Unskilled Labour Component=	318924	Unskilled Labour %=	28.95	Total Area in sft:	1338.00	sft Rate:	Rs. 952.91

Sl. No.	Description of Item	Nos.	Length	Breadth	Depth	Quantity		Rate per		Amount	Material component		Unskilled Labour		Skilled & Semi-		Total Col. (11+13+15)
								Rate	per		Rate	Amount	Rate	Amount	Rate	Amount	
1	2	3	4	5	6	7		8		9	10	11	12	13	14	15	16
1	Earth work excavation and depositing on bank with initial lead of 10m and initial lift of 2m in Loamy and Clayey Soils like B.C. Soils, Red earth & Ordinary Gravel (SS 20-B) including shoring, strutting, sheeting, planking and labour charges etc., complete, but excluding dewatering with cost of hire charges of T & P, for finished item of work for Foundation of Building.(APSS No. 308)																
	Under R.R.Masonary for																
	Long walls	1 x 2	13.71	0.90	0.90	22.21											
	Cross walls	1 x 3	7.67	0.90	0.90	18.64											
	Long walls - between MGS & toilet	1 x 1	2.99	0.90	0.90	2.42											
	Cross wall between toilets in MGS	1 x 1	0.53	0.90	0.90	0.43											
	Long wall between Meeting hall & V.O., Sarpanch & corridor	1 x 1	8.02	0.90	0.90	6.50											
	Corridor	1 x 2	2.99	0.90	0.90	4.84											
	Out side toilet cross walls	1 x 3	0.68	0.90	0.90	1.65											
	Out side toilet long wall	1 x 1	4.96	0.90	0.90	4.02											
	Under Steps																
	Entrance Steps	1 x 2	5.10	2.70	0.30	8.26											
	Gents Toilet Steps	1 x 1	1.35	1.50	0.30	0.61											
	Septic Tank	1 x 1	3.70	2.75	2.00	20.35											
						89.93	cum	145.78	/cum	13109.00	0.00	0.00	145.78	13109.00	0.00	0.00	13109.00
2	Plain Cement Concrete (1:5:10) prop nominal mix (cement: fine aggregate: coarse aggregate) using 40mm size HBG (SS5) metal from approved quarry including Cost and Conveyance of all materials like cement, sand, coarse aggregate, water etc. to site, including all operational, incidental, and labour charges such as mixing, laying and ramming concrete in layers in position not exceeding 15cm, finishing top surface, curing concrete, and including sales and other taxes etc, hire charges of T & P etc., complete for finished item of work for levelling Bed (APSS No. 402)																
	Under R.R.Masonary for																
	External Plinth beams																
	Long walls	1 x 2	13.71	0.90	0.15	3.70											
	Cross walls	1 x 3	7.67	0.90	0.15	3.11											
	Long walls - between MGS & toilet	1 x 1	2.99	0.90	0.15	0.40											
	Cross wall between toilets in MGS	1 x 1	0.53	0.90	0.15	0.07											
	Long wall between Meeting hall & V.O., Sarpanch & corridor	1 x 1	8.02	0.90	0.15	1.08											
	Corridor	1 x 2	2.99	0.90	0.15	0.81											
	Out side toilet cross walls	1 x 3	0.68	0.90	0.15	0.28											
	Out side toilet long wall	1 x 1	4.96	0.90	0.15	0.67											
	Under Steps																
	Entrance Steps	1 x 2	5.10	2.70	0.15	4.13											
	Gents Toilet Steps	1 x 1	1.35	1.50	0.15	0.30											
	Septic Tank	1 x 1	3.70	2.75	0.15	1.53											
						16.08	cum	3091.43	/cum	49708.00	2667.23	42887.00	389.20	6258.00	35.00	563.00	49708.00
3	Filling with useful available excavated earth (excluding rock) in trenches, sides of foundations and basement with initial lead in layers not exceeding 15cm thick, consolidating each deposited layer by watering and ramming including cost and Cost and Conveyance of water to site and all operational, incidental, labour charges, sales and other taxes etc, hire charges of T & P etc., complete for finished item of work. (APSS NO. 309 & 310)																
	Total Quantity of Excavated earth					89.93											
	Deductions																
	PCC (1:5:10)					-16.08											
	RR Masonry below Ground level					-29.57											
	Quantity to be re-filled below Ground level					44.28											
	Basement filling					60.42											
	Total Quantity to be filled					104.70	cum										
	Filling with excavated soil					74.70	cum	14.47	/cum	1081.00	0.00	0.00	14.47	1081.00	0.00	0.00	1081.00

Sl. No.		Description of Item	Nos.			Length	Breadth	Depth	Quantity		Rate per		Amount	Material component		Unskilled Labour component		Skilled Labour component		Total Col. (11+13+15)
											Rate	per		Rate	Amount	Rate	Amount	Rate	Amount	
1		2	3			4	5	6	7		8		9	10	11	12	13	14	15	16
		Filling with excavated soil							74.70	cum	14.47	/cum	1081.00	0.00	0.00	14.47	1081.00	0.00	0.00	1081.00
4		Filling with Sand/gravel (excluding rock) in trenches, sides of foundations and basement with initial lead in layers not exceeding 15cm thick, consolidating each deposited layer by watering and ramming including cost and Cost and Conveyance of water to site and all operational, incidental, labour charges, Seignorage charges, sales and other taxes etc, hire charges of T & P etc., complete for finished item of work. (APSS NO. 309 & 310)																		
		Basement: MGS & toilet	1	x	1	3.66	8.11	0.60	17.81											
		Sarpanch Room	1	x	1	3.66	3.66	0.60	8.04											
		Village Secretary	1	x	1	3.05	3.66	0.60	6.70											
		Corridor	1	x	1	1.50	3.66	0.60	3.29											
		Meeting Hall	1	x	1	8.69	4.16	0.60	21.66											
		Gents Toilet	1	x	1	1.35	1.95	0.60	1.58											
		Sarpanch Toilet	1	x	1	1.35	1.65	0.60	1.34											
									60.42											
		Balance quantity to be refilled with either carted sand/ gravel							***30.00***	cum	821.93	/cum	24660.00	807.46	24226.00	14.47	434.00	0.00	0.00	24660.00
5		Randum Rubble Masonry in CM (1:6) prop (cement:sand) using RR stone and CR Stone from approved quarry including Cost and Conveyance of all materials like cement, sand, stone, water etc., to site and sales & other taxes on all materials., including materials, all operational, incidental and labour charges such as mixing cemen mortar, constructing masonry, curing, etc., complete for finished item of work as per standard specifications																		
	b	***Under Walls for***																		
		1st step																		
		Long walls	1	x	2	13.41	0.60	0.30	4.83											
		Cross walls	1	x	3	7.74	0.60	0.30	4.18											
		Long walls - between MGS & toilet	1	x	1	3.29	0.60	0.30	0.59											
		Cross wall between toilets in MGS	1	x	1	0.83	0.60	0.30	0.15											
		Long wall between Meeting hall & V.O., Sarpanch & corridor	1	x	1	8.32	0.60	0.30	1.50											
		Corridor	1	x	2	3.29	0.60	0.30	1.18											
		Out side toilet cross walls	1	x	3	0.98	0.60	0.30	0.53											
		Out side toilet long wall	1	x	1	4.66	0.60	0.30	0.84											
		2nd step																		
		Long walls	1	x	2	13.26	0.45	0.45	5.37											
		Cross walls	1	x	3	7.89	0.45	0.45	4.79											
		Long walls - between MGS & toilet	1	x	1	3.44	0.45	0.45	0.70											
		Cross wall between toilets in MGS	1	x	1	0.98	0.45	0.45	0.20											
		Long wall between Meeting hall & V.O., Sarpanch & corridor	1	x	1	8.47	0.45	0.45	1.72											
		Corridor	1	x	2	3.44	0.45	0.45	1.39											
		Out side toilet cross walls	1	x	3	1.13	0.45	0.45	0.69											
		Out side toilet long wall	1	x	1	4.51	0.45	0.45	0.91											
		For Basement																		
		Long walls	1	x	2	13.19	0.38	0.60	6.01											
		Cross walls	1	x	3	7.96	0.38	0.60	5.44											
		Long walls - between MGS & toilet	1	x	1	3.51	0.38	0.60	0.80											
		Cross wall between toilets in MGS	1	x	1	1.05	0.38	0.60	0.24											
		Long wall between Meeting hall & V.O., Sarpanch & corridor	1	x	1	8.54	0.38	0.60	1.95											
		Corridor	1	x	2	3.51	0.38	0.60	1.60											
		Out side toilet cross walls	1	x	3	1.20	0.38	0.60	0.82											
		Out side toilet long wall	1	x	1	4.44	0.38	0.60	1.01											
									47.45	cum	2745.27	/cum	130250.00	1765.27	83754.0	560.00	26569.00	420.00	19927.00	130250.00
6		**Damp proof course 40mm thick** with cement concrete (1:2:4) Nominal mix, using 12mm hard broken stone aggregate including cost and conveyance of all materials to site, seigniorage charges, mixing, placing in position, levelling, vibrating, curing etc., complete for finished item of work (using concrete mixer)																		
		Long walls	1	x	2	13.26	0.45		11.93											
			1	x	1	8.47	0.45		3.81											
			1	x	1	3.44	0.45		1.55											
		Cross walls	1	x	3	7.89	0.45		10.65											
			1	x	1	0.98	0.45		0.44											
		Corridor	1	x	2	3.44	0.45		3.10											

SL. No.	Description of Item	Nos.	Length	Breadth	Depth	Quantity		Rate per		Amount	Material component		Unskilled Labour component		Skilled Labour component		Total Col. (11+13+15)
								Rate	per		Rate	Amount	Rate	Amount	Rate	Amount	
1	2	3	4	5	6	7		8		9	10	11	12	13	14	15	16
	Out side toilet	1 x 1	4.51	0.45		2.03											
	MGS Toilet wall	1 x 3	1.13	0.45		1.53											
						35.04	sqm	172.91	/sqm	6058.00	149.33	5232	22.18	777	1.40	49	6058.00
7	Brick Masonry in superstructure with **CM (1:6) prop(cement:Sand) using 2nd class bricks** from approved quarry having compressive strength of not less than 35kg/sqcm including Cost and Conveyance of all materials like cement, sand, bricks, water etc., to site and sales & other taxes on all materials, including materials, all operational, incidental and labour charges such as mixing cement mortar, constructing masonry, scaffolding charges, lift charges, curing, etc., complete for finished item of work. (APSS No. 501 & 504).																
	For Steps																
	Entrance Steps	1 x 2	5.10	2.70	0.15	4.13											
		1 x 2	4.50	2.40	0.15	3.24											
		1 x 2	3.90	2.10	0.15	2.46											
		1 x 2	3.30	1.80	0.15	1.78											
		1 x 2	2.70	1.50	0.15	1.22											
		1 x 2	2.10	1.20	0.15	0.76											
	Gents & Ladies Toilet Steps																
		1 x 1	1.35	1.50	0.15	0.30											
		1 x 1	1.35	1.20	0.15	0.24											
		1 x 1	1.35	0.90	0.15	0.18											
		1 x 1	1.35	0.60	0.15	0.12											
		1 x 1	1.35	0.30	0.15	0.06											
	Septic tank : Long Walls	1 x 2	3.70	0.23	1.88	3.19											
	Cross walls	1 x 2	2.29	0.23	1.88	1.98											
	Super Structure																
	Corners of the rooms	1 x 12	0.45	0.23	3.08	3.83											
	"	1 x 15	0.22	0.23	3.08	2.34											
	Under Beams	1 x 4	0.90	0.23	2.98	2.47											
						28.29	cum	3648.08	/cum	103201.00	1427.41	40380	1898.40	53704	322.27	9117	103201.00
8	Brick Masonry in superstructure with **CM (1:6) prop(cement:Sand) Rat trap bond using 2nd class bricks** from approved quarry having compressive strength of not less than 35kg/sqcm including Cost and Conveyance of all materials like cement, sand, bricks, water etc., to site,and sales & other taxes on all materials, including materials, all operational, incidental and labour charges such as mixing cement mortar, constructing masonry, scaffolding charges, lift charges, curing, etc., complete for finished item of work. (APSS No. 501 & 504).																
	Long walls	1 x 2	13.04	0.23	3.08	18.48											
	Cross Walls	1 x 3	8.11	0.23	3.08	17.24											
	Long walls: MGS.Room	1 x 1	3.66	0.23	3.08	2.59											
	Meeting Hall	1 x 1	8.69	0.23	3.08	6.16											
	Meeting hall Toilet	1 x 1	1.20	0.23	3.08	0.85											
	Sarpanch & V.O.Rooms	1 x 2	3.66	0.23	3.08	5.19											
	Gents Toilet	1 x 3	1.35	0.23	3.08	2.87											
	Sarpanh Toilet	1 x 1	4.29	0.23	3.08	3.04											
	Parapet wall alround	1 x 2	13.64	0.23	0.90	5.65											
		1 x 2	8.71	0.23	0.90	3.61											
	Deductions																
	Bed blocks below beams	1 x 4	0.90	0.23	0.10	-0.08											
	Openings																
	Doors,D1	1 x 4	1.20	0.23	2.10	-2.32											
	D2	1 x 3	1.00	0.23	2.10	-1.45											
	D3	1 x 4	0.75	0.23	2.10	-1.45											
	Windows,W	1 x 8	0.90	0.23	1.35	-2.24											
	Ventilators,V	1 x 4	0.60	0.23	0.45	-0.25											
	Bed blocks																
	Doors D1	4 x 6	0.23	0.23	0.10	-0.13											
	D2	3 x 6	0.23	0.23	0.10	-0.10											
	D3	4 x 6	0.23	0.23	0.10	-0.13											
	Windows W	8 x 4	0.23	0.23	0.10	-0.17											
	Deduct Solid brick masonry Qty. provided at room corners & bellow beams					-8.63											
						48.72	cum	3887.17	/cum	189397.00	1110.69	54117	2216.89	108015.00	559.59	27265.00	189397.00
9	Vibrated Reinforced Cement Concrete M20 grade using Cement Content 330kgs per cum of concrete using 20mm size graded machine crushed hard granite metal (coarse aggregate) from approved quarry including cost and conveyance of all materials like cement, fine aggregate (sand) coarse aggregate, water etc., to site and including sales & other taxes on all materials including all operational, incidental and labour charges such as machine mixing, laying concrete,vibrating, curing, including centering, shuttering etc.,complete but excluding cost of steel and its fabrication charges for finished item of work for the following items.																
	a Roof Beams																

Sl. No.		Description of Item	Nos.	Length	Breadth	Depth	Quantity		Rate per		Amount	Material component		Unskilled Labour component		Skilled Labour component		Total Col. (11+13+15)
									Rate	per		Rate	Amount	Rate	Amount	Rate	Amount	
1		2	3	4	5	6	7		8		9	10	11	12	13	14	15	16
			1 x 2	4.62	0.23	0.30	0.64											
							0.64	**cum**	6733.98	/cum	4289.00	4985.97	3175	1436.50	915	311.51	198	4288
	b	**Slab 125mm thick**																
		Roof slab 125mm thick	1 x 1	13.64	9.17		125.08											
		Gents &Sarpanch's Toilet	1 x 1	1.28	4.29		5.49											
		Entrance Verandahs	1 x 2	2.10	1.20		5.04											
		Septic tank slab	1 x 1	3.70	2.75		10.18											
							145.79	sqm	815.87	/sqm	118942.00	609.12	88801.0	170.75	24893.00	36.00	5248.00	118942.00
10		Reinforced Cement Concrete M20 grade using Cement Content 330kgs per cum of concrete using 20mm size graded machine crushed hard granite metal (coarse aggregate) from approved quarry including cost and conveyance of all materials like cement, fine aggregate (sand) coarse aggregate, water etc., to site and including sales & other taxes on all materials including all operational, incidental and labour charges such as machine mixing, laying concrete, curing, including centering, shuttering etc.,complete but excluding cost of steel and its fabrication charges for finished item of work for the following items.																
	i)	For Lintels																
		Doors D1	4 x 1	1.66	0.23	0.10	0.15											
		D2	3 x 1	1.46	0.23	0.10	0.10											
		D3	4 x 1	1.21	0.23	0.10	0.11											
		Windows W	8 x 1	1.36	0.23	0.10	0.25											
							0.62	cum	7144.37	/cum	4394.00	4882.48	3003.00	1941.50	1194.00	320.39	197.00	4394.00
	ii)	For Sunshades 75 mm thick at fixed end 50 mm thick at free end																
		Door D1	1 x 1	1.66	0.60		1.00											
		D2	1 x 1	1.46	0.60		0.88											
		Windows W	1 x 8	1.36	0.60		6.53											
							8.40	sqm	546.44	/sqm	4590.00	370.56	3113.00	139.75	1174.00	36.13	303.00	4590.00
11		Plain Cement Concrete (1:3:6) prop nominal mix (cement: fine aggregate: coarse aggregate) using 20mm size HBG (SS5) metal from approved quarry including Cost and Conveyance of all materials like cement, sand, coarse aggregate, water etc. to site and including sales & other taxes on all materials, including all operational, incidental, and labour charges such as mixing, laying and curing concrete, etc., complete for finished item of work for Bed Blocks for holdfasts.(APSS No. 402)																
		For Bed Blocks																
		Doors D1	4 x 6	0.23	0.23	0.10	0.13											
		D2	3 x 6	0.23	0.23	0.10	0.10											
		D3	4 x 6	0.23	0.23	0.10	0.13											
		Windows W	8 x 4	0.23	0.23	0.10	0.17											
							0.52	cum	4066.99	/cum	2108.00	3642.79	1888.00	389.20	202.00	35.00	18.00	2108.00
12		Plain Cement Concrete (1:2:4) prop nominal mix (cement: fine aggregate: coarse aggregate) using 20mm size HBG (SS5) metal from approved quarry including Cost and Conveyance of all materials like cement, sand, coarse aggregate, water etc. to site, and including sales & other taxes on all materials ,including placing of 2 rods of 8mm dia along the length of the wall at Lintel level including all operational, incidental, and labour charges such as mixing, laying and curing concrete, etc., complete for finished item of work for Bands (APSS No. 402) and for Bedblocks under Roof																
	i	Sill Level band																
			1 x 2	13.04	0.23	0.10	0.60											
			1 x 3	8.11	0.23	0.10	0.56											
			1 x 1	3.66	0.23	0.10	0.08											
			1 x 1	1.20	0.23	0.10	0.03											
			1 x 1	8.69	0.23	0.10	0.20											
			1 x 2	3.66	0.23	0.10	0.17											
			1 x 3	1.35	0.23	0.10	0.09											
			1 x 1	4.29	0.23	0.10	0.10											
	ii	Lintel Level band	1 x 2	13.04	0.23	0.10	0.60											
			1 x 3	8.11	0.23	0.10	0.56											
			1 x 1	3.66	0.23	0.10	0.08											
			1 x 1	1.20	0.23	0.10	0.03											
			1 x 1	8.69	0.23	0.10	0.20											
			1 x 2	3.66	0.23	0.10	0.17											
			1 x 3	1.35	0.23	0.10	0.09											
			1 x 1	4.29	0.23	0.10	0.10											
		Deduct Lintels:																
		Doors D1	1 x 4	1.66	0.23	0.10	-0.15											
		D2	1 x 3	1.46	0.23	0.10	-0.10											
		D3	1 x 4	1.21	0.23	0.10	-0.11											
		Windows W	1 x 8	1.36	0.23	0.15	-0.38											
	iv	Bed blocks below beams	1 x 4	0.90	0.23	0.10	0.08											
							3.01	cum	4418.99	/cum	13280.00	3994.79	12005	389.20	1170	35	105	13280

Sl. No.	Description of Item	Nos.	Length	Breadth	Depth	Quantity		Rate per: Rate	per	Amount	Material component: Rate	Amount	Unskilled Labour component: Rate	Amount	Skilled Labour component: Rate	Amount	Total Col. (11+13+15)
1	2	3	4	5	6	7		8		9	10	11	12	13	14	15	16
13	Providing high yield strength deformed (HYSD) steel (**Fe 415** grade as per IS 1786-1985) of 8mm to 40mm diameters, cutting, bending, to required sizes and shapes placing in position with cover blocks of approved size and binding wire of 20SWG, forming grills for reinforcement work as per approved designs and drawings including Cost and Conveyance of bars from approved sources to site of work with all taxes including Cost and Conveyance of binding wire, cover blocks chains, overlaps, spacess, dowels, wastage etc, and all operational, incidental, and labour charges such as cutting, bending, placing in position, tying etc., and other taxes,on cost of all materials complete for finished item of work (APSS No.126) in all floors																
	@ 1.87kg/- per sft					2.50	MT	53120.00	/MT	132800.00	46620.00	116550.0	2800.00	7000.00	3700.0	9250.00	132800.00
14	**Bearing plastering** of **20mm thick** in **CM(1:3)** over top of the wall below slab level including cost and conveyance of all materials to site and labour charges etc., complete including Cost and Conveyance of all materials like cement, sand, water etc., to site,and sales & other taxes on all materials, including materials, all operational, incidental and labour charges such as mixing cement mortar, curing, etc., complete for finished item of work																
	Long walls front & Rear	1 x 2	13.04	0.23		6.00											
	Cross walls	1 x 3	8.11	0.23		5.60											
	Long wall in MGS & Toilet	1 x 1	3.66	0.23		0.84											
	Long wall of meeting hall & V.O., Sarpanch	1 x 1	8.69	0.23		2.00											
	Cross walls between V.O., Sarpanch & corridor	1 x 2	3.66	0.23		1.68											
	Toilet Long walls	1 x 3	1.35	0.23		0.93											
	Toilet cross wall	1 x 1	4.29	0.23		0.99											
						18.04	m^2	90.58	$/m^2$	1634.00	67.01	1209	22.18	400	1.40	25	1634
15	**Ellis pattern Flooring** with **100mm thick CC (1:5:10) using 40mm size and 20mm thick CC surface** (Ellis pattern, 1st sort, in alternate panels of size not exceeding 1.50 m x 1.50 m and finishing the top surface to required smoothness and slopes and thread lining including cost of all materials like cement, metal, sand and water etc., complete, including seigniorage chargesand sales & other taxes on all materials, including materials, all operational, incidental and labour charges such as mixing and placing, etc., complete for finished item of work																
	Mahila Gramaikya Sangam & toilet	1 x 1	3.66	7.88		28.84											
	Sarpanch Room	1 x 1	3.66	3.66		13.40											
	Village Secretary room	1 x 1	3.05	3.66		11.16											
	Corridor	1 x 1	1.50	3.66		5.49											
	Meeting Hall	1 x 1	8.69	4.16		36.11											
	Gents Toilet	1 x 1	1.35	1.95		2.63											
	Sarpanch Toilet	1 x 1	1.35	1.65		2.23											
						99.86	sqm	567.79	/sqm	56697.00	400.14	39956.00	151.20	15098.00	16.45	1643.00	56697.00
16	**Ornamental plastering** to ceiling **8mm thick in CM (1:4)** with dubara sponge finish including Cost and Conveyance of all materials like cement, sand, water etc., to site, including other taxes on all materials, all operational, incidental and labour charges such as mixing mortar, finishing, scaffolding, lift charges, including cutting of Grooves wherever necessary as directed by Engineer-in-charge, curing, etc., complete for finished item of work.(APSS 901& 903)																
	Mahila Gramaikya Sangam & toilet	1 x 1	3.66	7.88		28.84											
	Sarpanch Room	1 x 1	3.66	3.66		13.40											
	Village Secretary room	1 x 1	3.05	3.66		11.16											
	Corridor	1 x 1	1.50	3.66		5.49											
	Meeting Hall	1 x 1	8.69	4.16		36.11											
	Gents Toilet	1 x 1	1.35	1.95		2.63											
	Sarpanch Toilet	1 x 1	1.35	1.65		2.23											
	Slab Projection																
	Over Long Walls	1 x 2	15.22	0.30		9.13											
	Cross Walls	1 x 2	9.17	0.30		5.50											
	Entrance Veradahs	1 x 2	2.10	1.20		5.04											
						119.53	sqm	891.77	/10sqm	10659.00	314.01	3753.00	358.06	4280.00	219.70	2626.00	10659.00
17	**Plastering 12mm thick in single coat in CM (1:4)** dubara sponge finish including cost and conveyance of all materials like cement, sand, water etc., to site, seigniorage charges, sales & other taxes on all materials,all operational, incidental and labour charges such as mixing mortar, scaffolding charges, lift charges, including cutting of Grooves wherever necessary as directed by Engineer - in - charge, finishing, curing, etc., for **Even Surfaces of brick wall** complete for finished item of work. (APSS 901,903 & 904)																
	M.G.S.Room Alround	1 x 2	3.66		3.30	24.16											
		1 x 2	6.68		3.30	44.09											
	Toilets	2 x 2	1.20		3.30	7.92											

Sl. No.	Description of Item	Nos.			Length	Breadth	Depth	Quantity		Rate per		Amount	Material component		Unskilled Labour component		Skilled Labour component		Total Col. (11+13+15)
										Rate	per		Rate	Amount	Rate	Amount	Rate	Amount	
1	2	3			4	5	6	7		8		9	10	11	12	13	14	15	16
		1	x	2	3.66		3.30	24.16											
	Meeting Hall	1	x	2	8.69		3.30	57.35											
		1	x	2	4.16		3.30	27.42											
	V.O.	1	x	2	3.05		3.30	20.13											
		1	x	2	3.66		3.30	24.16											
	Verandah	1	x	2	3.66		3.30	24.16											
	Sarpanch room A/R	1	x	2	3.66		3.30	24.16											
		1	x	2	3.66		3.30	24.16											
	Sarpanch Toilet A/R	1	x	2	1.35		3.30	8.91											
		1	x	2	1.65		3.30	10.89											
	Gents Toilet A/R	1	x	2	1.35		3.30	8.91											
		1	x	2	1.95		3.30	12.87											
	Around openings																		
	Doors,D1	4	x	1	1.20	0.23		1.10											
		4	x	2	2.10	0.23		3.86											
	D2	3	x	1	1.00	0.23		0.69											
		3	x	2	2.10	0.23		2.90											
	D3	4	x	1	0.75	0.23		0.69											
		4	x	2	2.10	0.23		3.86											
	Windows,W	8	x	2	0.90	0.23		3.31											
		8	x	2	1.35	0.23		4.97											
	Ventilators,V	4	x	2	0.60	0.23		1.10											
		4	x	2	0.45	0.23		0.83											
	Deductions																		
	Doors,D1	4	x	1	1.20		2.10	-2.52											
	Doors,D1 other side	1	x	1	1.20		2.10	-2.52											
	D2	3	x	1	1.00		2.10	-2.10											
	D2 other side	2	x	1	1.00		2.10	-2.10											
	D3	4	x	1	0.75		2.10	-1.58											
	D3 other side	3	x	1	0.75		2.10	-1.58											
	Windows,W	8	x	1	0.90		1.35	-1.22											
	Ventilators,V	4	x	1	0.60		0.45	-0.27											
	Parapet	1	x	1	46.94		1.02	47.64											
								400.52	sqm	931.92	/10sqm	37325.00	408.42	16358.00	317.93	12734.00	205.58	8234.00	37326.00
18	**Plastering 20mm thick in single coat in CM (1:4)** dubara sponge finish including cost and conveyance of all materials like cement, sand, water etc., to site, seigniorage charges, sales & other taxes on all materials, all operational, incidental and labour charges such as mixing mortar,scaffolding charges, lift charges, finishing,including cutting of Grooves wherever necessary as directed by Engineer - in charge, curing, etc., for **Uneven Surfaces of Brick Wall** complete for finished item of work. (APSS 901,903 & 904)																		
	Long walls	1	x	2	13.04		4.03	104.97											
	Cross wall	1	x	2	8.57		4.03	68.99											
	Deductions																		
	Doors,D1	1	x	3	1.20		2.10	-7.56											
	D2	1	x	1	1.00		2.10	-2.10											
	D3	1	x	1	0.75		2.10	-1.58											
	Windows,W	1	x	8	0.90		1.35	-9.72											
	Ventilators,V	1	x	4	0.60		0.45	-1.08											
	Parapet	1	x	1	48.18		1.02	48.90											
	Add for steps																		
	Entrance Verandahs including treads	1	x	2	5.10	2.70		27.54											
	Gents toilet Entrance	1	x	1	1.35	1.50		2.03											
								230.39	sqm	1383.05	/10sqm	31865.00	568.19	13091.00	500.49	11531.00	314.38	7243.00	31865.00
19	Painting to internal walls with white lime in two coats																		
								400.52	sqm	216.95	/10sqm	8689.00	43.35	1736.00	89.60	3589.00	84.00	3364.00	8689.00
20	Painting to new external walls with 2 coats of Water proof cement paint of approved brand and shade over a base coat of approved cement primer exterior grade 2 making 3 coats in all to give an even shade after thoroughly brushing the surface to remove all dirt and remains of loose powdered materials to work site and all operational, incidental, labour charges etc., complete for finished item of work																		
								230.39	sqm	997.52	/10sqm	22982.00	164.72	3795.00	420.00	9677.00	412.80	9511.00	22983.00
21	Painting to ceiling with white lime in two coats																		
								119.53	sqm	216.95	/10sqm	2593.00	43.35	518.00	89.60	1071.00	84.00	1004.00	2593.00

Sl. No.	Description of Item	Nos.	Length	Breadth	Depth	Quantity		Rate per: Rate	per	Amount	Material component: Rate	Material component: Amount	Unskilled Labour component: Rate	Unskilled Labour component: Amount	Skilled Labour component: Rate	Skilled Labour component: Amount	Total Col. (11+13+15)
1	2	3	4	5	6	7		8		9	10	11	12	13	14	15	16
22	Supply and fixing of Sal wood Door Double shutter fully pannlled door of size 1.20 x 2.10mt with frame made of well seasoned sal wood scantlings of size 100 x 75mm mm and shutter made of side rails 125mm X38, top rail 125mmX38mm, bottom rail 125mmX38mm and intermediate rails of 125 x 38 mm and panels - 8 no's are of 25mm thick as per approved design with fixtures of 6 nos of 9" ' z" holdfasts, 300 mm long aluminium aldrop-1 no,125mm long aluminium butt hinges 4 No's, Door stoppers-1 no, 150mm long Tower bolts - 1no's alumium, 200mm long Tower bolts - 1no's alumium,Aluminium fancy handles 150mm long 1no's, with necessary screws complete including cost and conveyance of all materials and labour charges etc. complete as per specifications (APSS NO.1001 & 1002)																
	D1 Doors	1 x 4				4	Nos	7500.00	/Each	30000.00	7500.00	30000.00	0.00	0.00	0.00	0.00	30000.00
23	Supply and fixing of salwood Door single shutter fully pannlled door of size 1.00 x 2.1mt with frame made of well seasoned sal Wood scantlings of size 100 x 75mm and bottom reeper of size 75x38mm and shutter made of side rails 125mm X38, top rail 125mmX38mm, bottom rail 175mmX38mm and intermediate rails of 125 x 38 mm and panels - 4 no's are of 25mm thick as per approved design with fixtures of 6 nos of 9" ' z" holdfasts, 300 mm long aluminium aldrop-1 no,125mm long aluminium butt hinges 4 No's, Door stoppers-1 no, 150mm long Tower bolts - 1no's alumium, 200mm long Tower bolts - 1no's alumium,Aluminium fancy handles 150mm long 1no's, with necessary screws complete including cost and conveyance of all materials and labour charges etc. complete as per specifications (APSS NO.1001 & 1002)																
	D2 Doors	1 x 3				3	Nos	6500.00	/Each	19500.00	6500.00	19500.00	0.00	0.00	0.00	0.00	19500.00
24	Supply and fixing of salwood Door single shutter fully pannelled door of size 0.75 x 2.1mt with frame made of well seasoned Sal Wood scantlings of size 100 x 75mm and bottom reeper of size 75x38mm and shutter made of side rails 125mm X38, top rail 125mmX38mm, bottom rail 125mmX38mm and intermediate rails of 125 x 38 mm and panels - 4 no's are of 25mm thick as per approved design with fixtures of 6 nos of 9" ' z" holdfasts, 300 mm long aluminium aldrop-1 no,125mm long aluminium butt hinges 4 No's, Door stoppers-1 no, 150mm long Tower bolts - 1no's alumium, 200mm long Tower bolts - 1no's alumium,Aluminium fancy handles 150mm long 1no's, with necessary screws complete including cost and conveyance of all materials and labour charges etc. complete as per specifications (APSS NO.1001 & 1002)																
	D3 Doors	1 x 4				4	Nos.	5500.00	/Each	22000.00	5500.00	22000.00	0.00	0.00	0.00	0.00	22000.00
25	Supply and fixing of Window size 0.90 x 1.35 mt with sal wood frame of size 75x100mm along with II class teak wood three shutters made with styles& rails of 100mmx30mm thick with 12mm prelaminated particle board both side laminated interior grade and S/F of 4Nos. MS Hold fasts, 6Nos. MS tower bolts 100mm long. 6 Nos. MS Hinges 75mm long,2Nos MS Handles 3 Nos window stays. incl. all labour charges such as making window frame & shetter and fiXing 11 Nos. 16mm plain safety bars in to frame etc,																
	W- Windows	1 x 8				8	Nos.	3000.00	/Each	24000.00	3000.00	24000.00	0.00	0.00	0.00	0.00	24000.00
26	Manufacture, supply and fixing of RCC ventilators size 0.60 x 0.45m in position																
	V- Ventilators	1 x 4				4	Nos.	500.00	/Each	2000.00	500.00	2000.00	0.00	0.00	0.00	0.00	2000.00
27	Providing impervious coat to exposed RCC roof slab surface with CM(1:3) 20mm thick with 1kg of water proof compound per bag of cement laid over roof when it is green including cost of all materials, seigniorage charges, including other taxes on all materials , including cost and conveyance of all materials to site, all incidental, operational and labour charges for mixing mortar, laying rendering smooth and thread lining curing, rounding off junctions of wall and slab etc., complete for finished item of work																
	Roof slab 125mm thick	1 x 1	13.64	9.17		125.08											
	Gents &Sarpanch's Toilet	1 x 1	1.28	4.29		5.49											
	Entrance Verandahs	1 x 2	2.10	1.20		5.04											
						135.61	sqm	248.76	sqm	33735.00	72.78	9870.00	103.60	14049.00	72.38	9815.00	33734.00
										1101546.00		666917.0		318924.00		115705.0	1101546.0
28	Add LS for Electrification, Water supply & Sanitary items @ 7.5%									82616.00	%	**60.54**		**28.95**		**10.50**	
										1184162.00							
29	Provision for VAT @ 5% (On Value of Work)									59208.00							
30	QC charges @ 0.5% (On Value of Work)									5921.00	**Mandays for skilled & semi skilled labour @ Rs.335/- average rate**					**345.39**	
31	LS Provision for unforeseen items, variation in depth of foundations, undulations in ground levels etc.									25709.00	**Mandays for unskilled labour @ Rs.169/-**			**1887.00**			
	Total Estimate cost									**1275000.00**							

ANNEXURE XVII: FORMAT FOR THE APPLICATION FORM FOR DEMAND OF WORK AND INDIVIDUAL ASSET

To,
Sarpanch
Gram Panchayat _______________,
Block _______________,
District _______________,

To,
The Programme Officer,
Block _______________ District

Date _______________ **Application Code** _______________ (To be filled by Office)

Subject: Application for work and MGNREGA work on my land.

Sir/Madam,

I hereby submit my application for work under section 5(1) and Paragraph 9 of Schedule-II of MGNREGA. The details of my request and the period for which work is required are:

S.No.	Name of the applicant with Father's / Husband's name	Address	Job Card Number	Period(s) from which employment is needed		Requirement of Creche (Yes/No)
				From	To	

I am willing to work for at least 14 continuous days in the work allotted to me. Under section 4(3) and Paragraph 5 of Schedule-I of MGNREGA, I also want to get Land Development/ Irrigation Facility/ Horticulture/ Plantation/ NADEP composting pit/ Vermi composting pit/ liquid bio- manure pit/ poultry shelter/ goat shelter/ cattle shed/ fish drying yard/ work to be carried out on my land/ homestead. The photo copy of khasra map of my land/ homestead is enclosed herewith. The other required details are as follows-

1. **Total land holding, Area (khasra No.) : __________ Hectare (Khasra No. ______)**
2. **Land holding, Area (Khasra No.) on which work is to be carried out: _____ Hectare (Khasra No. _____)**
3. **My Job Card No. is __________________**
4. **Declaration that the maintenance of asset created under MGNREGA on my land/ homestead, as per the prescribed schedule of maintenance by the State will be my responsibility.**

(Signature/ LTI Thumb Impression of the Applicant)

ACKNOWLEDGEMENT RECEIPT (for office use only)

Received application for work from Shri ____________________ s/o / w/o ________________________ of village __________________ who's Job Card Number is _________________On date ____________________ (date/month/year).

(Signature of Sarpanch/ Programme Officer)

ANNEXURE XVIII: MAINTENANCE SCHEDULE FOR WORKS UNDER MGNREGA

S. No.	Type of work	Routine Maintenance	Batural calamity Maintenance
(1)	**(2)**	**(3)**	**(4)**
1.	Plantation work	**(a)** Weeding, hoeing, watering, manuring, insect/ pest control for 3-5 years in case of horticulture plantation and 3-4 years in case of forestry plantation **as a part of execution of works.** **(b)** Thereafter, post plantation maintenance as per species wise model estimates.	**(c)** Because of drought, flood, typhoon etc., based on inspection/ survey and estimation.
2.	Kachha work	**(a)** 1st year after completion of work and after 1st rain i.e. repairing rills & gullies, ruts & potholes, backfills, clearing drainage system, clearing and cutting weeds, repairing designed slopes **as a part of execution of works.** **(b)** Thereafter, post construction maintenance after every rainy season, based on inspection/ survey.	**(c)** Because of flood, cloud burst, typhoon etc., based on inspection/ survey and estimation.
3.	Pucca work	**(a)** In case of water harvesting structures and building repairing after 1st rainy season as per need based on survey, like repairing leakages/ dampness, earthen refill etc. **as a part of execution of works.** **(b)** Thereafter, post construction maintenance after every 3 years based on inspection/ survey.	**(c)** Because of flood, cloud burst, typhoon etc., based on inspection/ survey and estimation.

ANNEXURE XIX: FORMAT FOR PUBLIC ASSET MAINTENANCE REGISTER

S. No.	Name of asset	Year of creation/ completion	Entered in asset register at page number	Post plantation/ construction maintenance due on (month/year)	Post plantation/construction maintenance work			
					AS & FS No./ TS No.	carried out in (month/year)	Amount spent	Present status/ condition of the asset
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

ANNEXURE XX: FORMAT FOR INDIVIDUAL ASSET MAINTENANCE REGISTER

S. No.	Name of asset	Year of creation	Name of beneficiary/ Job Card No.	Entered in asset register at page number	Post plantation/ construction maintenance due on (month/year)	Post plantation/construction maintenance work		
						carried out in (month/year)	Amount spent	Present status/ condition of the asset
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

ANNEXURE-XXI: LIST OF CIRCULARS/ ADVISORIES/ GUIDELINES ISSUED FROM THE MINISTRY AND ARE RELEVANT TO MGNREGA WORKS AND CONVERGENCE

CIRCULARS/ ADVISORIES/ GUIDELINES ISSUED FROM THE MINISTRY AND ARE RELEVANT TO MGNREGA WORKS			
S.NO.	**SUBJECT**	**LETTER NO.**	**DATE OF ISSUE**
1	Guidelines on expanding the scope of works under schedule Para 1(g) to include construction of Bharat Nirman Rajiv Gandhi Sewa Kendra (BNRGSK)	J-11013/2/2009-NREGA (Pt.)	30th Dec. 2009
2.	Advisory on construction of inlet & outlet in Farm Pond/ Talab	J-11017/40/2011-MGNREGA (UN)	23rd Nov. 2011
3.	Advisory on Tree Guards	J-11017/40/2011-MGNREGA (UN)	11th Jan. 2012
4.	Repair & Renovation of water bodies	J-11016/48/2011-MGNREGA	17th April,2012
5.	Advisory on live fencing to protect crops from wildlife depredation	J-11017/40/2011-MGNREGA (UN)	5th July, 2012
6.	Advisory on development of pasture lands under MGNREGA for drought proofing	J-11017/40/2011-MGNREGA (UN)	14th Aug.2012
7.	“Muzaffarpur Model on roadside plantations under MGNREGS”	J-11017/40/2011-MGNREGA (UN)	10th Sep.2012
8.	Forest fire preventation works	J-11017/41/2012-MGNREGA (UN)	11th Sep.2012
9.	Guidelines on construction water courses	J-11017/41/2012-MGNREGA (UN)	18th Sep.2012
10.	Guidelines for field trials for production of building materials only for MGNREGA works	J-11017/26/2008-MGNREGA (UN)	13th Jan. 2014
11.	Estimation of period required in completion of MGNREGA works	J-11017/40/2011-MGNREGA (UN)	28th Feb.2014
13.	“Action Plan for Roadside Tree Plantation” under MGNREGA	J-11017/17/2008-NREGA (UN) (Part II)	31st July, 2014
14.	Outcome orientation in works under MGNREGA	J-11011/02/2010-MGNREGA (Policy)10093	5th Aug. 2014
15.	Special focus on recharging ground water including drinking water sources	J-11017/40/2011-MGNREGA (UN)	7th Aug. 2014
16.	Guidelines on, “ Watershed Management works taken independently under or in convergence with IWMP”	J-11017/17/2008-NREGA (UN)	11th Aug 2014
17.	Clarification regarding use machines in MGNREGS works	J-11011/09/2014-RE-I	25th Aug.2014
18.	Maintenance & Rehabilitation of canals/drains	J-12036/1/2013-MGNREGA (Pt.III)29080	16th Sep. 2014

S.NO.	SUBJECT	LETTER NO.	DATE OF ISSUE
19.	Clarification on, "MGNREGA works directly linked to agriculture and allied activities through development of land, water and trees".	J-11017/41/2012-MGNREGA (UN)(Pt.-II)	17th Sep. 2014
20.	Construction of Individual House Hold Latrines (IHHLs) under MGNREGA	J-11017/41/2011-MGNREGA (Part)	25th Nov. 2014
21.	Construction of Goat shelter under MGNREGA	J-11017/40/2011-MGNREGA (UN)	3rd Dec 2014
22.	Advisory on, "Plantation & Maintenance of trees producing oilseeds"	J-11017/17/2008-NREGA (UN)(Part-II)	29th Dec.2014
23.	Action Plan for Swatch Bharat Mission under MGNREGA	J-11017/41/2011-MGNREGA (Part)	19th Jan. 2015

GUIDELINES ISSUED FROM THE MINISTRY AND ARE RELEVANT TO CONVERGENCE:

S.NO	SUBJECT	LETTER NO	DATE OF ISSUE
1.	Guidelines for providing inputs under the schemes of by ICAR and its field institutions like KVKs, etc.	J-11019/12/2008-NREGA (ICAR)	24th Dec.2008
2.	Guidelines for convergence between MGNREGS and the scheme of the Ministry of Environment & Forest	J-11019/2/2008-NREGA	19th Jan. 2009
3.	Guidelines for convergence of MGNREGS with the schemes of Ministry of water Resources	J-11019/2/2008-NREGA	18th Feb. 2009
4.	Guidelines for Convergence NREGA with Programmes of MOA for Development of Agriculture and Allied sector.	J-11019/2/2008-NREGA	12th Oct. 2009
5.	Construction of Play fields under MGNREGS Scheme	J-12055/1/2007-NREGA	11th Feb,2013
6.	Additional Convergence guidelines MGNREGA & Programme of Ministry of Agriculture	J-13011/1/2009-MGNREGA	13th June.2013
7.	Guidelines for taking up Rubber Plantation through Convergence of MGNREGS & Schemes of Rubber Board, Ministry of Commerce & Industry	J-11017/17/2013-MGNREGA (UN)(Part-III)	2nd Aug. 2013
8.	Guidelines on, " Watershed Management works taken up independently under MGNREGA or in convergence with IWMP"	J-11017/17/2008-NREGA (UN)	11th Aug 2014

S.NO	SUBJECT	LETTER NO	DATE OF ISSUE
9.	"Guidelines for Convergence MGNREGA with Catalytic Development Programmes of Ministry of Textiles"	J-11017/17/2013-MGNREGA (UN)(Part-II)	8th Oct.2013
10.	"Convergence Guidelines for MGNREGS & PMGSY"	J-11060/1/2011-MGNREGA	7th Nov. 2013
11.	Convergence guidelines MGNREGS & PMGSY	J-11060/1/2011-MGNREGA	7th Nov, 2013
12.	Guidelines for construction of Houses (Sanctioned under IAY or such other State or Central Government scheme) under MGNREGA	J-11017/40/2011-MGNREGA (UN)	30th June, 2014
13.	Guidelines on watershed management works taken up independently under MGNREGA or in convergence with IWMP	J-11017/17/2008-NREGA (UN)	11th Aug 2014
14.	Advisory on, " Convergence of MGNREGS and Railways"	J-11017/42/2013-MGNREGA (UN)	21st Sep. 2014
15.	Guidelines for taking up Coconut plantation through convergence of MGNREGS & Expansion of Area under coconut (AEP) scheme of Coconut Development Board, MOA	J-11017/48/2014-MGNREGA (UN)	20th Feb. 2015
16.	Guidelines for convergence MGNREGS with Green India Mission (GIM) of MoEF & CC	9-5/2015/GIM/MGNREGS	3rd March 2015

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Back Cover